The role of hemicircumferential periosteal transaction and elevation

Jörg A. Auer, MS, Dipl. ACVS, ECVS
Brigitte von Rechenberg, Dipl ECVS
Equine Department, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

PRELIMINARY CONSIDERATIONS

Physeal growth is regulated through the cross talk of signaling molecules between the different zones and the surrounding periosteum/perichondrium. An important part of this molecular interaction is taken over by the molecules PTHrP, PTHrP-R and Ihh. The latter is mainly synthesized in prehypertrophic- and hypertrophic chondrocytes and regulates chondrocyte differentiation via the signaling molecules Patched 1 (Pct1), Gli and Smoothened (Smo). PTHrP is expressed in the proliferating and also in the early hypertrophic zone, but also in the perichondrium, where it inhibits the pathway of chondrocyte differentiation and subsequent ossification. PTHrP-R is mainly expressed in the cells of the late proliferating- and prehypertrophic zone, where it is responsible for the effect of PTHrP/PTH to take place. Pct1, Gli and Smo, TGF and FGF act as intermediaries in the perichondrium also inhibiting chondrocyte differentiation, while BMP7 promotes ossification. Ihh acts as an upstream positive regulator for PTHrP, such that after Ihh secretion PTHrP is upregulated via Pct1, Gli and Smo inhibiting chondrocyte differentiation, while activating the cells of the proliferative zone and, thus, promoting longitudinal growth of the bone. Without concurrent expression of PTHrP, Ihh can also promote already predetermined chondrocytes to differentiate into the osteoblastic lineage cells. Together with BMP7 and under the influence of vascular endothelial factor (VEGF) provided by the bone marrow of the metaphysis it regulates bone formation and the development of a bone collar at the metaphyseal site of the growth plate. The following is clear. Ideally, bone growth should occur evenly across the entire physis; immediately after birth, growth is most active; and each physial region has an approximate time span during which new bone is formed. Closure of the physes of the different long bones occurs at predictable time points. Therefore, if manipulations to correct growth are to be effective, the closure time of the physes have to be considered. A recent study investigated the relationship of conformation to injury, which found that offset carpi (offset ratio) contributed to MCP joint problems. Long pasterns increased the odds of a fracture in the front limb. A certain degree of carpal valgus deformity exhibited a protective mechanism, as the odds for a carpal fracture and carpal effusion decreased with an increase in the carpal angle.

Based on recent studies, the goals of effective management of ALD have changed. Severe deformities that do not correct on their own need to be distinguished from deviations that are a variation of the normal. The art of management of ALD involves deciding which conditions require immediate aggressive management and which can tolerate a wait-and-see approach. This topic was discussed in detail in the preceding paper.

GROWTH ACCELERATION

Since its introduction into equine surgery in 1981, periosteal transection and elevation (stripping) has gained universal acceptance. Periosteal transection is performed on the concave aspect of the limb (e.g., in an animal with a valgus deformity in the carpal region, on the lateral side). The original technique described involved an inverted ‘T’ incision prepared in the metaphyseal region of the involved bone, followed by elevation of the two triangular periosteal flaps and subsequent closure of the subcutaneous tissues and the skin. The surgery can be carried out in a foal as young as 2 weeks of age. Theoretically, the earlier the surgery is performed, the faster the correction occurs. However, opting for surgical intervention at such an early age may include foals in which the deformity would have corrected spontaneously if the animal was allowed stall rest. Therefore, most foals are selected for this surgery after 4 months of age, unless the ALD is severe (greater than 10 degrees).

The procedure has also been described for the treatment of ALD of the distal third metacarpal/metatarsal bone (MCIII/MtIII), the distal tibia and the proximal phalanx. Additionally, the “bench knee” conformation, which consists of a valgus deviation of the distal radius combined with a varus deviation of McIII, can be corrected surgically by means of periosteal transection and stripping at the lateral aspect of the distal radius and at the distal and medial aspect of MCIII.

Periosteal transection has its effect for approximately 2 months. Periosteal transection can be repeated if complete correction is not achieved. Overcorrection of the deformity does not occur. Periosteal transection and elevation are routinely carried out on an outpatient basis, with the mare and foal returning home immediately after recovery from surgery.
The most critical location for early diagnosis and surgery is the distal MCIII/MTIII. Later on, growth occurs at a very slow pace, and delaying surgery leads to incomplete correction. Additionally, the prolonged abnormal loading of the metacarpophalangeal joints leads to the development of compensatory deformities in the proximal phalanx. Thus, the limb may appear to be straight, but when the foal walks, an outward rotation is noted (Fig. 1).

Recently, the effectiveness of hemi-circumferential periosteal transection and elevation in treating ALD was questioned. In a controlled study, temporary transphyseal bridging was performed on the lateral aspect of the distal radius to induce a carpal valgus ALD of 15 degrees in normal young foals. At the time of implant removal, the foals were divided into two groups. One group was subjected to an immediate hemi-circumferential periosteal transection and elevation on the same lateral aspect of the distal radius, whereas the other group underwent a sham surgical procedure at the same site to mimic the hemi-circumferential periosteal transection and elevation procedure. In both groups, the deformity corrected, leading to the conclusion that periosteal transection and elevation was ineffective. On first thought this assumption sound logical. However, new research data in the authors laboratory (publication in preparation) suggests that cross talk or molecule signaling between the periosteum and the growth plate is responsible for this accelerated growth after periosteal transection and elevation. The same effect could have been achieved by the mere implant removal as well as with the combination thereof with periosteal transection. The above mentioned study design did not respect these molecular cross talk and thus, may be seriously questioned in its rather undifferentiated conclusions. Since in controls and transected growth plates a surgical stimulus was applied, periosteal transection could not be expected to further trigger this cascade. Therefore, no difference between groups could be expected.

Additionally, clinical experience has shown that a foal with a carpal valgus deformity of 15 degrees does not correct without surgery, and physeal growth is influenced by mechanical load, which in turn triggers signal molecules in a feedback loop between the cells of the different cartilage zones and the perichondrium or periosteum of the limb involved. Recent data of ongoing research in the authors' laboratory to elucidate the effects of hemi-circumferential transection of the periosteum and local periosteal stripping, confirmed the hypothesis that processes occurring at the physeal level involve the negative feedback loop between parathyroid hormone like peptide (PTHrP), the PTH/PTHrP receptor 1 (PTHrPR) and Indian hedgehog (Ihh) as well as changes in expression of transforming growth factor β2 (TGFβ2) and fibroblast growth factor 2 (FGF2) pertinent for bone formation in chondrocytes of the GP as well as in the surrounding perichondrium. Additional work is needed, but there is a evidence that the phenomenon of growth acceleration through hemi-circumferential transection of the periosteum and local periosteal stripping can be explained through these processes and thus lay to rest the discussion on efficiency once and for all.

REFERENCES