Management of Distal Radial Physeal Closure

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Limb deformity is a common sequela to disturbances in normal longitudinal bone growth in young growing dogs, and to a much lesser extent in cats. Growth plate disturbances are most often the result of trauma to one or more physeal growth plate(s). The antebrachium is the limb segment which most commonly develops clinically relevant deformities ascribed to physeal anomalies. The physeal plate of the adjacent paired bone may become secondarily involved due to the abnormal forces caused by retarded growth of the bone that was initially affected. The radius and ulna normally grow in an asynchronous fashion. The proximal ulnar physis contributes to only 15% of the final length of the ulna, with the distal physis responsible for the remaining 85%. The distal ulnar physis is responsible for virtually all the ulna's longitudinal growth occurring distal to the elbow. The proximal radial physis contributes approximately 40% of the final length of the radius. Thus, the distal radial growth plate contributes approximately 60% of the overall length of the radius. While congruency between the proximal and distal radial and ulnar articulations is normally conserved in the developing antebrachium, the spatial relationship between the radial and ulnar diaphyses is not static. This dynamic relationship is necessary because the distal physis is responsible for virtually all the effective longitudinal growth of the ulna distal to the elbow, while effective longitudinal growth occurs from both radial physes.

If one of the physeal plates of this paired bone system is impaired, causing either retardation or cessation of growth, and the other physes continue to have sustained continued physeal growth - deformity is likely. The radius and ulna have strong ligamentous attachments, and retarded growth in one bone will restrict growth in the complementary bone which often generates osseous deformity as well as articular incongruency in either the elbow or carpus.

Distal radial physeal growth abnormalities occur much less frequently than disturbances of the distal ulnar physis. Aberrant distal radial growth can be either eccentric or symmetric, causing variable degrees of progressive forelimb deformity and lameness in skeletally immature dogs. Studies using radiation to induce symmetrical closure of the distal radial physis in dogs have shown that although there is accelerated growth from the proximal radial physis, the resultant compensatory growth is inadequate for the radius to obtain normal length. Premature distal radial physeal closure typically retards ulnar growth secondarily, and most dogs demonstrate a decrease in overall antebrachial length. Dogs with distal radial physeal injuries typically have a decrease in radial length and normal procurvatum, decreased cortical thickness and a reduction in diaphyseal diameter. The radial head displaces distally relative to the coronoid processes, with a resultant increase in the width of the radiohumeral articulation. The humeral condyle may subluxate distally, resulting in abnormal trochlear notch development. Anomalies of the coronoid process, particularly fragmentation of the medial coronoid process, are often a consequence of distal radial displacement. Dogs typically demonstrate effusion, decreased range of motion and pain with manipulation of the affected elbow. Although marked angular deformity of the radius does not typically develop in dogs with symmetric distal radial physeal closure, continued ulnar growth positions the ulnar styloid process more distal relative to the adjacent radial articular surface, and produces slight to moderate varus and external rotation.

The distal radial physis often closes eccentrically, either due to a Salter-Harris type I or II fracture or focal physeal compression (sometimes referred to as a Salter-Harris type VI fracture). Lateral asymmetric physeal closure is most common, resulting in a mild-to-moderate degree of valgus deformity with external rotation. The relative distal location of the ulnar styloid process and angulation of articular surface of the distal radius often produces a discrepancy in the width of the radiocarpal articulation, with the joint space being wider laterally. Eccentric medial physeal closure can produce a varus deformity and internal rotation.

Treatment is dependent on the dog's age at diagnosis, the congruency of the elbow and the degree of incongruency if present, as well as the expertise of the attending surgeon. In younger dogs with no or a nominal discrepancy of elbow incongruency, a mid-to-distal segmental radial ostectomy can be done with adjunctive periosteal excision and placement of an autogenous free fat graft. In dogs approaching skeletal maturity, one strategy is shortening the ulna to restore elbow congruency. This approach seems rational if the discrepancy in radial length is small. A proximal ulnar ostectomy is done to shorten the ulna and align the radial head with the semilunar notch of the elbow: the ostectomy can be stabilized with a plate or possibly an intramedullary pin, pin and tension band fixation, or a pin and adjunctive fixator. Outcomes in 11 dogs with radial physeal closure treated with acute arthroscopic-assisted ulnar shortening were reported by von Pfeil et al. with the lion's share of dogs having acceptable outcomes. Larger discrepancies can be addressed by performing a proximal diaphyseal radial osteotomy and using a circular construct to evoke distraction osteogenesis. This approach allows for concurrent lengthening of the entire antebrachial limb segment through distal radial and ulnar osteotomies, if antebrachial lengthening is needed. In addition, incongruency of the antebrachiocarpal articulation, if present, can be addressed acutely during surgery. A recent publication by de Moya et al. reviewed results of using a circular construct and distraction osteogenesis to address antebrachial deformities secondary to premature distal radial physeal closure in 12 skeletally immature dogs. As with other procedures utilized to address antebrachial deformity, the degree of pre-operative elbow incongruency and the presence of existing degenerative joint disease can adversely affect the eventual functional outcomes, but results in these dogs were generally positive with intervention occurring just prior to the time of skeletal maturity (mean $\pm$ SD age at the time of surgery: 7.5 $\pm$ 1.7 months). Uncomplicated osseous union was documented in 9 of 12 dogs and the mean $\pm$ SD time to fixator removal was 78 $\pm$ 20 days following surgery. The procedure requires commitment from the owner and vigilant post-operative care by both the owner and the attending surgeon. Questionnaires assessing long-term outcome were obtained from the owners of 8 of the 12 dogs with all owners reporting good to excellent limb function.

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