EUROPEAN SOCIETY OF VETERINARY ORTHOPAEDICS AND TRAUMATOLOGY

10th Annual ESVOT Congress
March 24th - 26th 2000
Munich, Germany

PROCEEDINGS

Department of Veterinary Surgery
School of Veterinary Medicine
Ludwig-Maximilians-University,
Munich, Germany

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M. Schramme
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4th E.S.V.O.T. - Congress 1990 Uppsala, Sweden
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Opening Address
from Dr. Edmund Stoiber,
Premier of Bavaria

The Millennium Convention
European Society of Veterinary Orthopedics and Traumatology
ESVOT

Munich, Germany
March 23 - 26, 2000

As patron of the 10th ESVOT conference, I would like to extend a warm welcome to all in attendance at the Veterinary Faculty of the Ludwig-Maximilians-University of Munich. For the guests from around the globe as well as for the organizers, I sincerely hope that this conference is fruitful and that the exchange of knowledge and experience proves useful.

I am pleased that the millennium conference of the ESVOT is taking place in the capital of the State of Bavaria and hope that the programme renews interest in the future development of veterinary medicine. Our responsibility for our four-legged companions will be an important moral obligation in the new century. The themes of this conference, which encompass research, teaching and clinical practice, indicate that the veterinary community is well aware of this responsibility. The topics addressed in the area of animal welfare and the discussion of animal experimentation are timely topics for researchers and scientists.

I hope that this ESVOT conference will bear testimony to the sense of responsibility of the veterinary community. With this in mind, I wish you a successful meeting here in Munich.

Dr. Edmund Stoiber
Premier of Bavaria
Welcome Address from Prof. Dr. Uli Matis, President of ESVOT

Dear colleagues and friends,

On behalf of ESVOT, I would like to welcome you to our tenth conference here in Munich. It is the third time that Munich has been chosen for the conference; this is a mark of confidence, which is both an honour and a challenge.

I would like to thank Minister President, Dr. Stoiber, who has once again very kindly acted as our patron; Professor Heldrich, the rector of the Ludwig-Maximilians-University and Professor Stangassinger, the dean of the Veterinary Faculty, for their generous hospitality. Their support makes it possible to open our millennium conference here in the magnificent Munich Residence and to enjoy an interesting scientific programme at our university.

The programme is composed of current topics and research results as well as wet labs and in-depth seminars. I hope that we can present a broad clinical and scientific spectrum in our fields of interest, with some reference to human medicine. Many thanks are due to John Houlton, Jean Francois Bardet, Chris Riggs and Michael Schramme for the preparation of the scientific programme. A special thank you goes to Aldo Vezzoni, who has proved himself a multitalent in many areas.

I would also like to thank all the exhibitors and sponsors. Without their financial support, such a conference would not be possible. The industrial exhibitors provide very useful information about new drugs, equipment, instruments, books and many other things. We realize that despite general and widespread financial restraints, we have been receiving very generous support.

International conferences should not only serve the needs of clinical practice and science but also cultivate personal contact. In this respect, the rich culture of Munich has much to offer. I thank Cornelia Schröttenhammer and her team for preparing the social programme. Last, but of course not least, I would like to express my gratitude to the staff of the Department of Veterinary Surgery, who have given me their continued support.

Uli Matis
President of ESVOT
# Programme at a Glance

## Thursday 23rd March, pre-Congress day

<table>
<thead>
<tr>
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<th>Room D2</th>
<th>Room B1-B2</th>
<th>Room A1</th>
<th>Room C</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.45</td>
<td>Small Animal Interlocking Nail wet lab</td>
<td>Small Animal TPLO wet lab</td>
<td>Small Animal Shoulder Instability course</td>
<td>Large Animal Lameness Diagnosis wet lab</td>
</tr>
<tr>
<td>18.30</td>
<td>Room A1 - Small and large animals State of the Art Lecture</td>
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</tbody>
</table>

## Thursday 23rd March, evening

- Max Joseph Saal - Residenz of Munich
- Opening Ceremony - Greetings addresses
- Paatsama Lecture: The life and works of Saki, G. Sumner Smith, CAN
- Concert - Welcome reception

## Friday 24th March

<table>
<thead>
<tr>
<th>Time</th>
<th>Room A1 - Small and large animals State of the Art Lecture</th>
<th>Room B1 small animal</th>
<th>Room C large animal</th>
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</thead>
<tbody>
<tr>
<td>8.45</td>
<td>Cruciate and meniscal injuries - R. Ascherl, D</td>
<td>The Stifle</td>
<td>The Stifle</td>
</tr>
<tr>
<td>9.30</td>
<td>Room A1 small animal</td>
<td>Tibial Plateau</td>
<td>Prevention of Racing Injuries</td>
</tr>
<tr>
<td>10.00</td>
<td>The Stifle</td>
<td>Advanced Arthroscopy in Dogs</td>
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<tr>
<td>14.30</td>
<td>Tibial Plateau</td>
<td>Arthrodesis</td>
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<tr>
<td>18.00</td>
<td>Levelling Osteotomy</td>
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<td>18.10</td>
<td>Levelling Osteotomy</td>
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## Saturday 25th March

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<thead>
<tr>
<th>Time</th>
<th>Room A1 - Small and large animals State of the Art Lecture</th>
<th>Room B1 small animal</th>
<th>Room C large animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00</td>
<td>Imagining Techniques in Orthopaedic Trauma - M. Reiser, D</td>
<td>Carpal and Tarsal Arthrodesis Management of Osteoarthritis</td>
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</tr>
<tr>
<td>10.30</td>
<td>Small Animal State of the Art Lecture</td>
<td>Intensive Care</td>
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<tr>
<td>11.00</td>
<td>Small Animal Growth Disturbances</td>
<td>Abdominal Trauma</td>
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<td>14.30</td>
<td>Alignment Problems of the Hind Limb</td>
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## Sunday 26th March

<table>
<thead>
<tr>
<th>Time</th>
<th>Room A1 small animal</th>
<th>Room B1 small animal</th>
<th>Room C large animal</th>
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<tbody>
<tr>
<td>9.00</td>
<td>Free Communications</td>
<td>Elbow Dysplasia</td>
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<tr>
<td>11.30</td>
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<tr>
<td>11.45</td>
<td>Room A1 - small &amp; large animals State of the Art Lecture</td>
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<tr>
<td></td>
<td>What is true in Physiotherapy? - N. Seichert, CH</td>
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Programme Small and Large Animals

Friday, 24th March 2000

ROOM A1
Small and Large Animals

08.45 Small and Large Animals State of the Art Lecture:
Cruciate and Meniscal injuries - Prof. Dr Rudolf Ascherl
09.30 Opening of the Commercial Exhibition.

ROOM A1
Small Animal
THE STIFLE

10.00 Recent advances in understanding cruciate disease
D. Bennett, UK

10.20 Diagnosis of meniscal injuries
H. van Bree, B

10.40 Arthroscopic meniscal treatment; meniscectomy, meniscal release and meniscal ablation
D. Hulse, USA

11.00 Commercial Exhibition and Coffee Break

11.40 Arthroscopic Intra-articular reconstruction of the CCL deficient stifle using the Over the Top Technique
D. Hulse, USA

12.00 Post-operative rehabilitation of the reconstructed stifle joint
D. Hulse, USA

12.20 Arthroscopic revision of failed cruciate repairs - J. F. Bardet, F

12.40 Discussion

13.00 Commercial Exhibition and Lunch

ROOM A1
Small Animal
TIBIAL PLATEAU LEVELLING
OSTEOTOMY SEMINAR

14.30 Biomechanics of the knee joint
B. Slocum & T. Devine, USA

16.00 Commercial Exhibition and Coffee Break

16.30 Diagnosis and treatment of partial and complete CCL rupture
B. Slocum & T. Devine, USA

18.00 End

ROOM B1
Small Animal
CARPAL and TARSAL ARTHRODESIS

10.00 Pancarpal arthrodesis - dorsal plate
R. Kostlin, D

10.20 Pancarpal arthrodesis - alternatives to the dorsal plate
D. Hulse, USA

10.40 Partial carpal arthrodesis
K. Johnson, USA
11.00 Commercial Exhibition and Coffee Break
11.40 Calcaneoquartal arthrodesis
   D. Bennett, UK
12.00 Tarsometatarsal arthrodesis
   J. Houlton, UK
12.15 Pantarsal arthrodesis
   R. Vannini, CH
12.40 Discussion
13.00 Commercial Exhibition and Lunch

ROOM B1
Small Animal
ADVANCED ARTHROSCOPY IN DOGS
Current experiences in Belgium, France, UK and USA

14.30 H. van Bree, B
15.15 J. F. Bardet, FR
16.00 Commercial Exhibition and Coffee Break
16.30 J. Innes, UK
17.15 D. Hulse, US
18.00 End

ROOM C
Large Animal
The stifle

10.00 Detailed anatomy of the equine & bovine stifle
   J. M. Denoix, F
10.30 Diagnosis and management of meniscal injuries in the horse
   J. Walmsley, UK
11.00 Commercial Exhibition and Coffee Break
11.40 Diagnosis and management of cruciate ligament injuries in the horse - G. Trotter, US
12.00 Arthroscopy of the bovine stifle
   M. Hurtig, CAN
12.30 Round table discussion with speakers: What is realistically possible to restore a traumatised stifle in large animal species to athletic fitness?
Saturday, 25th March 2000

ROOM A1
Small and Large Animals

9.00  Small and Large Animals State of the Art Lecture: Imaging techniques in Orthopaedic Trauma. - Prof. Dr. Maximilian Reiser, D

10.30  Commercial Exhibition and Coffee Break

ROOM A1
Small Animal
GROWTH DISTURBANCES

11.00  Role of nutrition
        H. Hazelwinkel, NL

11.20  Limb deformities assessed by CT
        S. Hecht, D

11.35  Management of angular deformities of the canine forelimb using the Ilizarov fixator
        A. Ferretti, I

11.40  Bone transport in man using the interlocking nail
        R. Baumgart & R. Mutschler, D

12.30  Discussion

13.00  Commercial Exhibition and Lunch

ROOM A1
Small Animal
ALIGNMENT PROBLEMS OF THE HINDLIMB

14.30  Predisposing factors to malalignment
        B. Slocum & T. Devine, USA

16.00  Commercial Exhibition and Coffee Break

16.30  Diagnosis and treatment of malalignment conditions
        B. Slocum & T. Devine, USA

17.30  Discussion

18.00  End

ROOM B1
Small Animal
ABDOMINAL TRAUMA SEMINAR

11.00  Triage and preoperative management of the abdominal trauma patient
        T. Hackett, USA

11.40  Imaging the acute abdomen
        M. Fluckiger, CH

12.00  Open peritoneal drainage
        T. Hackett, USA

12.20  Parenteral feeding
        H. Hazelwinkel, NL

12.40  Discussion

13.00  Commercial Exhibition and Lunch
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ROOM B1
Small Animal
INTENSIVE CARE SEMINAR

14.30 Treatment priorities in the small animal trauma patient
T. Hackett, USA

16.00 Commercial Exhibition and
Coffee Break

16.40 Post-operative management of the trauma patient
T. Hackett, USA

17.40 Discussion

18.00 End

ROOM C
Large Animal
MANAGEMENT OF OSTEARTHRITIS

11.00 Joint resurfacing in the horse -
A practical proposition?
M. Hurtig, CAN

11.25 Micropicking - Technique of the future? G. Trotter, USA

11.45 Experiences with total joint replacement in the horse
P. Stolk, NL

12.05 Chemical arthrodesis
M. Schramme, UK

12.20 What's new in medical management of OA?
G. Trotter, USA

12.45 Discussion

13.00 Commercial Exhibition and Lunch

ROOM C
Large Animal
WOUND MANAGEMENT

14.30 Management of open wounds
J. Wilmink, NL

15.00 Selection of appropriate wound dressings for open wound management in large animals
What has recent research taught us?
D. Knottenbelt, UK

15.30 Useful tips for primary wound reconstruction in large animals
H. Gerhards, D

16.00 Commercial Exhibition and
Coffee Break

16.30 WOUND PANEL
90 minutes for 6 to 8 case presentations
Convenor:
M. Schramme, UK; C. Riggs, USA
Panel members:
Y. Wilmink, NL; G. Trotter, USA;
D. Knottenbelt, UK; A. Steiner, CH and H. Gerhards, D

18.00 End
10th ESVOT Congress, Munich, 23-26th March 2000

Room C
Large Animal
PREVENTION OF RACING INJURIES

14.30 Aetiopathogenesis of fatigue fractures - D. Nunamaker, USA
15.00 Aetiopathogenesis and diagnosis of fatigue injuries to tendons and ligaments - R. Smith, UK
15.30 Early diagnosis of musculo-skeletal fatigue injuries in racehorses - M. Martinelli, USA
16.00 Commercial Exhibition and Coffee Break
16.30 Management of early diagnosed fatigue injuries to the skeletal system in racehorses
D. Nunamaker, USA
16.55 Prevention and early management of fatigue injuries of tendons/ligaments in racehorses
R. Smith, UK
17.20 Novel training strategies
D. Nunamaker, USA
17.45 Discussion
18.00 End

Sunday, 26th March 2000
ROOM A1
Small Animal
Free Communications

08.30 Mechanical Properties of the CCL in different degrees of stifle flexion: an experimental study in dogs
I. Leopizzi, BRA
08.45 The use of plate & rod for the repair of complex and unstable fractures of femur, tibia and humerus
R. De Keyser, B
09.00 Effects of oral Chondroitin Sulfate, Glucosamine and Manganese administration on Synovial fluid 3B3 and 7D4 epitope levels in a canine model of Osteoarthritis
K. A. Johnson, USA
09.15 A prospective study of the Surgical Treatment of Unilateral FCP using Force Plate Analysis
L. Theyse, NL
09.30 Nutritional research on bones and joints in the dog
R. Nap, NL
09.45 Cauda Equina Compression through OCD-like lesions in the Sacrum: Clinical signs, Treatment and Outcome in 10 German Shepherds Dogs
H. Kriegleder, D
10.00 The maxillofacial miniplate Compact 1.0 used for fracture repair in 12 dogs and 2 cats
C. von Werthern, CH
10.15 A new surgical technique for spinal stabilisation: the pedicle screw fixation. Anatomic and technical considerations
P. Mheust, F
10.30 Coffee Break
11.00 Eleven cases of Angular Deformities in the Dog corrected by means of the Ilizarov technique
G.L. Rovesti, I
11.15 TPO in Dogs: proposal of a caudal iliac osteotomy
B. Pierone, I
11.30 Application of the Point Contact Fixator for Fracture Treatment in Dogs; a retrospective study of 53 cases
C. von Werthern, CH
ROOM B1
Small Animal
ELBOW DYSPLASIA SEMINAR

08.45 New Aspects of the Functional Anatomy of the Canine Elbow Joint, J. M. aierl, D
09.0 CT absorptiometry in dogs with elbow diseases J. Korb, D
09.15 Management of UAP by lag screw fixation U. Matis, D
09.30 Dynamic ulnar osteotomies A. Vezzoni, I
09.50 Arthroscopic treatment - the Belgian experience H. van Bree, B
10.10 Arthroscopic treatment - the French experience J.-F. Bardet, F
10.30 Commercial Exhibition and Coffee Break
11.00 Non-surgical treatment H. Hazewinkel, N L
11.20 Discussion
11.30 End

ROOM C
Large Animal
Free Communications

09.00 Osteochondral fragments from the medial malleolus in horses: a comparision between radiographic and arthroscopic findings F. Torre, I
09.15 A radiological study to evaluate suspected scapulohumeral joint dysplasia in Shetland ponies J. Boswell, U K
09.30 Age related changes in the equine calcified cartilage layer M. Martinelli, USA
09.45 Quantitative ultrasound and biochemical markers for equine bone assessment O. Lepage, F
10.00 Correlation of radiological and clinical findings in horses with assumed back-problems W. Ranner & H. Gerhards, D
10.15 Contrast radiography and 3D reconstruction of bovine limb joints K. Nuss, D
10.30 Commercial Exhibition and Coffee Break
11.00 Experiences with the application of VET BIOSIST in equine wounds W. Brehm, C H
11.15 Preliminary results with a bio-absorbable implant for flexor tendon lacerations in horses R. Smith, U K
11.30 Diagnosis and management of severe corneal and scleral lacerations B. Wollanke & H. Gerhards, D

ROOM A1
Small and Large Animals

11.45 Small and large animals State of the Art Lecture. What is true in Physiotherapy? - Prof. Dr. N. Seichert, C H
12.45 Discussion
13.00 End of the Meeting
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Main Program

State of the Art Lectures
Small & Large Animals
Cruciate and meniscal injuries

R. Ascherl

The cruciate ligaments act both as strain gauges (proprioception) and stress absorbers. They function according to the principle of isometricity and thus are able to control motion in a perfect way. Any disorder results in instability and malfunction of the joint. Hyperextension and flexion-internal rotation-valgus (as occurs in contact sports) are the most important mechanisms which lead to tears of the cruciates. The maximal load in humans is 700-1100 N, in dogs, 800 N and in sheep, 850 N.

Clinical history and physical examination are the best pathways to diagnosis. MRI can demonstrate the location of the rupture and accompanying injuries such as meniscal tears, chondral injuries and microfractures of the bone („bone bruising“). Arthroscopy is not only a diagnostic measure but also of therapeutic value, especially in reconstruction techniques.

For a successful repair one should rely on bone-tendon-bone transplants using the central third of the patellar tendon. Transplants have to be implanted as close as possible to their isometric points using bone tunnels. Immobilisation has to be avoided as much as possible; transplants which are mobilized have almost twice the maximal load strength of immobilized controls. Recovery of proprioceptive function of cruciate repairs takes months or more.

Tears of the menisci can only be sutured, regardless of technique, close to their insertion (outer third) due to their blood supply. Tears in the edges have to be removed.

Meniscal tissue should never should be used for the repair of the anterior cruciate ligament, and should never be completely removed.

Up to now there is no synthetic material or prosthesis which can replace the anterior cruciate or the meniscus. Both robotics and navigation techniques will improve cruciate replacement.
Imaging Techniques in Orthopaedic Trauma

M. Reiser

Magnetic Resonance Imaging (MRI) has unique capabilities which make it a highly useful tool for the diagnosis of orthopaedic trauma. Orthopaedic MRI has been employed in human medical imaging early after the introduction of this technique in the early eighties. Nowadays, MRI of the musculoskeletal system is the second most application of MRI following brain- and spine imaging. Superior contrast resolution (soft tissue contrast) and multiplanar anatomical representation are unique features. In this talk, the application of MRI in orthopaedic trauma of human patients will be discussed and possible use in veterinary orthopaedics and traumatology will be evaluated.

Ligaments, tendons, menisci, and joints
Due to their high content of collagen fibres and low concentration mobile protons, normal ligaments have a low signal intensity. In rupture and degeneration, tendons and ligaments exhibit an increase in signal intensity. The morphological appearance and the signal alterations allow for assessment of degeneration, partial and complete rupture of the ligaments and tendons. In the assessment of cruciate ligament lesions, collateral ligament lesions of the ankle and supraspinatus muscle and tendon disorders, MRI has a very high accuracy. The menisci of the knee are delineated as low signal intensity triangular shaped structures. When linear signal increase is found, which communicates with the surface of the meniscus, a tear is present. Fragmentation is also a reliable sign of meniscus lesions. Joint effusion highlight the internal joint structures (arthrographic effect) and can be assessed also in those areas, where ultrasound might be difficult. The hyaline cartilage of the joints can also be precisely evaluated utilising adequate MRI-techniques.

Muscle injuries and degeneration's
Ruptures, hematoma and edema of the muscles are adequately displayed with MRI. Hematoma exhibits specific signal intensities depending upon the concentration of various metabolites of hemoglobin (oxyhemoglobin, deoxyhemoglobin, methemoglobin, hemosiderin). With longitudinal slices (coronal, sagittal, oblique) the extent and location of intramuscular hematomas can be precisely assessed. In rupture of muscles, discontinuity is found. Minor trauma manifest as edema within the muscle, which can be highlighted by T1-weighted and STIR-sequences. In degenerative changes, due to nerve injuries and chronic inflammatory lesions, the fat content is increased which can be verified by T2-weighted spin-echo and fat suppression techniques.

Bony contusions, occult and stress fractures
Bony contusions (bone bruises) result in edema and haemorrhage as well as microtrabecular fractures of the spongy bone. These alterations are displayed with specific signal intensities and, when present, allow for otherwise unexplained clinical symptoms. Within several months, the signal alterations are reversible. Occult fractures are defined as fractures which cannot be detected on adequately performed plain radiograms. In MRI bone marrow edema and low intensity fracture lines are detected. Also early stages of stress fractures are detected with MRI even when in plain films are normal. There is a clear evidence that MRI can be utilised as an reliable and cost-effective method for the detection of occult fractures and stress fractures as well as stress reactions.

Conclusion
It can be anticipated, that the beneficial role of MRI in human orthopaedics and traumatology will also apply for animals and, when available, will have major impacts on veterinary medicine.
What is true in Physiotherapy?

N. Seichert

In human medicine, physiotherapy plays an important role in the rehabilitation of patients suffering from functional disorders after degenerative or traumatic processes. The principle of physiotherapy is the application of physical stimuli to different tissues or organs in order to produce a reactive answer of the organism. This reaction may be an improvement of joint ROM (range of motion), a reduction of pain, an increase in muscular force or an improvement of motor control. Advantages of physiotherapy are the lack of side effects and the low cost instrumentation.

Physiotherapeutic techniques can be generally divided into two classes:

- The so called “active” techniques, where the patient must contribute actively to the therapeutic process, carrying out some special forms of physical exercise. The physical stimulus applied in active techniques may be seen as the loading or the stress produced by the movement on joints, muscles and other structures.
- The so called “passive” techniques, e.g. massage, kryo- and thermotherapy, hydrotherapy, electrotherapy and phototherapy. These techniques are called passive ones, because the patient does not contribute actively to the therapy. But nevertheless they are active in the sense, that the applied stimuli trigger reactive answers of different tissues and organs, which are believed to be responsible for the therapeutic effect.

In human medicine, the most important techniques are the active ones, namely the so called “based on neurophysiology”, examples of which are the methods according to Maitland, to Bobath or the Proprioceptive Neuromuscular Facilitation (PNF). Such powerful techniques are not applicable to animals, because they need the comprehensive and conscious collaboration of the patient. Less sophisticated active techniques are possible in animals, but they reduce to simple physical exercises. E.g., a dog with a wounded limb can be trained on a treadmill, but instinctively it will put less load on the affected limb or even not use it at all. Instead, it will develop compensatory locomotor mechanisms, resulting in a forced training of the healthy limbs, increasing the functional asymmetry. In the worst case, the animal will permanently use only three limbs after therapy.

Due to these reasons, passive techniques seems to be better suited for veterinary medicine, but most of them are rather difficult to apply in animals. Muscle massage could be a powerful tool in certain cases, but it is seldom used, as far as I know. Some of the electrotherapeutic methods are also possible in principle, but the application is hindered by the coat of most animals. In electrotherapy, there are three scientifically and clinically confirmed working principles, namely analgesia, muscular stimulation, and tissue heating. All methods of electrotherapy established in human medicine are based on those three basic principles. At present, some “complementary” forms of electrotherapy are being increasingly advocated. Most of them, called by us “electromythology”, lack any rationally founded working principle and are not clinically confirmed. Unfortunately such methods, namely the so called “magnetotherapy” and the “soft” or “low level laser therapy”, currently invade veterinary medicine. This lecture should help the participants to distinguish between realistic and excessive expectations.
Main Program
and
Free Communications

Small Animal
Recent advances in understanding cruciate disease

D. Bennett

Cruciate ligament failure is a very common entity in the dog; the term 'Cruciate disease' was introduced in 1988 to cover a number of pathological entities and clinical syndromes associated with this particular problem (Bennett D et al, Journal of Small Animal Practice 29 1842-1854). Several studies have identified the Rottweiler, Newfoundland and Staffordshire Bull Terrier as having the highest prevalence; neutered dogs also have a higher prevalence as do dogs greater than 22kg which also tend to rupture their cranial cruciate ligament at an earlier age. Rupture of the cranial cruciate ligament can follow severe trauma; this is generally where there is sudden internal rotation of the stifle with the joint at 20 to 30 degrees of flexion or where there is severe hyperextension of the joint or a combination of both. Major trauma as a cause of cruciate failure is rare; in most cases cruciate failure is associated with minimal or no trauma although the effect of repeated episodes of minor trauma to the cranial cruciate ligament in causing its failure is uncertain. There is histological degeneration of the cranial cruciate ligament with advancing age. The histological features include basophilic staining of collagen fibrils, cells aligned in columns with pyknotic nuclei and cytoplasmic vacuoles, fibrillation of collagen fibres, focal thickening of the intima of endoligamentous blood vessels, gross thickening of blood vessel walls with obliteration of the lumen and pigment deposits in walls of some of the degenerate blood vessels. The pathological changes within the ligamentous blood vessels, could indicate a degree of ischaemia with increasing age. Although the blood supply to the cranial cruciate ligament is relatively good compared to other ligaments, it has been suggested that the twisting of the two cruciate ligaments on each other during flexion of the joint might reduce the blood flow to the mid-portion of the cranial cruciate ligament. There is also a decline in strength of the cranial cruciate ligament strain, with increasing age which appears to be greater in dogs weighing more than 15kgs.

Studies have shown significant levels of autoantibodies in the synovial fluid of dogs with cranial cruciate ligament failure. Such autoantibodies have included those against collagen and proteoglycan molecules and also anti-globulins (rheumatoid factors). These autoantibodies are regularly found in osteoarthritic joints and are almost definitely a secondary phenomenon relating to tissue damage within an arthritic joint. However, such autoantibodies could contribute to the pathogenesis of ligament failure. Many authors have reported a more severe inflammatory reaction within the stifle joint of dogs with cruciate failure and suggested this could be an important pathogenetic mechanism. However, the dog is particularly prone to an inflammatory form of osteoarthritis and it is more likely that the marked synovitis reflects a particular subtype of osteoarthritis rather than being a primary pathological event causing cruciate ligament failure.

It has been suggested that certain gait and/or postural abnormalities may be involved in cranial cruciate ligament failure. Recent studies at the University of Edinburgh (Wingfield and Stead 1998 unpublished data) looked closely at the Rottweiler breed comparing it with the Greyhound. No difference was found in the standing angle of the stifle joint although they reported the Rottweiler having a greater range of stifle movement during locomotion with the stifle more extended when the limb initially bears weight. The Rottweiler was also noted to protract the limb further forward compared to the Greyhound. They also reported that the Rottweiler would weight bear for longer periods of the gait cycle compared to Greyhounds. When the cranial cruciate ligament was loaded to failure, the Greyhound showed higher tensional strength, linear stiffness and tangent modulus and ultimate load per body mass was higher compared to the Rottweiler. Slocum B and Slocum T D (1998 in Current Techniques in Small Animal Surgery, 4th Edition, edited by M J Bojrab) also believe that the hyper-extension conformation could be important in cruciate ligament failure. They suggest that the shape of the femoral condyle acts as a cam and causes the distance between the femoral and tibial attachments to become greater than the actual length of the cruciate ligament thus causing it to stretch and ultimately to fail. This cam effect may be accentuated by subtle changes to the angle of the tibial plateau. Severe deformity of the proximal tibia associated with failure of the cranial cruciate ligament has been reported by Read and Robbins 1982 (Vet Record 111, 295).

Stenosis of the intercondylar fossa of the distal femur has also been suggested as an aetiological factor in cranial cruciate ligament failure. Congenital intercondylar fossa stenosis may account for 2 to 4% of cruciate
ligament failures in man. It is possible that there is a similar congenital stenosis of the intercondylar fossa of the dog although this is not proven. Certainly the intercondylar fossa is an area where osteophytes develop in the arthritic stifle joint thus narrowing the fossa and once these osteophytes develop they may contribute to further degeneration of the cruciate ligament prior to its eventual failure.

Cranial cruciate ligament failure has been reported associated with inflammatory joint disease such as immune-based polyarthritis/rheumatoid arthritis. Environmental factors such as nutrition and exercise may also need consideration. It is well known that immobilisation and cage rest reduce the strength of the cranial cruciate ligament and thus insufficient exercise especially during puppyhood as is often recommended for the larger breeds may result in a weakened ligament. Obesity will obviously increase the stress applied to the cranial cruciate ligament during locomotion and contribute to its early failure.
Diagnosis of meniscal injuries

H. Van Bree, B. Van Ryssen

The clinical diagnosis of a meniscal tear by provoking a ‘meniscal click’ is not reliable. Most meniscal tears are diagnosed by direct inspection either during an arthrotomy or an arthroscopy. During a stifle arthrotomy, it is not always easy to visualize the menisci. The question is: can the menisci be inspected better arthroscopically, are the findings reliable and what is the technique for a good visualization. Although the canine stifle is a relatively large joint, it is not always easy to obtain a clear arthroscopic image. The correct interpretation of the visualised lesions can be difficult as well. In the arthroscopic evaluation of the traumatised stifle, the inspection of the menisci is very important. The presence of hypertrophic villi, the fat pad and parts of the ruptured cruciate ligaments can hinder the visualisation substantially. It is therefore imperative to maintain a good orientation and to remove all disturbing structures, so a clear view and open joint space is obtained.

A 2.7 mm arthroscope can be used in most large and middle large dogs. In smaller breeds a 2.4 or 1.9 mm arthroscope is more convenient. High flows (pressure of 50-300 mm Hg) are necessary to flush away the blood and debris that is inevitable in the stifle. Distension will enlarge the joint space and diminish the haemorrhage by the increased pressure. Care should be taken to avoid periarticular fluid accumulation caused by exaggerated pressures or by insufficient outflow. Adequate outflow is easily obtained with a drainage cannula, inserted in the suprapatellar pouch. A motorized shaver combines a rotating blade or burr with suction. Soft tissue or bone can be removed gradually. During the removal of the fat pad and synovial villi, considerable haemorrhage may occur. Electrocautery will provide a quick and efficient coagulation. ‘Arthrocare’ (Arthrex) provides a low temperature bipolar type of electrocautery. With this instrument tissue can be ‘melted’ away. It can also be used to coagulate minor bleedings.

The most advantageous position for the arthroscope to inspect the menisci is as distal in the joint as possible. This means the arthroscope should be inserted close to the tibial plateau. Inevitably, the view will be obstructed by the fat pad and synovial villi, requiring the use of the previously mentioned tools to create a clear view. A correct direction of arthroscope and view angle and the application of varus, valgus and tibial compression will help to maximize the visualization.

Bucket handle tears are the most common lesion of the medial meniscus. Longitudinal and radial tears may be visualized with the help of a hooked probe. The lateral meniscus is seldom seen torn. Very often the inner border is fibrillated. In chronically inflamed joints, this fibrillation can be very extensive. The clinical meaning of this fibrillation and the need to remove it still has been determined.

Our conclusion is that with experience and with the right equipment and technique, it is possible to visualise the menisci arthroscopically, better than during an arthrotomy. With arthroscopy detailed and enlarged images of menisci are obtained. Additionally, it provides new insights in stifle pathology.

Literature

Arthroscopic meniscal treatment

Don Hulse

Anatomy and function
The lateral and medial menisci are two semilunar fibrocartilage discs interposed between the femur and tibia. They are positioned in the joint with the open side of the "C" facing the midline and are held in place by cranial meniscotibial ligaments, caudal meniscotibial ligaments, and meniscocapsular ligaments. The lateral meniscus has an additional ligament which inserts into the caudal intercondyloid fossa of the femoral condyles. (Fig 1) This ligament and loose meniscocapsular ligaments of the lateral meniscus render it (the lateral meniscus) more mobile than the medial meniscus. Clinically, the lack of mobility of the medial meniscus predisposes it to injury. The menisci are important intra-articular structures; functions attributed to the menisci include: 1.) load transmission and energy absorption, 2.) rotational and varus-valgus stability, 3.) lubrication, and 4.) rendering joint surfaces congruent. Isolated meniscal injuries are not common in the dog. Occasionally, the author has seen isolated meniscal tears involving the mid-body of the lateral meniscus; these have been associated with a fall and twisting motion. Almost all meniscal tears causing clinical lameness in dogs are associated with cranial cruciate ligament ruptures. The incidence of meniscal tears in conjunction with CCL ruptures may be as high as 75% and almost always involve the caudal body of the medial meniscus. This is because the cranio-caudal instability associated with CCL rupture displaces the medial femoral condyle caudally during flexion of the stifle joint. The caudal body of the medial meniscus becomes wedged between the femur and tibia and is crushed upon weight bearing and extension of the joint. The most common type of tear is a “bucket handle tear” of the medial meniscus. This is a transverse tear in the caudal body of the medial meniscus which extends from medial to lateral in a transverse direction. The free portion of the meniscus is frequently folded forward with these tears. The second most frequently seen meniscal injury is a peripheral meniscal tears. These injuries are associated with a severe traumatic episode which results in a multiple ligament injuries. Rupture of the medial meniscocapsular ligaments are commonly seen allowing the entire body of the meniscus to fold forward. Rarely, isolated meniscal tears are seen and when present involve the caudal body of the lateral meniscus.

Physical examination findings
Meniscal injury is almost always associated with cranial cruciate ligament injury. Often the client will report a popping sound when the dog walks or one will feel a popping sound upon examination of the stifle. This is due to movement of the “free” section of the bucket handle tear. Not all patients with meniscal tears will present with an audible or palpable click. Close inspection of the medial and lateral menisci at surgery will provide a definitive diagnosis.

Treatment of meniscal injury
Inspection and treatment of meniscal injuries must be completed at the time of CCL reconstruction whether performed through the arthroscope or open joint surgery. The objective of this lecture is to describe the arthroscopic treatment of meniscal injury. There are three meniscal treatments to be discussed in this lecture: 1. Partial meniscectomy, 2. meniscal release, and 3. meniscal ablation. Proper positioning of arthroscopic port sites and availability of appropriate instrumentation are essential when treating the meniscus through the arthroscope.

Special equipment needed for stifle joint arthroscopy include small joint hand instruments (probe, graspers, biters), motorized shaver and shaver blades, and if possible, a tissue ablation unit. (Fig. 2-4) The placement of an arthroscope entry port, instrument entry port, and egress exit port are very important. The arthroscope port is located lateral to the patella tendon and just proximal to the tubercle onto which the distal fascia lata inserts. (Fig. 5) This places the arthroscope at the level just above the tibial plateau. The instrument port is placed at the same proximodistal level but medial to the patella tendon (Fig. 6). The egress port is placed superior and medial to the patella. Once the egress port is established, a scope port is made and the arthroscope inserted. A systematic examination of the suprapatellar compartment and trochlear ridges is
performed. As the joint is flexed, the arthroscope is positioned lateral to the intercondylar notch. Further thorough examination of the joint is limited by the presence of the fat pad. The latter structure is generally inflamed and obscures visualization of the cruciate ligaments and menisci. Use of a motorized shaver is the best method to remove inflamed fat pad. An instrument port is established and the shaver blade inserted. Tissue is removed by the suction and cutting action of the shaver blade. (Fig. 7) A thermal ablation instrument is also helpful to remove tissue which obstructs viewing of the internal structures of the joint. (Fig. 8) Once a viewing window is established, the cruciate ligaments and menisci are examined. Remnants of a torn CCL can be ablated or removed with the motorized shaver. Both the lateral and medial meniscus are examined for the presence of fraying or classical bucket handle tears. The medial meniscus is most commonly injured (bucket handle tear, radial tears, or fraying). Visualization of the posteromedial compartment (medial meniscus) can be assisted by placing a Hohmann retractor through the scope portal or applying a valgus stress to the joint.

Partial meniscectomy
The most common type of meniscal tear requiring excision is a bucket handle tear of the medial meniscus. (Fig. 9) The caudal body of the meniscus is torn in a transverse direction. The torn meniscus retains an attachment at the lateral border near the meniscotibial attachment (axial) and at the medial border near the center of the meniscal body (abaxial). (Fig. 10) The treatment method that results in the least long term OA is partial meniscectomy. Through the instrument port, insert a right angled probe beneath the torn meniscus and pull it forward maintaining slight tension. (Fig. 11) Transect the abaxial attachment of the "bucket handle" with a hand instrument or tissue ablator placed through the instrument port adjacent to the angled probe. Remove the right angled probe and insert a grasping forceps through the instrument port. Grasp the bucket handle tear near the point of trans-section. Place slight tension on the torn meniscus with the grasping forceps and transect the axial attachment of the bucket handle. Force the joint open with the Hohmann retractor to inspect the remaining meniscus. (Fig. 12)

Meniscal release
Meniscal release is a technique described by Slocum to prevent meniscal injury following a TPLO. Slocum believes the TPLO procedure will place the caudal body of the medial meniscus in a position where it can be frayed postoperatively. Releasing the meniscus allows caudal retraction of the body to a position where it is unlikely to be crushed by the medial femoral condyle. A meniscal release will eliminate normal hoop stresses in the meniscus. The mechanical result relative to stress on the articular cartilage is the same as performing a total meniscectomy. Also a radial cut through the meniscus (as with a meniscal release) is known to heal. Perhaps in the healed position, the caudal body is less subject to injury and affords some cushioning for the articular surface. The technique of arthroscopic meniscal release can be approached from inside the joint or from outside the joint. To perform an outside to in meniscal release, pass a guide needle into the joint. The point of guide pin entry is caudal to the medial collateral ligament. The guide pin is then directed to triangulate with the arthroscope. Once the guide pin is visualized and in position, pass a number 11 scalpel adjacent to the pin and transect the body of the meniscus. An intra-articular meniscal release can be performed at the caudal tibial meniscal insertion or through the central meniscal body. Visualize the area to be released and insert the cutting instrument through the instrument port. Transect the meniscus under arthroscopic guidance.

Meniscal ablation
Meniscal ablation is a technique used for frayed menisci or for prophylaxis with TPLO in lieu of a meniscal release. The medial meniscus is visualized arthroscopically. If frayed or if incomplete radial tears are present, ablate the damaged meniscus. Place an ablation probe through the instrument port and under arthroscopic guidance ablate the damaged meniscus. (Fig. 13). Meniscal ablation can be used with TPLO. The premise of this procedure is that by prophylactically removing the thin central section of the meniscus, the incidence of future meniscal injury is decreased. Also, this procedure simulates a partial meniscectomy and partially preserves the mechanical function of the meniscus. This is conjecture and is not proven scientifically. Visualize the medial meniscus. Under arthroscopic guidance, ablate the central section of the meniscus. Approximately 40% of the peripheral caudal meniscus remains following ablation. (Fig. 14)
Arthroscopic Intra-articular Reconstruction of the CCL Deficient Stifle Using the Over the Top technique

Don Hulse

Cranial Cruciate Ligament Anatomy

Primary ligamentous support of the stifle joint is provided by collateral ligaments and intra-articular cranial and caudal cruciate ligaments. Nutritional support for the intra-articular ligaments arises from small vessels traversing the ligament structure and, as important, through synovial fluid bathing the ligament. Mechanoreceptors and afferent nerve endings have been identified within the interfiber layers of the cranial cruciate ligament. Innervation of the ligament serves as a proprioceptive feedback mechanism to prevent excessive flexion or extension of the stifle joint. This protective action is through stimulation or relaxation of muscle groups which lend support to the joint. The geometry of the CCL femoral attachment is responsible for a reciprocal loosening and tightening of the ligament through a normal range of motion. The CCL arises within the intercondylar fossa of the lateral condyle of the femur and extends diagonally across the joint space to insert onto the craniomedial tibial plateau. The ligament enters the joint space through the intercondylar notch (INC) and spirals approximately 90° as it crosses the joint between attachment sites. A intercondylar notch width index (ration of the width of the INC to the width of the distal femur) has been established in the dog. The normal distal notch width index .41.

Mechanism of Injury

The mechanism of injury of the cranial cruciate ligament directly reflects its function as a constraint to joint motion. Hyperextension of the stifle joint with forced external rotation of the femur are joint positions that favor injury to the CCL. Injury of the ligament can be purely traumatic; however, there are other factors that may be involved in the pathogenesis of cruciate disease. One of these is age related change in the structural and histologic properties of the ligament. With increasing age, there is a loss of fiber bundle organization and metaplastic changes of the cellular elements. These changes lead to a decrease of structural and material properties of the cranial cruciate ligament that may lead to partial or complete tearing of the CCL. Another factor that contributes to CCL injury is abnormal conformation. Certain breeds such as the Rotweiler, Chow Chow, Labrador, Newfoundland, appear to stand with a straight legged stance in the hindlimb (post legged). In this “post legged” position, the stifle joint and tarsal joints are hyper-extended. Hyperextension of the stifle joint can predispose to complete or partial tearing of the craniomedial band of the CCL by roof impingement from the intercondylar notch. Hyper-extension of the tarsal joint (and stifle joint) accentuates the slope of the tibial plateau placing cranial cruciate ligament fibers under high stress. The result may be a gradual tearing of the ligament fibers during normal activity. Partial or complete ligament tears lead to joint instability. With partial tears, gross palpable instability may not be detected early in the course of the lameness. Although the joint may appear stable during palpation, it is unstable at the cellular level. Eventually, as more fibers are torn, instability is detectable through palpation. Instability arising from partial or complete tears, results in an inflammatory response that is highlighted by the release of cytokines. One proposed sequence of events is that abnormal shear stress arising from instability leads to deformation of ion gated receptors of synovial lining cells and chondrocytes. Deformation of these receptors allows an influx of calcium which, when combined with calmodium increases the production of inducible nitrous oxide synthase. NOS upregulates the production of eicosanoids (leukotrienes, prostaglandins) and other pro-inflammatory cytokines. Leukotrienes are responsible for chemotaxis of inflammatory cells while an increase prostaglandin production through COX-2 upregulation triggers an increase in pro-inflammatory cytokines. Pro-inflammatory cytokines (IL-1, IL-6, NO and TNF) are known to be present in cruciate deficient knees and when present upregulate the expression of matrix metaloproteases (collagenases MMP-1, MMP-13 and stromelysin MMP-3) by synovial lining cells, chondrocytes and inflammatory cells. Pro-inflammatory cytokines also upregulate the expression of a yet to be classified, but important, enzyme called aggregcanase. Stromelysin (MMP-3), neutrophil collagenase (MMP-8) and aggregcanase break down aggregcan (proteogly-
can) within the cartilage matrix by cleavage of the molecule within the intr-globular domain. Collagenases (MMP-1 and MMP-13) disrupt the collagen network of articular cartilage causing further damage. Simultaneously, natural inhibitors of MMPs (TIMP 1 & 2) and anti-inflammatory cytokine expression (IL-4, IL-10, IL-13) are down regulated.

Clinical Presentation
There are two common clinical presentations associated with cranial cruciate ligament injury: (1) acute complete tears and (2) partial tears. Patients with acute tears will present with an acute non-weight bearing or partial weight bearing lameness. Instability can generally be easily elicited unless the dog is very apprehensive about having the stifle palpated. Gentle manipulation is generally sufficient to detect instability. If not and stifle joint pathology is suspected, sedation should be administered and palpation of both stifle joints performed. Dogs with partial ligament tears will be more difficult to diagnose. Initially, the owner will notice a subtle lameness associated with exercise. The owner may note that the first sign of lameness was associated with some form of activity (hunting, playing in the park, etc.). The lameness will resolve with rest only to return with activity. With time, the lameness becomes more severe and will not resolve with rest or medication. The reason for presentation to a veterinarian is often an acute exacerbation of the lameness. The acute lameness is often associated with complete tearing of remaining CCL fibers or a meniscal tear. At this stage, physical examination will show a decrease in thigh muscle mass when compared to the normal limb and crepitus may be evident through flexion and extension. When the joint is extended from a flexed position a clicking or popping may be heard and felt; this is commonly associated with the meniscal tear. However, it should be noted that the presence of joint noise neither confirms nor denies the presence of meniscal injury. Osteophytes are present along the medial and lateral trochlear ridges and a palpable enlargement of the medial surface of the joint (medial buttress) will be evident. Cranio-caudal instability can be difficult to elicit in the awake dog due to the proliferative response of the fibrous joint capsule. This is particularly true in large, apprehensive dogs. If stifle joint pathology is suspected, careful palpation and side to side comparison of both stifle joints is helpful in establishing the correct diagnosis. Other helpful tests to establish a diagnosis of partial CCL tear are joint fluid analysis and arthroscopic evaluation of the involved joint.

Treatment
Treatment of the CCL deficient joint is through surgical reconstruction of the cranial cruciate deficient stifle joint or through alteration of joint mechanics. Joint mechanics are altered by changing the tibial slope (Slocum or Montavon osteotomy). The Slocum tibial leveling osteotomy (TPO) is the most popular technique in the USA while both the Slocum and Montavon techniques are popular in Europe. The advantage of the Slocum TPO is that this technique allows for correction of abnormal limb alignment at the same time as one is leveling the tibial plateau. In-vitro studies of the Slocum technique suggest that the CCL deficient joint is stable under axial load following TPO to 6 degrees. Cranio-caudal translation remains present under passive manipulation (cranial drawer test) and is possible with sufficient anterior shear loading. Stability is gained by re-direction of normal cranial tibial thrust to one of a caudal tibial thrust. When the joint is loaded after a TPO, a caudal tibial thrust is generated. The caudal cruciate ligament stabilizes (prevents) the joint against caudal tibial translation. The advantage of TPO techniques are their success in the large active dog relative to that seen with the traditional intra-articular or extra-articular techniques. The disadvantage of the TPO techniques are their expense relative to traditional techniques. Also, the majority of dogs under 50 - 55 lb have classically performed very well with traditional extra-articular or intra-articular reconstruction of the CCL deficient joint. For these reasons, the author prefers to use a traditional reconstruction in dogs less than 55lbs and in those cases where the client cannot afford a TPO. The choice of which traditional technique (intra-articular or extra-articular) to use has been a subject of debate for more than 30 years. Seemingly, dogs in this weight category (<55lbs) function equally well with an intra-articular or extra-articular reconstruction. Those favoring intra-articular reconstruction believe the technique more closely re-establishes the normal biomechanics of the stifle joint. Those favoring extra-articular techniques report on its simplicity relative to an intra-articular reconstruction. Which traditional technique to apply is at the discretion of the surgeon and most often is based upon personal experience with one or the other techniques. The author (DAH) has over the years favored intra-articular reconstruction of the CCL deficient sti-
file joint. Many variations of the technique have been proposed over the past 30 years but one that has served well through the years is the "under and over" technique using distal fascia lata and lateral patella tendon. When performing an intra-articular reconstruction using the "under and over" technique, a graft must be harvested. A skin incision is made from a point 2cm proximal to the patella and extended distally to the tibial crest. The loose connective tissue overlying the patella tendon and fascia lata is sharply dissected. An incision is made through the lateral part of the patella tendon from a point just lateral to the inferior pole of the patella and extended to its insertion onto the tibial crest. A parallel incision is made through the distal fascia lata approximately 1.5cm lateral to the initial incision through the patella tendon. Both incisions remain parallel as they are carried proximally beneath the skin margin as far as is possible. The graft is then freed proximally with long curved scissors, folded onto itself, and sutured with absorbable suture. A "passing" suture is placed through the looped end of the graft to aid in passage of the graft through the joint. (Fig. 1,2)

Arthroscopy
Arthroscopy for joint pathology has been used extensively in man and in the horse. Only recently has arthroscopic assisted joint procedures been advocated for the dog. The advantages of arthroscopy are increased visualization of the joint in question and decreased post-operative patient morbidity. Also, with increased experience, shorter operative time is an advantage of arthroscopy relative to traditional open joint surgery. The primary indication for arthroscopy of the stifle joint is diagnosis of partial CCL tears, treatment of intra-articular pathology (meniscal tears), and reconstruction of a torn CCL. Special equipment needed for stifle joint arthroscopy include small joint hand instruments (probe, graspers, biters), motorized shaver and shaver blades, and if possible, a tissue ablation unit. (Fig. 3,4) The placement of an arthroscope entry port, instrument entry port, and egress exit port are very important and are described in detail. The arthroscope port is located lateral to the patella tendon and just proximal to the tubercle onto which the distal fascia lata inserts. (Fig. 5) This places the arthroscope at the level just above the tibial plateau. The instrument port is placed at the same proximodistal level but medial to the patella tendon (Fig. 6). The egress port is placed superior and medial to the patella. Once the egress port is established, a scope port is made and the arthroscope inserted. A systematic examination of the supra-patella compartment and trochlear ridges is performed. (Fig. 7) As the joint is flexed, the arthroscope is positioned lateral to the intercondylar notch. Further thorough examination of the joint is limited by the presence of the fat pad. The latter structure is generally inflamed and obscures visualization of the cruciate ligaments and menisci. Use of a motorized shaver is the best method to remove inflamed fat pad. An instrument port is established and the shaver blade inserted. Tissue is removed by the suction and cutting action of the shaver blade; a thermal ablation instrument is also helpful to remove tissue that obstructs viewing of the internal structures of the joint. Once a viewing window is established, the cruciate ligaments and menisci are examined. Remnants of a torn CCL can be ablated or removed with the motorized shaver. Both the lateral and medial menisci are examined for the presence of fraying or classical bucket handle tears. The medial meniscus is most commonly injured (bucket handle tear, radial tears, or fraying). (Fig. 8,9) Visualization of the postero-medial compartment (medial meniscus) is performed by placing a Hohmann retractor through the scope portal. Alternatively, a valgus stress can be applied to open the medial compartment of the joint. Small hand instruments such as a grasper or probe are used to hold a torn section of meniscus that is then removed with the ablation unit.

Once the internal structures of the joint are treated, the reconstructive procedure is completed. A small suture passer is placed through the instrument port under the inter-meniscal ligament. The free end of the "passing" suture is placed in the suture passer and the graft pulled into the joint under the inter-meniscal ligament. A graft passer is then passed over the top of the fabella to exit through the scope port. The "passing" suture is placed in the graft passer and used to pull the graft through he joint in the "over the top" maneuver. The graft is secured to the femoral-fabellar ligament with non-absorbable suture and the remaining soft tissue sutured using standard methods. (10-12).
Fig. 1 - Working beneath the skin margin

Fig. 2 - Graft is folded and sutured to itself

Fig. 3 - Motorized shaver and blades

Fig. 4 - Small joint instruments

Fig. 5 - Scope port

Fig. 6 - Instrument port
Fig. 7a – Trochlear

Fig. 7b – Osteophyte off lateral ridge

Fig. 8 – Frayed medial meniscus

Fig. 9 – Bucket handle tear

Fig. 10

Fig. 11

Fig. 12
Rehabilitation of the Reconstructed Cranial Cruciate Deficient Stifle joint in the Dog

Don Hulse

There are many reconstructive techniques described for stabilization of the cranial cruciate deficient stifle joint in the dog. Outcome is variable and seems to be independent of technique; outcome also varies significantly even when evaluating the results of a single technique. The reason for outcome variability is multi-factorial. Surgeon experience, pre-operative degree of DJD, presence of meniscal injury, intended use of the dog following surgery, and client cooperation all affect outcome. In man, use of endoscopic assisted intra-articular knee reconstruction has improved outcome in the past decade. Another factor which has markedly improved outcome in man is careful attention to post-operative rehabilitation. Almost from the moment the patient awakes from surgery, controlled knee movements are begun. This is continued for months in an effort to prevent early graft failure or stretching. In contrast, veterinarians have always relied upon a surgical technique alone to solve the problem of a CCL deficient joint in the dog. Post-operative rehabilitation is often no more than a few words of encouragement given the owner relative to the dog’s activity for the first month after surgery. Although surgical technique is important, veterinary surgeons should take note of the benefits seen with proper post-operative rehabilitation in humans undergoing reconstruction of a torn ACL. The purpose of this lecture is to describe the post-operative care used by the author for endoscopic assisted extra-articular or intra-articular CCL reconstruction in the dog.

The objective of post-operative rehabilitation is to encourage limb use as soon as the dog is able to do so comfortably. Early controlled limb use helps maintain muscle strength and flexibility, increases blood flow, and maintains joint motion. Proper rehabilitation is achieved by controlling pain, preventing over use of stifle joint, and applying proper physical therapy. Peri-operative pain control comes from administration of medication and early immobilization of the soft tissues about the knee. Administration of pain medication should be done preemptively, ie, prior to a noxious stimuli. Analgesic drugs given before surgery prevents spinal chord sensitization (“wind up”) and increased sensitivity. An analgesic such as oxymorphone is recommended as part of ones pre-medication protocol. Additionally, prior to arthroscopic intervention, injecting bupivicaine into the joint blocks sensory fibers in the joint lining. Bupivicaine is also injected into the joint at the completion of surgery. Pain medication is continued post-operatively as long as necessary to assure comfortable limb use and physical therapy. (See below) Immobilization of the soft tissues will also control peri-operative pain and is accomplished through application of a soft cast. Immobilization of the soft tissues for peri-operative pain control is only necessary for 7 - 10 days. However, preventing over use of the stifle joint is an important consideration and dictates that the soft cast remain in place for 6-8 weeks. Premature activity is the most common cause of CCL reconstruction failure in the dog. Often the only method used to prevent overuse of the stifle joint after surgery is instructions not to let the dog have too much activity. This simply will not suffice. Even if more explicit instructions are given, often the client is very cooperative for the first or second week following surgery but by the third or fourth week tire of their responsibility. The result is that the dog is allowed too much free activity and the reconstruction fails. The optimum method to prevent over use of the stifle joint after surgery is to apply semi-rigid immobilization with a soft cast. (Fig. 1) Advantages of soft cast are: 1. Soft cast will not cause abrasions of the medial thigh and other areas as are often seen with a hard cast; 2. Soft cast will not slip distally since it can be applied with the limb in a normal standing position; 3. Soft cast allows some flexion and extension of the stifle joint which helps maintain cartilage integrity during immobilization; 4. Semi-rigid immobilization provides controlled stress of the peri-articular soft tissues as they strengthen following surgery; 5. Additional loading of peri-articular soft tissues (and an intra-articular graft) is achieved by modifying the cast at 2 weeks post-operatively. Two weeks after surgery the cast is modified such that the dog can bear weight on the foot; (Fig. 2) 6. Soft cast can be worn comfortably for 6-8 weeks. (Fig.3) All these advantages are dependent upon the cooperation of the client in restricting activity of the dog to walks on a leash and preventing soiling of the cast. When the soft cast is removed, flexion is often limited to 90 degrees. Physical therapy must be per-
Physical therapy is paramount to regain normal motion and rapid return to normal limb function. Therapy is started as soon as the soft cast is removed. If needed, mild analgesia can be administered initially until the dog will allow manipulation of the limb. Rimadyl alone or combined with butorphenol are sufficient to control discomfort associated with physical therapy. However, it is very unusual to need analgesic medication when the soft cast is removed at 6-8 weeks. Physical therapy is a combination of active and passive activities. Active manipulations include walking, swimming, and strength exercises. When walking, the pace should always be one that encourages the dog to bear weight with each step. (Fig. 4) Initially walking must be at a very slow pace and short distance. As weight bearing improves, the pace and distance can increase. Never walk at a pace that encourages the dog to shift off the leg. If the dog shifts off the leg, slow the pace until the dog bears weight with each step. Swimming therapy is an excellent form of exercise if a safe place is available. The duration should not exceed 5 minutes initially but can be done multiple times during the day. Underwater treadmills are becoming popular in the US; these units allow joint motion without excessive loading. Strength exercises are similar to close chain strength exercises in man. With the dog standing and both rear limbs placed in line with the respective hip joint, the therapist pushes down on the rump with enough load to flex the stifle joints. This movement simulates leg presses recommended for rehabilitation in man. Movements are small in the beginning but increase with time. Passive manipulations are flexion and extension of the operated joint and non-affected all the joints of the limb. Begin with small movements and gradually increase the range of motion. One should not flex or extend to a point where the dog expresses discomfort. Warm packs applied prior to passive manipulation or muscle massage make the manipulations of the operated joint more comfortable. The number of passive movements vary but should not be less than 20/therapy session. If possible, physical therapy sessions should be done 2 times a day.
Revision the failed cranial cruciate ligament rupture repair using arthroscopy

J-F. Bardet

Repair of the ruptured cranial cruciate ligament is among the most common orthopedic procedures in small animal orthopedic with over 250 surgical techniques. Unfortunately, most authors agree with 15 to 20% of failures and complications. The goals of the paper is to describe the usefulness of arthroscopy in the postoperative evaluation and treatment of the failed cranial cruciate ligament repair and review the results of the medical records and findings in our patients.

Material and Methods
Forty-two patients were reviewed and treated between 1993 and 2000. Each patient had a complete orthopedic and neurologic evaluation as well as a synovial fluid analysis, mediolateral and craniocaudal radiographs and arthroscopy of the stifle joint. Patients were treated initially using either extracapsular (7 patients) or intraarticular technique (35 patients).

Results
All patients except one having had a modified over-the-top technique had a torn graft associated or not with a torn medial meniscus. The torn graft was removed under arthroscopy and a medial menisectomy was performed as well. Stifle instability was treated using either an extra-capsular technique or a tibial plateau leveling osteotomy. When the rupture was very chronic with periarticular fibrosis, no stabilizing technique was used. Of the forty-two patients with failed cranial cruciate ligament rupture repair, 3 had a septic arthritis treated by arthrolavage and 2 had a immune mediated inflammatory arthritis.

Conclusions
Arthroscopy has been most useful in the diagnosis and treatment of postoperative complications and failures of repair of the cruciate ligament. It allows direct visualization of intra-articular structures, excision of torn graft, menisectomy and treatment of septic arthritis.
TPLO: Tibial Plateau Leveling Osteotomy for Treatment of Cranial Cruciate Ligament Injuries

Barclay Slocum, Theresa Devine Slocum

Rupture of the cranial cruciate ligament has presented difficulties to the veterinary orthopedic surgeon because results have been good in some cases using traditional methods, however other cases have been less than satisfactory, yielding fibrosis of the joint inhibiting the ability to fully flex the stifle during sitting, chronic soreness and the resulting incomplete return of thigh musculature. In addition the progression of degenerative joint disease has occurred and patients have failed to return to preinjury function. All traditional methods have been directed towards replacing the cranial cruciate ligament or substituting for its function. The criterion for success of these surgeries has been by the elimination of the cranial drawer sign. In some cases, patients have returned to normal function and maintained a cranial drawer sign. Others have had no drawer sign but have continued to degenerate. Therefore, the success of stifle surgery cannot be evaluated by the absence of a cranial drawer sign.

In the search for a successful outcome in the treatment of a cranial cruciate deficient knee, the criteria for judging the results of surgery hinge on four factors: the ability of the dog to sit fully, return of thigh musculature, cessation of the degenerative process, and return to preinjury function. The discovery of the tibial compression test by Henderson and Milton in 1978 provided the initial insight to understand the stifle biomechanics. They observed that when the hock was flexed, cranial translation of the tibia occurred with a ruptured CCL. In 1983 the cranial tibial thrust was described as responsible for that translation. This introduced the concept of forces to treatment of the cranial cruciate ligament deficient stifle.

The unique anatomy of the canine hindlimb allows the creation of a force called the cranial tibial thrust. There are two features that are responsible for this: the combined tendon of the biceps femoris and the semitendinosus links the distal femur to the calcaneus. The consequence of that anatomic structure is that when the stifle is extended, the joint is automatically extended. When the stifle is flexed, the hock joint can be flexed or extended. The second anatomic feature is that the tibial plateau is at an angle to the perpendicular to the line between the instant centers of motion between the stifle and the hock. The forces generated in the Achilles tendon define the direction and magnitude of the forces along the long axis between the joint centers. Since the tibial plateau is sloped, the contact point between the femoral condyle and the tibial plateau lies cranial to the line of force. The force of compression across the stifle joint passes through the point of contact between the femoral condyle and the tibial plateau, and is perpendicular to the tibial plateau surface. This force of compression across the stifle joint can be resolved into two components, a component parallel to the line between the centers of the hock and stifle and a component perpendicular to the line between the centers. The second component is called the cranial tibial thrust. It is generated by the presence of the slope of the tibial plateau and it increases in its magnitude proportional to the tangent of the slope of the tibial plateau. If the slope of the tibial plateau were zero, the cranial tibial thrust would be zero. If the slope of the tibial plateau were 45 degrees, the cranial tibial thrust would be equal to the force along the axis of the instant centers. As the slope of the tibial plateau approached 90 degrees, the cranial tibial thrust would become infinite.

In the stifle the cranial tibial thrust is opposed by the muscle forces of the biceps femoris, and the hamstring muscle group. If these forces and the cranial tibial thrust are in balance, there is no stress on the CCL. Since perfect balance at all times is unattainable, the CCL is under intermittent stress of a cranial tibial thrust that exceeds the forces of the hamstrings and biceps. Rupture of the cranial band of CCL occurs when the force of cranial tibial thrust exceeds the ligament’s ability to respond. Secondary to rupture of the CCL cranial translation of the tibia can occur. The next structure to restrain the cranial tibial thrust is the caudal horn of the medial meniscus. As this structure is stressed in the absence of the CCL, it responds by being crushed, producing a bucket handle tear, or undergoing metaplasia which is characterized by a stiff or "woody" texture.

The problem of the cranial cruciate ligament deficient stifle is the control of the cranial tibial thrust. The
Tibial Plateau Leveling Osteotomy effectively reduces the cranial tibial thrust to zero by changing the angle of the tibial plateau slope. Since the biceps femoris and the hamstring muscles of the pes anserinus group pull caudally, a balance of these muscle forces and the cranial tibial thrust is achieved at approximately 5 degrees of tibial plateau slope. In 1999 Arnoczky et al confirmed this amount of tibial plateau slope to neutralize the effects of the cranial tibial thrust. If the tibial plateau slope is reduced further, stress is applied to the caudal cruciate ligament.

Treatment of the meniscus is necessary when the cruciate is absent or ruptured. The problem is that the caudal horn of the medial meniscus attempts to prevent the cranial translation and the full pathologic consequence of the cranial tibial thrust is directed to that structure. In order to relieve the stress on the caudal horn of the medial meniscus, a meniscal release is performed. The purpose of this procedure is to free the meniscus from the crushing effects of the femoral condyle. The most common approach to the medial meniscus is caudal to the medial collateral ligament. A sixteen gauge needle is inserted caudal to the medial collateral ligament and proximal to the tendon of the semimembranosus. A number 11 blade is inserted to cut the tension band ring of the medial meniscus transversely. The cut is directed toward the tubercle of Gerdi. The cross section of the cut meniscus is visualized for evidence of trauma to the meniscus by the femoral condyle. Horizontal cleavage lesions, crushing of the caudal horn, and bucket handle tears are commonly seen on inspection.

The cranial half of the cranial cruciate ligament is responsible for restraint of cranial tibial translation whereas the caudal half of the CCL is responsible for restraint of internal rotation. The cranial cruciate deficient stifle can be successfully treated by a TPLO as long as the alignment of the limb is normal. If there is a bowlegged conformation, internal rotation at the stifle is the consequence of that conformation and limb realignment to the sagittal plane is necessary.

The TPLO procedure has been performed on over 1500 cases. The results have been uniform and most gratifying. Criteria for success are the ability to return to full sit, return of full thigh circumference, cessation of the degenerative process and return to preinjury function. Clients are given strict instruction on the postoperative management as the dogs often want to return to activity prior to complete healing and rehabilitation. Stress to the straight patellar tendon occurs by propulsive activity in the first 2 months post surgery. Other postoperative complications have included fracture of the tibial tubercle, medial patellar luxation, disruption of internal fixation, and infection.

The overall experience of TPLO for the surgeon, patient and client has been excellent. Early return to function with minimal inconvenience has endeared this procedure to the owners of both pet and working dogs.
Pancarpal arthrodesis - dorsal plate

R. Köstlin

Introduction
The structures responsible for maintaining the normal carpal angle of 10-12° extension are the palmar ligaments and the palmar carpal fibrocartilage. For the assessment of a carpal injury, careful radiographic imaging is necessary. With the patient under general anaesthesia, a medial or lateral exposure is made with the limb stressed to maximal carpal extension. In chronic middle carpal instability, the radial and ulnar carpal bone pivot in a palmar direction, their dorsodistal edges coming to rest on the bases of the metacarpals, creating a wide gap between the cranial surface of the radius and the radial carpal bone.

Two basic types of arthrodesis are performed in the carpal region. Panarthrodesis involves surgical fusion of all three joint levels, the antebrachiocarpal, the middle carpal and the carpometacarpal level. Partial arthrodesis involves only fusion of the middle carpal and carpometacarpal joints.

The most common indication for pancarpal arthrodesis is a carpal hyperextension injury, which results in chronic painful instability. The necessity of carpal arthrodesis in the cat is not so common; the techniques are the same as in the dog.

Material and methods
For dorsal panarthrodesis, a dorsal approach from the level of the distal radius to the mid metacarpal level is used. A bow-shaped skin incision is performed to prevent contact between suture material and plate. Skin nerves have to be preserved to avoid later lick dermatitis. The cartilage of the antebrachiocarpal joint, the middle carpal and intercarpal joints are debrided with a turbine drill. After debridement of articular cartilage of all three joint levels and autogenous cancellous bone from the proximal humerus packed in all joint spaces, a dorsal plate is fixed with screws of different diameter. Three screws are placed in the distal radius, one in the radial carpal bone and three in the third metacarpal bone. The plate is contoured to produce about 10 degrees of extension in the carpus. A coaptation splint or cast is needed until fusion is well advanced, i.e. for about six weeks following surgery. If function of the limb is good, most plates will need to be removed in six to 12 months due to loosening or irritation.

Fifty-nine patients treated with a dorsal plate panarthrodesis of the carpus were controlled either by clinical and radiological follow-up or by telephone interviews with the owners. Nine further patients could not be evaluated because of early patient death, moving of the owner or other reasons.

Results
Thirty dogs showed complete absence of lameness in every gait and situation. In 22 of them, the process of healing was uneventful, no complication occurred and no further surgery was necessary. The remaining eight dogs showed intermittent complications, had to be operated again or the plate had to be taken out earlier than usual. Twenty-nine patients had problems with their operated leg, ranging from low-grade lameness up to complete disuse of the leg. Some clinical and radiological features could fairly often be associated with lameness and pain. These complications occurred in various combinations and many patients suffered from more than one complication. Main complications were:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cases</th>
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<tbody>
<tr>
<td>Synostoses between the metacarpal bones</td>
<td>23</td>
</tr>
<tr>
<td>Loosening of the implant</td>
<td>9</td>
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<tr>
<td>Slow or missing consolidation of the joint</td>
<td>8</td>
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<tr>
<td>Infection</td>
<td>7</td>
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<tr>
<td>Implant failure</td>
<td>7</td>
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<tr>
<td>Arthropathies of neighbouring joints</td>
<td>6</td>
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<tr>
<td>Malalignment</td>
<td>4</td>
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<td>Lick dermatitis</td>
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Conclusion
We observed that, in comparison to partial arthrodesis, pancarpal arthrodesis does not affect gait significantly and the rate of clinically significant complications is lower. For this reason, we prefer the pancarpal arthrodesis by dorsal bone plate fixation to other fixation and arthrodesis techniques, particularly in large breeds and regardless of the type of lesion.

References
Use of Plate/Rod technique for Carpal Arthrodesis

Don Hulse

Carpal hyperextension injuries are divided into the following three categories. Type 1 injury is a subluxation or luxation of the radiocarpal joint. A Type 11 injury is a disruption of the accessory carpal ligaments, palmar fibrocartilage and palmer ligaments of the middle carpal and carpometacarpal joints. The result is a subluxation of the middle carpal and carpometacarpal joints with dorsal displacement of the free end of the accessory carpal bone and ulnar carpal bone. A Type 111 injury is a disruption of the accessory carpal ligaments, carpometacarpal ligaments, and the palmer fibrocartilage. In these injuries a subluxation of carpometacarpal joint occurs without disruption and displacement of the accessory carpal and ulnar carpal bones. With an acute injury, ligamentous disruption is complete and the patient presents with a non-weight bearing lameness. Swelling, pain, and instability are evident on examination. In Type 1 injuries, the patient generally remains non-weight bearing until definitive treatment is achieved; in Type 11 or Type 111 injuries, the patient may begin to bear minimal weight with the limb after the injury. However, as the patient increases the amount of weight placed on the limb, collapse and hyperextension of the carpus is evident. Standard craniocaudal and medial to lateral radiographs are indicated to determine the presence of bone fractures and/or joint malalignment. However to accurately assess the integrity of the carpus, stress radiographs should be taken. (Fig.1) If the patient will bear weight on the limb, a standing lateral radiograph is taken. In acute presentations when the patient will not bear weight on the limb, stress is applied to the foot with the patient in lateral recumbency. Surgical exposure is best accomplished with a cranial approach. Make a skin incision over the midline on the dorsal surface of the carpus extending from 4 cm proximal to the radiocarpal joint line to 4cm distal to the carpometacarpal joint line. Incise the subcutaneous tissue, proliferative fibrous tissue and joint capsule overlying the radiocarpal, middle carpal, and carpometacarpal joints. The fibrous proliferation will be confluent with the joint capsule proximally and distally. The tendon of the extensor carpi radialis muscle will cross the craniolateral aspect of the joint and should be preserved. Reflect the synovial joint capsule incision from the cranial face of the carpal bones both medially and laterally with sharp dissection. Place gelpi retractors to maintain exposure of the joint surfaces. Place a small Hohmann retractor between the joint surfaces to help visualize the articular cartilage of each joint. Use a low speed power burr to remove articular cartilage from the surface of the carpal bones in each joint. (Fig. 2) Harvest a cancellous bone graft and insert the graft within the denuded surfaces of each joint. For a pancarpal arthrodesis, the joint surfaces of the radiocarpal, middle carpal, and carpometacarpal are exposed for removal of articular cartilage. Apply a bone plate such that the proximal 2-3 plate screws enter the distal radius and distally 3 plate screws enter the third metacarpal bone. Place 1 intermediate plate screws in the radial carpal bone. If one wishes to support the plate with Im pins, place them at this time. Place one pin from medial to lateral entering the bone near the head of the second metacarpal and exiting through the distal ulna. Place a second pin from lateral to medial entering the bone near the head of the fifth metacarpal exiting through the distal radius. (Fig. 3,4)
Fig. 1 - Stress radiograph of carpus (Type 3)

Fig. 2 - Position of Hohmann retractor

Fig. 3 - Pre-op view of DJD

Fig. 4 - Pancarpal arthrodesis
Partial carpal arthrodesis

Kenneth A. Johnson

Introduction
Partial arthrodesis may be feasible in multi-compartment or multi-level synovial joints, such as the carpus and tarsus, where the injury or disease process is somewhat localized. The carpus is a three-level, complex hinge joint composed of the antebrachiocarpal, middle carpal and carpometacarpal joints. In addition, there are vertically oriented inter-carpal joints between the radial and ulna carpal bones in the proximal row, and also between the numbered carpal bones in the distal row. During carpal joint flexion, the majority of motion occurs at the level of the antebrachiocarpal joint. Therefore it is very important to evaluate this articulation clinically and radiographically, and to note the position of the accessory carpal bone when assessing the integrity of the antebrachiocarpal joint. The accessoro-ulnar carpal joint can be injured in conjunction with hyperextension injury of the palmar ligaments and fibrocartilage.

Partial Joint Fusion
In principle, it is a desirable goal to aim to preserve those compartments of the carpus that are normal, and to attempt to perform a partial carpal arthrodesis in lieu of a pancarpal arthrodesis. Following the physical examination of the carpus, one of the most useful diagnostic tests that can be performed is stressed radiology. Stressed radiographs are taken with the joint held in a position that will demonstrate subluxation radiographically. Hyperextension injury, with sprain injury of the palmar carpal ligaments and fibrocartilage, is one of the most common, severe traumatic lesions of the carpus that we encounter in practice. In these cases, a medio-lateral radiograph taken with the carpus held in a hyperextended position using sponges or tape will demonstrate the level(s) of joint injury. This information is valuable in making the decision to perform a pancarpal arthrodesis versus a partial carpal arthrodesis.

Types of Partial Carpal Arthrodesis
Depending on the nature and location of the injury, there is a choice of several procedures.

a. Antebrachiocarpal arthrodesis
Traumatic injuries confined to this proximal joint are uncommon. Complete luxation of the antebrachiocarpal joint may occur in combination with fracturing of the radial or ulnar carpal bones. There are few reported cases describing partial arthrodesis of the carpus at this level. The main reason seems to be that most carpal flexion-extension normally occurs at this level, and following an antebrachiocarpal arthrodesis, range of motion in the remaining distal joints is minimal. Furthermore, one report suggested that fusion of the antebrachiocarpal joint placed additional stresses on the more distal joints and subsequently lead to their breakdown. Therefore for these reasons, most injuries of the antebrachiocarpal joint that warrant arthrodesis are managed by pancarpal arthrodesis, not partial arthrodesis.

b. Middle carpal and carpometacarpal arthrodesis
The main indication for performing partial carpal arthrodesis at these levels is traumatic hyperextension injury. Although the injury might be confined to one or other of these joint levels, both levels are fused. This is because these are normally low-motion joints, and it is technically difficult to internally fix and stabilize an arthrodesis of just one of these levels.

The antebrachiocarpal joint is carefully evaluated by physical examination and stressed radiographs to ensure that it is normal. Particular attention is paid to the position of the accessory carpal bone, and the width of the accessoro-ulnar carpal joint. Widening of this joint, or proximal tipping of the accessory carpal bone is evidence that there has been disruption of accessoro-metacarpal ligaments IV and V, and thus some involvement of the antebrachiocarpal joint. In these cases, I would now recommend that a pancarpal arthrodesis be performed, not a partial.

Surgical technique is similar to pancarpal arthrodesis, except that the antebrachiocarpal joint capsule need
not be opened. Articular cartilage is removed from all joint surfaces with a bur or bone curette. Cancellous bone graft collected from the ipsilateral humerus is packed in the joint spaces. Internal fixation of the arthrodesis is by a T plate that is placed on the third or fourth metacarpal bone. The transverse part of the plate is screwed to the radial and ulnar carpal bones, but must be kept low to prevent impingement of the plate on the distal end of the radius during full extension of the carpus. Alternatively, Kirshner wires are driven up the third and fourth metacarpal bones, and seated into the proximal row of carpal bones. Bone fusion of the arthrodesis takes 6-12 weeks. During this time the joint is protected with a splint.

In one study of 45 partial carpal arthrodeses, hyperextension persisted in 11%, and 15% developed antebrachio-carpal joint osteoarthritis, but no dog needed to have a pancarpal arthrodesis at a later date. In 68% of dogs, lameness was eliminated by partial carpal arthrodesis, and in the rest it was improved.

c. Accesso-Ulnar Arthrodesis: Partial carpal arthrodesis at this level is only rarely indicated. Indications for such an arthrodesis include hyperextension injuries that have resulted in disruption of accessorometacarpal ligaments IV and V and lead to disruption of the accessor-ulnar joint. On the mediolateral stressed radiographs, the palmar end of the accessory carpal bone will be tipped more proximally, and the accessor-carpal joint will be increased in width. Another indication would be type I and II accessory carpal bone fractures that involve the articular surface of the accessory carpal bone. These are sprain-avulsion fractures of the accessory carpal bone that disrupt the accessor-ulnar ligaments and the palmar accessor-radial ligaments.
Calcaneoquartal arthrodesis

Thirty five cases of proximal intertarsal subluxation were treated at Glasgow University Veterinary Hospital over a 12 year period (1988-1999). Nine cases had acute traumatic injuries and the remainder, in which there was no or minimal trauma, had presumed degenerative lesions of their plantar ligaments. Most cases occurred in the Shetland Sheepdog. The clinical and radiographical features were similar to those reported previously (Bennett D, Campbell J R and Lee R 1976. J. Small Animal Practice 17 427 - 442). A single lag screw inserted from the proximal calcaneus into the fourth tarsal bone (and base of the fourth metatarsal bone) was used in all cases. In 18 cases a tension band wire was additionally used to augment the lag screw fixation.

Case records and radiographs were examined for each case. Arthrodesis of the calcaneoquartal joint was determined radiographically (calcaneoquartal joint space not visible, with trabecular continuity between the calcaneus and the fourth tarsal bone). Arthrodesis occurred in 13 of 17 cases in which the lag screw was used alone (time taken six to twelve weeks; median six weeks). In two cases, following arthrodesis the screw loosened, requiring surgical removal. Two cases required revision surgery (application of a laterally applied plate) due to the screw breaking with failure of arthrodesis. Arthrodesis subsequently occurred. Two cases were lost to follow-up, although progress had been uneventful and arthrodesis was likely to have occurred. Arthrodesis occurred in all 18 cases in which a lag screw and a tension band wire were both used (time taken six to twenty eight weeks; median twelve weeks). The screw loosened in three cases and was subsequently removed along with the wire. In a further three cases, soft tissue problems caused by the wire necessitated its removal.
Arthrodesis of the Tarsometatarsal Joint

J.E.F. Houlton

Abstract
The efficacy of tarsometatarsal arthrodesis using a laterally applied plate was evaluated retrospectively in 10 dogs (11 joints). Arthrodesis was performed to manage a tarsometatarsal subluxation in two hocks; in the other cases, the tarsometatarsal subluxation was accompanied by tarsal or metatarsal fractures. Arthrodesis was achieved in all of the joints following initial surgery. Implant removal was indicated in three dogs that remained intermittently lame. Implants were left in situ in the remaining seven dogs. After an average follow-up period of 28 months, all dogs had resumed normal activity. Seven dogs were reported to be completely sound, one was stiff after rest following vigorous exercise and two had an intermittent mild lameness following strenuous exercise.

Materials and Methods
Case records were retrieved for 10 dogs which had undergone tarsometatarsal arthrodesis by application of a lateral plate at the Department of Clinical Veterinary Medicine, Cambridge between 1988 and 1996. Nine dogs presented with unilateral hock instability and one with bilateral instability.
TMTJ arthrodesis was performed with the dog in lateral recumbency and the affected limb uppermost. An Esmarch bandage and tourniquet were applied to limit haemorrhage at the time of surgery. A standard lateral approach to the tarsus was made with the incision extending from the proximal calcaneus to the mid-metatarsus. Torn collateral ligaments and joint capsule were excised. The joint was stressed to expose the articular surfaces of the proximal metatarsal bones and distal row of tarsal bones. Articular cartilage was removed with a drill or hand curette to expose subchondral bone.
The TMTJ subluxation was reduced and the joint spaces packed with an autogenous cancellous bone graft obtained from the ipsilateral proximal humerus. The curetted joint was immobilised with a laterally applied dynamic compression plate in ten instances and with a veterinary cuttable plate in the remaining dog. Post-operative radiographs were taken to check alignment of the distal limb and the positioning of the implants. A pressure bandage was applied and, once swelling had subsided, a short full cylinder cast (eight limbs) or metasplint (three limbs) was applied. All animals were discharged with instructions for controlled activity.

Results
Partial or complete arthrodesis of all joints was achieved by six weeks after surgery. Seven joints were totally fused, three showed 75% fusion of the TMTJ and two were 50% fused. Significant disuse osteoporosis was noted in one of the latter cases. Chronicity and external coaptation prior to arthrodesis showed no correlation with final outcome.
Minor skin abrasions were identified in four of 11 limbs at the time of cast or implant removal. All of these resolved with topical treatment. Wound dehiscence was identified over the distal end of the plate in one dog. This subsequently healed without implant removal.
Three dogs had continued lameness or poor exercise tolerance when examined three to five months post-operatively. All returned to full soundness following implant removal. No loosening or failure of implants was identified in these cases. Mild tarsal valgus and rotation of the foot was identified on the post operative radiographs of two dogs. Both dogs were Border Collies which subsequently worked successfully as sheep dogs. All owners were contacted by telephone for long term information. The average follow up period was 28 months (range six to 78 months). All owners considered their dog to have improved as a result of the surgery. A return to full soundness was reported in seven cases, including the dog with the bilateral subluxation. One owner reported their dog to be stiff following vigorous exercise. Two dogs had an intermittent lameness after strenuous exercise but there was no restriction of activity and neither had received any further treatment.

Reference
Arthrodesis of the Tarsometatarsal Joint using a Laterally Applied Plate.
J. Dyce, R.G. Whitecock, K.V. Robinson, F. Forsythe and J.E.F. Houlton
Tarsal panarthrodesis

R. Vannini

The indications for a pantarsal arthrodesis include severe shear wounds, end-stage degenerative joint disease, irreparable or chronic articular fractures, irreparable calcanean tendon injury and sciatic nerve injury. Arthrodesis is achieved with cartilage debridement, autogenous cancellous bone grafting and rigid fixation of the joints. A variety of techniques to stabilise the joints have been described using either lag screws, plantar-, medial- or dorsal surface plates or external fixation. Primary goal of all techniques is a solid fusion of the talocrural joint - this being the major joint of the hock. The tarsus seems to be difficult to arthrodese successfully. Overall success rates of 49 - 66 % are reported. A high rate of complications has been observed and is the major reason for poor results. Implant failures, such as breakage or loosening, lack of joint fusion, osteomyelitis as well as degenerative joint disease of the intertarsal or metatarsal joints are the most common complications reported. Lack of rigid fixation seems to be the most important factor leading to complications. Lack of stability causes delayed fusion of the talocrural joint. This increases the risk of implant failure due to chronic cycling loads. Inadequate implant strength and inadequate implant placement (i.e. dorsal plating) are reported to be important factors in lack of stability. Prolonged external coaptation was therefore recommended to protect the internal fixation. In a study of 16 dogs and cats with tarsal arthrodesis, we found that inadequate stabilisation of the calcaneus with subsequent failure to fuse its joints was another common cause of complications and poor functional results. Even though the talocrural joint is the high motion joint of the hock, significant motion also occurs at the level of the calcaneal joints. This is primarily due to the Achilles tendon apparatus pulling on the calcaneus.

Based on the findings of our study, the following recommendations for tarsal arthrodesis can be made:
1. Arthrodese all joint levels of the tarsus by a pantarsal arthrodesis, even if only the talocrural joint is injured.
2. Stabilise the tarsus by a plate placed on the dorsal surface of the joint.
3. The size of the plate selected is determined by the size of the largest screw that can be inserted in the 3rd metatarsal bone.
4. The plate should be fixed to the distal tibia and the 3rd metatarsal bone with a minimum of 3 screws on each bone.
5. A minimum of 2 screws should be placed through the plate-holes into the talus and calcaneus. These screws should function as interlocking screws.
6. Incorporation of the calcaneus in the fixation is important to achieve complete and painfree fusion of all joint levels.
Advanced arthroscopy in dogs: current experiences in Belgium

B. Van Ryssen, H. van Bree

Problems and complications in canine arthroscopy: experiences after 10 years

Problems during an arthroscopic procedure can be divided into two different groups. The first group includes problems that occur when the instruments are inserted into the joint: starting an arthroscopy. These problems occur during each step of the procedure: the first puncture of the joint with a needle, the insertion of the arthroscopic sleeve, and the insertion of the instruments (with or without an instrument cannula). Especially in the shoulder and the elbow these problems occur. A good knowledge of the anatomy and puncture sites is important, as is practice on cadavers and experience with several tens of joints.

The second group of problems deals with how to carry on with the procedure. A clear view and correct handling of the instruments are required to finish an arthroscopy successfully. There are several causes of an insufficient view: incorrect positioning of the arthroscope, insufficient irrigation, tissue obstructing the view, and joint collapse. A successful accomplishment of an arthroscopic treatment may be difficult when the right instruments are not available. The procedure will often fail when the surgeon is unexperienced or without the help of a trained assistant.

Intra-operative complications are often encountered but are usually of minor clinical importance. Most commonly are iatrogenic cartilage lesions. They are caused during the insertion and manipulation of the instruments in 70% of the treated joints. It is often inevitable because of the small size of the joints. Dissection of cadaver joints demonstrated the innocent aspect of lesions that looked dramatic through the arthroscope. However, these iatrogenic lesions should be avoided as much as possible by proceeding carefully and using small instruments. Intra-articular haemorrhage is often limited. Increasing the pressure of the irrigation fluid will stop the bleeding. Periarticular fluid accumulation resorbs spontaneously within a few hours. It can be prevented by limiting the pressure and providing an adequate outflow. During the treatment, fragments may float away. In most cases they can be retrieved with a hooked palpator or a small grasping forceps that is inserted deep into the joint. In some cases, the fragment migrates to areas that cannot be reached by the arthroscope and/or instruments. Instrument breakage is not uncommon in arthroscopy. Reasons are the low quality of some instruments or an improper use.

Even after several years of experience, problems and complications still occur, although less frequently and less severely than in a beginners stage. Arthroscopy in small animals remains a difficult procedure, the most important reason being the small size of the joints.

Elbow incongruency plays an important role in elbow dysplasia, either as a primary disease or as a cause of other primary disorders (FCP, OCD, UAP). The presence and severity of the incongruency is estimated on different radiographic views. The accuracy of the radiographic diagnosis can be questioned, because the positioning of the limb and the direction of the x-rays may alter the image. Another method to evaluate elbow incongruency is computerized tomography (CT). The joint structures are not superimposed and by reconstructing the images, the relationship between radius, ulna and humerus can be visualized in different planes.

Since a few months, we are trying to estimate the presence and severity of incongruency arthroscopically. During an arthroscopic examination (medial approach), the relationship between the different bony structures can be visualized directly. This relationship is altered by the insertion of the arthroscopic sleeve in between both the humerus and the medial coronoid process. However, when the arthroscope is positioned in a similar fashion, a difference can be noticed between congruent and incongruent joints. In congruent joints, the level of the medial coronoid process, radial head and lateral coronoid process lies in the same plane. In incongruent joints, these levels are located in different planes. This can be appreciated in the medial part of the joint (medial coronoid process - radial head) and in the lateral part of the joint (lateral coro-
noid process – radial head). The arthroscopic findings are confirmed when looking back to the CT images. Further studies are required to determine the accuracy of the different imaging techniques.

SHOULDER: RUPTURE OF THE BICEPS TENDON
Diagnosis of a ruptured bicipital tendon is not always evident. On plain and contrast radiographs alterations at the insertion of biceps (supraglenoid tubercle) and of its groove can be diagnosed. With ultrasoundography the structure and shape of the tendon can be visualized. To obtain a reliable diagnosis with the above mentioned methods, a good technique and considerable experience is required. In cases with minimal alterations, diagnosis still may be doubtful. Arthroscopy provides a clear view of a large part of the shoulder joint, including the craniomedial region. Thus, a partial or complete rupture of the bicipital tendon can directly be visualized through the arthroscope. In some cases, palpation with a probe is necessary to detect a rupture or to determine the altered consistency of the tendon. Under arthroscopic control, the affected tendon can be cut near its insertion at the supraglenoid tubercle. By doing this, tensile forces on the partially ruptured tendon are eliminated. The distal part of the tendon is left in the groove, and is not attached to the humerus. The dogs seem to do very well after this procedure. Flexion of the elbow is not impaired, and gait is not or minimally altered. A follow-up period of one year is too short to draw any definite conclusions, but so far results seem very promising.
Advanced arthroscopy in dogs: arthroscopy of the hip joint

J-F. Bardet

The development of hip arthroscopy in human medicine is a new field as well as in veterinary medicine. Hip arthroscopy is indicated in dogs for pain of unknown origin of the hip joint. The technique uses a 2.7mm arthroscope through the dorsal portal above the greater trochanter with the hip under ventral distraction. The accessory instrumental portal is located cranially to the greater trochanter. The author will review the results of the arthroscopic examination in 40 hip joints in dogs. The most common indications are the pre and postoperative evaluation of hip dysplasia treated by triple pelvic osteotomy, trauma of the hip, hip pain of unknown origin. Arthroscopy was diagnostic in most patients. All the intraarticular are visualized. The following pathologies may be found: torn labrum, loose articular fragments, torn ligament of the femoral head, synovitis, inflammatory arthritis, septic arthritis, osteochondromatosis, cartilage trauma....

Hip arthroscopy has been the easiest arthroscopy to perform in dogs. As in many other joints it allows the inspection of each intrarticular structure and identification of pathologies that were not recognized in the past.
Advanced arthroscopy in dogs: current experience in U K

John F. Innes

Arthroscopy is currently used at the University of Bristol for diagnosis and treatment of conditions of the canine shoulder, elbow, hip, stifle and hock joints. This paper will discuss some recent clinical studies involving the application of arthroscopy.

Shoulder arthroscopy

Lateral glenohumeral ligament tears (Mitchell and Innes 2000)

Glenohumeral ligament tears have been reported previously (Bardet 1998) but the lateral ligament has received little attention. In addition, treatment of such lesions has not been described. Tearing of the lateral glenohumeral ligament is a common finding during arthroscopy of the painful canine shoulder joint in our clinic. Typical case presentation is chronic shoulder lameness in a medium to large breed working dog. We have also identified similar pathology in smaller breeds with dysplastic shoulders such as the Bassett Hound. Here we discuss diagnosis and treatment in three cases.

Three adult large breed dogs were presented with a chronic low-grade forelimb lameness: a four year old female neutered Flat Coat retriever, an eight year old female neutered English pointer and a three year old male neutered Collie cross. Clinical examination revealed pain in the shoulder joint. No history of obvious trauma was reported. Arthroscopy demonstrated complete tears of the proximal part of the lateral glenohumeral ligament in all cases. All joints examined had other pathological changes, including synovitis and synovial hyperplasia. Other diagnostic evaluation including radiography was unrewarding. Treatment in all cases was intraarticular methylprednisolone and strict rest for six weeks. Two of the three cases responded with a resolution of the lameness at the six week follow up whilst the third failed to improve. Surgical intervention in this case involved lateral capsulorraphy by placement of a lateral glenohumeral ligament prosthesis of nylon leader line secured by a tissue anchor (Mitek II, Ethicon, UK) to the glenoid rim and inserted in the tendon of insertion of the infraspinatus muscle. Re-examination at five weeks post-operatively showed the dog to be without lameness. Tearing of the lateral glenohumeral ligament should be considered in the differential diagnosis of shoulder lameness. Surgical stabilisation should be considered in cases refractory to conservative treatment.

Elbow arthroscopy

Elbow arthroscopy is well-established for diagnosis and treatment of elbow dysplasia (ununited anconeal process, OCD of the medial humeral condyle, medial coronoid process chondopathy). Arthroscopy should be considered the gold standard for diagnosis of such lesions. As such, other disease measures should be compared against arthroscopy. In addition, the reliability of arthroscopy for assessment of joint pathology must be assessed. We have recently undertaken studies to investigate the reliability of arthroscopic staging of chondopathy in the canine elbow joint. In addition, we are using arthroscopy as the reference standard for studies of biochemical markers of joint disease.

Intra- and inter-observer reliability of elbow arthroscopy (Sadalak and Innes 2000)

Eighteen video taped arthroscopic examinations of canine elbow joints were examined by two observers. A standard discontinuous ordinal grading scale of cartilage pathology was used to assess defined regions of each joint and an aggregate score produced for each joint. Each observer undertook repeat assessments two weeks after the initial assessment. The concordance correlation coefficient was calculated for both intra- and inter-observer reliability. These studies will be fundamental to further studies which will use arthroscopy as a disease measure (e.g. evaluation of candidate disease-modifying treatments).

A candidate synovial fluid marker for elbow dysplasia, bone-specific alkaline phosphatase (BAP): relationship to arthroscopic staging of chondopathy (Innes 2000)

(originally presented at the Veterinary Orthopedic Society meeting, Val d’Isere, March 2000)
Elbow dysplasia (ED) is a common condition of larger breed dogs. Traditional diagnosis (i.e. radiography) is unsatisfactory because of poor sensitivity and specificity. Arthroscopy allows accurate diagnosis of the degree of cartilage loss. Biochemical markers are potential methods to diagnose ED. Previous data from this laboratory has shown a correlation between articular cartilage loss in the equine carpus and BAP concentrations in synovial fluid (SF). The aim of this study was to investigate the hypothesis that a marker of bone activity (BAP) in SF would correlate with stage of cartilage loss in ED. This prospective study involved 35 dogs presented with (ED). All dogs underwent arthroscopy of the index (lame) joint. Prior to arthroscopy, synovial fluid (SF) was aspirated from both elbow joints. Cartilage disease in three anatomical sites was scored on a five-point discontinuous scale (0-4) and an aggregate score calculated. SF was assayed for BAP using a commercially available immunoassay (Alkphase-B, Metra Biosystems). The median age was 11.5 months (range 5-30). There was no significant difference in BAP concentrations between index and contralateral joints although there was a moderate correlation ($r_s=0.668$, $p<0.001$, $n=21$). For index joints there was a moderate correlation between BAP and age ($r_s=0.6715$, $p<0.001$, $n=27$). In addition, there was a moderate negative correlation between BAP and lesion score ($r_s=-0.4197$, $p=0.029$). However, after allowing for age, the partialled rank correlation between BAP and lesion score was reduced ($r_s(\text{BL/A})=-0.299$, $p=0.150$). This study does not support the hypothesis that BAP is a useful marker in ED. The skeletal immaturity of dogs with this disease poses problems for the use of biochemical markers. However, further studies are in progress with other candidate markers (e.g. aggrecanase activity, BC-3; chondroitin sulfate markers 7D4 and 3B3) since these techniques may provide cost-effective screening methods and deserve further investigation. Arthroscopic staging of chondropathy should be considered the current gold standard for validation of such techniques.

References
Role of nutrition in growth disturbances

H. Hazewinkel

Although the skeleton in newborn pups is far from completely mineralized at birth, the calcium (Ca) content of the litter at birth may correspond to 10% of whole body Ca of the bitch. Due to placental regulation, Ca deficiency and equally excessive Ca intake in pregnant bitches does not affect the offspring (c). Nevertheless, as in milk fever in post-parturient cows, a diet with an increased Ca content should not be fed to the pregnant bitch. A complete diet, tested according to AAFCO, is adequate throughout life including pregnancy. During lactation, food intake is not always adequate to provide the energy and Ca requirements, especially in dogs of small breeds and/or those with large litters. The newborn puppy starts to eat solid food as early as 3 weeks of age. Its Ca absorption is mainly driven by the Ca concentration-gradient and is increased if Ca uptake is high (a,b,c). The intake of food with an increased Ca content, as may be available to the bitch in their period of lactation, can disturb skeletal development when eaten by pups, even later when food intake of the pup is normalized. Enostosis was found at the age of 6 months in puppies raised on a food with an increased Ca content at 3-6 weeks of age (c), but was absent in control dogs. This expression of disturbed widening of vascular foramina in long bones can be explained by hypercalcemia-induced hypercalcitoninism, with long-lasting effects on osteoclastic-regulated skeletal modeling (a, d). Giving this type of food from partial weaning onward (3-17 weeks of age), caused hypoparathyroidism, hypophosphatemia and disturbed vit D metabolism. Thus high Ca intake may cause poor mineralization of cartilage and newly formed bone. A high Ca intake at a later stage causes less disturbance of Ca regulation but there is abnormal maturation of cartilage cells and their intercellular substance in large (a,c) but not in small-breed (b) dogs. Osteochondrosis (OCD) develops in growth plates and in epiphyseal cartilage. OCD and diminished skeletal modeling are also seen in young dogs fed a diet with increased Ca and P (a, c) and in young dogs overfed with an enriched but balanced diet (d). Feeding a diet with half the amount of Ca recommended by NRC-74 (i.e., 0.55% on dmb) caused severe hyperparathyroidism with increased osteoclastic bone resorption leading to pathological fractures of long bones and vertebrae in large (a), but not in small-breed dogs (c). The research described here demonstrates that the Ca content of the diet and the amount of Ca ingested every day are very important to skeletal growth and development. There is sufficient evidence to advise keeping the content of absorbable Ca in the food approximately 0.8 – 1.0 % on a dmb, and not to overfeed young dogs with this or other balanced diets.

References
(a) Hazewinkel, HAW (1985), (b) Nap RC (1993), and (c) Schoenmakers I. (1998) theses Utrecht University; (d) Hedhammar, A et al. Cornell Vet (1974); 64.
The use of computed tomography (ct) in the assessment of torsional and rotational deformities of the canine hind limb

B. Löer, Dr. med. vet., U. Matis, Prof. Dr. med. vet., Dipl. ECVS, S. Hecht, Med. vet.

Introduction
Abnormal twist of the limb can be differentiated into torsional and rotational deformities. Torsion is defined as the projected angle projected on the transverse plane of the long bone between the proximal and distal epiphyseal axes. In contrast, rotation is defined as the motion-dependent angle between the epiphyseal axes of a joint, i.e. the angle between two adjacent long bones. While the determination of the site and degree of axial rotation is easy in bones in vitro, it is difficult in vivo. To date, for the canine tibia, there has been no technique that yields measurements that can be verified with those obtained in vitro. Except for extreme malalignment, two-plane radiography yields reliable assessment of deformities of the femur. Reproducible measurements using CT have not been reported in dogs. Specifically, imaging techniques for quantification of rotational deformities in the stifle and hock joints are lacking. In cases of complex axial rotation, assessment of incorrect positioning at the joint level, in addition to abnormalities at the bone level, is crucial for responsible planning of rotational osteotomy.

Materials and methods
174 hind limbs of 96 dogs were examined using a Somatom DR 2 (Siemens). In addition to CT measurement, femoral torsion was also assessed by radiography in two planes in 50 dogs and by tropometry on macerated femurs of 21 dogs. In 20 dogs, measurement of tibial torsion via CT was confirmed at post mortem. The reproducibility of the method was determined by repeating measurements ten times.

Results
A mean difference of 0.3° (r=0.96) was determined for femoral torsion. The mean difference from post mortem measurements was 2.3° (p=0.071; r=0.93) for radiography in two planes and 1.3° (p=0.0706; r=0.94) for CT. The mean difference between tibial torsion measured by CT and tropometry was 1.2° (p=0.031; r=0.94). Measurement of tibial torsion by CT in dogs was easy and precise. Reliable measurements were also made on canine femurs after a computer programme was developed for correction of position-associated errors in measurement.

Conclusions
Our results indicate that torsional and rotational deformities of the canine hind limb can be readily measured by CT and that this technique can be considered the gold standard. Computed tomography allows differential diagnoses and provides optimal information regarding the indication for, and the judicious planning of rotational osteotomy.

References
Management of angular deformities of the canine limb with the Ilizarov Method

Antonio Ferretti

Causes of limb deformity in the dog are various. In the growing animal they may depend on metabolic disorders or on traumas affecting the growth cartilage; the radio-ulnar segment is the most affected. In both mature animals and puppies the deformity may present itself as a stiff nonunion, a malunion or joint stiffness.

Deformity analysis
The deformity may be simple, if it has a single plane of deviation, or complex if the deviation is on more planes. Taking the radius curvus as an example there are three planes of deviation: valgism, forward curvature and external rotation. The first two may be assessed radiographically, while the external rotation is to be assessed on the patient.

A careful analysis of the deformity helps to plan the procedure and to carefully pre-assemble the apparatus. The intervention is thus easier and faster.

Assembly of the apparatus
The apparatus is pre-assembled using radiograph as reference. The ring and half ring diameter is selected according to the patient's size: it has to be greater (by at least 2 cm per side) than the maximum diameter of the segment to be treated. Taking the radius and the tibia as an example the dimension which determines the diameter of the assembly is the proximal third of the bone. The rings have to be perpendicular to the longitudinal axis of the bone segment. To apply the rings correctly it is therefore fundamental to recognize the various planes of deviation. In a deformity with both valgism and forward curvature the rings have to be perpendicular to the bone on both the frontal plane (valgism) and on the lateral plane (forward curvature). The rings are consequently positioned in an oblique position, downward anteriorly and medially (Fig. 1).

It is not always necessary to correct all the deformities present. In a deformity with a serious valgism and a slight forward curvature it may be for example better to treat the first and not the second, clearly only if this should not lead to functional disorders.

Hinge positioning
The hinges are the mechanical elements which enable the dynamic correction of the deformity (Fig.2). It is thanks to the invention of the “hinges” that Ilizarov transformed a circular external fixator into a real bio-apparatus capable, via distraction and compression, of progressively altering the shape of a bone segment.

Hinges
They have to be positioned at the same level of the deformity with their axis exactly perpendicular to the plane of deformity (Fig. 3).
If the deformity is characterized by more deviations (as in the case of the radius curvus), the plane of deformity is not exactly frontal or lateral but is instead an oblique plane resulting from the combination of the two deviation planes (Fig. 4-5).

- They may be positioned in correspondence with the apex of the convexity (Fig. 6a): by progressively distracting the opposite side a wedge shaped space is obtained which will then be filled by regenerated bone (Fig. 7).
- If the correction of the axis together with a bone lengthening are desired, the hinges have to be positioned...
beyond the apex of the deformity and the amount of lengthening is proportional to the distance between the hinge axis and the apex of the deformity (Fig. 6b).

- If they are instead set in an intermediate position between the convex and concave apex of the deformity this determines the distraction of the concave part and the compression of the convex part (Fig. 6c).

Site of the deformity
The site of deformity does not always correspond to the part which is visually deformed. To establish the exact site it is necessary to trace the axes of the segment. Their point of intersection corresponds to the real point of deformity, the point where the hinges have to be positioned with the possible variations presented in Figure 6 a, b, c.

Figure 8 explains this concept in greater detail: the position of the stumps is presented (a). The point of intersection of the segment’s axes enables to identify the real site of the deformity (b). The hinges are positioned in correspondence with such point (c). In Figure 8d the axis is perfectly corrected, while in Figure 8e the hinges have been positioned in correspondence with the apex of the malunion area. This enables to correct the angle however a lateral shift of the stump remains.

Distraction
The correction requires that the cortical bone distraction on the concave side of the deformity is of 1 mm per day (A) (Fig. 9). To achieve this it is necessary to measure (both on x-rays and on the patient) the distance between the hinge axis and the distraction rod (C) and between the hinge axis and the cortical bone on the concave side of the deformity (B). The C:B ratio gives the daily rod distraction which generates a 1 mm bone distraction per day. These measurements are obviously approximate since both radiographic and patient measurements are also approximate. To verify if the amount of distraction is sufficient a radiographic examination is carried out after 7 days.

If a corticotomy or an osteotomy have been carried out, the bone distraction rate has to be of 1/4 mm every 6 hours (after a 3-7 day waiting period depending on the damage produced).

Fixation
The fixation period following deformity correction (meaning lengthening) is necessary to enable the consolidation of the regenerated tissue and is proportional to the extent of the lengthening. For example: a 3 cm lengthening of a dog radius-ulna requires about 30 days of fixation.
References


Callus distraction with a fully implantable motorized distraction nail

R. Baumgart, W. Mutschler

During the last 10 years callus distraction has been shown to be a valid method for the treatment of limb-shortening and long-bone defects - not only for posttraumatic or congenital lesions but also for bone defects following tumor resections which underwent completely new orientations. Disadvantages of the usual treatment using external fixation are a high risk of infection, remarkable pain and discomfort especially at the thigh. A first fully implantable computerized system has been developed and clinically tested in cases of shortening alone, shortening combined with axis deviations and shortening combined with bone defect. The system consists of a marrow nail with a diameter of 13mm for the femur and 10mm for the tibia. It is equipped with an electrical motor within the proximal part. The energy is supplied transcutaneously via a transmission antenna placed on the skin during night hours without a material connection to the implant. The daily distraction of about 1mm is divided into more than 700 rates that is controlled by a microprocessor. The distraction related to the system is painfree and not recognized by the patient. The bone formation occurs circularly around the nail. Over all 35 patients were treated with the new implant. In 28 cases femur-lengthenings, in 2 cases tibia-lengthenings and in 3 cases simultaneous lengthening of femur and tibia have been performed. Large-bone defects were treated in 2 cases. Lengthening was combined with axis corrections in 23 cases and combined with bone transport in 2 cases. The minimal distance was 25mm, the maximal distance was 80mm at the femur and 100mm while lengthening femur and tibia simultaneously. The goal of treatment, the continuity of the bone and complete correction was achieved in all cases. There was no infection and beneficial scar formation. In 2 cases of simultaneous distraction of the femur and tibia, knee-flexion was temporarily reduced to less than 45°. In 3 early cases a technical problem occurred which lead to a replacement of the motor-system. The fully implantable motorized distraction nail is a modern implant for the treatment of bone shortening and large bone defects of the femur and the tibia. Axis deformities even near to the knee-joint can be completely corrected with the same implant. The treatment has a minimal risk of infection, is painless and is comfortable due to lack of external fixation.
Alignment problems of the hindlimb

Barclay Slocum, Theresa Devine Slocum

Although the success of repairs became improved with perfection of ligament substitution techniques and extracapsular procedures, treatment of the rupture of the cranial cruciate ligament with the Tibial Plateau Leveling Osteotomy technique consistently provided results that provided four characteristics to the patient. The dog regained a full sit, except when permanent bony changes were present preoperatively. The progression of the degenerative joint disease was halted. The musculature of the limb returned to normal, and patients returned to preinjury function. Evaluation of 700 cases revealed a pattern from the small percentage that demonstrated incomplete return to preinjury function as is generally expected by the Tibial Plateau Leveling Osteotomy technique. A review of these cases revealed excessive internal tibial torsion, which would give the dog a bowlegged appearance. This was the beginning of an indepth review and prospective evaluation of cases which had an inadequate limb alignment.

The most common malady of limb alignment is the bowlegged appearance of a patient. This corresponds with breeds such as the bullmastiff, rottweiler, pit bull and other bowlegged dogs. In modeling the bowlegged conformation, it was found that bowleggedness occurs from four different sources. The most common bowleggedness seen in Labrador retrievers, and golden retrievers is due to a varus deformity of the distal femur. A varus deformity of the distal femur is often associated with a medial patellar luxation and often rupture of the cranial cruciate ligament due to the internal rotation mechanism. The patella rides high and medial on the trochlear ridge and will often luxate. Treatment of the medially luxating patella by lateral fabella to patella sutures or lateral capsulorrhaphy is doomed to failure as the alignment of the quadriceps will dictate a medial displacement of the patella, which will stretch any repair provided. Treatment by deepening the trochlear sulcus will also be under pressure to create a medial luxation. The standard lateral tibial tubercle transposition is an enticing treatment as patellar stability is assured. Unfortunately, patellar stability is at the expense of a bowlegged conformation due to an exceptionally lateral tibial tubercle which will cause internal rotation of the stifle and an accentuated bowlegged conformation. In this patient the bowleggedness created by the distal femoral varus has been compounded by internal rotation at the stifle which will accentuate the bowleggedness. The long term effect on the patient is excessive pressure on the medial condyle secondary to the bowleggedness and excessive internal rotation of the stifle which predisposes the rupture of the cranial cruciate ligament. The straightforward and proper treatment of this condition lies in a distal femoral valgus osteotomy for the treatment of femoral varus. Once this limb alignment is corrected, the structures will function normally. Stress will be relieved from the structures attempting to maintain quadriceps alignment as well as the cruciate ligament which was countering the internal rotation of the stifle. If the cruciate ligament is stretched, then a Tibial Plateau Leveling Osteotomy is warranted. The bowlegged patient is often seen to have an unusual gait at the time of weight bearing. When viewed from the rear, if the patient has a lateral projection of the stifle at the instant of weight bearing, then this motion is called a pivot shift. The pivot shift is created by a combination of cranial translation of the tibia combined with internal rotation of the stifle. If the pivot shift is present, two types of repair will fail unless the alignment is corrected. Almost all revisions for failed cruciate ligament repairs by fibular head advancement, over the top technique and lateral capsular sutures are associated with this kind of conformation. Revising such surgeries with larger suture or fishing line will have the same results as the failed surgery. The ideal correction for this condition is a valgus osteotomy of the distal varus femur, which will realign the patella and reduce the stress on the medial condyle of the femur. Correction of the ruptured cra-
nal cruciate ligament by means of a Tibial Plateau Leveling Osteotomy with the associated external torsion osteotomy of the tibia will restore full function. It is important to recognize whether the deviation creating the bowleggedness is in the femur or the tibia, and whether it is created by a varus or a torsion. In order to ascertain the location of the deformity and malalignment, perfect radiographic positioning is necessary. A lateral view of the stifle with the greater trochanter, fibular head, lateral malleolus in one plane will present as superimposed trochlear ridges and condyles in the normal dog. It is important that the knee is at ninety degrees for this positioning. If the lateral femoral condyle is cranial to the medial femoral condyle when the patient is properly positioned, then a distal femoral varus is suspected. Varus of the distal femur can be demonstrated radiographically by an anteroposterior view of the femur. This always requires the patient to be raised vertically to allow the long axis of the femur to be perpendicular to the xray beam. Once this position is accomplished and the patella is located in the trochlear sulcus, it should overlay the medial and lateral walls of the intercondylar notch. Once this position is attained, the varus of the femur can be readily measured. Surgery is recommended when the varus equals or exceeds ten degrees.

Internal tibial torsion is best diagnosed on the posteroanterior (caudocranial view ) of the stifle, tibia and hock. The radiographic position that is most effective is to place the patient in sternal recumbency, and extend the hip with the stifle and tibia located on the cassette. The stifle is extended and the hock is allowed to be in its extended position, making no attempt to center the calcaneus over the distal tibia. Since the stifle is forced into extension, no rotation at the knee joint is possible. If the stifle is not forced into extension, then errors will occur as the stifle is free to rotate both internally and externally. Perfect positioning for the stifle places the patella between the medial and lateral walls of the intercondylar notch. When the stifle is in this position, the medial border of the calcaneus should lie at the greatest depth of the talar sulcus. The hock is forced into extension simultaneous with forced extension of the stifle. If the patient is bow-legged due to internal tibial torsion, then the medial border of the calcaneus will lie lateral to the talar sulcus.

Internal torsion of the femur and varus of the proximal tibia are less commonly seen than the varus of the distal femur and internal torsion of the tibia. If present, these can be corrected by an external torsion osteotomy of the femur and a valgus osteotomy of the tibia. Since these are usually accompanied by rupture of the cranial cruciate ligament, a Tibial Plateau Leveling Osteotomy is a convenient kerf through which alignment correction of the tibia can be made. Failure to gain alignment of the femur and tibia will result in continued medial patellar luxation and the destructive forces of the stifle. The tibial tubercle should be in a line with the foot, hock and patella when the dog is under anesthesia in a supine position. The dog is on his back, with the knee flexed at 90 degrees without internal or external rotation of the stifle. If the tibial tubercle is medial to the plane which includes the patella, the hock and foot, then a lateral tibial tubercle transposition is necessary back to that plane. If the alignment of the patella, tibial tubercle, hock and foot are in one plane, and a tibial tubercle is transposed laterally to treat a medially luxating patella, then the long term appearance of this patient will be a bow-legged conformation which predisposes this patient to rupture of the cranial cruciate ligament and excessive wearing of the medial compartment of the stifle. This results in cartilage eburnation.

In the field trial springer spaniel, the patient may appear in normal conformation when standing on the exam table or participating in non-working activities. This patient may become bow-legged as a result of a hunting posture specific to this breed. The springer spaniel works and hunts in a very low “vacuum cleaner crouch” in which the hips are externally rotated and the stifles are internally rotated. This seems to lower the center of gravity of the dog. When the patient assumes this posture, the tibial tubercle will be medial to the patella, as the hip is externally rotated and the stifle is internally rotated. This conformation creates a medial patellar luxation. Since the bone structure of this patient is normal, and the posture is desirable, the patient has been genetically engineered for this characteristic. The best correction for this medial patellar luxation is a rectus femoris transfer from the origin to the cervical tubercle. This allows the origin of the quadriceps muscles to be on the proximal femur. Consequently, rotation of the hip does not necessarily dictate abnormal alignment of the patella because all four heads of the quadriceps now originate on the femur. This eliminates the medially directed force on the patella. This is the only functional cause of medial luxating patella that I have experienced in clinical practice. All others are associated with anatomical malalignments. The opposite appearance of bowleggedness is the knock-kneed conformation. The knock kneed confor-
mation places the stifle medial to the sagittal plane. This should be distinguished from true cow hocked appearance. The cow hocked appearance places the hip, stifle, tibial tubercle, hock and foot in a singular plane with the knee lateral to the sagittal plane. This cow-hocked appearance is created by external rotation at the hip. Knock kneed conformation is pathologic because the stifle undergoes external rotation and frequently an anterorotary instability. Anterorotary instability is the desire for the tibia to move cranially and rotate externally. This instability shifts the line of axial rotation of the tibia laterally, and stresses the cranio medial joint capsule which may produce an enlarged knob on the tibia just cranial to the medial collateral ligament. Patients which have knock kneed connotations are German shepherds, great danes, akitas, malamutes or huskies. The first feature to diagnose is the presence or absence of an OCD lesion on the lateral femoral condyle. Sometimes this lesion is subtle and is seen only as a flattened area without loss of cartilage. If an OCD lesion is present on the lateral condyle, then the patient may have laxity within the joint that is caused by a lack of bony spacer which is due to loss of the joint space with the OCD lesion. This laxity is often diagnosed as a rupture of the cranial cruciate ligament, when in fact, the problem exists due to loss of bone. The tibial conformation must be observed as it is usually normal, but may have proximal tibial valgus or external tibial torsion present. The presence of OCD of the lateral femoral condyle, proximal tibial valgus and external tibial torsion causes a stress on the cranio medial joint capsule which leads to cranio medial rotary instability. Correction of the tibial deformities is by a proximal tibial varus osteotomy and an internal tibial osteotomy. If the lesion on the femur causes minimal deviation, the latter two osteotomies will shift the weight from the lateral to the medial condyle. The most significant change in alignment comes in the femur for the knock-kneed patient. There are two forms seen clinically of distal femoral valgus. The first is when the trochlear is in line with the femur, but the supporting condyles are externally rotated around an axis that is perpendicular to the frontal plane. The second form is a distal femoral valgus deviation which occurs proximal to the trochlea. The treatment for the first is an osteotomy perpendicular to the sagittal plane, which separates the femoral condyles from the trochlear for the patella. Once that separation has occurred, then the distal femur can be relocated in alignment with the trochlea. If the distal femoral valgus is present, then a distal femoral varus medial closing wedge osteotomy will be curative. Caution should be taken in giant breeds that two plates be utilized at ninety degrees to one another. In addition, bone graft taken in strips from the ilium will enhance the rapidity of healing on these patients. The thin cortices and long limbs predispose dogs such as Great Danes to traumatic fractures without taking these precautions.
Triage and perioperative management of the abdominal trauma patient

Tim Hackett

Please, refer to p. 68
Imaging the acute abdomen (trauma)

M. Fluckiger

Radiology
Advantages: rapidly performed; good general overview; good spatial orientation; precise assessment of bone and lung.
Disadvantages: limited information on internal organ architecture; superposition of organs; poor organ identification in the presence of free abdominal fluid.

Read the films: check organ visualisation; identify all organs, check integrity of diaphragm, ribs, spine, pelvis and abdominal wall.
Search for free abdominal gas, usually located between diaphragm and liver on a lateral radiograph.

Loss of abdominal detail
Common causes: hemorrhage after laceration of liver, spleen, diaphragm; urine after bladder rupture.
Diagnosis is made by fluid aspiration. Do not evacuate blood! Bladder rupture is confirmed by positive contrast cystography: dilute water soluble contrast agent 5 times, instil thru urethra, simultaneously check for urethral trauma. Air as contrast agent is not recommended since it may be misinterpreted as bowel gas. Voiding urine does not rule out bladder rupture!
Uncommon cause: Avulsion of mesentery, resulting in bowel necrosis, causing bowel spasm for 2-3 hrs followed by dilation (ileus). Ileus may also be a result of intramural hemorrhage (ultrasound).
Deterioration of the animal within 24-48 h may be the result of bile peritonitis after hepatic or biliary tract trauma. Confirm diagnosis by peritoneal lavage.
Pancreatitis as sequelae of trauma has been described in cats. Radiographs are not diagnostic

Abdominal wall rupture
Loss of sharp delineation
Soft tissue swelling
Organ displacement
Common sites: rib insertion, inguinal ring, pelvic attachment (associated with bony avulsion).

Diaphragmatic rupture
Loss of diaphragmatic silhouette
Cranially displaced or missing abdominal organs
GI displacement and entrapment may result in obstruction
Common bile duct compression may result in icterus

Retroperitoneal space
Loss of renal delineation after renal capsule rupture or avulsion of ureter is not uncommon. Consider also muscular hemorrhage, check for fractures of transverse processes, vertebrae, ribs, soft tissue swelling. Caution: the right kidney is difficult to visualize in normal dogs, while easily seen in cats. If retroperitoneal fluid accumulation increases over 24 h an excretory urogramm is indicated to assess renal and ureteral integrity (2 ml/Kg water soluble contrast agent containing 370 mg/ml iodine. Contraindications for EU are dehydration, shock).

Pelvic canal
Rupture of urethra, hemorrhage, in combination with pelvic trauma. Bloody urine may warrant retrograde urethrogram.

Spine, pelvis
Check for fractures, luxations, collapsed disc space.
Ultrasonography (US)

Advantages: immediate information on internal organ architecture, precise location of lesion in parenchymal organs.
Disadvantages: limited spatial separation; limited visualization in obese animals, and in gas distended GIT; may be time consuming.

Loss of organ visualization on radiographs justifies US. **Screen the entire abdomen systematically.** Sequential scans may reveal progression or regression of free, subcapsular and/or intraparenchymal fluid accumulation.

**Free abdominal fluid:** anechoic triangular zones best identified between liver lobes and around bladder vertex. Suggestive of hemorrhage (liver, spleen, mesentery) or rupture of the urinary bladder. Fresh blood is hypo- or anechoic. Location of fluid may help to identify source of hemorrhage. A sample of fluid may be aspirated under US control for analysis (urea, bilirubin, ingesta, amylase). Do not evacuate abdomen in case of hemorrhage, since blood will be reabsorbed and used by animal. Large amounts of fluid justify laparotomy.

**Free abdominal gas:** subperitoneally located hyperechoic line causing reverberation, best identified when scanning from above. Do not confuse with aerated lung in caudal thoracic cavity (lung moves forth and back with respiration, free air does not) or with gas distended bowel loop (identify the bowel wall). Free gas may be the result of a perforating abdominal trauma or GIT-perforation.

**Retroperitoneal space/kidneys:** increased irregular fluid accumulation associated with renal, ureteral or muscular trauma. Fluid pocket may be aspirated. Perirenal fluid accumulation (either anechoic or mixed) indicative of hemorrhage or leakage of urine from renal pelvis. Patchy renal echos suggestive of hemorrhage. Severity of trauma difficult to assess, excretory urogram is more precise.

**Liver:** perihepatic fluid, patchy heterogenous parenchyma suggestive of hemorrhage, check gall bladder and common bile duct for integrity.

**Spleen:** patchy heterogenous parenchyma suggestive of hemorrhage.

**Urinary bladder:** irregular wall and hypoechoic content suggestive of hemorrhage. At site of rupture usually thickened wall but no obvious rupture, since bladder wall contracts. Distend bladder with NaCl-solution. Sudden collapse of distending bladder and simultaneous accumulation of fluid within abdominal cavity are diagnostic of urinary bladder rupture. Urethra cannot be assessed reliably.

**GIT:** difficult to scan due to intestinal gas. Check for displacement, peristalsis (often reduced or absent after trauma). Urinary hemorrhage may cause bowel wall thickening and signs of obstruction.

**Abdominal wall:** hemorrhage may cause thickened, patchy hypoechoic wall layers, gas accumulation secondary to skin perforation or bowel prolaps. Severity of trauma difficult of access.

**Diaphragmatic rupture:** hyperechoic layer (normally caused by lung surface) not identified. Caution: free pleural fluid as well as paralyzed or cranially displaced diaphragm may mimic diaphragmatic rupture.
Open peritoneal drainage

Tim Hackett

Please, refer to p. 68
Total parenteral nutrition in companion animals

L.F.H. Theyse, H. Hazewinkel

The term total parenteral nutrition (TPN) is used to describe the provision of all essential nutrients by an intravenous route. In most critically ill or injured patients using enteral feeding is the best way to maintain nutritional requirements. TPN should be considered in those patients, anticipated to be unable to assimilate nutrients administered into the gastrointestinal tract for a period longer than 3 to 5 days. Examples include animals undergoing massive small bowel resection, impaired intestinal motility or function, severe diarrhea, intractable vomiting, or prolonged pancreatitis (1, 2). Abdominal trauma can lead to a severely compromised gastrointestinal tract including the aforementioned problems and thus require TPN.

The goal of TPN in companion animals is to prevent deterioration of the nutritional status and if possible treat malnutrition until the patient can return to full enteral feeding. The three basic components of parenteral feeding solutions are dextrose (50 to 70 per cents solutions), crystalline amino acids (8.5 or 15 per cents solutions), and lipid emulsions (20 per cent). Water-soluble vitamins and trace minerals can be added. Fat-soluble vitamins are not necessary for short periods of support. Although varying mixtures of these components can be prepared, in general the animal’s nonprotein caloric requirements are met using a 1 to 1 ratio of 50 per cent dextrose and 20 percent lipid emulsion (1, 3). TPN requires a central venous catheter for infusion because of the high osmolality of the feeding solutions. This catheter should be used solely for parenteral nutrition therapy and not for drawing blood samples, administering medications, or measuring central venous pressure. Preventing complications due to the catheter is a major concern (4). In the retrospective study of Reuter et al evaluating TPN in dogs metabolic complications were frequent and predominantly due to hyperglycemia. Mechanical and septic complications occurred less commonly. In this study the overall mortality rate for dogs receiving TPN was close to 50 per cent (5).

In conclusion TPN can be a beneficial mode of therapy for carefully selected patients that have impaired gastrointestinal function and are expected to be anorectic for more than 3 to 5 days.

References

Perioperative care of the critical Trauma patient

Tim Hackett

Abstract
Morbidity and mortality from trauma is devastating. Many traumatic deaths may be prevented if certain conditions are promptly recognized and quickly treated. Surgeons presented with trauma patients for treatment of orthopedic injuries should remain alert to the systemic complications of trauma. Some injuries have diffuse systemic effects; others mainly involve one or two organ systems. Finally, the effects of an injury may be modified significantly by individual and environmental factors such as age, sex, nutritional status, concurrent diseases, local contamination, ambient temperature, and duration of the injury. It is not possible to incorporate such an array of variables into simple, uniform, approaches to the management of the trauma animal. Rather, the approach of this presentation will be one to provide guidelines for a systematic, thorough, physiologically sound approach, which should be useful, when the surgeon is faced with the traumatized animal.

Introduction
Orthopedic small animal patients can be some of the most challenging, intensive cases to manage from admission to discharge. Before the trauma, these animals are usually very healthy however, with severe trauma however, these patients can decompensate with a variety of systemic complications affecting anesthesia, surgery, and perioperative care. It is important that the surgeon, anesthesiologist and nursing remain alert to changes in patient condition.

Surgery may be delayed until a patient has been stabilized. For most, to stabilize means to correct hemodynamic, cardiopulmonary and electrolyte problems before subjecting the patient to the systemic depression of general anesthesia. The word “stabilize” should not be an excuse to delay surgery. For some conditions, surgery is required to correct the immediate threats to life.

Initial assessment
Assessment of the traumatized patient should be accomplished in an orderly and systematic routine. This routine is administered to each patient. An initial, brief physical examination is performed to identify any life threatening problems. Attention is directed toward the respiratory and cardiovascular system. Obviously, those injuries which interfere with vital physiological functions should receive the highest priority. These patients have sustained injuries which pose an immediate threat to life, and usually involve the respiratory system, cardiovascular system, or neurological system. Patients which sustain injuries which are severe but offer no immediate threat to life receive lower priority. These are generally animals with fractures, luxations, and abdominal injuries (including a ruptured spleen, liver or damage to the urological system). Finally there will be patients which have sustained minor injuries and merely require observation, monitoring, and thorough, serial evaluations to assure they do not slip to a more serious status.

The purpose for the initial assessment of the trauma patient is to identify life-threatening physiological injuries. Whenever a problem is identified immediate therapy is begun. The “primary survey” is an assessment of the ABCDE’s:

* Airway—Is the patient having difficulty breathing? Are there mandibular injuries which are interfering with the airway? Has the bite wound disrupted the larynx or trachea?
* Breathing—Is the patient dyspneic? What is the color of the mucous membranes? Does the dyspnea get worse with positional changes of the animal? Is there evidence of thoracic penetration or is there a flail chest? Are the peripheral veins distended?
* Circulation—Is there evidence of hemorrhage? Is the hemorrhage arterial or venous? How large is the swelling associated with the extremity fracture? Are the mucous membranes pale and tacky? Are the femoral pulses weak and rapid? Are the extremities cold?
* Disability—Is there evidence of neurological injury? What is the posture of the animal? Is the animal bright, alert and responsive? Does the animal respond to painful stimuli? Are the pupils dilated, constricted, of equal
size, and responsive to light? Is there an extremity fracture which might threaten a peripheral nerve?

*Examination—Are there lacerations? Where is the bruising and is this bruising getting worse? Are there multiple fractures? Is the abdomen painful? Is there evidence of debilitation or concurrent disease?

**Injuries affecting vital functions**

Respiratory function represents the highest priority in trauma. These injuries require immediate recognition and treatment. Studies in dogs have shown thoracic injuries to occur in 38.9% of all fracture cases. In these patients, multiple thoracic injuries were present in 57.7% of the dogs. Pulmonary contusions, pneumothorax, and fractured ribs were most commonly observed.

**Pulmonary contusions.** The most common initial pulmonary complication in blunt chest trauma is lung contusion. Such a contusion may occur under the site of a flail chest or independent of obvious external injury. Alveoli in the contused area fill with blood, edema fluid accumulates resulting in atelectasis. Severe hypoxemia will result from subsequent shunting and V/Q mismatching. Diffuse intrapulmonic hemorrhage appears radiographically as an infiltrate in the lung but does not follow an anatomical pattern. There is increasing evidence that many of the syndromes of post-traumatic respiratory insufficiency are iatrogenic in nature. Specifically, the use of large volumes of rapidly administered crystalloid solutions will cause progressive pulmonary insufficiency. Use of plasma or other colloid solutions may lessen the occurrence of respiratory insufficiency. It is postulated that use of homologous plasma will maintain near normal plasma colloid oncotic pressure, thereby preventing local water loss into the injured lung.

Currently we are recommending fluid replacement in the patient with pulmonary contusion be administered with a combination of crystalloid fluids (not to exceed 40 ml/kg/hour) and plasma or whole blood.

**Pneumothorax.** Simple pneumothorax occurs when gas accumulates in the pleural space but pleural pressure does not significantly exceed atmospheric pressure. Gas can enter the space either from outside the chest wall, as occurs with bite wounds, sharp objects, or weapons, or via the lung through a breach in the visceral pleura. Small amounts of gas cause pleural pressure to increase slightly, but it remains subatmospheric during inspiration because it is in equilibrium with the negative alveolar pressure. Although pleural and alveolar pressures become positive during forced expiration, slight separation of the pleural spaces does not compromise ventilation. If the pneumothorax is small and the pleural leak seals itself, the gas will be absorbed as a result of partial pressure differences between gas in the pleural space and in the blood. Tension pneumothorax is characterized not only by abnormal gas exchange but also by a progressive increase in pleural pressure sufficient to impair circulation. This occurs as gas enters the pleural space during spontaneous negative pressure inspiration and remains there during expiration because tissue or fluid occludes the pulmonary parenchyma. The accumulating gas not only collapses the lungs but also interferes with venous return to the right atrium. Thoracocentesis is preferred in the initial evaluation of thoracic injury. With a 20 gauge needle attached to an intravenous extension set, 3-way stopcock, and 60 ml syringe, one will aspirate air, fluid, or both. It is advisable to aspirate from both right and left sides of the thorax. If it becomes necessary to use needle thoracocentesis more than twice to alleviate dyspnea, placement of the thoracic drain is necessary.

The most common complications of rib fractures are pain and limited diaphragmatic and chest wall motion, or splinting, that result in atelectasis of the underlying lung and hypoxemia through ventilation-perfusion (V/Q) mismatching. Flail chest occurs when three or more ribs, or the junction of ribs and the sternum, are each fractured at two points. This injury is suggested by paradoxical inward movement of the flail segment during inspiration when the rest of the thoracic cage expands. Therapy is aimed at relieving pain through analgesics and local blocks, correcting hypoxemia, and supporting patients while the contused lung is healing.

**Cardiovascular complications of trauma.** The cardiovascular system is also at risk of being traumatized. It is important to assess not only the vascular system and blood volume but also the heart. Contusion of the myocardium is common after blunt chest trauma in dogs and is generally manifested as cardiac dysrhythmias.

The etiology of these dysrhythmias is often obscure but likely results from myocardial trauma. Aggressive antiarrhythmic therapy is required with serious or life-threatening dysrhythmias. His therapy is generally directed at the treatment of the cause and in controlling the dysrhythmia. Hypovolemia and pain should be appropriately treated before using specific antiarrhythmics. In the case of multifocal premature ventricular contractions or ventricular tachycardia, lidocaine (2 mg/kg IV) bolus followed by a constant rate infusion of 50 - 80 ug/kg/minute and the use of oral long-acting antiarrhythmic drugs are indicated.

**Neurologic complications of trauma.** A rapid neurological evaluation is the final step in the primary survey. Its
purpose is to establish the patient’s level of consciousness, pupillary size and reaction, and to note any abnormal postures of the animal. Additionally, one should quickly assess and note peripheral nerve injuries which may be present with certain fractures (i.e. fractured humerus—radial nerve; fractured acetabulum = sciatic nerve).

Intracranial injury. Normal pupillary function implies that the midbrain and third cranial nerve are intact. Symmetric or diffuse diencephalic lesions will produce small reactive pupils while asymmetric anisocoria with bilateral reactivity is most likely a structural lesion. Midbrain damage can produce midposition and unreactive pupils. Dilated unreactive pupils which develop from miotic pupils imply brain stem lesions and a grave prognosis. Skeletal motor responses induced with stimulation may also assist in defining the location of the lesion and suggest prognosis. Decerebrate rigidity is characterized by quadrilateral rigidity and opisthotonos. Prognosis is generally regarded as grave for decerebrate patients. Treatment of the brain trauma patient is directed to treating cerebral edema in order to preserve brain function. Control of cerebral edema involves hyperventilation and hyperosmotic agents (Mannitol 0.5 to 1 gm/kg).

Spinal Cord Injury. In assessing a patient with spinal cord injuries, one should look at the motor, sensory, and autonomic responses associated with the various levels of the cord. Generally, lesions of the cervical spinal cord produce tetraplegia as their principal symptom. When the lesion is above the C5 cord segment, hyperreflexia is exhibited. As the cord segments of the brachial plexus becomes involved, lower motor neuron lesions are present. It is important to assess for superficial and deep pain sensation in the forelimbs. Additionally, the cervical cord injury patient is prone to apnea and must be closely monitored. Lesions of the T1 - L2 cord segments will produce the classical Shiff-Scherington motor response with the forelimbs rigidly extended and the rear limbs with flaccid paralysis and hyperreflexia. One key to prognosis is in the ability of the patient to perceive superficial and/or deep pain. The in ability to perceive pain is associated with an extremely grave prognosis. These patients will be unable to voluntarily micturate and good nursing care is a necessity. Lesions in the L4 - S1 cord segments will present with paraplegia and reduced lower motor neuron reflexes from the lumbosacral plexus. Surgical stabilization of this section of the spinal column can be beneficial in selected cases. Therapy in spinal cord trauma is directed to the cause. In some instances surgical decompression and stabilization can be useful. The key to success is a correct diagnosis and the presence of pain perception. Most spinal trauma cases will receive glucocorticoids (methylprednisolone, 30 mg/kg) for control of edema.

Peripheral Nerve Injuries. There are certain fractures which may result in peripheral nerve injury or entrapment. It is especially important one examines peripheral nerves with fractures involving the humerus, pelvis, femur and tibia. Notations should be made indicating you did check the nerve and its status. Correct external coaptation devices should be applied to reduce the occurrence of nerve injury. Continue to recheck nerve function prior to surgical repair of the fracture to assure a successful surgical outcome. Should a change in neurological status be detected, early surgical intervention may preserve the integrity of the peripheral nerve.

Abdominal Trauma. Abdominal injuries are often occult. Most injuries are caused by blunt trauma inducing lacerations of the liver and/or spleen, urological trauma, infarcted bowel, or reproductive organ damage during pregnancy. Blunt abdominal trauma cases are challenging diagnostic problems because the clinical manifestations may be delayed for hours or days. With blunt abdominal trauma, the physical examination is the most informative portion of the diagnostic evaluation and should be as complete as time and the patient's condition permit. Increasing abdominal size can be an important clue for intra-abdominal injury. Consequently, measurements of the abdominal girth at the umbilical level should be made soon after admission. This baseline measurement can be used to measure subsequent significant changes.

A four quadrant abdominocentesis is our preferred means for confirming blunt abdominal injury. From the fluid obtained, packed cell volume, total solids, cytology, and blood urea nitrogen sample are submitted. Additionally, it is probably a good idea to submit some of the intra-abdominal blood for analysis of total bilirubin. With major biliary tree or common bile duct injury, the clinical signs of icterus are often delayed 4 to 6 weeks. If the packed cell volume of centesis fluid exceeds the peripheral packed cell volume, very likely there is either a splenic, hepatic or renal parenchymal laceration.
In the dog or cat the current approach is to approach these patients as conservatively as possible. In fact, it is very unusual to require surgery for a splenic or hepatic laceration. Caution should be employed in applying an excessively tight bandage when thoracic injuries are also present.

With urological injury, the packed cell volume of the abdominal fluid will be lower than the peripheral packed cell volume due to hemodilution with urine. Emergency management of intraperitoneal rupture of the bladder, urethra, and/or ureters involves drainage of the abdominal fluid via an indwelling Foley catheter until the patient is sufficiently stable to undergo anesthesia and surgical repair. Prior to surgery, contrast studies of the kidneys, ureter, and bladder should be performed to assess the severity of injury using an excretory urogram. Additionally, if there is evidence of lower urinary tract injury, positive contrast urography and cystography are advocated.

Should plant debris or significant numbers of mixed bacteria be found with centesis of the abdominal fluid, a ruptured viscus is likely and exploratory surgery is indicated.

**Shock in Trauma**

Patients with intra-abdominal hemorrhage may present in hypovolemic shock. The systemic inflammatory response syndrome may result from overwhelming tissue damage, systemic activation of inflammatory mediators result in vasodilation, increased vascular permeability. Regardless of cause, circulatory shock results from reduced oxygen delivery to tissues. Since oxygen delivery is a function of cardiac output and the oxygen content of the blood anything which will improve these variables will help the patient. Cardiac output is determined by heart rate and stroke volume. Rapid heart rates decrease output because of poor ventricular filling. Heart rate can be optimized by treating arrhythmias, reducing anxiety and pain, and supporting intravascular volume. Volume, in the form of crystalloid fluids, synthetic colloids and blood components, will also improve stroke volume. A large bore (16 to 18 gauge) jugular catheter is preferred for volume loading. Patients in shock may need crystalloid fluids at a rate of up to 90 ml/kg in dogs and 60 ml/kg in cats. It must be emphasized that the systemic complications of trauma may diminish the patients ability to tolerate rapid fluid loading. Patients should be closely monitored for signs of overhydration (pulmonary edema, serous nasal discharge, chemois) during rapid infusions. The jugular catheter will allow CVP measurement. By maintaining a CVP of 5-10 cm H₂O, cardiac preload is optimized. Oxygen content is a function of oxygen saturation and hemoglobin content, this can be increased by saturating the hemoglobin with oxygen (face mask, oxygen tent, or oxygen cage) and increasing hemoglobin concentration. Non-hemoglobin containing fluids during resuscitation and rehydration can hemodilute patients. Although the improvements in cardiac output are important, and necessary, whole blood or packed red cell transfusion should be used to maintain a packed cell volume between 27% and 33%. Cell free hemoglobin products (Oxyglobin, Biopure inc.) can be used to maintain a hemoglobin concentration of 8-10 gm%.

Fluid and electrolyte disorders are usually due to hemorrhage and third-space sequestration. In most animals, restoration of a normal circulating blood volume will return the acid/base balance to normal. Most hypovolemic animals will have a metabolic acidosis due to poor tissue perfusion. Assessment of renal concentrating ability should be made by evaluating the urine specific gravity before starting intravenous fluids.

**Postoperative Critical Care**

Patients recovering from trauma related surgery develop a variety of predictable complications. Postoperative-ly these patients are at risk of organ failure. Acute respiratory distress, systemic inflammatory response syndrome (SIRS), sepsis, disseminated intravascular coagulation, acute renal failure and cardiac arrythmias are just some of the problems seen regularly in our critical care practice. By anticipating multiple organ dysfunction, monitoring critical hemodynamic and respiratory variables and treating abnormalities that are identified, these patients may be supported during the post-operative period.

Intensive, serial monitoring is the core of critical care medicine. Readily obtainable physiologic variables are used for screening, early warning and hopefully, early correction of life threatening problems. Packed cell volume, oxygenation and central venous pressure have already been discussed. Other variables include fluid balance, oncotic pressure, serum electrolytes, urine production, coagulation function and patient comfort.

**Fluid Balance**

Because of increased capillary permeability and decreased systemic vascular resistance, Postoperative patients
with SIRS can experience large fluid movement from the vascular compartment into the interstitium. Crystalloid fluids can lower fluid oncotic pressure. With increased vascular permeability and abnormal distribution this may cause interstitial edema. If fluid accumulates in the lungs, gas exchange is impaired and oxygen delivery reduced. Cerebral edema will cause progressive changes in mentation. Frequent checks of the body weight, central venous pressure, mentation and urine production are vital. Thoracic auscultation should be repeated listening for changes associated with pulmonary edema. Patients with abdominal or thoracic drains may have large sensible fluid losses associated with the surgery. These fluid losses should be measured or estimated and replaced as they occur.

Oncotic pressure
Serum albumin should be monitored and kept above 2.0 g/dl using plasma or whole blood transfusions. If unavailable, total solids should be monitored instead and kept above 3.5 g/dl. Persistent hypoalbuminemia is associated with increased mortality in critically ill animals. When patient size and albumin deficit makes plasma transfusion alone impractical, any one of the synthetic colloid solutions can be used to maintain plasma oncotic pressure. Dextran 70 or Hydroxyethyl starch are the most commonly used synthetic colloids and can be given at a rate of 20 ml/kg/day.

Electrolytes and glucose
Calcium, sodium, chloride and potassium should be maintained within normal limits. Potassium should be added to maintenance fluids to avoid iatrogenic hypokalemia. Potassium containing fluids should never exceed a rate of 0.5 mEq/kg body weight/hour. Blood glucose should be maintained between 100 and 200 gm/dl. Drops in blood glucose or levels that are not above normal despite the addition of dextrose can be a sign of sepsis. Hypokalemia that does not rapidly correct with high levels of supplemental potassium may respond to magnesium supplementation. Hypomagnesemia is common in the critically people and animals. Unfortunately, serum magnesium represents only a small fraction of whole body magnesium and is not a reliable measure. Magnesium can be replaced at 0.75 - 1 mEq/kg/day by constant rate infusion in 5% dextrose in water. After 24 hours the dose is lowered to 0.3 to 0.5 mEq/kg/day or the animal can be switched to a magnesium containing maintenance crystalloid fluid like Normosol-R® (Abbott Laboratories, Chicago, IL) or PlasmaLyte® (Baxter Healthcare, Deerfield, IL).

Urine production.
Urine output reveals important information about renal blood flow and function. Recumbent and azotemic patients, and those at risk for multiple organ dysfunction should have an indwelling urinary catheter in place with a sterile closed collection system. Low urine output (< 2 ml/kg/hour) in a hydrated patient may represent acute renal failure. Quick intervention with fluids, diuretics (furosemide 1-2 mg/kg) and vasoactive drugs like dopamine (3-5 µg/kg/min) may start urine flow and prevent permanent renal damage.

Coagulation
Disseminated intravascular coagulation (DIC) is a common component of SIRS. Examination of a blood smear for decreased platelets and fragmented red blood cells is inexpensive and easy. Activated clotting times should also be checked daily. More specific tests for fibrin degradation products (FDP's) and Antithrombin III (AT III) levels may help guide therapy. Therapy is directed toward decreasing microthrombi (heparin, heparinized plasma), providing missing factors (fresh frozen plasma) and improving perfusion (fluid/colloid support).

Pain control
Animals in constant stress will become immunosuppressed. It is vital to the care of the patient that it be made as comfortable as hospitalization will allow. The appropriate use of analgesics, padding, bandage changes and personal contact will have positive effects on the patients overall sense of well-being. Analgesia will be covered in much greater detail in other lectures during this conference.
Mechanical properties of the cranial cruciate ligament in different degrees of stifle flexion. An experimental study in dogs

N. Leopizzi, C.M. Pereira, R. Bolliger-Neto, T.E.P. Barros-Filho

Introduction
The Cranial Cruciate Ligament is a composite structure formed by two anatomically distinct portions, the Cranio-Medial Band and a Caudo-Lateral Portion that act singularly or in synergy, depending on the degree of flexion or extension of the stifle joint. As the most important structure for the stability of the stifle, the CCL restrains cranial tibial displacements, also controlling its internal rotation during the flexion of the joint. During extensions, it is responsible for the “screw home mechanism”, also participating actively against hyperextensions of the stifle joint. Because of the anatomical and functional specialization of the CCL, it was hypothesized that this ligament could have different mechanical behaviour related to the flexion-extension degrees of the joint. To examine the hypothesis, a biomechanical analysis was performed and the CCL submitted to traction load after the positioning of the femoral-tibial angle in maximum extension (where the need for stability is maximum), in flexion (where the requirement is of greatest mobility) and in medium angles. The objective of this study was to investigate the biomechanics of the CCL, to obtain values that could be used in future studies comparing the mechanical performance of autografts or any other graft used for the stabilization of the stifle, surgical techniques, and development of new biomaterials for implantation.

Material and methods
The specimens were obtained by the Faculty of Medicine of the University of Sao Paulo from 45 adult mongrel dogs (age 2-5 years; weight 10-25 kgf), euthanized following the international criteria and standards. Selection was based on clinical examination where the anatomical conformation and the musculoskeletal system development were analyzed; static and dynamic functional tests were also performed. The exclusion criteria included “closed” stifle joints, short length of the leg (related to the spinal length), bone deformity or any other alteration of the skeletal system; under anesthesia, cranial drawer tests were conducted. After euthanasia, the collected specimens were placed in a freezer (-22°C) and maintained until the date of the mechanical test in the Lim 41-FM USP (30-90 days). After the removal of muscular tissues and the fibula, Collateral ligaments, joint capsule and Caudal Cruciate ligament were progressively sectioned, leaving the Cranial Cruciate Ligament as the only union structure between femur and tibia. These were mounted in a Universal Testing Machine (Kratos K5002) through special clamps that allowed easy changing of the test angles. The specimens were randomly assigned to three testing groups: Group A) = bone-ligament-bone preparations tested in 110°; Group B) = bone-ligament-bone preparations tested in 135°; Group C) = bone-ligament-bone preparations tested in 155°. The destructive mechanical tests were performed at a displacement rate of 20 mm/min and the resultant load/deformation curves obtained were used to calculate the quantitative mechanical parameters of each group: 1) Elastic Limit (N); 2) Elastic Deformation (mm); 3) Stiffness (kN/m); 4) Plastic Deformation (mm); 5) Ultimate Load (N). Failures of the CCL were classified following an anatomical localization (Femoral, Central, Tibial) and Mechanism. Statistical analysis was conducted and quantitative parameters were compared through the Kruskal-Wallis test; where the difference was significant, multiple variables tests were done. Qualitative parameters were analyzed using $\chi^2$ test. Significance level adopted was 5% ($\alpha=0.05$).
RESULTS: CHARACTERIZATION OF MECHANICAL PROPERTIES OF THE CRANIAL CRUCIATE LIGAMENT, RELATED TO TEST ANGLES

<table>
<thead>
<tr>
<th>Angle</th>
<th>EL (N)</th>
<th>EL Def (mm)</th>
<th>Stiffness (kN/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>761.87</td>
<td>759</td>
<td>98.06</td>
</tr>
<tr>
<td>SD</td>
<td>362.50</td>
<td>2.33</td>
<td>30.14</td>
</tr>
<tr>
<td>SE</td>
<td>64.08</td>
<td>0.41</td>
<td>5.33</td>
</tr>
<tr>
<td>Min.</td>
<td>122.63</td>
<td>1.20</td>
<td>32.27</td>
</tr>
<tr>
<td>Max.</td>
<td>1755.99</td>
<td>12.80</td>
<td>163.50</td>
</tr>
<tr>
<td>n</td>
<td>32</td>
<td>32</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Angle</th>
<th>EL (N)</th>
<th>EL Def (mm)</th>
<th>Stiffness (kN/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>135°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>736.57</td>
<td>6.44</td>
<td>122.17</td>
</tr>
<tr>
<td>SD</td>
<td>341.44</td>
<td>3.26</td>
<td>38.64</td>
</tr>
<tr>
<td>SE</td>
<td>62.34</td>
<td>0.60</td>
<td>7.05</td>
</tr>
<tr>
<td>Min.</td>
<td>245.25</td>
<td>2.20</td>
<td>34.88</td>
</tr>
<tr>
<td>Max.</td>
<td>1785.42</td>
<td>18</td>
<td>210.92</td>
</tr>
<tr>
<td>n</td>
<td>30</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Angle</th>
<th>EL (N)</th>
<th>EL Def (mm)</th>
<th>Stiffness (kN/mm)</th>
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<tr>
<td>155°</td>
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<td></td>
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<tr>
<td>M</td>
<td>767.46</td>
<td>5.90</td>
<td>132.04</td>
</tr>
<tr>
<td>SD</td>
<td>331.03</td>
<td>1.68</td>
<td>49.25</td>
</tr>
<tr>
<td>SE</td>
<td>59.72</td>
<td>0.32</td>
<td>9.31</td>
</tr>
<tr>
<td>Min.</td>
<td>328.64</td>
<td>2.80</td>
<td>79.03</td>
</tr>
<tr>
<td>Max.</td>
<td>1648.08</td>
<td>10.80</td>
<td>336.45</td>
</tr>
<tr>
<td>n</td>
<td>28</td>
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</table>

Conclusions
1. In extension and medium amplitude of the femoral-tibial angle, stiffness of the CCL is higher than in flexion.
2. In flexion, laxity of the CCL is higher than in extension and medium angles.
3. Anatomical localization of failure is related to the test angle. Flexion increases the frequency of femoral failures and lessens the tibial ones; the contrary happens in extension.
4. CCL failures during “In Vitro” tests is more frequent at the tibial site than at the femoral one.
The use of plate & rod for the repair of complex and unstable fractures of femur, tibia and humerus

R. De Keyser, Geyser, F. Luyckx, M. Schepmans, P. Vandekerckhove, J. Van Tilburg, G. Verhoeven, and R. Vranckx

This multi-center study was performed by the Flemish orthopaedic workgroup to evaluate the use of the plate and rod method for the repair of complex and/or unstable fractures in dogs and cats. The intramedullary pin is effective in protecting the fracture from bending forces and the plate protects the fracture from rotational and compression forces. This method has the advantage of not requiring any special equipment plus the fact that most surgeons have experience with handling pins and plates.

All fractures were treated with 1 IM pin filling 25 to 50% of the medullary canal and different plates, depending on the size of the dog/cat and complexity of the fracture. There were at least 2 transcortical screws on both sides of the fracture line and multiple mono- or transcortical screws in the mid-fragment. The results of the procedures, which were performed by different members of our group in their own practices, were compiled for further evaluation and discussion.

24 cases have been treated with follow-ups from 6 months to 1 year. In dogs, 13 femoral, 8 tibial and 3 humeral fractures were treated. The cases in cats (5) were limited to 4 femoral fractures and 1 tibia. Of all the animals had pre- and postoperative radiographs with follow up films at 3 and 6 weeks. Most of the dogs and cats did very well after 2 to 3 weeks post surgery.

In 62.5% of the cases the pin was removed between 4 and 20 weeks after surgery. 1 dog and 1 cat developed fracture disease, which was seen as early as 3 weeks after surgery, 1 dog had osteomyelitis (which existed already before the application of the plate/rod) and 2 dogs showed very good bone healing, but developed serious neurological problems. 1 dog developed osteosarcoma 1-year after surgery and was euthanised.

The plate and rod method is a very useful method for treating complex and unstable fractures in both dogs and cats: it provides good stability and rapid healing and no extra equipment is required.

Number of cases treated by the workgroup

<table>
<thead>
<tr>
<th>NR</th>
<th>Breed</th>
<th>Age</th>
<th>Sex</th>
<th>W (Kgr)</th>
<th>Limb injured</th>
<th>Pin removed</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C. K. Charles</td>
<td>2y</td>
<td>M</td>
<td>12</td>
<td>Femur</td>
<td>6w</td>
<td>Good</td>
</tr>
<tr>
<td>2</td>
<td>E. shorthair cat</td>
<td>20mo</td>
<td>M</td>
<td>5</td>
<td>Femur</td>
<td>6w</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>C. Spaniel</td>
<td>3y</td>
<td>F</td>
<td>15</td>
<td>Femur</td>
<td>4w</td>
<td>Neurologic complication</td>
</tr>
<tr>
<td>4</td>
<td>E. shorthair cat</td>
<td>1y</td>
<td>F</td>
<td>4</td>
<td>Femur</td>
<td>6w</td>
<td>Fracture disease</td>
</tr>
<tr>
<td>5</td>
<td>Barzois</td>
<td>6y</td>
<td>M</td>
<td>40</td>
<td>Humerus</td>
<td>8w</td>
<td>Osteosarcoma 1y p.o</td>
</tr>
<tr>
<td>6</td>
<td>Beagle X</td>
<td>11mo</td>
<td>M</td>
<td>13</td>
<td>Tibia (+acetab.)</td>
<td>4mo</td>
<td>Good</td>
</tr>
<tr>
<td>7</td>
<td>Poodle</td>
<td>10y</td>
<td>M</td>
<td>7</td>
<td>Tibia</td>
<td>5mo -&gt;</td>
<td>Neurologic complication.</td>
</tr>
<tr>
<td>8</td>
<td>German Shepherd</td>
<td>3y</td>
<td>F</td>
<td>28</td>
<td>Tibia</td>
<td>no</td>
<td>Good</td>
</tr>
<tr>
<td>9</td>
<td>Alaskan Malamute</td>
<td>1y</td>
<td>F</td>
<td>25</td>
<td>Tibia</td>
<td>9w</td>
<td>Good</td>
</tr>
<tr>
<td>10</td>
<td>E. Shorthair cat</td>
<td>3y</td>
<td>F</td>
<td>4</td>
<td>Femur</td>
<td>no</td>
<td>Good</td>
</tr>
<tr>
<td>11</td>
<td>M. elshar</td>
<td>1y</td>
<td>F</td>
<td>25</td>
<td>Tlibia</td>
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<td>Good</td>
</tr>
<tr>
<td>12</td>
<td>Border Collie</td>
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<td>F</td>
<td>27</td>
<td>Femur</td>
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<td>Good</td>
</tr>
<tr>
<td>13</td>
<td>M. unsterlander</td>
<td>4y</td>
<td>F</td>
<td>32</td>
<td>Femur</td>
<td>no</td>
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<tr>
<td>14</td>
<td>Jack Russel terrier</td>
<td>3y</td>
<td>M</td>
<td>8</td>
<td>Tibia</td>
<td>6w</td>
<td>Good</td>
</tr>
<tr>
<td>15</td>
<td>Bouvier</td>
<td>7y</td>
<td>M</td>
<td>41</td>
<td>Tibia</td>
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<td>Osteomyelitis</td>
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<tr>
<td>16</td>
<td>Weimaraner</td>
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<td>M</td>
<td>27</td>
<td>Tibia</td>
<td>4w</td>
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<tr>
<td>17</td>
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<td>6mo</td>
<td>M</td>
<td>13</td>
<td>Femur</td>
<td>4w</td>
<td>Good</td>
</tr>
<tr>
<td>18</td>
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<td>M</td>
<td>36</td>
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<td>Good</td>
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<tr>
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<td>M</td>
<td>6.9</td>
<td>Femur</td>
<td>6w</td>
<td>Good</td>
</tr>
<tr>
<td>20</td>
<td>M. elshar</td>
<td>5y</td>
<td>M</td>
<td>31</td>
<td>Humerus</td>
<td>6m</td>
<td>Fracture disease</td>
</tr>
<tr>
<td>21</td>
<td>Mongrel</td>
<td>15y</td>
<td>FN</td>
<td>9</td>
<td>Femur</td>
<td>no</td>
<td>Good</td>
</tr>
<tr>
<td>22</td>
<td>E. shorthair cat</td>
<td>4y</td>
<td>M</td>
<td>6</td>
<td>Tibia</td>
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<td>Non union</td>
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<td>23</td>
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<td>3.5</td>
<td>Femur</td>
<td>5m</td>
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<tr>
<td>24</td>
<td>Siberian husky</td>
<td>3y</td>
<td>M</td>
<td>30</td>
<td>Femur</td>
<td>12w</td>
<td>Good</td>
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</table>
Effects of oral chondroitin sulfate, glucosamine and manganese administration on synovial fluid 3b3 and 7d4 epitope levels in a canine model of osteoarthritis

K.A. Johnson, D.A. Hulse, R.C. Hart, D. Kochevar, Q. Chu

Objective
To evaluate effects of oral administration of exogenous chondroitin sulfate, glucosamine and manganese ascorbate (CS-G-M) on articular cartilage metabolism in dogs with cranial cruciate ligament (CCL) deficient and reconstructed knees, as reflected by levels of synovial fluid 3B3, 7D4 and total sulfated glycosaminoglycan (GAG).

Methods
16 adult dogs that underwent unilateral CCL transection were divided randomly into 4 groups. CS-G-M were administered orally to half the dogs beginning the day after CCL transection for 5 months. One month after the index CCL transection surgery, all knees were reoperated for either an intra-articular CCL reconstruction (R-CCL) or sham CCL reconstruction (S-CCL). Group I (n=3) had S-CCL alone, group II (n=3) had CS-G-M and S-CCL, group III (n=5) had R-CCL alone, and group IV (n=5) had CS-G-M and R-CCL. Synovial fluid from CCL transected and contralateral non-operated knees at 0, 1, 3 and 5 months were assayed for 3B3, 7D4 and GAG concentration.

Results
In the longitudinal analysis 7D4 and 7D4/GAG concentrations in synovial fluid of CCL transected knees were significantly (p = 0.0012) greater in CS-G-M treated dogs (groups II and IV) than non-CS-G-M controls (groups I and III). In cross-sectional analysis at 3 months, levels of 3B3 (p = 0.029), 7D4 (p = 0.036) and 7D4/GAG ratio (p = 0.007) were significantly greater in the CCL transected knees in CS-G-M treated dogs than in non-CS-G-M treated dogs. However, when synovial fluid variables in the CCL transected knees were expressed as a ratio to the contralateral non-operated knee, there were no significant treatment effect due to CS-G-M, suggesting that the effects of these compounds on articular cartilage metabolism were systemic and not localized to OA joints. Cranial cruciate ligament reconstruction had no significant effect on synovial fluid variables.

Conclusions
Administration of CS-G-M was associated with an elevation in levels of 7D4 and 3B3 in synovial fluid, suggesting that these compounds modulate matrix synthesis by articular chondrocytes in vivo.
A prospective study of the surgical treatment of unilateral fragmented medial coronoid process using force plate analysis

L.F.H. Theyse, H.A.W. Hazewinkel, and W.E. van den

In this prospective study force plate analysis was used to objectively assess the gait abnormalities induced by a unilateral fragmented medial coronoid process (FCP) and the results of surgical treatment. Eleven dogs were diagnosed with unilateral FCP based on clinical and radiological examination of both elbow joints and included in the study. Radiological screening of both elbow joints was performed prior to and at six months after surgery to determine the osteoarthritis (OA) score according to the International Elbow Working Group (IEWG) and to exclude any bilateral involvement. Force plate analyses were performed at three consecutive intervals; prior to surgery, at six weeks and at six months after surgery. Peak braking force Fymax, peak propulsive force Fymin, peak vertical force Fzmax and the impulses of these forces Iymax, Iymin, and Iz of the front legs were determined. The symmetry index SI of these forces (ratio affected side : non-affected side) was assessed for gait analysis. At the end of the six months period four dogs were diagnosed to have osteoarthritis of the contralateral elbow joint after radiological examination and excluded from the study. In the remaining seven dogs the SI of Fymin, Fymax, Iymin, and Iymin proved to be more sensitive than the SI of Fzmax and Iz in determining front leg lameness due to FCP. The SI of Fymin and Iymin was the most sensitive factor in this patient group. In six out of the seven dogs the SIs of Fymin, Fymax, Fzmax, Iymin, and Iz had returned to normal within six months after surgery and these dogs showed no clinical lameness at that time. Although the SIs of these forces and impulses improved in general, the only SI to improve significantly (P <0.05) were SI-Fymin and -Iymin. Radiological examination at six months after surgery showed progressive signs of OA in all joints. In conclusion normal gait was restored after surgical treatment of FCP in these dogs despite progressive OA.
Nutritional research on bones and joins in the dog

Allan J. Lepine & Richard C. Nap

Normal Changes With Increasing Age

Just as changes occur in the articular cartilage during the process of maturation, normal age related changes continue to occur subsequent to maturation. Data from porcine articular cartilage has shown a decrease in hydration, a decrease in collagen on a dry matter basis, a decrease in glycosaminoglycan concentration especially chondroitin sulfate and a decrease in proteoglycan size with age.\(^1\),\(^2\) Although the total glycosaminoglycan concentration may not vary much with increasing age, the ratio of keratan sulfate to chondroitin sulfate increases.\(^2\) With respect to chondroitin sulfate it was also noted that the 4-sulfated compound decreased while the 6-sulfated compound increased. The alteration of proteoglycan composition and size is most likely the result of proteolytic cleavages that are not limited to the period of growth and maturation but appear to occur throughout the aging process in all species.\(^3\) The link proteins are also subject to proteolytic cleavages as aging progresses.\(^3\) This is likely a normal component of aging and could contribute to the destabilization of the proteoglycan component of the extracellular matrix. The obvious result of these normal age-related changes of the articular cartilage will be a matrix of reduced capability to withstand the forces associated with normal joint functioning.

Changes Associated With Joint Disease/Injury

Articular cartilage injuries are characterized by the degree of involvement of the extracellular matrix composition and resultant damage to the chondrocytes.\(^4\),\(^5\) Three general types of injury are described involving the articular cartilage: microdamage or blunt trauma, chondral fractures and osteochondral fractures.\(^5\) Microdamage may be caused by a single impact or repetitive blunt trauma. It is characterized by a loss of matrix components, most notably proteoglycans, without chondrocyte damage. If the traumatic event is short in duration, the chondrocytes may be able to repair the cartilage by restoring the lost proteoglycans and matrix components. Damage resulting from sustained blunt trauma, however, may eventually become irreversible.\(^5\) Chondral fractures result from a penetrating traumatic event disrupting the articular surface but sparing the subchondral plate. The pathophysiological response of articular cartilage surrounding the injury results in chondrocyte proliferation and synthesis of extracellular matrix protein. Unfortunately, since chondrocytes cannot migrate to the lesion, these efforts do not result in complete repair.\(^4\) The third type of injury is described as a full thickness defect or osteochondral fracture. These injuries are characterized by an insult crossing the tidemark into the underlying bone resulting in chondrocyte damage and marrow cell involvement. Full thickness injuries invoke an inflammatory process since vascular structures are now involved. This is in contrast to the lack of inflammatory response to less traumatic articular cartilage injuries resulting from the inherent avascular nature of this tissue. Following a full thickness injury, fibroblasts differentiate into chondrocytes and repair of the tissue is attempted, but the fibrocartilaginous repair tissue produced is not “normal” articular cartilage.\(^4\),\(^5\) After several phases of remodeling the repair tissue has a lower proteoglycan content and a substantial component of type I collagen rather than type II.\(^5\) Therefore, the resulting repair is often of sub-optimal quality resulting in compromised joint function.

Changes Associated With Osteoarthritis

Normally, turnover of the extracellular matrix is relatively low and chondrocytes are able to synthesize the proteoglycans, collagen, fibronectin and other components needed to maintain joint homeostasis and integrity. When chronic trauma or disease disrupts this homeostasis, the articular cartilage may undergo a progressive degeneration ultimately resulting in the development of osteoarthritis. It is the imbalance between synthesis and degradation of matrix components that sustains the progression of articular cartilage damage and promotes osteoarthritis. Osteoarthritis is defined as a noninflammatory degenerative joint disease characterized by degeneration of the articular cartilage, hypertrophy of the bone at the margins and changes in the synovial membrane. During the initial stage of osteoarthritis, chondrocyte proliferation occurs with subsequently increased syn-
thesis of extracellular matrix similar to responses seen in subchondral injury of the articular cartilage. Chondrocyte activity is in part stimulated by the release of growth factors such as insulin-like growth factor 1 (IGF-1). Unfortunately, the newly synthesized proteoglycans have an abnormal composition. Specifically, in early osteoarthritic cartilage the concentration of keratan sulphate is decreased, the length of the chondroitin sulphate side chain is reduced and the ratio of chondroitin-4-sulphate to chondroitin-6-sulphate is increased. The newly synthesized proteoglycan subunits do not demonstrate normal aggregation with hyaluronic acid. Inflammation of the synovium is present in established osteoarthritis although the inflammatory response is considerably less than would be expected in other joint diseases. One of the earliest changes seen in an experimental model of osteoarthritis was an increase in hydration (2-3%) in the entire cartilage of the joint. This hydration appears to be the result of the cleavage of type II collagen by collagenase. The functional collagen network is disrupted thereby permitting the proteoglycans to bind increased amounts of water resulting in the cartilage swelling described in early osteoarthritis. This is possible because the collagen network no longer restricts the hydration capacity of the proteoglycans.

With the progression of osteoarthritis, chondrocyte necrosis is evident; the synthesis of extracellular matrix ceases while degradative activity remains elevated. The collagen network becomes increasingly disorganized and disintegrated. The content of several extracellular components including collagen and proteoglycans are progressively reduced. The removal of functional proteoglycans from the extracellular matrix results in a decreased water content of the cartilage and a subsequent loss of biomechanical properties, such as resilience and elasticity. As a result the chondrocytes are subjected to increasing mechanical stress and trauma thereby accelerating the osteoarthritic process.

Chondroprotectants

Recently, considerable attention has been focussed on nutritional compounds potentially capable of mitigating the articular cartilage damage associated with joint disease. Two compounds of particular interest are glucosamine and chondroitin sulfate. The effect of glucosamine on joint health has been investigated during oral administration in the dog and in the human. Chondroitin sulfate efficacy has also been reported following oral administration to the dog and human. During treatment ranging from 2 to 14 weeks, glucosamine and(or) chondroitin sulfate efficacy was evaluated by several measures including pain at rest, pain on active movement, pain on passive movement, locomotion, joint mobility, resolution of lameness, and swelling. Glucosamine and(or) chondroitin sulfate administration has been reported to consistently improve these criteria and therefore are considered efficacious in enhancing joint health in several species including the dog. The mechanisms of action appear to be the provision of cartilage building blocks via glucosamine and the ability of chondroitin sulfate to reduce the ability of metalloproteinases to degrade the articular cartilage.

Conclusion

It is readily apparent that articular cartilage is a complex amalgamation of molecules with disparate functions. Furthermore, maintaining appropriate functional characteristics within the articular cartilage is dependent on correct structural interactions between these molecules. This structure/function relationship is clearly demonstrated in the structural modifications observed during growth and development of the joint in response to the increasing forces naturally applied during this period. It is also clear that traumatic injury or disease can substantially disrupt the normal architecture of the joint by altering the concentrations of glycosaminoglycans, proteoglycans, collagens and associated structures within the cartilage. Compressive resistance is compromised through negative effects on cartilage hydration and collagen tensile strength. Failure to correct such damage can allow for the progression to advanced joint disease from which complete reversal may not be possible. Understanding the changes in the structural/functional relationships of articular cartilage during joint trauma or disease will allow for the application of nutritional management to minimize the negative outcome. The provision of nutritional compounds that decrease cartilage degradation, increase matrix synthesis, provide matrix precursors or assist in the control of the inflammatory response must be a primary directive in the control and management of joint health of the companion animal.
References
Cauda Equina Compression through Osteochondrosis-like lesion in the Sacrum: Clinical Signs, Treatment and Outcome in 10 German Shepherd Dogs

H. Kriegleder

Osteochondrosis (OCD)-like lesions as cause of cauda equina compression in German Shepherd Dogs was first reported in 1992 (Lang et al., Vet Radiol., 33). Since specific clinical data are lacking clinical findings and treatment in 10 athletic German Shepherd Dogs are described. Age distribution of the dogs was 12 to 60 months (mean 35 mo). 6 dogs were pretreated unsuccessfully with nonsteroidal analgesics. Diagnosis was established through clinical examination, plain radiography, myelography (n-3) and computed tomography (n-6). Predominating symptoms were lumbosacral pain and/or unilateral lameness and paresis of the tail. Lateral plain radiography revealed a defect in the craniodorsal sacral endplate with a dorsally displaced fragment (n-6) or without a fragment plus radiopacity of the intervertebral foramen (n-3) or a defect in the endplate plus a dorsally directed exostosis (n-1). Myelography confirmed a compression of the dural sac in the area of the sacral defect. Computed tomography showed a radiographically undiagnosed fragment in 2 cases and was superior to radiography and myelography for localisation of the defect.

In 8 dogs therapy consisted of surgical decompression of the cauda equina using a limited approach to the lesion with (n-6) or without (n-2) removal of the fragment. Histologically the tissue surrounding the fragment showed chondroid degeneration. All operated dogs remained active athletes without symptoms throughout the observation period of maximum 4 years (mean: 2.5 y) postoperatively. 1 out of 2 dogs treated conservatively had no visible signs during non-athletic activity according to owners observation, the remaining dog was lost to follow up.

Conclusion

OCD lesions of the sacrum can cause clinical signs in young German Shepherd Dogs presumably due to traumatic dislocation of a preexisting fragment during athletic activity. Surgical decompression of the cauda equina using a limited approach, with or without removal of the fragment achieves clinical soundness for a certain time period. Radiological examination of young asymptomatic athletic German Shepherd Dogs is recommended since the condition is thought to be congenital.
Application of the maxillofacial mini-plate compact 1.0 in the fracture treatment of small animals

C.J. von Werthern, C.E. Bernasconi

Introduction
An AO/ASI F maxillofacial mini-plate system was developed for fixation of craniofacial fractures in humans (PREIN und RAHN, 1998). At the small animal surgery department of the University of Zurich the mini adaptation-plate of this system (Compact 1.0) has been successfully used for fixation of mandibular fractures in cats, metacarpal and -tarsal fractures in cats and one dog, phalangeal fractures in a dog and for a partial tarsal arthrodesis in a cat. Furthermore a distal fracture of the tibiotarsus in a parrot was repaired with this implants.

Implants
For economical reasons we put together a partial set of the maxillofacial implant system Compact 1.0, which is listed below:
• one maxillofacial mini-plate (34 holes, thickness 0.7 mm, length 100 mm)
• selftapping screws (core diameter 0.7 mm, outer diameter 1.0 mm, length of 6 and 8 mm)
• emergency screws (core diameter 0.9 mm, outer diameter 1.2 mm, length 6 and 8 mm)
• screwdriver with a cruciform tip
• plate cutting forceps
• two 0.7 mm drills
The handpice of the screwdriver and the drill were the ones of the AO/ASI F mini-implant set.

Patients and Fractures
Fifteen patients have been operated with the maxillofacial mini-plates at our small animal surgery department. The animals treated were 6 cats with mandibular fractures, 2 cats and one dog with metatarsal fractures, 1 cat with metacarpal fractures and 1 dog with multiple phalangeal fractures. A partial tarsal arthrodesis was performed in a young cat. Furthermore 2 avulsion fractures were fixed with single screws of the Compact 1.0 system only: One avulsion of the medial tarsal collateral ligament in a cat and an avulsion-fracture of the accessory carpal bone in a Dachshund. A distal fracture of the tibiotarsus of a parrot was repaired with two maxillofacial mini-plates.
The malleable mini-plates were contoured and cut to the appropriate length intraoperatively. The length of the self-tapping screws were either 6 or 8 mm, which was judged from the radiographs. Fourteen cases accomplished fracture healing, one developed a non-union.

Discussion
Fracture treatment in cats, small dogs and exotic animals can be challenging regarding the relation between the size of the bones and available implants. Most of the smaller bone fractures can be repaired with the AO/ASI F mini instrument and implant set (MONTAVON et al., 1988). Especially in very small animals some of the bone fragments are too small for these implants. The thread pitch of the maxillofacial miniscrews (Compact 1.0) is narrower than the one of any other bone screw. Even bone fragments with a thickness of only 0.5 mm can be fixed safely. The plate is only 0.7 mm thick which allows a tensionfree closure of the soft tissue. This is advantageous in the distal extremities of cats and birds, where the soft tissue envelope is very thin.
The use of self-tapping mini-screws and their application without measuring the depth of the drill hole provides a time saving osteosynthesis. A short anaesthesia time is important in very small animals because of the risk of severe hypothermia.
The costs of an osteosynthesis with the described maxillofacial mini-implants are similar to those with AO/ASI F mini-implants. The screws cost much more, but the cuttable plate is less expensive.
Many instruments used with this system, such as the handle of the mini screwdriver and the mini air drive, are already available in most orthopaedic clinics. Once more experience has gained with this maxillofacial implant system, more indications will be found.

References
A new surgical technique for spinal stabilisation: the pedicle screw fixation. Anatomic and technical considerations

P. Meheust

Objective
Define the anatomical and radio-anatomical characteristics of the lumbar vertebral pedicle of the dog for assessment of a surgical approach for placement of vertebral pedicle screws.

Animals
20 lumbar spines (L1 to L7) of adult dogs, weighing more than 20 kg.

Method
5 mm cross section of five spines were taken to allow identification of the transversal plane, where the pedicle presents its maximum width. In the plane as defined above, and for each vertebra, the pedicle thickness, the angle of the pedicle from vertical axis, the dorso-lateral pedicle wall height (axial length), the dorso-ventral height in addition to the length of the portion of the vertebral body located just below ("straight forward" length) and its frontal length were directly measured on dry bones. Each vertebra was X-rayed in a ventro-dorsal plane and the greatest width measured.

Results
The location of the transversal plane of maximum pedicle width was identical between individual vertebrae: it lies directly in the middle of the junction between transverse process and the vertebral body. On this plane, the pedicle width depends on the weight of the dog and on the lumbar level in question. Pedicle width measurement on dry bone was not significantly different from that measured on the X-ray (analysis of the prediction intervals). The angle of the pedicle was constant for each vertebral level. Its axial length (always more than 20 mm) was greater than the "straight forward" length except for L7. Pedicle frontal length was always longer than 20 mm.

Conclusions and Clinical relevance
Placement of pedicle screws is possible if certain guidelines are adhered to: the insertion point for the implant, which is always the same, is directly accessible. It is located on a small bony crest at the base of the cranial articular process. The direction of the implantation follows the angle of the pedicle (axial screwing) on the upper lumbar spine (L1 to L5) and a perpendicular direction to the horizontal axis of the spine ("straight forward" screwing) on the lower lumbar spine (L6-L7). The main limiting factor of this technique is the pedicle width which can be evaluated sufficiently via plain ventro-dorsal radiography. Placement of pedicle screws, via a simple dorsal approach, produces a very stable method for internal fixation as evidenced by successful lumbo-sacral fusion in five cases.
Eleven cases of angular deformities in the dog corrected by means of the Ilizarov technique

G.L. Rovesti, K. Schmidt, A. Margini

Introduction
Angular deformities are caused by many factors, including trauma, especially to the growth plate, metabolic diseases, genetic predisposition, and suboptimal realignment of fractures. Some treatments for this condition have been proposed, and each one has specific features. The aim of this study was to retrospectively evaluate the treatment protocol and results in dogs treated for angular deformities by means of the Ilizarov technique.

Materials & Methods
Clinical records of patients treated by means of the Ilizarov technique at the Ambulatorio Veterinario Associato “M. E. Miller” in Cavriago (RE), Italy, from November 1st, 1996 to July 31st, 1999, were evaluated. Eleven limbs in 9 dogs were treated during this period for angular deformities. For each case the dog's signalment, presenting deformity, system used for treatment, duration of treatment, complications and outcome were recorded. The systems used for treatment were 2: the Small Bone Fixator (SBF) and the Multi-planar C-Fix (MCF). The main features of the MCF system are the hemispheric nuts and washers, that allow the surgeon to keep the rings angulated to a maximum of 30° to the threaded bar, and the 8-mm-diameter holes in the rings, allowing for rotational adjustments. The SBF system has many more fittings, allowing for more complex frames construction. The dogs' average age at the time of treatment was 13 months (range, 5 to 20; SD 6), and the average body weight was 23 kg (range, 5 to 50; SD 13). The segments treated were 7 radio-ulnae (5 right, 2 left) and 4 tibiae (3 right, 1 left); the presenting problems were carpus valgus (6), hindlimb pes supinatus (3), valgus hock (1), and carpus varus supinatus (1). The causes of the deformities were fractures of the growth plate at a younger age (4), a potentially genetic developmental problem (4), and congenital (3). The preoperative average valgus deviation was 22° (range, 6 to 40; SD 11), the average supinatus was 42° (range, 25 to 70; SD 13), the average procurvatus was 17° (range, 2 to 30; SD 10), and only one dog had a 45° varus deformity. The preoperative average segment length was 13.6 cm (range, 10 to 18.7; SD 3.5). Complications were graded as minor if they didn't influence the course of the treatment, or if they required modifications of the frame without general anesthesia (GA), or as major if they negatively influenced the course of the treatment or required modification of the frame under GA. The results were classified as excellent, good, fair and poor, following a previously reported grading system for both the functional and cosmetic outcome.

Results
The SBF system was used in 8 dogs, the MCF system in 1 dog, and a hybrid frame with both components in 2 dogs. The levels of fixation ranged from 3 to 5, and the Kirschner wires' size ranged from 1 to 1.5 mm, depending on the patient's size and the wire's location. Three and 4-mm-diameter threaded pins were used, and all the frames were hybrid, i.e. with wires and pins in the same. Three of the corrections were for pes supinatus, and they were corrected during the surgical procedure, while all the other corrections were made by progressive distraction. The distraction was usually started 3 days after the osteotomy, and the mean time to achieve clinical realignment was 15 days (range, 0 to 27; SD 6) while, including only the progressive corrections, the average was 20 days (range, 7 to 27). The average whole treatment period, considered as the time from surgery to implant removal, was 73 days (range, 49 to 107; SD 20). Six frames required modifications during the treatment period. Nine dogs experienced minor complications; these were serous discharge from the wires or pins tracts (8), the need to correct an axial displacement without GA (4), carpal flexion contracture (2), and wires and pins breakage (1). Four dogs experienced major complications that included frame modification under GA (2), pins breakage with the need to reply them under GA (1), and flexion contracture of the carpus (1); 3 patients had both minor and major complications, and some had more than one minor complication. The postoperative (PO) average valgus deviation was 5° (range, 0 to
16), the residual varus of the only dog with this deviation was 10°, and the PO average supinatus was 5° (range, 0 to 10). The PO average segment length was 14.1 cm (range, 10.5 to 19.3; SD, 3.3). The results were graded as excellent in 10 limbs (91%) as for the functional outcome, and as good in the other one. The cosmetic evaluation was graded as excellent in 7 (64%), good in 3 (27%), and fair in the other one.

**Discussion**
Axial deviations and limb lengthening are considered specific indications for the Ilizarov technique, and its application revolutionized the treatment of these diseases. The correction can be performed on 3 planes, and it doesn’t require a limb’s shortening. On the contrary, a limb’s lengthening may be achieved during the same treatment in selected cases. In our case series the technique proved very effective, and free weight-bearing was allowed immediately after the surgery, minimizing muscle atrophy and facilitating complete functional recovery. The technique has a steep learning curve, however, and a constant owner’s cooperation is required.
Triple pelvic osteotomy (TPO) in dogs: proposal of a caudal iliac osteotomy

B. Peirone, A. Valazza, E. Ciliberto, P. Buracco, P. Botti

In the triple pelvic osteotomy (TPO) described by Slocum (4), the iliac osteotomy should be performed just caudal to the auricular facet of the sacrum, thus allowing the insertion of at least two screws in the body of the sacrum, increasing screw purchase. In order to get this result it is necessary to palpate the caudal aspect of the sacroiliac joint, inserting a finger on the medial cortex of the ilium. The caudal border of the sacroiliac joint is not so easily identifiable and it is known that the iliac osteotomy line represents a critical phase of this surgery. In this work, the possibility to perform a more caudal iliac osteotomy to facilitate the surgical procedure is evaluated.

Materials and methods: in 9 dogs submitted to TPO (group A), the following modifications to the original technique were introduced: 1) limited elevation of the gluteal mass; 2) very limited dissection of the m. iliacus from the ventral border of the body of the ilium, without digital palpation of the sacroiliac joint; 3) identification of the tuberosity for the insertion of the m. rectus femoris; 4) plate positioning just cranial to this tuberosity and consequent definition of the osteotomy line. According to these modifications, none of the screws resulted inserted in the sacrum. After 6-8 weeks from the surgery, the dogs were evaluated and compared with a second group (group B - 16 dogs) in which the Slocum’s original technique was performed, with at least two screws in the sacrum, considering the following parameters: articular congruency, callus formation at the iliac osteotomy site, screw loosening or rupture with dislocation of the acetabular segment (< or > of 5 mm of superimposition of the segments at the ischiatic osteotomy site).

The two groups were homogeneous for body weight (median: group A, 28 kg; group B, 30 kg) and age (median: group A, 8 months-old; group B, 7 months-old). Acetabular covering of the femoral head was improved in both groups; bone healing at the iliac osteotomy was good in most dogs, except for three (group B) in which hypertrophic callus developed. Minor complications were the followings: 1) screw loosening: group A, 6 cases (66.7%); group B, 11 cases (68.75%); 2) medial dislocation of the acetabular segment: group A, mild (<5 mm) in 6 cases, marked (>5mm) in 1 case; group B, mild in 5 cases, marked in 4 cases. No plate deformation or screw rupture were observed. Major complications were observed only in 1 case (group A), in which the mobilisation of the three screws in the acetabular segment at the 4th postoperative day due to a severe trauma rendered necessary a second surgical procedure.

Discussion: the proposed technical modification has several advantages: 1) minimises the surgical approach to the ileum reducing gluteal muscles dissection and elevation; 2) simplifies landmark identification for the iliac osteotomy line, avoiding medial sacroiliac joint palpation; on the contrary, the insertion of the m. rectus femoris is readily apparent and corresponds to the caudal limit of plate positioning; gluteal nerve has always been retracted, without interfering with the plate positioning; 3) the sacroiliac joint has a slight mobility and this is the cause of screw loosening observed in previous papers (1,2); our modification can avoid screw insertion in the joint and allows screw insertion in a more caudal position, where the ileum is thicker. The comparison between the two groups shows that the incidence of screw loosening is similar; thus the modification doesn’t resolve the problem; this is probably due to the small size of the Slocum’s plate, to the early weight bearing in case of bilateral dysplasia, and to the lesser purchase of cortical screws in juvenile bone. Despite the high incidence of screw loosening, we observed a good healing of the osteotomy lines in most patients of both groups. The three patients with hypertrophic callus were all heavier than 40 kilograms and showed respectively 1,3,5 screws mobilisation. Dislocation of the acetabular segment, either medial or lateral, is another complication reported in the literature (2,4); in our experience, we only observed medial dislocation. Mild dislocation was twofold in group A than in group B (75% vs 31%), but marked dislocation was more represented in group B (25% vs 12.5%). Mild dislocation is considered normal and caused by the tension on the sacrotuberous ligament; for this reason Slocum suggested to partially cut the ligament. The tension caused by the ligament could explain cases of mild dislocation without screws mobilisation. On the opposite, severe dislocation was always related to mobilisation of two or more screws, in the cranial or in the acetabular segment. Four out of five cases of severe dislocation were represented by dogs heavier than 40 kilos. We suppose that Slocum’s
plate, relatively short and designed for medium to large breeds, could result undersized in giant breeds. In conclusion, the proposed technical modification simplifies the surgical approach to the ilium and the identification of the osteotomy line, but does not resolve the problem of screw mobilisation. It should be advisable to add a hole for the passage of a cerclage in the cranial iliac segment; the application of the cerclage is allowed by the more caudal position of the plate. In giant breed dogs, it should be advisable to study a larger plate in order to better sustain forces during the healing of the iliac osteotomy.

References

Application of the point contact fixator for fracture repair in dogs: a retrospective study of 53 cases

C. J. von Werthem, S. Tepic and P. M. Montavon

Introduction
The name Point Contact Fixator (PC-fix) stands for point contact internal fixator and is a new bone plate for fracture fixation. It has been developed by the AO Davos, Switzerland (Tepic et al., 1997). At the small animal surgery department of the University Zürich, 53 dogs with long bone fractures have been operated between August 1992 and May 1998 with this new bone plate and were retrospectively investigated.

Material and Methods
Ninety-three percent of the fractures were classified as diaphyseal fractures, 39% each were simple and wedged, and 23% complex. Single PC-Fix application was performed in 44 and double plating with 2 plates in a perpendicular plane in 9 cases. Additional fixations used in conjunction with the PC-Fix was used in 14 cases. With the 3.5 mm PC-Fix system only medium and large breed dogs, 12 to 45 kg (mean 28 kg) in weight were included. The dogs ranged in age from 4 to 144 months (median 24 months). Fractures were reduced manually or with the help of pointed reduction forceps. Care was taken to avoid additional trauma to the periosteum and soft tissue.

A precise and tight fit of the screw heads in the implant is mandatory to achieve stability of the plate-bone construct. Therefore the drillholes had to be drilled with a special drill sleeve, which was placed squarely into the plate holes. PC-Fix was applied over the periosteum and fixed with monocortical screws. In the beginning of this study a PC-Fix was used in neutralisation function, later on it was applied also in higher comminuted fractures with buttress function. This was achieved by means of double bone plating.

Results
In 50 cases (94%) fracture fixation with the 3.5 mm PC-Fix led to clinical bone healing after 36 - 184 days (mean 95 days) after surgery. Three failures of the fracture repair occurred either secondary to breakage of the plate (1 case) or due to loosening of the screws (2 cases). Lysis around one screw hole was radiographically diagnosed in 4 cases but did not impair fracture healing. No early or late postoperative infection was diagnosed.

Discussion
Atraumatic soft tissues handling in fracture treatment is a basic principle for biological osteosynthesis. Healing of a fractured bone relies on the soft tissue surrounding the fracture which initiates callus formation. Internal fixation of the fracture should add as little soft tissue damage as possible to achieve an uncomplicated and fast bone healing. The design of the new PC-fix plate is based on this concept. The plate is laid only with point contact on the periost of the bone. This leaves space under the plate for vascularity and callus formation. The PC-fix is hold in place by the threads of the screws and the stable 90° angle determined between the screws and the plate (Fig. 1). The screws do not press the plate on the bone, as in DC-plate application, which prevents the development of implant-related cortical necrosis under the plate. The complete different screw design allows beside monocortical application a smaller number of screws for fracture fixation (6 average). Selftapping screws reduce the operation time and the instrumental equipment. This biological concept of the PC-fix resulted in a 38% shorter healing time (Savoldelli, 1995) and a superior healing of fractured bone compared to conventional DC-plate application (Tepic, 1997).

References
New aspects of the functional anatomy of the canine elbow joint


An understanding of the physiological mechanical properties of the canine elbow joint is becoming increasingly more important parallel to the rising number of cases of elbow dysplasia. A parameter yielding information on the long-term distribution of load is subchondral bone density. Bone density, however, is an unspecific parameter concerning information on tensile stress which influences the orientation of collagen fibres. In decalcified specimens orientation of tensile stress can be visualised by the split line patterns. Tensile stress is caused by incongruence which in this context does not necessarily mean pathological incongruence.

Elbow joints of healthy German Shepherd dogs were scanned by CT. These serial scans were evaluated for the subchondral bone density by CT osteoabsorptiometry (Müller-Gerbl, 1989). In a second step the humeroulnar joint was tested in a material testing device (Zwick, Ulm-Einsingen) in order to evaluate contact areas and joint space width. Finally these specimens were decalcified to visualise the split line pattern.

Bone density
Maximum bone density in the ulna is positioned at the medial side, especially the anconeal process and the medial coronoid process. Maximum density in the radial notch can be found medially, too. The maxima in the humerus are located medial on the trochlea and within the fossa olecrani.

Split line pattern
Concerning split lines their orientation is clearly proximo-distal in the ulnar notch and a cranio-caudal in the radial head. Interestingly collagen fibres are oriented transversely in the fossa olecrani while there is no clear pattern in the remaining articular surface.

Contact studies
At low loading (10 N) the joint surfaces of the humeral trochlea and the ulnar notch only have contact at the medial coronoid and anconeal processes, respectively. Between these areas of contact there is a space of 0,25 mm. If loads are increased (400 N) the bicentric pattern merges into a single area and the joint space vanishes completely. All of these findings indicate that the canine elbow joint shows a physiological incongruence as it has been proven for the human elbow joint (Eckstein, 1993, 1994). Thus a similar mechanism of adaptation to high loading can be expected in the canine elbow joint. This means that loads are transmitted more even including all parts of the articular surface at low or high loads. This leads to a better compensation of loading pressure reducing stress in all tissues of the joint.
CT-Osteoabsorptiometry in dogs with elbow diseases

J. Körbel, U. Matis, J. Maierl, M. Müller-Gerbl

CT-Osteoabsorptiometry is a method used to present the distribution of radiological density within the subchondral bone plate. It is based on the knowledge about the relationship between mechanical stress and bone morphology (Wolff, 1892). The aim of this investigation is to illustrate the mineralisation pattern of the subchondral bone plate with reflection on the long-term stress within the canine elbow joint. Especially elbow dysplasia (ED) should be examined for characteristic changes in comparison to healthy joints (for definition see International Elbow Working Group (IEWG), 1999).

Both elbow joints of healthy dogs (n = 8) and those with clinical and radiological signs of elbow dysplasia (FCP, UAP, OCD; n = 27) were serially scanned in the transverse plane. First primary transversal CT-sections are reformatted into secondary sagittal sections, because a predicate about the mineralisation patterns are only allowed, if the section is nearly orthogonal to the joint surface. Otherwise the partial-volume-effect causes aberration.

The patient is placed in prone position on the CT-table, with both elbow joints on the same level and at an angle between 90-110°. Slice thickness and table movement should be set to 1 mm using overlapping sequences (slice 2 mm, table 1 mm) if necessary. CT datasets have been evaluated on a workstation (IBM RISC System/6000) using the software Analyze (Version 7.0) according to Müller-Gerbl et al. (1989).

In the final CT-OAM-picture different Houndsfield stages in the area of the joint surface are presented in false-colour and projected onto the three-dimensional reconstruction of the bone. The mineralisation pattern, localisation of maxima and relative calcium concentrations are described and compared for the different patient groups.

In cases of a healthy elbow joint the mineralisation within the joint surface showed a characteristic distribution pattern. The central region of the trochlea humeri shows a maximum, as well as the articular surface of the olecranon fossa and the proximal part of the groove between trochlea and capitulum humeri. In the fovea capitis radii the density maximum is located on the medial half of the joint surface. In a few cases two maxima are seen, but they are localised on the medial part of the surface. Last but not least the trochlear notch reveals a maximum, which extends from the anconeal process to the medial coronoid process. It is partly interrupted by areas of lower mineralization. The lateral region of the trochlear notch usually presents a small maximum. The medial and lateral maximum are separated through an area of less mineralization from distal.

All patients with an UAP show an obviously lower mineralization of all three articular facets, in diseased joints as well as in healthy joints. The extension of the density maximum in the articular surface of the distal part of the humerus seems to be smaller in diseased compared to healthy joints. The maximum in the olecranon fossa has the peak density in comparison to the other maxima described in the humerus. The isolated part of the anconaeal process shows a lower mineralization than the remaining parts of the maximum. Both distal articular facets show the tendency of lower bone density compared to the healthy dogs.

Diseased dogs with a FCP are subdivided into a group with congruent and another one with incongruent joints. The distribution patterns in both groups are the same in principle. Incongruent joints are characterised by lower density in comparison to congruent joints, but the difference is not as obvious as described for joints with UAP. The mineralisation of the trochlea and capitulum humeri, as well as the fovea capitis radii distinguished little from that of healthy dogs. Only on the trochlear notch differences are found. The central maximum is most highly mineralized, with the mineralisation falling off towards the margins, especially in the region of the medial coronoid process.

In case of OCD there is an oval area with minimal density on the medial part of the trochlea instead of the normal main maximum. On the one hand this could be a hint to a longer existence of the illness giving time to the bone to remodel. On the other hand the origin of OCD might be within the subchondral bone.

In most healthy cases the ulnar trochlear notch shows the peak mineralization, followed by the trochlea and capitulum humeri and finally by the fovea capitis radii. The relationship between the mineralization of the three articular surfaces of the elbow joint stays the same in diseased dogs as described for healthy dogs. This
would stand contrary to the actual understanding of biomechanics of the canine elbow joint, in which the radius carries the main bodyweight. The interpretation of all mineralization patterns lead to the conclusion, that the medial part of the canine ulnar trochlear notch is the main part of load transmission of the distal articular facets.

To draw conclusion from these results, the biomechanical situation within the fractured medial coronoid process hardly varies from the normal joint. Consequently the aetopathogenesis of FCP has to be considered.
Management of the UAP by internal fixation

U. Matis

In the last 10 years, the number of advocates for retaining the anconeal process as an important stabilizer of the elbow joint has increased. Support for this opinion is based on follow-up studies involving a large number of dogs, in which excision of the anconeal process revealed a poor long-term prognosis. Proximal ulnar osteotomy, which was proposed by Sjöström et al. (1), does not guarantee fusion of the anconeal physis (2, 3). For the last 15 years, we have preferred internal fixation of the UAP, provided there is no or only minimal arthrosis (4). A caudolateral approach offers good visualization, with the patient in dorsal recumbency. In dogs less than 6 months of age with minimal instability, fixation using two wires is often sufficient. In older animals, and in cases with moderate to severe instability, a screw is used in place of the second wire. Anconeal osteosynthesis should always be combined with ulnar osteotomy (5, 6). In bassett hounds and dachshunds, distal ulnar osteotomy is recommended, because proximal ulnar osteotomy carries a high risk of pseudoarthrosis in chondrodystrophic breeds. In dogs with long legs, the latter is recommended for better correction of joint incongruity. However, proximal ulnar osteotomy is associated with a higher morbidity.

Thirteen out of 20 dogs that had internal fixation of an UAP were re-examined clinically and radiographically 1 to 6.5 (mean=2.5) years post-operatively. There was no lameness in 9 patients and no arthrosis in 4. Telephone inquiries revealed that 16 of 20 owners were satisfied with the outcome of surgery (7). Anconeal osteosynthesis produces the best results in dogs less than 6 months of age.

References

Dynamic ulna osteotomies in treating canine elbow dysplasia

Aldo Vezzoni

Introduction

Elbow dysplasia (ED) is a well recognised developmental orthopaedic disease affecting growing dogs of several large to giant breeds. Common aspect of this condition is a progressive degenerative joint disease causing forelimb lameness. As asynchronous growth of radius and ulna has been described as one of the main causes of ED,[16,26,27] different types of ulna osteotomy has been proposed to restore joint congruity during the remaining growth time.[11,13,14,15,16,20,22,23] This paper is a review of the published experiences about dynamic ulna osteotomies in treating canine elbow dysplasia.

Pathogenesis of Elbow Dysplasia

Three pathologic conditions are included as causes of elbow dysplasia: ununited anconeal process (UAP), fragmented coronoid process (FCP) and osteocondritis dissecans (OCD) of the medial ridge of the humeral condyle.[10] Several authors believe that all three conditions are manifestations of osteochondrosis (OC).[16,26,27] The pathogenesis of OC is considered multifactorial, with a combination of generic and local factors being involved. OC occurs as a result of abnormal endochondral ossification. Olsson[16] stated that slight joint incongruity caused by disproportional growth of the radius and ulna is probably the most important reason for the occurrence of OC lesions in the elbow joint. Wind[26,27] suggested that joint incongruity was a common denominator in all forms of elbow OC and that this incongruity was due to an abnormality of the ulnar trochlea notch, creating major contact points in the area of the anconeal and coronoid processes. In UAP there is an increased growth of the radius relative to the ulna, which causes proximal displacement of the radius head and subsequent abnormal pressure on the anconeal process by the humeral trochlea preventing the bony union of its ossification centre.[16,19,25,26] In the FCP there is a delayed growth of the radius relative to the ulna, which causes a step between the coronoid processes of ulna and the radial head, which resultant increased weight bearing by the humeral condyle on the medial coronoid.[16,19,21,26,27]

Elbow Incongruity (EI)

EI is widely accepted as a common aspect of the different conditions leading to elbow dysplasia.[16,23,24,26,27] A step in the elbow joint causes an uneven load distribution, with a stress concentration on the anconeal process when the radius is too long and on the medial coronoid process when the radius is too short.[16,21,26,27]
As radius is the main weight bearing bone in the forearm, ulna is usually selected for corrective osteotomies. Dynamic proximal ulnar osteotomy described by Gilson for the treatment of humeroulnar subluxation has been used to restore joint congruity both in UAP and FCP. Dynamic distal ulnar osteotomies has been proposed in treating moderate joint incongruity both in UAP and FCP.

**Duo in UAP**

DUO for treatment of UAP was described by several authors; osteotomy of proximal ulna has been demonstrated to restore a better joint congruity and to relieve the pressure on the anconeal process enough to allow the process itself to unite with the ulna. Osteotomy of distal ulna was shown to be effective in protecting a screw fixation of the anconeal process when the joint incongruity was no more evident at time of surgery.

**How it works**

Osteotomy of ulna in UAP is a lengthening osteotomy, because in this condition ulna is shorter than radius. After ulna osteotomy the action of the triceps brachii muscle allows lengthening of the proximal ulna and a reduction in the pressure exerted on the anconeal process by the humerus. It improves joint congruity allowing a physiologic adaptation of the articular surfaces.

**UAP Treatment:**

- **Conservative**
  
  Conservative treatment includes weight control, limited exercise and NSAIDs. Degenerative joint disease (DJD) is usually progressive and causes severe reduction of the joint range of motion, crepitation and pain on extension of the elbow.

- **Removal of the AP**
  
  The removal of the loose anconeal process has been described in the past as the main treatment of UAP. This treatment has been shown not to reduce significantly the DJD; the instability of the humeroulnar joint, resulting in abnormal wearing of articular surfaces, is not affected by this treatment.

- **Fixation of the AP**
  
  Screws and pins fixation of the anconeal process to the proximal ulna has been described. Implant failure was a common finding when marked joint incongruity was exerting cycling forces on the fixed anconeal process.

- **Duo only**
  
  Dynamic and lengthening ulnar osteotomy has been described to allow the anconeal process to unite spontaneously to the ulna in a varying percentage. The success rate was related to early treatment (5-7 months in large breed dogs and 6-9 months in giant breed dogs) and to a remaining strong fibrocartilaginous connection of the process to ulna. Varying angulations of the osteotomy line has been described. Transverse osteotomy is the simplest one, being possible to be performed with a Gigli saw too. O wing to the small osteotomy surface, the instability of the transverse osteotomy is marked, resulting in a higher mobility for the patient. It could result in delayed bone union and in an excessive inclination of the proximal ulnar segment on the pull of the triceps brachii muscle. Inclined osteotomy, with a proximal to distal direction, needs to be performed with an oscillating saw. O wing to the larger osteotomy surface, the instability of the oblique osteotomy is reduced, resulting in lesser morbidity for the patient. Bone union is faster and excessive inclination of the proximal ulnar segment is inhibited by the bone contact of the fragments. A small size intramedullary pin is placed proximally by some authors to provide limited stabilisation. Usually no fixation is applied, to allow a spontaneous anatomic realignment of the proximal ulna in the elbow joint. While fixation of the osteotomy might speed recovery and reduce callus formation, there is a risk that the fragment would be fixed in an inappropriate position. A light bandage to protect soft tissues is kept for ten days. Before performing Duo, joint inspection, through arthroscopy or arthrotomy, to ascertain the still firm connection of the anconeal process to ulna, has been shown to increase the prognosis of the anconeal process bony union. When the treatment is successful, anconeal process unites with ulna radiographically in 7-12 weeks. Complete healing of the
Osteotomy takes several months for remodeling of the hypertrophic callus. DUO, even without achieving the anconeal bony union, was shown to result in much improved function, due to the resulting better joint congruity.\textsuperscript{12,23}

- **DUO and fixation of the AP**

Combining both DUO and lag screw fixation has been shown to increase the possibility of bony union of the anconeal process.\textsuperscript{12,23}

Fusion of the process can be achieved even when it is no more firmly connected. Bone healing can be enhanced by curettage of the fibrous tissue in the fracture gap and by filling it with cancellous bone graft. Internal fixation of the anconeal process is performed through a caudo-lateral approach, using an aiming device to drill the screw hole from the caudal ulnar cortex to the tip of the process. One or two cortical 2.7 screws in lag fashion or one 4.0 partially threaded cancellous screw are inserted. In the latter case it is usually necessary to remove some of the proximal threads from the screw that would be engaged in the proximal ulna inhibiting the lag effect. In a study by Meyer-Lindenberg\textsuperscript{13} proximal DUO in association with screw fixation was performed every time joint incongruity was radiographically and surgically evident, otherwise a middle or distal ulnar osteotomy was made. In my study\textsuperscript{23} a proximal ulnar osteotomy was always performed when the anconeal process was fixed with a screw.

Fixation of a completely loose process is unlikely to be successful and failure of implants would be anticipated, both because of the bone reabsorption of the process and because of the remodelling of the trochlear notch which causes abnormal cycling load on the process by the humeral condyle.\textsuperscript{23}

**DUO in FCP**

- **How it works**

Osteotomy of ulna in FCP is a sliding osteotomy. Proximal osteotomy allows caudo-medial rotation of the proximal ulna, estimated to be 10 to 15° caudally and 0 to 5° medially.\textsuperscript{15} According to the reported studies, it is not necessary to remove an ulnar segment to get the proper realignment in the elbow joint.\textsuperscript{1,2,14,15} The reposition of the proximal ulna in an anatomic configuration in the elbow joint relieves the abnormal humeroulnar joint contact at the medial coronoid ridge. At the same time more normal humeroradial weightbearing in the elbow is restored.\textsuperscript{15}

Distal ulnar osteotomy, with removal of 5 to 7 mm of bone, is a sliding osteotomy which allows the weightbearing forces to stretch the interosseous ligament and the proximal ulna to slide distally until a full humeroradial contact is restored and the pressure on the medial coronoid process is relieved.\textsuperscript{11}

- **FCP Treatment**

- **Conservative**

Conservative treatment includes weight control, limited exercise and NSAD. It is indicated when the clinical signs are mild and responsive to this treatment.
Removal of the FCP

Removal of the fragmented coronoid process is a common procedure, performed either with a limited medial arthrotomy or with arthroscopy. Even after a complete removal of the loose fragments, if joint incongruity is still present, the uneven weightbearing loading in the joint causes permanent pain and lameness, limiting the results of this treatment.11,14,15

D U O and removal of FCP

The association of both procedures has been shown to increase the functional and radiographic results in treating FCP.1,2,11,14,15 After removal of the loose coronoid fragments, proximal or distal ulnar osteotomy is made. Proximal ulnar osteotomy can be performed transversely or obliquely. A transverse osteotomy is made using an oscillating saw or a Gigli saw, approximately 2.5 cm distal to the level of the humeroulnar joint, after periosteal elevation.11,14,15 An oblique proximal osteotomy is made using an oscillating saw, with a distal to proximal direction.21 Distal ulnar osteotomy was performed in young still growing dogs, where secondary joint changes inhibiting anatomic readaptation were not yet established.11,23 It was performed subperiosteally 2 to 3 cm proximal to the distal ulnar physis line, removing a bone segment 5 to 7 mm wide. In young dogs distal ulnar osteotomy is easily performed with a bone rongeur, biting the bone piece by piece. It might be made with an oscillating saw too, but the risk of injuring the interosseous vein and/or artery is higher. Distal ulnar osteotomy has a very low morbidity and the weightbearing on the operated leg is encouraged soon after surgery to promote the downward sliding of the proximal ulna before callus formation. Complete bony fusion of the distal ulnar osteotomy take place after several months.

D U O only

In very young dogs (5 to 7 months old), showing elbow lameness caused by incongruity with short radius and overload of the coronoid process, distal sliding ulnar osteotomy as a sole procedure was performed, to promote a spontaneous anatomical joint congruity.21 In this preliminary study, the early restoration of joint congruity was enough to stop the stress on the medial coronoid process. In few cases, where it was indicated, it was performed simultaneously in both arms. Further wider studies are necessary to find the right time and the right indications for this procedure.

Conclusions

Dynamic ulnar osteotomies are keeping a place in the treatment of elbow dysplasia, demonstrating the role of joint incongruity in the pathogenesis of this condition. Published studies offer good indications and results both to treat UAP and FCP.

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Treatment of FCP: the Belgian experience

H. van Bree, B. van Ryssen, I. Gielen

During the last ten years, the treatment of fragmented coronoid process has been performed arthroscopically at our department. After a clinical, radiographic and CT examination, a diagnostic arthroscopy of both elbows is performed. If a fragmented coronoid process is diagnosed, it is removed arthroscopically. In most bilateral cases, both elbows are treated during the same anaesthesia. Until now, we have not been treating concomitant incongruency.

A follow-up study of a limited number of dogs reflects our results. One hundred and fifty-three dogs (191 joints treated for FCP) were available for a telephone questionnaire. A clinical and radiographic re-examination was possible in 112 joints 3 months to 3 years after the arthroscopic treatment. Most dogs (89%) recovered within a few weeks to a few months. Fifty-eight % was completely free of lameness, 28 % showed an intermittent, mild lameness. Seven percent was frequently lame or showed an occasional severe lameness. Fifty percent was permanently lame. Ninety-two percent of the owners were satisfied with the final result. No postoperative complications were recorded. On clinical examination a clear distension was found in 74 % (moderate distension in 48 %; severe in 35 %). The flexibility of the joints was reduced in one third of the treated joints. Radiographic arthrosis had progressed in 82%. In this study, different parameters were found to influence the result after arthroscopic treatment. Positive factors were: a young age at treatment, a short duration of lameness, absence of pre-existing arthrosis, and limited coronoid and kissing lesions found on arthroscopy. The presence of incongruency did not seem to have a clear influence on the results. Further studies on this subject are now being performed at our department.

Our conclusion is that the arthroscopic treatment of FCP offers a valuable alternative to arthrotomy. Arthroscopy provides an early and accurate diagnosis and the possibility to combine the diagnosis with a minimally invasive treatment. Long term results are at least as good as those of other reported treatment methods.

Literature

Elbow dysplasia: arthroscopic treatment: the french experience

J-F. Bardet

Elbow dysplasia describes four developmental abnormalities that lead to degenerative joint disease of the elbow joint: ununited anconeal process (UAP), fragmented medial coronoid process (FCP), osteochondritis dissecans (OCD); and incongruity (IC). A common etiology for elbow dysplasia has been proposed with an abnormal development of the trochlear notch of the ulna. Several treatments have been used: conservative, surgical removal or arthroscopic treatment. Controversy still exists concerning the best treatment. The goal of this conference is to review the results of arthroscopic treatment of patients with FCP.

The author will review the results of arthroscopic treatment of 250 FCP between March 1st 1995 and March 1st 2000. Four breeds: Labradors, German Shepherds, Bernese Mountain and Rottweiler represent 90% of the case. The mean age was 1 year and 9 months (youngest: 5 months, oldest: 5 years). The mean follow-up was 12 months (mini: 5 weeks - maxi: 15 years).

The clinical outcome was excellent and good in 93%, and fair in 7%. The postoperative radiographic follow-up shows 2 groups of patients. The first group has no elbow dysplasia, no humeroradioulnar subluxation; these patients have minimal osteoarthritis following the arthroscopic removal of FCP and excellent clinical outcome. The second group is associated with obvious elbow dysplasia; the evolution of osteoarthritis appears to be related to the importance of dysplasia.
Treatment of the ununited anconeal process under arthroscopy in dogs

J-F. Bardet

The results of treatment of 30 ununited anconeal processes (UAP) under arthroscopy were reviewed between September 1st 1991 and September 1st 1999. The technique of arthroscopy uses both of a medial and caudal portals. The mean following was 2 years and 5 months (minimum 10 weeks - maximum 8 years). UAP were classified in 3 types. The medial coronoid process was abnormal in 22 patients (73%). OCD lesions of the medial humeral condyle was observed in 2 patients as well as a fragmentation of the lateral coronoid process. There was a ventral subluxation of the lateral coronoid process in 10 elbows (33%). Classification of UAP in 3 types was useful in choosing the appropriate treatment. The medial compartment was explored in every patient with excision of the fragmented medial and lateral coronoid processes. The OCD lesions were excised. The UAP process was either removed under arthroscopy or fixed using a lag screw under arthroscopic visualization.

A proximal dynamic ulnar osteotomy was performed in 20 patients. Clinical results was excellent in 25 elbows (83%), good in 4 (14%) and fair in 1 patient (3%).

Our study shows that in spite of UAP removal the evolution of osteoarthritis may be minimal. However untreated associated lesions and residual incongruency appears as a major contributing factor in the evolution of osteoarthritis. The clinical results of treatment of UAP under arthroscopy appears to be superior to the surgical conventional treatment.
Non-surgical treatment of elbow dysplasia

H.A.W. Hazewinkel, L.F.H. Theyse, B.P. Meij

In an aselective chosen cohort of Bernese Mountain Dogs, 28.2% were free of elbow dysplasia (ED), bilaterally, 54.3% had ED bilaterally, and 17.4% had unilateral ED. Of all elbow joints (n=184) 113 had ED, among which 104 had osteoarthrosis (OA) (92%). Non of these dogs were treated surgically before the investigation. OA without ED was seen in 13.3%. Incongruity (INC) was seen more frequently than fragmented coronoid process (FCP) (54.3 and 50.5%, respectively), but in 80.4% INC and FCP occurred together. When INC and FCP were present together, it was seen in 100% together with OA, whereas INC alone was found with OA in 66%. Lameness occurred more frequently when bilateral FCP + INC was diagnosed than with FCP, INC, or unilateral FCP + INC (76.5 vs < 50%). Only at OA grade III were significantly more dogs lame than not. In conclusion, not all dogs with elbow dysplasia (ED) are lame or seen lame by the owner. In case OA develops with its cause present, the chances increase that dogs will be lame.

A follow-up study in 87 Retrievers with a fragmented coronoid process (FCP), with a mean follow-up time of 2.7 (± 2.1) years, revealed that 33% of the non-surgically-treated dogs were not lame, compared with 73% of the surgically-treated dogs. The success rate was higher in dogs operated before the age of 24 months (78%), than in dogs that were older (60%) (a). To assess lameness in dogs with a FCP, force plate analysis (FPA) was used to measure mechanical forces in three directions (i.e., vertical, medio-lateral, and cranio-caudal) (b). This revealed that the cranio-caudal force gives good insight into lameness due to FCP. After surgery according to the technique described previously (c) significant improvement was seen 6 months later. Locomotion improved although the OA score (according to the International Elbow Working Group-I EW G) increased considerably. This led us to conclude that surgery has a better outcome than conservative treatment, irrespective of the continuation of the development of OA. A double-blind efficacy study was performed in a group of dogs which were lame due to OA originating from elbow dysplasia, by feeding a standard food for 6 weeks (i.e., the wash-out period) followed by the feeding of one experimental foods that differed only in their 3 and 6 fatty acid content, for 12 weeks. It was hypothesized that a higher ratio of 3:6 fatty acids (1:5 vs 1:50) influences the synthesis of mediators of inflammation in the affected elbow joints. Although there was a significant difference in plasma concentration of leukotriene B4 (LTB4) at the end of the 12-week period, no differences between groups could be found with FPA. The possible consequence of a too severe stage of OA in these dogs, and possibly a better effect if the diet is used as a preventative of OA development, was discussed (d).

A double-blind efficacy study was performed in another group of dogs which were lame due to OA originating from elbow dysplasia. Soft laser irradiation of the affected elbow was performed on 5 consecutive days with FPA before and 30 min after the first as well as after the 5th (double blind) treatment with either 0.5 (treatment group) or 0 (placebo group) Joule per cm². In addition, the owners were interviewed about the subjective clinical effect of the therapy. Most owners of dogs of both groups were positive about the treatment, however no statistical significant change in locomotion could be demonstrated by FPA at the three measure points in both groups (e). This led us to the conclusion that this physical technique used in the described mode was not effective in the treatment of OA in dogs. From these studies it can be concluded that an early diagnosis and surgical treatment has the best outcome for an undisturbed locomotion in later life, with no significant correlation between the OA score and the degree of lameness. When OA of the elbow causes lameness, treatment with soft laser is not effective. In these cases dietary intake of an increased ratio of 3:6 fatty acids for a longer period than three months might lead to clinical improvement of locomotion.

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Large Animal
Anatomy of the equine and bovine stifle joint

J.M. Denoix

In large animals, the anatomy of the stifle is more complex than in small species.

Femoropatellar joint
The femoropatellar joint is a modified trochlear joint in the horse and cow. The femoral trochlea presents 2 very asymmetric ridges. The medial ridge is thick and allows support of the patella over its tuberculum (presenting a high loading proximal surface) and free sliding of the patella during flexion and extension movements of the joint (high motion distal surface). The lateral ridge is sharp and sustains most of the pressure of the patella during propulsion when the joint is in a semi-flexed position. There are 3 patellar ligaments which insert on the tibial tuberosity. The medial one (M PL) inserts on the patella via a thick parapatellar fibrocartilage allowing locking of the patella. The lateral patellar ligament (LPL) receives the distal insertion of the gluteofemoral muscle.

The synovial cavity of the joint is wide and contains a large suprapatellar recess, a lateral recess, caudal to the LPL, and a medial recess, caudal to the M PL. Distally, it is separated from the patellar ligaments by a thick infrapatellar fat pad. The femoropatellar joint is specialized to provide static support of the body weight with minimal active muscle contribution thanks to the locking mechanism of the patella over the tuberculum of the femoral trochlea. In order to be positioned over this structure, the patella undergoes a proximal displacement coupled with a medial rotation. When the patella is in this position, the intermediate and medial PL prevent flexion of the stifle and passive support of the animal’s weight is provided. During locomotion, free movements of flexion and extension of the stifle require a lateral rotation of the patella which is caused by the gluteofemoral muscle.

Femorotibial joint
The femorotibial joint is a bicondylar joint specialized in flexion and extension movements and allowing a small amount of rotation and abduction/adduction movements (especially when the joint is flexed). The opposing femoral and tibial condylar surfaces are incompletely separated by 2 thick menisci. These structures provide some craniocaudal and lateromedial congruence and stability to the joint as well as proximodistal shock absorption. Both the lateral (LM) and medial (MM) menisci are inserted in the cranial intercondylar area of the tibia. The caudal attachment of the MM inserts in the caudal intercondylar area of the tibia whereas the LM presents 2 attachments: one thin and short on the caudal border of the tibial plateau and one strong and long (meniscofemoral ligament) which inserts proximomedially over the intercondylar crest of the femur. During flexion both menisci slide caudally; they slide cranially during extension. The medial collateral ligament (M CL) adheres to the MM whereas the lateral collateral ligament (M CL) adheres to the M M whereas the lateral collateral ligament is separated from the LM by the proximal tendon of the popliteus muscle. The cranial cruciate ligament is stronger and shorter than the caudal cruciate ligament in the equine and bovine species. The medial femorotibial joint present a large medial femoromeniscal recess between the M PL and M CL and a smaller meniscotibial recess. The lateral femorotibial joint present a long subextensorius recess and a short subpopliteus recess.
Diagnosis and management of meniscal injuries in the horse

J.P. Walmsley

Stifle injuries are an important cause of hindlimb lameness. It is often impossible to diagnose the site of lameness from the clinical examination without further tests such as diagnostic analgesia, radiography, scintigraphy and ultrasonography. Once the stifle is shown to be the affected region, it may still be very difficult to ascertain the exact injury. A systematic approach is required and this should commence with the taking of a careful history followed by a detailed clinical examination which includes trotting up, lunging and flexion tests before resorting to further diagnostic procedures.

Meniscal injuries do not show pathognomonic clinical signs and cannot at first be differentiated from most other soft tissue trauma in the stifle. Forty meniscal tears in 38 horses were diagnosed at arthroscopy at the Liphook Equine Hospital out of 226 horses arthroscoped for proven stifle lameness. Of these 38 horses, lameness was acute in onset in 80% and was often temporarily severe, but the mean grade of lameness in the horses at presentation was 3/10 and the duration of lameness of these was a median of 2 months. On physical examination 66% of the affected horses showed distension of either or both the femoropatellar and the medial femorotibial compartments of the joint. No consistent characteristic gait was observed. Flexion tests are usually positive (88% in the series) and many horses dislike abduction of the affected limb. Diagnostic analgesia of all three compartments of the stifle abolished or significantly improved the lameness in 88% of horses.

Radiographic changes were seen in 24/38 horses, the commonest change being new bone formation on the medial intercondylar eminence of the tibia (17 horses). This was more common for meniscal tears than for cruciate tears where it was seen in 7 of 45 horses diagnosed with cruciate ligament injury at arthroscopy. Advanced cases may show osteoarthritic changes (3) or dystrophic mineralisation of soft tissues (3) within the femorotibial joint. Ultrasonography has been shown to be useful for differential diagnosis but requires experience. Scintigraphy can also be helpful but the results have not yet been analysed for this series. Arthroscopy is the most reliable method of obtaining a definitive diagnosis, but even this technique is limited in the horse by the inaccessibility of the main body of the meniscus.

Rest and anti-inflammatory treatment, followed by controlled exercise should be given to acute cases of stifle injury. If this fails to resolve the lameness an arthroscopy is usually indicated. The exact configuration of meniscal tears in horses is not possible to define if the injury extends beneath the femoral condyle; so tears were graded as: (I) a tear in the cranial ligament leading into the meniscus but without significant separation of the tissues (21 cases); (II) a complete tear of the cranial pole but with the limits of the injury visible arthroscopically (15 cases); (III) a severe tear which extends beneath the femoral condyle and whose limits cannot be seen (4 cases). The meniscal injury was considered to be the primary injury in these cases but other pathology was seen in 35 horses (articular cartilage damage 19, MICET cartilage damage 7, minor cranial cruciate ligament disease 7, disruption of the long digital extensor tendon 5). This excluded fraying of the axial edge of the cranial ligaments of the menisci, which was seen as a finding of unknown significance in 70 of 188 horses whose femorotibial joints were arthroscoped.

Grade I tears were left untreated, though recently an attempt has been made to suture these. Grade II and III tears were debrided as effectively as possible. Postoperatively horses were maintained on controlled exercise for up to 6 months. Long term follow up was obtained on 29 horses. 7/15 horses with grade I tears, 6/10 horses with grade II tears and 0/4 horses with grade III tears were sound. 2/15 grade I, 2/10 grade II and 1/4 grade II horses were capable of light work. Overall 18/29 horses were sound or improved. The outcome of these cases may depend as much on the effect of concurrent damage in the joint as on the healing of the meniscal tear.
Diagnosis and Management of Cruciate Ligament Injuries in the Horse

Gayle W. Trotter

The incidence of isolated cruciate ligament injuries in horses is low. In one recent report, 37/93 (40%) stifle lameness cases were soft tissue injuries, and only 17% of these were cruciate injuries. Many cruciate ligament injuries are associated with concurrent injuries to other stifle region structures. Cruciate ligament injuries in horses are also more difficult to diagnose than in small animals, possibly due to a greater inherent stability of the equine stifle. The cranial cruciate ligament is thought to be maximally loaded during extension, and injuries may be more likely with hyperextension. Inward rotation of the tibia with the stifle flexed may also result in cranial cruciate injury. The horse falling with the limb in either full extension or flexion may precipitate this injury, and injuries seem to be more common in three-day event and jumping horses. Isolated caudal cruciate ligament injuries are very uncommon.

Clinical examination
Most cruciate ligament injuries are associated with acute onset lameness. Lameness is more severe if multiple site injury occurs. Medial femorotibial, and sometimes femoropatellar joint effusion, is often palpable. Drawer type tests rarely confirm instability, but may cause a painful response. Hindlimb flexion is often resented and lameness is usually accentuated. If used, IA anesthesia will improve or sometimes eliminate lameness. The medial collateral ligament should always be checked; generally the more severe the lameness and swelling, the more likely that multiple site stifle trauma has occurred.

Radiography
Fragmentation of the medial (and much less commonly lateral) intercondylar eminence is occasionally present, and bony irregularity is sometimes seen along the proximal tibia cranial to the intercondylar eminences. This bony irregularity does not always have an acute appearance. A stressed PA view can help identify medial collateral ligament laxity. Ultrasonography can help diagnose meniscal injuries, but is less useful for cruciate injuries.

Management
Arthroscopy is most accurate for evaluating cruciate ligament damage, and also evaluating other intraarticular structures. Most cranial cruciate ligament injuries seem to occur in the body and towards the tibial insertion site. Debridement using motorized resectors is recommended for fibrillated ligament, and small intercondylar eminence fragments are removed. Large eminence fragments may also be secured using a screw. Bony irregularity/fragmentation along the tibia may or may not be accessible. Intact cruciate ligament should always be preserved. If medial collateral ligament damage is confirmed, exploratory surgery should perhaps be delayed.

Prognosis
Confirmed partial tears may have a favorable result with prolonged rest, and the role of debridement is debatable. Intercondylar eminence fragment removal and/or repair can also be associated with a favorable outcome if ligament damage is minimal. Success was seen after eminence fragment removal in one case, and improvement was also seen where interfragmentary compression was used. Trauma affecting more than 2 sites is often associated with an unfavorable prognosis. Injury isolated to the cranial cruciate ligament only is very uncommon; one should always check for involvement of other tissues. With the rare caudal cruciate injuries, often many other structures are involved.
Arthroscopy of the Bovine Stifle Joint

Mark Hurtig

Most of us are more familiar with arthroscopic surgery of the equine stifle joint because osteochondrosis and sports injuries are common in horses. In our practice we do recognize internal injuries of the equine stifle in highly competitive sport horses, but cruciate and meniscal injuries are much more common in cattle than horses. This is particularly true in large breed dairy cows and breeding bulls.

The functional anatomy of the bovine stifle is wholly different from the horse and accounts for some of this predisposition to injury. The bovine femorotibial joint is relatively shallow and subject to higher rotational forces than its equine counterpart. The horse's massive periarticular musculature and deeply concave tibial plateau confer exceptional stability to this joint.

In our practice, the most common reason to use arthroscopy in the bovine stifle joint is to confirm suspected cranial cruciate injury. The second most common indication is sepsis with or without subchondral cyst-like lucencies. Unlike the horse, we do not recognize loose osteochondral fragments or flaps as significant problems in cattle.

Arthroscopic approaches to the bovine stifle are relatively uncomplicated. The normal femoropatellar joint has a thin dividing septum in the cranial joint compartment that divides the lateral and medial halves of the joint, but allows communication with the femorotibial joints through the caudal aspect of the joint. This septum may not be present in cattle with an unstable joint; in cattle with a cranial cruciate ligament injury the dividing septum may be torn or absent. These cattle typically have profound joint effusion and haemarthrosis but little debris and fibrin in the joint space. An arthroscope inserted 2 cm proximal to the tibial crest, and 1 cm lateral to or through the lateral patellar ligament, allows the operator to examine the femoropatellar and both femorotibial joints. A second medial portal is recommended for a more complete exploration of the joint, particularly of the medial meniscus and its associated meniscal ligaments.

Cranial cruciate injuries are often easily recognized by careful examination of the intercondylar region. Debridement of loose septal connective tissue and frayed cruciate ligament may be necessary. The success of surgical reconstruction of the cruciate ligaments depends on many factors including chronicity and body weight, but when meniscal injuries are present, they are often so severe that a poor prognosis is warranted. Thus, a thorough examination of the medial meniscus through a medial portal is warranted.

A serious complicating feature of bovine arthroscopy is the capacity of the bovine to produce fibrin in the face of inflammation. We are frequently frustrated by subacute and chronic sepsis of the stifle joint because the joint space becomes compartmentalized and divided into small loculi. An ultrasonographic examination is warranted because if the joint is filled with fibrin, no amount of motorized synovial resection or joint lavage will allow the arthroscopist a complete examination of this joint.

Subchondral cyst-like lesions are sometimes seen in either the femoral condyles, or more commonly, the tibial plateau. We are still not certain if these are osteochondritic or post-septic in origin. When fibrin is not a problem, arthroscopic debridement of the degenerate bone and exuberant synovial fronds is indicated. Though arthroscopic surgery of the bovine stifle is possible, body weight, temperament and chronicity of the lesion are major factors affecting prognosis.
Aetopathogenesis of Fatigue Fracture in Thoroughbred Racehorses

David Nunamaker

An understanding of the etiology, pathomechanics and pathogenesis of bone fatigue failure in the Thoroughbred racehorse would be helpful in determining treatment modalities and training regimens. Generations of veterinarians have been taught that bucked shins were the result of microfractures on the dorsal surface of M d I. These microfractures were thought to be the result of fatigue injuries that occurred when the animal ran at high speed or during short striding while leaving the starting gate. These microfractures were thought to form callus over the injured area and these fractures would heal incorporating callus. The amount of callous (periosteal new bone formation) that formed over the area seemed to be quite variable. Investigations in our laboratory have suggested a different understanding for the aetiology of bucked shins with the pathomechanics suggesting a methodology for decreasing the incidence of this condition. These studies when taken together have been used to form a hypothesis describing the generation of bucked shins. Our present hypothesis is as follows: High strain cyclic fatigue causes decreased bone stiffness in vivo just as it does in vitro. The decreasing stiffness causes the bone to respond by increasing its inertial properties, first using woven or lamellar type bone and later using fiber bone. Lamellar bone can be formed at a rate of 1-2 microns/day. Fiber bone can be formed much faster, so if the stiffness decreases quickly enough the bone changes from the lamellar bone formation to the periosteal type (fiber bone) that we recognize as "pathologic" and call this condition bucked shins. The bone is not pathologic at all and this periosteal new bone formation is probably a normal response to this decrease in bone stiffness. Microfractures may occur in vivo just as they do with in vitro cyclic fatigue, but the periosteal response is related to the change in stiffness not the micro cracks themselves. The more the bone is cycled the more stiffness is lost and the more periosteal new bone is formed. This explains the variable amount of periosteal new bone that is seen radiographically. Therefore the radiographic determination of periosteal new bone formation may be important in determining if any particular animal may continue training. The bone with a lot of periosteal new bone formation is considered to have lost significant stiffness and may need to stop its training and remodel. The bone with little periosteal new bone may be a candidate for continued training with significant modifications.
Aetiopathogenesis of fatigue injuries to tendons

Roger K. Smith

Tendon injuries can arise by intrinsic (strain) or extrinsic (penetrations, lacerations) damage, or by displacement. The most frequently observed injury is the intrinsic or strain injury which predominantly affects the palmar soft tissue structures which support the metacarpophalangeal joint, in particular the superficial digital flexor tendon (SDFT), but also the suspensory ligament (SL) and accessory ligament of the deep digital flexor tendon (ALDDFT).

The superficial digital flexor tendon (SDFT) not only supports the metacarpophalangeal joint but also stores energy for efficient locomotion. The organisation of its matrix imparts elasticity for this function but it also operates close to its functional limits during maximal exercise. The SDFT is preferentially loaded during early weight bearing where strain rates in excess of 200%/second have been recorded. Any slight alteration to its structure can adversely affect these functions – making it more elastic or stronger (which will also make it stiffer) will make it a less efficient energy store. The factors which promote the formation of this highly tuned system are still relatively poorly understood. However, ongoing research is providing valuable new information. At birth, tendon already has a hierarchical arrangement of linearly arranged collagen fibres. These fibres have a pronounced crimp pattern which is responsible for the elasticity in the early phases of extension. However, subsequent mechanical loading and presumably growth factors act on this naïve matrix to initiate growth in the tendon matrix and anisotropy where areas under compression develop cartilage-like matrix. Our studies and others have demonstrated, however, that after skeletal maturity at about 2 years of age, degenerative changes become apparent - focal hypocellularity, collagen fibril degeneration, selective fibril loading by the reduction of crimp, and alterations in the non-collagenous matrix (in particular COMP, Cartilage Oligomeric Matrix Protein) occur primarily within the central core region of the mid-metacarpal segment. This will weaken the tendon matrix and allow the initiation of clinical tendinitis when loading overcomes the resistive strength of the tendon. Factors which increase the peak loading of the SDFT, such as weight of rider and speed of horse, will therefore also act to increase the risk of clinical tendinitis.

Controlled exercise studies have demonstrated that exercise has the effect of accelerating this ageing change and suggest that after skeletal maturity the tendon has limited ability to adapt to stress. Other factors may contribute to this progressive deterioration in the tendon matrix – vascular factors such as hypoxia and reperfusion injury, physical effects such as hyperthermia, and metabolic factors such as the action of proteolytic enzymes.
Nuclear Scintigraphy for the Early Detection of Musculoskeletal Injury

Mark Martinelli

Musculoskeletal injury represents a significant risk associated with the athletic activity of equestrian sports, particularly racing. Recent efforts, however, have centered on early detection of these injuries in the hope of preventing catastrophic breakdown.

There is little doubt that the introduction of nuclear scintigraphy over 20 years ago has revolutionised the detection of bone injury. Nuclear scintigraphy is a metabolic bone imaging modality, which means it relies on the viability of the tissue to produce an image. Because the radioactive compound Tc99m is labelled with the bone-seeking agent methylene diphosphonate, it is capable of highlighting areas of significant bone remodeling such as those associated with radiographically 'silent' stress fractures. It has been reported to be able to detect as little as 10-13 grams of affected bone, whereas radiographs require almost a gram of bone to be affected in order for the defect to be visible. For this reason, nuclear scintigraphy is considered to be a very sensitive imaging modality. Initially, however, critics of the technique challenged its specificity. Although a hotspot could easily be detected, the clinician was dubious as to its meaning. Over the years, as more knowledge has been amassed about scintigraphy, it has become easier to assign clinical significance to certain patterns of increased radiopharmaceutical uptake. This pattern recognition has evolved to the point where the author feels more confident predicting which lesions are likely to lead to complete or catastrophic fracture and which ones are indicative of physiologic or unphysiologic stress remodeling. The author has divided pathologically increased radiopharmaceutical uptake into two general categories.

Strict Bone Remodeling- this category is undoubtedly the reason that scintigraphy is so popular as an imaging modality for horses. The classic example would be a stress fracture in the long bone of a racehorse. Such a lesion may be difficult to detect in the average case, especially when few clinical signs are present after a race. It is not uncommon that a trainer or groom has noticed just a few bad steps after a race and presents the horse for examination solely for that reason. Detection with scintigraphy will often lead to appropriate rest or surgery prior to catastrophic fracture, this saving the horse's career and possibly its life.

A second example of bone remodeling involves the subchondral region associated with joint disease. In this case, catastrophic fracture is unlikely.

Enthesis uptake- although this is a relatively new concept to the equine field, there are several patterns of IRU that appear to be associated with the attachment of soft tissue structures to bone. The most classic example is high suspensory disease, but includes other conditions such as avulsion of the muscles of the third trochanter of the femur and a similar lesion at the site of attachment of the biceps to the radius. Most importantly there appears to be a condition in the foot that mimics navicular disease in its presentation and diagnosis, but seems to be related to the attachment of the deep digital flexor tendon. Of significance in regard to these syndromes is that diagnosing them without scintigraphy would be difficult or impossible. More importantly, however, although most of these conditions would be associated with substantial lameness, none would be likely to lead to catastrophic fracture.

Although notable progress has been made in regard to the differentiation between these conditions based on the appearance and location of the increased radiopharmaceutical uptake, there are still many instances where it is difficult, if not impossible, to distinguish between a benign lesion causing soreness and one that may lead to a more serious injury. However, the information gained via the scintigraphic examination, especially in certain environments such as at the racetrack itself, has led to a decrease in wastage among these equine athletes (Dr. R. Arthur, Santa Anita Racetrack, personal communication).
Management of Early Diagnosed Fatigue Injuries to the Skeletal System in Racehorses

David Nunamaker

Diagnosis of early fatigue injuries in Racehorses is augmented with the use of nuclear scintigraphy. Hot spots diagnosed throughout the skeleton are warning signs of impending serious injury and the course of the condition can be altered with early diagnosis and treatment. Approximately one half of the horses presented with acute bucked shins can be continued in training. It is necessary to provide rest and analgesics for a short time (5-10 days) before training is continued. Cold water and phenylbutazone along with stall rest should be continued until the animal’s shins are able to be palpated without severe pain. The dorsal surface of the third metacarpal bone will not be free of pain for 4-6 weeks if training is to be continued. The training program that led to the development of these bucked shins must be closely examined. Since fatigue is related to high strain cyclic loading the number of cycles must be decreased. This will usually mean that the daily galloping distance is cut in half. Since bone modeling and remodeling are related to the strain magnitudes and principal directions then short distance high speed work must be maintained. The animals should have short (1/2-2 furlong) works at the end of their gallops twice a week. Speed and distance are introduced slowly with constant monitoring of the animal’s condition. When speed is increased then distance is decreased initially.

The other half of the horses presented with bucked shins may not be suitable for the above training regimen. These horses seem to have decreased bone stiffness sufficiently such that additional training will only exacerbate the condition. Many of these animals will already have large periosteal bone changes on their dorsal cortex at the time of presentation. Radiographs may be helpful in evaluating these cases. Rest will provide time for bone remodeling. The fatigued bone will eventually be replaced by non-cycled secondary osteons. The timing of this cycle is around 110 days.

Bibliography
Management and prevention of superficial digital flexor tendinitis

Roger K.W. Smith

Current management strategies
Over the years many treatment modalities have been tried with most showing equivocal or even deleterious effects. From our knowledge of the phases of tendon healing, the following have at least a rationale for treating tendinitis;

Acute (inflammatory) phase:
Physical therapies (rest, application of cold, and compression with bandaging) is the most important aspect of early management where the goal is to minimise inflammation and limit the action of proteolytic enzymes which continue to destroy tendon tissue. Pharmacological interventions include short-acting steroids within the first 24 hours and the use of polysulphated glycosaminoglycans which have been shown to inhibit proteolytic enzymes in vitro. Surgical treatment at this stage includes percutaneous tendon splitting which has been shown to accelerate the resolution of the ‘core lesion’ seen ultrasonographically. This can be done with a scalpel or less invasively performed with needle puncture when it can be combined with intra-tendinous polysulphated glycosaminoglycan therapy.

Subacute (fibroblastic) phase
Early and progressive mobilisation and regular ultrasonographic monitoring aims to improve the quality of the forming scar tissue, the goal of this stage. If the cross-sectional area of the healing tendon increases by more than 10%, the exercise level should be reduced. The quality of the longitudinal fibre pattern when the animal returns to full work has been linked with the overall prognosis. In an attempt to improve the quality of the scar tissue, beta-aminoproprionitrile fumarate (BAPTEN™) has been injected intra-tendinously 30-90 days after injury. This drug inhibits lysyl oxidase, the enzyme which cross-links collagen molecules. In preventing the formation of cross-links, it is believed that collagen fibres will form with better longitudinal alignment under the stimulus of controlled exercise. When the drug wears off, cross-linking occurs and the scar increases in strength. Clinical trials in the USA indicated a benefit in the more severe cases. A series of racehorses treated with BAPTEN in the UK (Marr) gave the following outcome:

<table>
<thead>
<tr>
<th>Horse type</th>
<th>Total no. treated</th>
<th>Ran 5x or more</th>
<th>Ran&lt;5x</th>
<th>Did not race</th>
<th>Convalescing</th>
<th>Lost to follow-up</th>
<th>Reinjured</th>
</tr>
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<tbody>
<tr>
<td>Flat</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Jump</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>2</td>
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</tbody>
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Other drugs, such as sodium hyaluronate, have been used both intratendinously and peritendinously but studies have shown equivocal results. Some benefit in reducing adhesion formation in intra-sheath tendon injuries has been demonstrated experimentally.

Chronic (remodelling) phase:
A controlled ascending exercise regimen with regular ultrasonographic examinations to detect signs of re-injury early on provides the optimum management in chronic tendinitis.

Prevention:
Because repair occurs rather than regeneration, prevention must still be considered superior to treatment. Desmotomy of the accessory ligament of the SDFT, often performed concurrently with percutaneous tendon splitting early on in the disease process, is suggested to reduce peak strains on the SDFT by bringing the superficial digital flexor muscle into play. However, although initial data suggested a beneficial effect, this has not been confirmed in other studies and has been suggested to contribute to a higher incidence of suspensory desmitis after its use.

Our recent research has indicated other strategies for the prevention of tendinitis. In this research, tendons
were examined from Thoroughbreds, Dutch Warmblood foals, working horses and also a group of wild horses to evaluate effects of age, function and exercise. Gross mechanical properties did not differ significantly with age or exercise, but showed a high variance within each group. Mechanical properties of tendon tissue did show significant differences as a function of age and location. The collagen fibril crimp angle and length showed a regional reduction in the central core with exercise and age, with a synergistic effect. In the matrix, regional differences in collagen fibril diameter were seen in long-term exercised older horses, but not in short-term exercised, or younger, horses. The higher proportion of small fibrils in the central region of the long-term exercised horses did not correlate with new collagen formation and thus appears to result from disassembly of the larger diameter fibrils. Fibril diameter distributions were influenced by exercise regimens in the growing foal. Changes in molecular composition occurred in longer-term exercise and older horses, in the centre of the tendon, with higher levels of type III collagen and changes in GAG content. Cartilage Oligomeric Matrix Protein (COMP) levels were low in the neonate, increased in response to loading until they peaked at 2 years of age in the midmetacarpal region of the SDFT. Levels subsequently declined and this loss was accelerated by exercise. Other studies have demonstrated gene activity in the metacarpal region of bovine tendons in young, growing animals, but no gene activity in these areas in the adult. Our studies have shown high expression of growth factors, especially TGF-β, in young equine tendon, but with declining amounts after skeletal maturity. Cells recovered from both young and old tendons show similar responses to growth factors in vitro. These studies have led us to suggest a hypothesis that the midmetacarpal region of the equine SDFT can adapt to exercise during skeletal development but has poor or no ability to do so after skeletal maturity, possibly due to the absence of growth factors. Exercise accelerates the ageing effect of cumulative degeneration. From this work, four strategies for the prevention of tendinitis in the horse can be deduced:

1. Maximise the quality of tendon prior to skeletal maturity with the early introduction of exercise or improved genetic determinants
2. Reactivate resident cell populations to repair/remodel fatigue microtrauma using growth factors
3. Prevent the cumulative microdamage in adult tendon by addressing the processes involved
4. Improve early detection using more sensitive ultrasonography or serological markers.
Novel Training Strategies for Preventing Fatigue Failure in Racehorses

David Nunamaker

If our hypothesis of high strain cyclic fatigue causing decreased bone stiffness is true then prevention of this condition should be possible and desirable. Almost all of the horses that develop metacarpal stress fractures (saucer fractures) bucked their shins earlier in their career. True incidence figures are not available but only approximately 12% of the horses that buck their shins may go on to develop these saucer fractures. If one could decrease the incidence of bucked shins then one would in turn decrease the incidence of these fractures as well.

Revised training regimes are designed to decrease the number of high strain cycles while at the same time introducing the bone to the environment in which it must survive. This is accomplished by changing the classical training programs that gradually increase the exercise of a horse to 2 mile/day gallops with breezes every 7-10-14 days. Classically these high speed works are gradually increased so the animals are breezing the distance of their race, with 1/2 mile or more works being common. The revised training program is aimed at decreasing the distance galloped usually to 1 mile. Slow speed jogging for conditioning is detrimental to the bone because the principal strain directions in the bone are rotated up to 40 degrees from the fast working gait. Short higher speed works are included two times a week at the end of the gallops, with the distances slowly increasing from a furlong to 1/2 mile. Every time the speed is increased the distance is decreased so the cycle repeats itself. Using these ideas for training will allow the bone to model its shape to resist the large loads of high speed racing without sudden decreases in its stiffness.

Recent prospective and retrospective studies in 226 Thoroughbred racehorses have shown the statistical evaluation of such training programs and the risks and rewards of galloping and breezing horses in training.
Joint resurfacing in the horse - A practical proposition?

Mark Hurtig

The answer to this question is a qualified "yes". The "here and now" technology is mosaic arthroplasty using autogenous osteochondral grafts. Under arthroscopic control, a hollow harvesting chisel is used to remove cylinders of bone and cartilage from a "less important" donor site such as the trochlear ridges of the femur. After the cartilage erosion is lightly debrided, a calibrated drill guide and delivery tamp system is used to transfer the graft to the articular defect. While there are many scientific questions about the heterotopic transfer of osteochondral grafts, donor site morbidity and the use of allografts, human surgeons have successfully used these techniques to restore people to an active lifestyle. Is this practical in the horse?

We are encouraged by our recent success in experimental mosaic arthroplasty of the equine third carpal bone and are exploring the use of allografts in the lateral trochlear ridge of the horse. In our Veterinary Teaching Hospital, we have operated 6 horses with this technique including four yearlings with osteochondritis dissecans that comprised nearly the entire lateral trochlear ridge. Conventional debridement was not an option because patellar luxation was imminent. We elected to use several 6.5 or 4.5 mm diameter osteochondral grafts to restore the articular surface and subchondral attachment of these large flap-like lesions. In two other cases adult horses were treated. A Standardbred racehorse with a chronic subchondral cyst of the fetlock joint received a single 8.5mm graft and a traumatic medial femoral condylar defect in a Warmblood jumper was treated with several 6.5 mm grafts. Our results have been good to excellent in all but one of these cases. Gabor Bodo, (the veterinary collaborator of Lazlo Hangody the father of mosaic arthroplasty) has successfully treated one horse with a subchondral cyst of the medial femoral condyle. This is a more difficult undertaking because the subchondral bone is often very abnormal and unlikely to serve as a satisfactory bed for grafts. In my opinion, mosaic arthroplasty has a role in treatment of carefully selected equine patients where the lesion is accessible, small and not accompanied by degenerative arthritis.

Cell-based technologies using chondrocytes in a fibrin matrix have been relatively successful in an experimental horse model and in managing subchondral cysts of the medial femoral condyle. While mosaic arthroplasty relies on a straight line arthroscopic approach perpendicular to the joint surface, Dr. Nixon’s application can be used anywhere the fibrin-cell suspension can be injected. This is a great logistic advantage. The disadvantages may be that the resulting tissue is very fragile and poorly attached, and long-term studies on directly weight bearing joint surfaces such as the fetlock or carpus have not been done.

Tissue engineering is a term applied to the manipulation of cells in an artificial matrix to produce a functional tissue. We have successfully produced cartilaginous equine tissue in vitro that appears promising but clinical studies have not been done.

In summary, promising joint resurfacing methods are available and in development. In selected cases, osteochondral grafts may be successful. One resurfacing technique will not work for all types of lesions, and so, as we develop new methods we will be able to address more of the clinically important lesions in the horse.

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1 The OATS system by Arthrex and the MosaicPlasty system by Smith+Nephew are commercially available, though both systems require modification for use in the horse.
3 Repair of damaged joint surfaces using fresh osteochondral allografts in the horse: An integrated experimental and clinical trial using arthroscopic surgery. In progress.
4 Personal communication October 1999
Micropicking – Technique of the Future?
Gayle W. Trotter

Articular cartilage has limited capacity for self-healing, and numerous methods have been tried to enhance healing. Repair tissue that forms usually contains type I vs type II collagen, and is more fibrous to fibrocartilaginous in nature. Reestablishment of the subchondral bone plate and a tidemark is uncommon, likely rendering the repair tissue mechanically inferior. If cartilage defects are large, or located in certain intraarticular locations, eventual progression to further joint deterioration is common. The lack of durability of repair tissue may relate to inferior biochemical characteristics, or to incongruity of the new repair tissue/bone interface and biomechanical incompatibility. The ultimate osteoarthritic deterioration is often debilitating.

There are limitations associated with all of the techniques that have been used to improve cartilage healing. In an attempt to improve healing of full-thickness cartilage defects in the human knee, a human orthopaedic surgeon (Dr. Richard Steadman) developed a technique he called micropicking (or microfracture). His goal was to preserve the subchondral plate, but concurrently gain access to undifferentiated mesenchymal stem cells and growth factors from the cancellous spaces. The roughness created by the micropick technique was also thought to provide a rough surface for improved early blood clot and ultimately tissue attachment. By using an orthopaedic awl without drilling, thermal necrosis would also not be a factor. Combining this technique with continuous passive motion in human knee patients, he observed improvements in pain scores out to 3 years after surgery. He also noted improvements in daily living activities, and in strenuous work and strenuous sport activities.

The technique is very simple. Once the defect is debrided, an orthopaedic awl is guided into the defect using arthroscopic guidance. Numerous micropick holes are sequentially created by gently tapping the awl until it penetrates into the bone for 2-3 mm. The rough surface created is not disturbed to hopefully enhance attachment of the blood clot that forms within the defect. Awls can be obtained that have different angles at the tip to facilitate micropicking. At CSU, we have been evaluating this technique in experimentally created full thickness defects in the carpus and femorotibial joints of horses. In the first study, a greater volume of repair tissue was seen in treated defects (74%) vs control defects (45%) at both 4 months and 12 months, but the histologic features were not different. There was also more type II collagen in the treated defects as determined by HPLC. In a second similar study using molecular biology techniques to evaluate the early events of cartilage healing, gene expression for type II collagen was higher in micropicked defects and the difference was noted at both 6 weeks and 8 weeks after defect creation. Type II collagen was most likely expressed in tissues deep within the defects, and expression was present in tissues from most defects. Expression of aggregan was not different between treated and control defects, and expression was more typically in tissues near the repair surface.

It is likely that enhancements (such as the addition of growth factors) will need to be made to this technique for its full potential to be realized.
Experiences with total joint replacement in the horse

Peter W. Th. Stolk

Degenerative joint disease (DJD) of the metatarsophalangeal (MTP) joint is a frequent cause of lameness in the horse. Although many therapeutic measures exist, the final results following medical or surgical treatment of the more severe cases of DJD of the fetlock joint are often disappointing.

The present study was carried out to investigate the possibility of total MTP joint replacement by a human endoprosthesis. In fourteen healthy adult Dutch Warmblood Horses (mean body weight 540 ± 45 kg) the left MTP joint was replaced by a human 52 mm (LM) cruciate ligament sacrificing Install/Burstein® total knee system (Johnson & Johnson, Raynham, MA, USA). Following surgery a supportive fibreglass cast was applied for six weeks. Two cases were excluded: one horse with a stable joint reconstruction died three days after surgery due to septic colitis and one horse was killed six weeks postoperatively because of severe collateral instability in the operated joint. After removal of the cast of the remaining 12 horses each animal’s exercise was increased to walking in hand on a tarmac surface twice a day for approximately 15 minutes. Each day throughout the experiment the horses received a single low dose of a non-steroid anti-inflammatory drug. During the observation period none of the horses showed any sign of discomfort. Also, during the walking exercises visual inspection invariably showed no marked difference between load bearing of the operated limb and the contralateral limb. In addition, stance times of the operated and contralateral limbs were equal, though hyperextension of the replaced MTP joint at load bearing was reduced in all animals.

To allow macroscopic and histological examination, the animals were euthanized 4 months (2 horses), 6 months (6 horses) and 8 months (4 horses) after MTP joint replacement. Post-mortem macroscopic and histological examination showed that all femoral and tibial compounds of the endoprostheses were firmly anchored into the metatarsal and first phalangeal bones respectively. In each horse the joint capsule with its synovial layer was slightly thickened with no apparent intra-articular granulation tissue. In all cases the articular sides of the sesamoid bones showed loss of cartilage. In the 4 animals that were euthanized 8 months after implantation of the endoprosthesis, additional marked loss of subchondral bone in the sesamoid bones was seen. This was most likely caused by the marked mismatching between the shape of the articular surfaces of the sesamoid bones and that of the femoral components of the human prostheses. This indicates that for future use in the equine species the femoral component of the endoprosthesis should be redesigned to fit precisely the specific shapes of the articular surface of the sesamoid bones. Furthermore, it is tempting to suggest that this mismatching of shapes is (at least partially) responsible for the reduction in hyperextension of the MTP joint following implantation of the endoprosthesis. It is concluded that further investigation into the equine MTP joint replacement by a redesigned endoprosthesis is fully warranted.
Treatment of osteoarthritis with monoiodoacetate

Michael Schramme

Osteoarthritis of the small tarsal joints (spavin) is a common and debilitating cause of lameness in the horse. Surgical arthrodesis attempts to achieve a bony ankylosis and thereby a movement-free and pain-free joint. Chemical arthrodesis of the small tarsal joints, performed by a single intra-articular injection of sodium monoiodoacetic acid (MIA) into the affected joints, may avoid the disadvantages of surgical arthrodesis and still create a satisfactory ankylosis.

MIA is a glycolytic blocking agent that causes chondrocyte death and fibroblastic inflammatory capsulitis. Horses selected for this treatment demonstrated hindlimb lameness which could be significantly improved or abolished by intra-articular anaesthesia of the small tarsal joints. Radiographic evidence of osteoarthritis of the tarsometatarsal and/or distal intertarsal joint was required for selection. Injection of the small tarsal joints was performed under general anaesthesia. Needle placement into the tarsometatarsal and distal intertarsal joints was confirmed with fluoroscopy. Positive contrast fluorography or arthrography was used to confirm the intra-articular placement of the needle and to ensure the absence of anatomical communication with the proximal intertarsal and tibiotarsal joints. Peroneal and tibial nerve blocks with bupivacaine hydrochloride were installed prior to recovery from general anaesthesia. If the spavin was bilateral, the small tarsal joints of the second leg were injected as a separate procedure several days later, when signs of post-injection discomfort in the first limb had resolved. Postoperative management included daily exercise to promote joint collapse and ankylosis throughout the follow-up period. Follow-up information was gained from clinical examination by the authors and radiography at 6 and 12 months after injection. In parallel with the clinical findings owner satisfaction was assessed by questionnaire.

Seventy four legs were injected in 60 horses. Fourteen horses had both hindlimbs injected and 46 horses one limb only. The duration of lameness prior to presentation ranged from 1.5 to 36 months. The lameness grade ranged from 1 to 7 (severity of lameness assessed using a scale of 0 - 10). Needle placement and MIA injection was frequently difficult in joints that demonstrated radiological collapse of the joint space or extensive peri-articular new bone formation.

So far 38 horses have been available for 6 month follow-up and 23 horses for 12 month follow-up examination. At 6 months, 7 of 38 patients were not lame in full work (18%), 16 were lame but improved at least 2 out of 10 lameness grades (42%), 13 horses had not improved (34%), 1 horse became worse and 1 developed a septic arthritis associated with infection of the injection site. At 12 months, 5 of 23 cases were not lame and in full work (22%), 7 horses were lame but improved at least 2 out of 10 lameness grades (30%), 10 horses had not improved (43%), and 1 was more lame than it had been prior to treatment (4%). Overall owner satisfaction was scored as very pleased (29%), pleased (33%) or disappointed (38%). Owner satisfaction (very pleased + pleased = 62%) correlated well with the total number of sound and improved horses at 6 months (60%) and 12 months (52%). Radiological evidence of joint space collapse was present in all cases at 6 and 12 months, evidence of partial joint fusion was present in 81% at 6 months and 92% at 12 months. In view of the radiological evidence of joint fusion in the majority of cases treated, it remains unclear why many horses continued to show persistent long term lameness. Complications of the technique are minimal but extra-articular leakage of MIA must be avoided.
What's New in Medical Management of OA?

Gayle W. Trotter

NSAIDs
NSAIDs mainly act through the inhibition of the cyclooxygenase (COX) enzyme, an enzyme involved proximally in the chain of events leading to the production of prostaglandins. Some NSAIDs are very weak COX inhibitors but they still provide symptomatic relief, suggesting that mechanisms of action other than inhibition of prostaglandin synthesis may also be important. There are 2 forms of COX, constitutive COX 1, and inducible COX 2. COX 1 is involved in many homeostatic physiologic processes, whereas COX 2 is responsible for the elevated prostaglandin levels associated with inflammation. Further work will likely identify selective COX 2 inhibitors that might be of considerable benefit in horses.

Corticosteroids
Corticosteroids remain the most potent anti-inflammatory medications used in the treatment of joint disease but controversy still surrounds potential negative effects on cartilage matrix metabolism. More recent evidence suggests that smaller dosages may actually be associated with chondroprotective properties. Corticosteroids are potent inhibitors of COX 2 (but not COX 1) synthesis. Work done at CSU using an osteochondral fragment/exercise model showed no consistent detrimental effects from betamethasone in either rested or exercised horses. In a similar study using triamcinolone (TA), improved cartilage and synovial membrane parameters in TA treated horses suggested a possible chondroprotective effect. Using MPA, deleterious effects on cartilage were observed. These collective findings suggest that there may be considerable differences in effects between the various suspensions.

Intravenous Hyaluronan
In an experimental study using an osteochondral fragment exercise model and 3 injections of IV hyaluronan (HA), the treatment group had fewer lame horses, better synovial membrane histologic scores, and lower TP and PGE2 fluid scores at the conclusion of the study. The mechanism of action is unknown, but could involve modulation of cellular CD44 (or other) receptors. Clinically HA seems most efficacious in the treatment of early synovitis/capsulitis.

Oral Supplements
Glucosamine is a precursor of the disaccharide subunits of cartilage proteoglycans, and is mostly used in its less expensive HCl salt form. Glucosamine salts are thought to be well absorbed enterally and clinical studies in both man and animals suggest efficacy in certain types of joint disease. Chondroitin sulfate is much less well absorbed, and uncertainty surrounds the efficacy of the absorbed components of the molecules. Nonetheless, efficacy has also been noted in human clinical trials. Limited clinical work in horses also suggests some efficacy, but further definitive work is necessary.

New Approaches Under Investigation
The therapeutic effects of synthetic metalloproteinase (MMP) inhibitors are being evaluated. The effect of inhibiting certain cytokine mediators that upregulate these MMP enzymes (such as Interleukin 1) is also being evaluated. We, as well as others are looking at modulation of IL1 by enhancing the effects of IL1 antagonist protein (IRAP). We are delivering IRAP using a gene therapy approach. The goal is to introduce the antagonist gene and provide more long-term local production of IRAP. Others are evaluating the anabolic agent insulin like growth factor IGF1, which may prove more useful in endogenous repair of cartilage defects rather than in arthritis prevention or treatment.
Management of open wounds

Jacintha M. Wilmink

Traumatic wounds in horses can not always be sutured, because of unmanageable contamination, established infection or excessive tissue loss. Even if sutured, partial or total dehiscence is a common complication. Then, wound healing will be by second-intention. In horses, second-intention healing of lower limb wounds is often complicated, whereas extensive and deep body wounds may heal remarkably well. The process of second-intention healing can be divided into several overlapping phases. A maximal clinical effect will be obtained if conditions for each phase are optimised. Therefore, the clinician should have a profound knowledge of the events occurring during wound healing, the factors that may influence these events and the effects of treatment.

Inflammatory phase/debridement phase

Inflammation is a prerequisite for healing. The use of NSAIDs or corticosteroids is therefore not advisable. It has been proved that factors that increase inflammation, such as certain bandages or ointments, may stimulate healing. Surgical debridement of the wound is advisable, especially in cases of necrosis or frayed tendons.

Formation of granulation tissue

The stimulus for granulation tissue formation is an oxygen gradient and a low pH. Therefore, formation is stimulated by bandages, casts etc. In the horse the formation of granulation tissue is excessively fast, and may often lead to exuberant granulation. Granulation tissue formation should be stimulated only until the wound has filled in.

Contraction

Wound contraction determines the speed of second-intention healing. Healing of body wounds is significantly faster than of limb wounds and healing in ponies is significantly faster than in horses, both because of the greater contribution of wound contraction. Contraction can be delayed by bandaging wounds or by stimulated granulation tissue due to some irritating factor. This stage can be stimulated by leaving the wound unbandaged or by the use of UVC light therapy. Any factors leading to irritation of granulation tissue should be eliminated.

Epithelialization

The main condition for good epithelialization is a regular, healthy granulation tissue bed that does not protrude, and a moist environment. The condition of the granulation tissue can be controlled by trimming and local medication. A moist environment can be provided by semi-occlusive bandages. Skin transplantation may enhance epithelialization dramatically and may act as a new stimulus for wound contraction.

Complications in the granulation tissue phase

In case of infection antibiotics are indicated. Local treatment is more effective than systemic administration. If the granulation tissue is still irritated without clear infection, first bacterial populations on the surface are reduced by the topical application of antibiotics. Then, a short local corticosteroid therapy can suppress the inflammatory response and further improve the condition of the granulation tissue. In case of an irregular surface the wound should be checked for the presence of sequesters, necrotic tendon parts, foreign bodies etc. If there is no cause, grooves can be excised. Excision is the best therapy for exuberant granulation tissue. It is important to interfere as soon as the tissue protrudes, as this protrusion will inhibit epithelial mitoses.
Selection of appropriate wound dressings for open wound management in large animals - What has recent research taught us?

Derek Knottenbelt

In the horse and (to a lesser extent in cattle and sheep) the problems of distal limb wound healing has been well recognised. Formerly dressings were used to restrict expansion of granulation tissue and were often left in situ for considerable periods on the pretext that the wound would heal under almost any restrictive conditions but would probably not if it was left open. Before the 1960’s dressings were considered to be passive products that had no real role in the healing process; all wound dressings were basically the same, being based on woven textile fibres – their primary objective was to cover, contain and conceal the wound. The remarkable healing capacity on the body trunk of horses and the tolerance of crude dressings (such as Stockholm Tar) on limb wounds of cattle and sheep served to delay progress, on the false premise that healing was already optimal! Many wounds healed despite the medical attention rather than because of it. Veterinary wound management remained a dormant science until the late 80’s.

Ideally a wound should heal as fast as possible; this minimises secondary effects and gives the best cosmetic results. Research into the cellular events of healing confirms that wound management in the first 12-24 hours is critical. Factors influencing the delicate balance of growth factors and cell functions will consequently influence healing. Clinical and experimental research confirms that a healthy, moist environment produces the best healing and modern wound dressings deliver a vastly improved physiological environment that in turn results in significant clinical benefit.

Cochrane and co-workers at Liverpool, have shown that most dressings result in bioadhesion of cells to the surface of a dressing. When dressings are changed the delicate healing surface of the wound is almost inevitably damaged (the wet-dry approach is probably the ultimate dressing insult that can be applied). The harmful effect of bioadhesion can be reduced either by leaving the dressings on for longer (assuming the local microenvironment remains healthy) or by selection of a dressing that reduces bioadhesion to a minimum (or preferably to zero!).

Technological advances inevitably result in increased costs and the more frequently a dressing is changed the greater the cost. If frequent changes are specifically required this is economically sound, but where there is no benefit or where changes can be deleterious, the more expensive approach is also potentially the worst option! The development of hydrogels, calcium alginate, synthetic skin substitutes and absorptive, non-adherent dressings means that frequent changes may not be required in many circumstances.

Not all wounds can be dressed due to anatomical restrictions. Conversely there are significant dangers of inappropriate dressings in areas that are amenable to dressing application.

What has current research taught us?

- The management of the wound in the first 12 hours is critical to its subsequent healing.
- A physiologically sympathetic, moist wound healing environment provides the best results.
- The type of dressing used almost inevitably has an influence on healing (whether beneficial or harmful).
- Dressings need to be selected to suit the individual wound and adjusted to the developing needs of the healing process.
- The interval between changes of dressings needs to take account of the specific needs of the wound. Every situation needs to be carefully assessed.
- Even with the best dressing technology available, a wound that is complicated by one of the recognised factors responsible for failure of healing will not heal unless the problem is addressed.

Wound healing has been described as a well-orchestrated sequence of events involving a delicate balance of molecular signals and cellular activities and there has been considerable development in our understanding of the process. In conjunction with an improved understanding of the process itself there has also been an
increased realisation that wound management (of which dressings form an essential part) has a profound influence on healing and repair. The maxim "No two wounds are ever the same" certainly applies to large animals and the corollary to this is that "no single dressing is suitable for all wounds at all times". The range of wounds that large animals (and horses in particular) suffer and the remarkable variation in the healing ability of these wounds makes it difficult to test the benefit of any particular management procedure. Research effort into wound dressings has entertained both clinicians and scientists for many years and the explosion of revolutionary approaches to wounds over the last 15 years is testament to that fact.

The future
The role of bioactive dressings is almost certain to increase as we come to understand more about wound healing and how the processes can be enhanced rather than inhibited. However, the simplistic idea of topical growth factor impregnated dressings is unlikely to be the way forward. The best controller of healing is undoubtedly the natural process and we will probably have to rely heavily on this for the indefinite future. Collagen and cellular skin substitutes seem to be a useful way forward. The problems in the horse in particular are somewhat unique and this requires a special approach that needs special research.
Useful tips for primary wound reconstruction in large animals

Hartmut Gerhards

Horses are frequently exposed to severe traumas, which in many cases result in substantial tissue defects that require surgical reconstruction. With wound reconstruction, a good, or at least an adequate functional and cosmetic rehabilitation should be provided. However, despite many advances in reconstructive surgery, the application of new techniques, such as silicone implants, tissue expansion techniques, and pedicle grafts to clinical large animal cases is limited.

Basic wound reconstruction techniques include tension-relieving procedures, tissue flaps, and skin grafting. Tension-relieving procedures are adjacent tissue undermining and mobilization, tissue debulking, V-to-Y plasty and Z-plasty, mesh skin expansion, skin flaps, and H-flaps. Each of these techniques have specific applications as well as limitations, e.g. the latter in very large wounds.

Free skin grafting techniques can be used to accelerate wound epithelization. The most common grafting techniques include pinch, punch, and tunnel grafts. The initial failure rates are about 30% for all techniques. Pinch and punch grafting can be performed in all body locations, in large open and (hyper-)granulating wounds, that cannot be bandaged, and also close to joints. No special equipment is needed. For these reasons, although epithelization is relatively slow and the cosmetic appearance is often poor after pinch and punch grafting, in the author’s experience, these techniques are preferred to all other grafting techniques in horses. The pinch grafting technique is demonstrated and examples of such wound healings will be demonstrated.
Osteochondral fragments from the medial malleolus in horses: a comparison between radiographic and arthroscopic findings

Fabio Torre

The tibiotarsal joint is considered a predilection site for equine OCD and lesions of the intermediate ridge of the tibia (IRT) represent the most common feature. Other locations include the lateral trochlear ridge of the talus (LTR), the medial malleolus (MM) and the medial trochlear ridge of the talus (MTR). The MM is the third most commonly reported location of tibiotarsal OCD. In the literature, lesions of the MM are minimally represented when compared with IRT, but when methods of investigation are considered, one can support the hypothesis that MM lesions are underrepresented because of absence of specific radiographic views.

Horses affected by MM lesions present with synovial effusion, variable degree of lameness or poor performance, and some lesions can be difficult to characterize radiographically. The purpose of this study was to investigate a group of horses in which lesions of the MM were identified during arthroscopic surgery. The preoperative radiographs of each joint were subsequently compared with arthroscopic findings in order to verify the relationship between the radiographic appearance of the MM and the corresponding arthroscopic appearance.

The study included 62 horses that were examined radiographically and submitted to arthroscopic surgery in which fragmentation of the MM was identified. The basic radiographic protocol included dorsolateral-plantaromedial oblique and plantarolateral-dorsomedial oblique views. Most of the cases had more projections, including a 30° dorsolateral-plantaromedial oblique view to highlight the dorsomedial aspect of the joint better. The surgery was straightforward in most of the cases. Each lesion recorded arthroscopically was compared with preoperative radiographs. Results were analyzed using Student’s t-test.

In 69 joints of 62 horses one or more fragments were removed from the MM. The left MM was involved in 32 cases and the right MM in 37 cases. The group included 27 intact males, 32 females, 1 gelding; in 2 horses the sex was not recorded. The breed distribution was: 60 Standardbreds, 1 Thoroughbred, 1 Show Jumper. The age ranged between 9 months and 7 years (mean age: 1.9 years; median age 1.5 years).

Based on radiographic patterns of the MM, findings were classified in 4 groups:

1. Absence of abnormalities on the MM: 14 joints.
2. Evidence of areas of radiolucency, irregular profile or loss of radiopacity in the most distal aspect of the MM: 19 joints.

In 7 cases lesions of the MM were concomitant with other lesions within the same joint: IRT (26 joints) and LTR (2 joints). In 16 joints contralateral to the joint affected by MM lesions, lesions with different locations were found: IRT (13 joints), LTR (2 joints) and 1 free-floating fragment.

The previously reported low incidence of MM lesions has probably been influenced by the incomplete standard radiographic protocol of several studies. Our comparison between radiographic and arthroscopic findings suggests that the MM is an area predisposed to discrepancies between radiography and arthroscopy. A complete radiographic examination including dorsolateral-plantaromedial 30° oblique view is mandatory when synovial effusion or other symptoms affect the tibiotarsal joint. The evidence of radiolucencies or loss of radiopacity on the MM may reflect fragmentation of the MM and represents an indication for diagnostic arthroscopy.
A radiological study to evaluate suspected scapulohumeral joint dysplasia in Shetland ponies

Jane C. Boswell, M.C. Schramme and A.M. Wilson

Osteoarthritis of the scapulohumeral joint is a rare cause of lameness in horses and is usually considered to be secondary to trauma, intra-articular fractures, sepsis or osteochondrosis. A higher prevalence of osteoarthritis of the scapulohumeral joint however has been reported in Shetland ponies than in other breeds, although no definitive aetiologic factor has been identified.

Osteoarthritis of the shoulder secondary to dysplasia of the scapulohumeral joint has been recognised in man and also in dyschondroplastic and toy breeds of dog. This study was performed to test the hypothesis that osteoarthritis of the scapulohumeral joint in Shetland ponies is associated with shoulder dysplasia.

Horses were selected into 3 groups according to the following criteria:

**Group 1**: Shetland ponies with a clinical diagnosis of osteoarthritis of the scapulohumeral joint.

**Group 2**: Skeletally mature Shetland ponies without history or signs of forelimb lameness.

**Group 3**: Skeletally mature horses without history or indications of lameness arising from the proximal forelimb.

Mediolateral radiographs of the scapulohumeral joints were evaluated to derive the radius of curvature of the glenoid (RCG), radius of curvature of the humeral head (RCHH) and glenohumeral conformity index (defined as the RCHH divided by the RCG). The Glenoid Ratio (defined as the maximum depth of the glenoid divided by the glenoid length) was also measured. Data were analysed using an ANOVA test and Tukey-Kramer test.

There was a significant difference in the mean RCG between the three groups (ANOVA test, \( p = 0.0096 \)). The mean RCG of both Group 1 (\( p < 0.05 \)) and Group 2 (\( p < 0.05 \)) was significantly greater than that of Group 3. There was also a significant difference in the mean Glenoid Ratio between the three groups (ANOVA test, \( p = 0.0002 \)). The mean Glenoid Ratio was significantly lower in both Group 1 (\( p < 0.001 \)) and Group 2 (\( p < 0.01 \)) than in Group 3. These results indicate that the glenoid cavity of “normal” Shetland ponies and Shetland ponies with osteoarthritis of the scapulohumeral joint was significantly shallower than the glenoid cavity of a control group of horses. There was no statistically significant difference in the mean RCHH or in the Conformity Index between the three groups, although there was a trend towards significance for Conformity Index (\( p = 0.09 \)).

The increased instability of the scapulohumeral joint in Shetland ponies makes it more susceptible to severe sprain or subluxation during normal exercise. This may result in traumatic arthritis and secondary osteoarthritis. The onset of lameness in the Shetland ponies in this series was acute and not associated with unusual circumstances or a known traumatic incident. The history and the breed predilection suggest a predisposing factor, which we postulate to be the presence of glenoid dysplasia.

Table 1 (Results)

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<th>ANATOMIC INDEX</th>
<th>GROUP 1 (n=8)</th>
<th>GROUP 2 (n=10)</th>
<th>GROUP 3 (n=10)</th>
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Age-related morphology of the equine calcified cartilage layer

Mark Martinelli

Osteoarthritis is a frequent diagnosis among horses used for a variety of athletic activities. While end stage joint disease may be characterized by full thickness loss of cartilage, the initiating causes remain unclear. Many researchers in the human medical field have established the significance of the subchondral bone and calcified cartilage layer in the initiation and progression of osteoarthritis. Because little has been reported about the calcified cartilage layer of the horse, the object of this investigation was to study the morphology of the calcified cartilage layer of the distal metacarpus over a range of ages.

The left distal forelimb of 35 horses was collected from abattoir specimens. A sagittal slab of bone approximately 500 microns thick was sectioned from the region of sesamoid contact on the medial condyle of each metacarpus. The slab of bone was preserved, dehydrated and embedded, undecalcified, in methylmethacrylate. The surface of the bone was exposed and stained with toluidine blue. A stereomicroscope with a video adapter was connected to a computer for digitizing the specimens at a magnification of 90X. One field was collected at the proximal extent of the calcified cartilage layer on the dorsal and palmar surfaces, one each through the midregion of sesamoid and P1 articulation, and one from either side of the transverse ridge. The average height of the calcified and noncalcified cartilage was recorded over five different 250 micron sections in each image and averaged. The percent calcified cartilage was calculated by dividing the average height of the calcified cartilage by that of the entire cartilage.

Morphologically, the most obvious difference between age groups occurred in horses under two years of age. Microscopic examination revealed a thin and highly irregular calcified cartilage layer. In some places, gaps existed where the uncalcified hyaline cartilage was in contact with the subchondral bone and the substance of the young calcified cartilage appeared to be vacuolated throughout. For all ages and samples, the calcified cartilage/subchondral bone interface undulated dramatically compared to the straight or gently wavy tidemark at the junction between calcified and noncalcified cartilage. The thickness of the calcified cartilage ranged from 111µm to 426µm. All samples showed an initial rise in the thickness of the calcified cartilage layer with increasing age, although sections 1, 4 and 5 showed a slight decrease in thickness in the oldest group of horses. The same initial trend was noted with respect to the calcified/non calcified cartilage ratio, however, both sections 3 and 4 experienced a peak ratio between 4 and 9 years of age before tapering off in the older horses.

The results indicate an age-related influence on the thickness of the calcified cartilage and on the calcified/noncalcified cartilage ratio. While this finding is significant, perhaps more importantly, a positional relationship was also identified, indicating that pressures endured by different regions within a joint may dictate morphological development of the tissues. This study has begun to lay the groundwork to determine whether the calcified layer of the hyaline cartilage could be involved in the development of osteoarthritis.
Quantitative ultrasound and biochemical markers for equine bone assessment

Olivier M. Lepage, Bianca Carstanjen

Non-invasive investigative tools such as biochemical markers and quantitative ultrasonography are developed for the horse in order to evaluate the general state of the skeleton and its adaptation to diverse stimuli. The aim is to facilitate the detection of horses at risk of skeletal disorders before clinical signs and pain become apparent and therefore to minimize economical losses. Osteocalcin is accepted as a biochemical marker of bone formation (2) and has been extensively studied in horses (4). One bone resorption marker of interest in equine clinical situation is the collagen type I carboxy-terminal telopeptide ICTP (3). Osteocalcin and ICTP are measured in the serum by a radioimmunological technique which cross-reacts with the equine species (4). A negative correlation between serum levels of the two markers and age is observed, with a much higher level in young individuals. A significant difference is observed between type of horse and a positive correlation exists between serum levels of ICTP and osteocalcin. Bone structure and density can be reflected by the speed of sound (SOS) (6). In horses, these measurements can be easily obtained at the level of the third metacarpal bone (MC III) by the use of a multi-site quantitative ultrasound device (5). Other easy measurement sites are metatarsal bone III, radius and tibia. For acoustic coupling, 1000 centistokes silicon oil is applied on the measured sites without prior shaving. In a study based on 25 Thoroughbred horses, the average 150 SOS measurements (mean +/- std) obtained on the lateral site of MC III were 4210 +/- 54 m/s compared to the medial 3993 +/- 63 m/s and the dorsal site 3834 +/- 93 m/s (1). We explain these variations by a difference in bone structure. The intra-operator coefficient of variation (CV) was less than 3 %, the lowest CV being obtained at the lateral site and the highest CV at the medial site. The technique revealed to be precise and reproducible in horses.

References
Correlation of radiological and clinical findings in horses with assumed back problems

Wolfgang Ranner and Hartmut Gerhards

In examining a horse's back one of the most difficult problems is to decide whether there is actually an underlying back problem or not. Until now there have been only a few statistical studies about the correlation of back pain in horses with clinical and radiological findings. These studies originated mainly from the United Kingdom in the 80's of the last century. With regard to the horse population specific to Bavaria no study has been presented to date. The purpose of this work was to give a comprehensive statistical account of horses with an assumed back problem for the South of Germany. One of the questions to be answered by this study was, whether horses with a positive palpation result suffer from a primary or, for example in cases of lameness from a secondary back problem. During 1995 - 1999 about 150 horses with assumed back problems were presented for clinical examination. The results of clinical and radiological examination and their correlations will be presented and discussed.
Contrast radiography and 3D reconstruction of bovine limb joints

Karl Nuss, S. Hecht, J. Maierl, P. Böttcher

Introduction
The contour of joint pouches is hidden behind soft tissues and bones, and therefore it is often difficult to visualize them completely.

Material and Methods
22 limb joints, from the metacarpophalangeal joints to the scapulohumeral joint and from the metatarsoophalangeal joints to the coxofemoral joint, of bovines of different ages were injected with contrast medium (Natrium- and Megluminamidotrizoat, a viscous material with a iodine content of 370 mg/ml). The contrast medium was injected with high digital pressure to achieve maximum joint distension. Standard radiographic projections of each joint were taken before and after injection. A CT scan was performed of each joint and an isolated 3D reconstruction was made by extracting solely the contrast medium.

Results
3D reconstruction enabled visualization of the isolated and distended joint cavity. The contrast image could be rotated in any direction, demonstrating different views and insights into otherwise invisible joint structures. This provided an accurate picture of the complex anatomy of the cavities and pouches of the different joints.

Conclusions
Contrast radiography and 3D reconstruction proved to be an effective means of outlining the joint pouches and visualizing them almost completely. These images may be valuable teaching tools, or helpful in the planning of an approach to a diseased joint, either by arthrocentesis, arthroscopy or arthrotomy.
Experiences with the application of VET BIO SIS T™ in equids

Walter Brehm, Beat Wampfler, Andrea Imhof, A. Fürst and Celia Dressel

VET BIO SIS T™ is a natural biocompatible collagen matrix, which is derived from the submucosal layer of the porcine small intestine (SIS = Small Intestinal Submucosa). It is disinfected during processing and sterilised after packaging to remove viable porcine cells, bacterial and viral components. This matrix is processed to maintain its three-dimensional framework and prepared into a ca. 0.1mm thick, freeze dried sheet, the use of which encourages and reinforces wound tissue healing. The body absorbs SIS as it is replaced by host tissue in the remodelling process.

Components of VET BIO SIS T™
Collagen (Types I, III and V), fibronectin, decorin, hyaluronic acid, chondroitin sulphate A, heparan sulphate and growth factors (TGFβ, bFGF).

Qualities of VET BIO SIS T™
- Accelerates wound healing
- Improves the quality of a new tissue formation
- Provides a scaffold for tissue ingrowth, and induces regeneration of vascular and connective tissues. SIS is also very resistant against infection, and is hemostatic. No reaction to the acellular xeno-graft has been observed in any of the cases. After 90 days the SIS was reabsorbed completely as it was replaced by host tissue in experimental studies.

Applications
Primary application:
Large or chronic dermal injuries where skin closure is not possible.
Possible applications:
Adhesion barrier, corneal wounds, periodontal wounds, oesophageal wounds, organ patch, haemostatic plug, cleft palate, other soft tissue repair.
Application on lacerations:
The wound must be cleaned with normal IV quality saline and necrotic tissue debrided before applying SIS. The rough serosal side of the SIS is then grafted onto the wound, and fenestrated well to drain further exudate. A non-adhesive dressing and a bandage are applied to protect the wound.

Case reports
Cases of equids showing different problems with wounds at different sites are presented.
Wound problems covered are:
- Two elder wounds of the forearm and carpus, covered with granulation tissue after initial wound revision.
- Fresh wound after excision of a fibrosarcoma at the ventral abdomen of a zebra.
- Wound of one day at the dorsal fetlock of a foal of 4 months with skin defect.
- Two cases of old caro luxurians ("proud flesh") at the dorsal fetlock and at the plantar pastern in two horses.
- Lacerations with the application of SIS under the damaged skin, which was used as primary "wound dressing".
- Reinforcement of the skin suture at the proximo-plantar aspect of the hock.

Conclusion
The above experiences with VET BIO SIS T™ in different clinical situations show a very good stimulation of wound healing, both for surgical wounds (case 2, 4, 5, 6) and revision of wounds which were not yet granulating (case 3) or already covered with granulation tissue (case 1). These positive experiences give reason to believe that the same results will be achieved in similar cases for similar indications.
Preliminary results with a bio-absorbable implant for flexor tendon lacerations in horses


Different methods of repair of flexor tendons using a variety of suture materials and patterns, as well as implants have been advocated, but successful repair is frequently not achieved. Tenorrhaphy and the use of bio-absorbable material have been shown to be advantageous over tendon repair using non-absorbable material or second intention healing in experimental studies in horses and other animals. Lacerations producing significant damage to the tendon ends also result in large deficits in the tendon negating the use of tenorrhaphy. In these cases, it is suggested that an implant has advantages in maintaining tendon end apposition and providing a scaffold for the formation of fibrous scar tissue. Previously used implants include carbon fibre and terylene, but these have demonstrated disadvantages related to their non-absorbable properties, including post-operative sinus formation and recurrent tearing of scar tissue surrounding the implant as a result of their different mechanical properties. The latter is believed to be responsible for persistent and/or recurrent lameness in horses treated with these implants. Currently available absorbable materials are too rapidly absorbed for tendon repair, and so this study investigated the potential use of a long term absorbable implant, poly-l lactic acid (PLLA), in four horses with clinical digital flexor tendon lacerations.

Four horses were presented to the Royal Veterinary College, Equine Referral Hospital because of a complete laceration to the superficial digital flexor tendon (SDFT) (horses 1 and 3), deep digital flexor tendon (DDFT) (horse 4), or both digital flexor tendons (horse 2). The wounds were explored and the ends of the lacerated tendons were identified and debrided leaving a gap between the tendon ends of 4-5 cm (horses 1-3), or 10 cm (horse 4) when the limb was in the neutral position. PLLA implants, in braided form, (a gift from Prof. Ikada, University of Kyoto, Japan) were used to link the two tendon ends. The subcutaneous tissues and skin were closed routinely, and a cast that incorporated the foot and extended to the proximal metatarsus was applied to the limb with the metatarsophalangeal joint in neutral position. Horses received strict box rest for 4-8 weeks before the cast was changed under general anaesthesia. The second cast was removed 10-12 weeks after the surgical repair. After cast removal, the repair was protected by the application of a plantar splint in 2 horses. Clinical follow-up, including ultrasonographic assessment, was between 7 and 19 months.

The implant was well tolerated by all horses, being well incorporated into significant fibrous scar tissue at the time of first cast removal. Six months after surgery ultrasonographic examination of horses 1-3 showed an echogenic fibrous bridge between the ends of the digital flexor tendons with the implants well incorporated into the fibrous tissue which had a limited striated pattern in the longitudinal image. After one year, horse 1 was being ridden for 30 minutes 2-3 times per week and was less than 1/5 lame. Two horses were sound at the walk 4-6 months after surgery, and horse 4 was convalescing after cast removal.

This study demonstrated that the PLLA implant is well tolerated by tissue. The implant may help maintain alignment of the tendon stumps and act as a scaffold for, and promoter of, scar tissue formation. Other studies are necessary to determine if this implant is superior to casting alone, other absorbable or non-absorbable implants, or tendon grafting.
Diagnosis and management of severe corneal and scleral lacerations in horses

Bettina Wollanke and Hartmut Gerhards

Penetrating lesions of cornea and sclera are not uncommon in horses. Cornea and sclera may be perforated by sharp objects or they may rupture after blunt trauma. Traumatic lesions can be caused by hoof kicks from other horses, by blunt trauma to the globe when horses get a fright and hit their head against doors, mangers or other fixed objects, by nails sticking out in the environment of horses, pitchforks, wood shavings in the stables, and splinters of wood. Other causes for severe corneal lesions are deep corneal ulcers.

Therapy of penetrating lesions of sclera and cornea might consist of wound closure and the attempt to save the globe (and, if possible, to save vision). In some cases enucleation might be the only possibility. Suturing is often difficult or impossible. If the wound closure option is desired, it should be done with thin, monofilament, and atraumatic suture material. A conjunctival flap is often required when corneal lesions are present, a subpalpebral catheter is implanted, and an ankyloblepharon is necessary. A head-bandage is useful to prevent additional damage to the globe by itching and rubbing. Usually the horses have to be fixed to both sides until the ankyloblepharon is opened to prevent rubbing. They are treated with antibiotic, atropine, and, if necessary, antmycotic eyedrops applied via a subpalpebral catheter, and with systemic antibiotics. For corneal ulcers the therapeutic regimen is similar after having performed a corneal debridement and collected samples for microbiology.

If wound reconstruction is attempted, enucleation might be required when the ankyloblepharon is opened and the sutured wound has dehisced, become infected, or ruptured. If possible, the ankyloblepharon should be left for 10-12 days. After that time the corneal healing has progressed far enough. Two to three days after removal of the ankyloblepharon (and the subpalpebral catheter) the eyes usually are without blepharospasm and can easily be examined. Then the resulting corneal or scleral healing process and vision can be assessed. If necessary sutures are removed (not if resorbable suture material is used), and when the corneal epithelium is intact, cortisone ointments are used to decrease corneal cloudiness. The size of corneal scars will reduce during the following months and years by itself once cortisone treatment has been discontinued. Opening the ankyloblepharon earlier than 10-12 days after surgery will be a disadvantage for the healing and should only be done if there is doubt about an endophthalmitis or rupture (severe pain, fever,...).

The decision whether or not to preserve the globe, and perhaps to preserve vision, is made by looking at the localisation of the lesion, the length of the lesion, the period of time which has gone since the injury, the degree of wound contamination, and the degree of damage to the intraocular structures. The prognosis has to be divided into two groups: prognosis for saving the globe and prognosis for saving vision. Depending on the prognosis, the age and the kind of usage of the horse and the cost of treatment, the owner has to decide if an attempt should be made to save the globe or not. Some owners prefer euthanasia to enucleation, so in these cases wound closure will be attempted even if the prognosis is bad. In cases with guarded prognosis for preserving the globe most owners want to attempt salvage of the eye, despite the significant cost and the prolonged stay at the Hospital if enucleation is necessary after removal of the ankyloblepharon. Few owners can easily accept a horse with one eye.
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