DEFINITION AND INDICATIONS
Arthrodesis is an elective surgical procedure to eliminate motion in a joint by providing a bony fusion. The procedure is used for several specific purposes: to relieve pain; to provide stability; to overcome postural deformity resulting from neurologic deficit; and to halt advancing disease. (1,2)

Pain in joints may be the result of end-stage joint disease, that is, instability or incongruity of joint surfaces as a result of trauma. It may also result from exuberant callus following fracture. A painful joint will result in animal discomfort and limb dysfunction for as long as motion remains; the range of motion need be only 1° or 2° but if the motion causes pain, the dysfunction will continue.

Instability of a joint due to disease or traumatic loss of ligaments necessitates arthrodesis. When ligaments can be successfully repaired surgically, joint function will return to normal or near normal. When ligaments are lost as a result of diseased tissue or are destroyed traumatically arthrodesis may be the only successful treatment. Spinal instability, resulting in spinal cord compression or nerve root irritation, may be prevented by bony fusion of the involved vertebral bodies.

Radial nerve injury in the forelimb generally results in flexion deformities of the carpus following loss of normal extensor muscle function. Assuming the animal's shoulder and elbow joints function normally and are not neurologically compromised, the carpus may be successful arthrodesed in a normal position, allowing the animal improved function and lessening the likelihood of dorsal decubital ulcers on the paw.

Tibial nerve dysfunction resulting in hock flexion or peroneal nerve dysfunction resulting in hock extension may likewise be corrected by arthrodesis if the hip and knee joints remain above the level of nerve dysfunction.

Joint diseases such as septic arthritis, degenerative joint disease, and rheumatoid arthritis may result in joint instability, pain, or both. Often when medical or conservative surgical means prove unsuccessful, arthrodesis.

is the only solution. Isolated joints with such disease processes may be treated very successfully; however, polyarthritis problems do not lend themselves to this technique, since multiple joint arthrodeses are not compatible with normal function.

PRINCIPLES
In order to accomplish successful arthrodesis, it is necessary to optimize the patient's condition prior to this elective procedure. The animal should be healthy, possess no generalized disease that might make it a poor surgical risk, and have no localized problems such as bacterial dermatitis over the surgical site, open wounds, or sepsis of the involved joint.
Planning of an arthrodesis is as important as planning an osteotomy. Equally important is observation of the patient standing and walking to determine the best angle for arthrodesis of that joint. Observation of the patient under anesthesia is useless and may result in a joint arthrodesed in too much extension.

When surgically approaching a joint on which arthrodesis is to be performed, the surgeon must handle all surrounding soft tissues and especially tendons with great care. It is important that tendons spanning the joint continue to function normally, since joints below the arthrodesis will have to function as well as possible to compensate for the loss of motion at the arthrodesed site. Because the joints above and below the arthrodesis will compensate to a degree, it is imperative that surgery does not damage tendons or muscles needed to allow these joints to function.

To best accomplish arthrodesis of a joint, all articular cartilage must be removed to a level of bleeding cancellous subchondral bone. If bone ends are sclerotic as a result of a disease process, they must be removed.

Where possible, flat surfaces should be cut on opposing joint ends to ensure optimal bony contact for the bony union. Joints with deep joint contours may be debrided of cartilage and allowed to remain with naturally stable geometry.

The angle of arthrodesis must approximate the normal anatomical position; however, this may differ from animal to animal as a result of other underlying disease of the limb or of the contralateral "normal" limb. It is best to carefully observe the animal preoperatively, in normal gait and standing, to determine the best angle for the particular patient. It is preferable to err by making the arthrodesed angle too flexed, rather than too extended, which may result in paw dragging. It must be remembered that if significant portions of bone ends are removed, the expected angle of arthrodesis must be extended to compensate for bony loss, or the limb may be too short to function well.

Following proper joint positioning, the internal fixation should be applied to ensure joint stability during the period of bony union. If normal joint contours have been used, autogenous cancellous bone should be interposed between the bony surfaces and also placed along the hidden surface of the joint prior to placement of the internal fixation. Following fixation, more cancellous bone should be placed around and over the arthrodesis surface. It is far better to place more than enough bone graft than too little.

Following completion of surgery, the limb must be placed in additional rigid external fixation until radiographic evidence of bony union. Failure to do so is likely to result in metal loosening or arthrodesis failure. Since the joint is being arthrodesed at a normal angle, the biomechanical forces of unprotected weight bearing will tend to bend the joint, cycle the metal, and result in failure.

A limb with an arthrodesed joint is more prone to subsequent injury than a normal limb. The remaining joints must compensate, probably by increased range of motion, and are under more wear and tear; thus they are more prone to subsequent degenerative arthritis. Bones are more prone to fracture because the shock-absorbing ability of one joint is gone. One is therefore more likely to see fractures resulting from axial loading (long spiral fractures or shear fractures at bone ends).

**TECHNIQUES AND METHODS**

Two types of arthrodeses are routinely done in veterinary medicine— intra-articular and extra-articular. Intra-articular arthrodesis is done when fusing peripheral joints after debriding the joint cartilage, grafting, and stabilizing. Extra-articular arthrodesis is performed on the spine when short or long segments of spine are bridged with bone to provide stability to entire segments of the spine. Generally this is performed without destroying each spinal facet or the intervertebral joints prior to bridging. Occasionally, both intra-articular and extra-articular arthrodeses are performed on the spine when intervertebral disks are removed, grafted, and the entire site bridged with an onlay graft. Similarly, peripheral joints can have both intra-articular and extra-articular arthrodesis. This may be accomplished by using dowels of bone that are placed through a joint or by using (corticocancellous) grafts that are cut into a trough that crosses a joint.

A final form of arthrodesis is the phantom arthrodesis. This procedure is performed by running fixation through a joint without removing the articular cartilage or adding bone graft. This procedure will not result in actual arthrodesis; at best, the joint will remain ankylosed; usually, however, such fixation will break down in time, resulting in the return of painful motion.
The technique used for articular cartilage removal depends on the available instruments and the surgeon's desires. The most efficient and fastest method is to use a power bur, usually a Hall drill, or similar cutting tool. This rapidly cuts through cartilage; however, the surgeon must cool the bur with saline to prevent burning, and extreme care must be used to avoid wrapping soft tissue around the bur. Equally effective, although slower, is the use of a sharp bone curette, rasps, or gouges.

Since cancellous bone is an integral part of arthrodesis, the surgeon must plan what sites to use and estimate how much bone is necessary. When arthrodesing a joint of the forelimb, enough bone can be harvested from the proximal humerus of the same limb. If in doubt as to the volume of cancellous bone available, the surgeon should always prepare the ipsilateral ilial wing. When arthrodesing in the pelvic limb, the entire limb, including the ilial wing, should always be prepared to ensure sufficient graft material.

If a cortical bone onlay or inlay graft is to be used for internal fixation, the donor site must be prepared as well. If the graft is to be a sliding graft from the area of the arthrodesis, no other special preparation is needed. If a rib or piece of ilial wing may be required, it must be prepared surgically.

**FIXATION**

All types of conventional internal and external fixation can be and have been used for arthrodesis fixation. The desired end result is rigid fixation, regardless of type of fixation used.

Plates and screws have proven very successful in arthrodesis and have been so used since their introduction into the United States. When an abaxially placed device, such as a plate, is used, the same rules apply as for internal fixation of fractures: place the device on the tension band surface to get best results. In an arthrodesis, that means over the convex surface. If placed on the compression surface (concave surface), the plate will be placed under incredible bending forces and probably will fail if not adequately supported.

Intramedullary pins, either cross pinning a joint or traversing the length of a bone in its medullary cavity then entering and transfixing the joint, work well. Single pins tend to be rotationally unstable; multiple pins or crossed pins are superior.

Single or multiple interfragmentary screws may be adequate fixation for arthrodesis when external fixation covers the limb postoperatively. However, as in fracture fixation, the result will be far better and more stable if a plate, namely, a neutralization plate, is also present to reduce the incredible load placed on the interfragmentary screws.

External half-pin devices work very well as fixation for an arthrodesis. A solid Kirschner-Ehmer apparatus will effectively prevent all motion and give a good result. Superior to a Kirschner-Ehmer apparatus is any device capable of compressing the arthrodesis site. The Stader device, a full-pin splint, or the Charnley apparatus is capable of providing stability by compressing the joint surfaces. In humans and animals this will result in rapid union of the arthrodesis.

**COMPLICATIONS**

Factors favoring the mechanical instability of an arthrodesis usually account for most postoperative complications. Therefore, the surgeon must provide well-apposed surfaces, use implants of adequate strength and number, and apply the implants in an optimal biomechanical position.

Premature removal of external fixation may result in arthrodesis failure.

Infection of the surgical site may result in bone destruction, implant loosening, and arthrodesis failure. Infection may be prevented by planning the surgery well so as to minimize the length of surgery and by careful handling of all bone and soft tissues.

**REFERENCES**


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