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Bilateral premature closure of ulnar growth plate in a golden retriever: Its diagnosis and surgical management with ulnar ostectomy and cuneiform osteotomy of radius

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Abstract
A 20 kg, 8 month old, male Golden Retriever was presented for not being able to walk normally. The condition started after 2 months of birth, there were gradual increase in the outward deviation of both the forelimbs from the carpal joint distally. Physiological parameters were all in normal range and body score of the animal was 3 (normal). Clinical evaluation revealed pain on carpal joints and valgus deviation of carpal joints and paws. Radiograph in lateral and cranio-caudal view showed cranial bowing of the radius in both the limbs with closure of distal ulnar physes. The left forelimb was more aggravated then the right one. Hemato-biochemical parameters were in normal range. Left partial ulnar ostectomy and left radial close wedge osteotomy (cuneiform osteotomy) were performed under general anesthesia using diazepam and ketamine HCl and was maintained with Isoflurane throughout the surgery. The left radius was then stabilized with 2.7 mm LCP. A caudal splint was applied and for rehabilitation hydrotherapy was advised for 2 months after the removal of skin suture. After 1 month of first surgery the right partial ulnar ostectomy was performed following the same anesthetic protocol as before and for rehabilitation hydrotherapy was advised as before.

Keywords: Golden retriever, growth plate, ulnar ostectomy, osteotomy

Introduction

Growth plates are the specialized endrochondral ossification zones present in between epiphysis and metaphysis of immature long bones (Netter, 1987; Aslanbey, 2002) [24, 2] that closes with the progress of the age of the animals i.e. is almost by the age of 220- 250 days (7-8 months) and fuses with metaphysis (Chapmann, 1965; Noser *et al.*, 1977; Fox and Bray, 1993; Bryan and Gerald, 2005) [7, 26, 17, 5]. They are also called as physes, epiphyseal cartilage, epiphyseal plate and epiphyseal disc (Netter, 1987) [24]. Anatomical growth of epiphyseal growth plate is essential for the longitudinal growth of the long bones and any damage/deformities could lead to retardation of longitudinal growth. In case of radius, distal epiphyseal plate accounts for the 60 percent of the longitudinal growth and proximal physis contributes 40 percent of the growth. Distal and proximal ulnar epiphyseal plate contributes 85 percent and 15 percent of the total longitudinal length of the ulna respectively. So it is very essential that distal ulnar growth plate develops at the same rate with proximal and distal radial growth plate (Fox, 1984; Fox and Bray, 1993; McKee, 2014) [15, 17, 23]. Normal growth of forelimbs depends on the synchronized growth of Radius and Ulna (Mason and Baker, 1978) [22].

Long bone growth deformities are very important cause of lameness and pain in dogs. Antebrachium growth deformities or angular growth deformities due to asynchronous growth or premature closure of growth plates of radius and ulna are very common in young dogs (O'Brien *et al.*, 1971; Carrig *et al.*, 1978; Fox, 1984; MacDonald and Matthiesen, 1991; McKee, 2014) [27, 6, 15, 23, 21]. This asynchronous growth of the ulna could result in the shortening of the ulna which ultimately leads to the cranial bowing of the radius (Carrig *et al.*, 1978) [6]. Premature closure of distal ulnar growth plate with normal growth of the radius leads to antero-posterior bowing of the radius, valgus of the carpal joint, lateral deviation of the part below carpus and distal humero-ulnar subluxation which leads to pain and discomfort while bearing weight (Ramadan, 1978; Fox, 1984; Newton, 1985; MacDonald *et al.*, 1991) [30, 15, 25]. There could be various etiology to the premature closure of the ulnar growth plate but most common cause of the condition is trauma (Mason and Baker, 1978; Loewen and Holmberg, 1982; MacDonald and Matthiesen, 1991; McKee, 2014) [22, 23, 21, 20].

In radiographs growth plate appears as a radiolucent structure between epiphysis and metaphysis of the long bones which gradually disappears as the animal attains maturity (Douglas *et al.*, 1987; Oviawe *et al.*, 2018) [10, 29]. Radiographically, cranial bowing of the radius, shortening of the ulna, closure of the growth plate and osteoarthritic changes in the carpal joints and humeroulnar joints could be noticed (O'Brien *et al.*, 1971; Evans, 1977; Oviawe *et al.*, 2018) [27, 29, 12].

The main objective to treat antebracium growth deformities is to remove the hindrance caused by restricted ulna, prevent secondary damage to the surrounding structures and to maintain the functionality of the normal growth plate and the uniformity of the elbow joint (Ramadan, 1978; Mason and Baker, 1978; Fox, 1984, Carrig, 1983) [30, 15, 22]. Techniques like multiple ulnar osteotomy, ulnar osteotomy with progressive spread of the ulna with a stader splint, ulnar osteotomy with a fat graft, and ulnar styloid transposition can be done to correct premature closure of ulnar growth plate only if distal radial physis is functional (Egger and Stoll, 1978; Ramadan, 1978; Craig, 1981; Fox, 1987) [30]. If there is subluxation of humero-ulnar joint then it can be reduced using proximal ulnar osteotomy with transverse pins and elastic bands, dynamic proximal ulnar osteotomy and proximal ulnar osteotomy with autogenous cortical bone graft and stabilization with a bone plate (Ramadan, 1978; Mason and Baker, 1978) [30, 22]. Dome osteotomy could be used to correct fracture malunion as well as can be used to treat growth plate deformities (Sikes *et al.*, 1986; MacDonald and Matthiesen, 1991) [21].

The present study was conducted on a 9 months old intact male Golden Retriever with bilateral premature closure of distal ulnar growth plate and treated surgically with bilateral partial ulnar ostectomy and left radial cuneiform osteotomy and stabilized with LCP plate at 1 month interval.

Materials and Methods

A 20 kg, 8 month old, intact male Golden Retriever was presented to the Department of Surgery and Radiology, College of Veterinary Science, AAU, Khanapara, Guwahati-781022 with history of pain in the both forelimbs since 2 months of age and gradual increase in the severity of bilateral outward deviation of forelimbs from carpal joint distally and lameness within months. The owner could not recall the history of traumatic injury but at the same time mentioned the playful and active nature of the pet and habit of jumping over people with forelimbs.

Thorough physiological, orthopedic and hemato-biochemical examination was done. The dog was found to be physiologically healthy and active and body score of the animal was 3 (normal). Hemato-biochemical parameters were found to be within the physiological range. During the orthopedic examination pain could be elicited on the left elbow joint and right and left carpal joint with obvious bilateral valgus deformity of the forelimbs and external rotation of the carpal joint and paw of both the limbs (Fig: 4 A). The preoperative lameness was graded 3 as per Tufts University School of Veterinary Medicine (TUSVM). No crepitus was felt while palpation of the forelimbs. It was also observed that the dog was reluctant to walk and elicited severe pain when made to walk.

The medio-lateral and cranio-caudal view of bilateral radius-ulna revealed closure of the distal ulnar growth plate, shortening of the ulna with respect to radius and cranial curvature of the radius (bowstring), opening of the distal radial physis along with increase angulation in the radio-carpal joint i.e. more than 10 degrees and movement of ulnar styloid process proximally. Radiographic signs were significant in the left forelimb (Fig. 1).

Surgical Procedure

Partial left ulnar ostectomy along with left radial cuneiform osteotomy was performed to relive the "bowstring" effect and cranial curvature of the radius. The radius was then stabilized using 2.7 mm LCP. All the standard pre-operative protocols were followed. The dog was anesthetized using diazepam @ 1 mg/kg body weight intravenously and ketamine HCl @ 10 mg/kg body weight intravenously and was maintained with Isoflurane 2% throughout the surgery. The limb was prepared aseptically. Radius and ulna was approached with cranio-lateral incision extending from the radial mid-shaft to the dorsal aspect of carpus. After skin incision, lateral digital extensor muscle was retracted to get access to the ulna (Fig: 2 A). Approximately, a segment measuring 1.5 times the diameter of the ulna was excised along with complete removal of the periosteum from the distal 3rd of the ulna using Gigli wire saw (Fig: 2 B). Than the radius was exposed cranially by separating and retracting carpal and digital extensor tendons. The area with greater curvature in radius that was predetermined radiographically was marked. Then a medio-lateral inclined cuneiform osteotomy was done. A small- sized wedge of the bone with apex pointing laterally was excised and removed. The radius was then realigned to correct the angulation. Then 5 degree bent 6 holes 2.7 mm LCP was placed on the cranial surface of the radius and secured with plate holding forceps to bridge the osteotomy gap. The screws were fixed with standard protocol to establish the compression. Great care was taken to avoid injury to the radial nerve. A firm splint bandaging was done for 1 month. After 1 month of the first surgery, partial right ulnar ostectomy was performed to relive the 'bowstring' effect and allowing remodeling of the radius as per previously mentioned procedure. Same standard pre-operative and anesthesia protocol and aseptic preparation of the limb as mentioned earlier was followed. The limb was bandaged with splint and soft padding for 3 weeks (Brinker *et al.*, 1990; Feichtenschlager *et al.*, 2018) [4, 13]. Post-operative radiographs were taken (Fig: 3). Hydro-therapy was advised for 2 months post removal of the sutures for rehabilitation. Post-surgery, Antibiotics, analgesics, bone and joint supplements and enzymes were prescribed.

Result

The 8 month old Golden retriever reported with pain, weight bearing lameness and outward deviation of the paw, was diagnosed to be bilateral closure of distal ulnar growth plate. The dog was treated surgically with bilateral ulnar ostectomy as well as left radial cuneiform osteotomy, 1 month apart. Ulnar ostectomy and cuneiform osteotomy was done in the severely affected limb (i.e. left). The dog was put under bandaging as mentioned earlier and was advised for hydrotherapy for 2 months post removal of the sutures. Follow ups were done for 2 months at an interval of 15 days. The pet showed no sign of pain or discomfort and demonstrated normal range of motion in the carpal as well as in elbow joints while examined by the 30th day post-surgery. The animal started walking with occasional lameness (Grade

1 as per TUSVM) by 30th day post-operatively. By 60th day after second surgery there was no perceptible lameness (Grade 0 as per TUSVM). The radiographs demonstrated improvement in the alignment of the radio-carpal joint and also in curvature of the radius. The implant was also intact. Telephonic follow ups taken for next 3 months revealed no complication. No complication was observed or reported due to LCP, so removal was not necessary. Cosmetic appearance of the limbs could be rated as good after 60th day of 2nd corrective surgery (Fig: 4 B).

Discussion

In the present study, the etiology of the bilateral angular deformity was the trauma as the owner mentioned having small children and habit of the pet to jump over people with forelimbs which might have caused trauma to the distal ulnar growth plate. Many authors like Mason and Baker (1978) [22], Loewen and Holmberg (1982) [20], MacDonald and Matthiesen (1991) [21] and McKee (2014) [23] mentioned that trauma was the prime cause of the premature closure of the ulnar growth plates. Other etiology includes nutritional imbalance due to calcium, phosphorus, vitamin A and D and some trace mineral deficiency could lead to abnormal skeletal growth deformities (Frassinetti *et al.*, 2006; Hazewinkel, 2010, Richardson *et al.*, 2010) [18, 31].

Radiographs aid in the diagnosis of the growth angular deformities like premature closure of ulnar growth plate. O' Brien *et al.* (1971), Evans (1977) [12]; and Oviawe *et al.* (2018) [29] mentioned radiographic characteristics (like sclerotic and remodeling of anconeal process, shallow trochlear notch, luxation of humeroulnar joint, distal displacement of the coronoid process, cranial angulation of the radius, increased radio-carpal joint, proximal situation of ulnar styloid process, secondary degenerative joint diseases and closure of the distal ulnar growth plate) in the premature closure of the ulnar growth plate in dogs. O'Brien *et al.* (1971) [27] mentioned that angulation of the carpus w.r.t radius should be 0- 10 degree in dorso-palmer view of carpus and 0-8 degree in latero-medial view of the carpus. In our study, premature closure of bilateral ulnar growth plate, cranial curvature of both the radius, increased radio-carpal joint angulation due to increased distance in distal radial growth plate especially in left forelimb and movement of the ulnar styloid process proximally was observed.

In the present study, bilateral forelimb angular growth deformity in a skeletally matured dog was corrected by ulnar ostectomy and cuneiform osteotomy. The closing wedge osteotomy was performed at the site of maximum angulation so that optimum realignment of the bone could be attained (Johnson, 1992) [19]. Cuneiform osteotomy also causes shortening of the bone (Balfour and Gores, 2000) [3]. Therefore in our study complete reduction of the osteotomy gap was not done to maintain the length of the radius. The surgical technique provided satisfactory result in correcting the radial angulation as well as alignment of radio-carpal joints. As implant failure was not observed in the study which indicated that the LCP system provides adequate biomechanical stability. LCP system was adopted for the surgical procedure as it provides versatility and eccentrically placement of cortical screws (compression method) and at the same time provides bridging between the proximal and the distal fragments of the radius. LCP system provides benefits over DCP system as it provide prolong angular stability (Ahmad *et al.*, 2007) [1] which is very essential to attain in cuneiform osteotomy. Decamp *et al.* (2016) [9] mentioned about using intramedullary pinning technique for ulna in radial fracture/osteotomy to provide additional support. But in our study, LCP system provided adequate stability in the left forelimb and in right forelimb surgical intervention of radius was not performed so radius itself worked as an internal splint.

External skeletal fixation technique could also be adopted post osteotomy/ostectomy. But it has many disadvantages. In young animals using external skeletal fixation system could lead to periosteal sensitivity and as a result premature loosening of the fixator pins leading to lameness. The external skeletal fixation system could catch infection/sepsis and ultimately could result in osteomyelitis, delayed union etc. (Fox and Bray, 1995) [17]. Regular attention and care is required in the external fixation technique which is not required in the internal fixation system.

Application of external coaptation after internal stabilization using LCP is controversial and completely depends on the choice of the surgeon. Authors like Balfour and Gores (2000) [3] and Feichtenschlager *et al.* (2018) [13] used external coaptation/bandaging only for initial 5-7 days. In the present surgery, the forelimbs were secured with firm padded splint bandaging to prevent the excessive movement of the limbs as the dog was very active and also to aid in reducing post-operative soft tissue swelling, licking and discomfort.

Fig 1: Pre-operative medio-lateral radiograph of left and right antebrachium of 9 month old Golden retriever

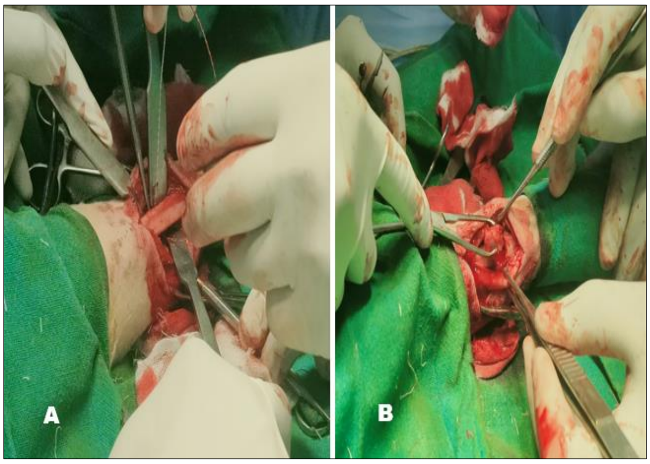

Fig 2: Partial ulnar ostectomy. A. Exposure of the ulna by retracting lateral digital extensor muscle. B. Removal of a segment from distal 3rd of the ulna

Fig 3: Post- operative radiograph. A and B. Medio-lateral and cranio-caudal radiograph of right antebrachium after partial ulnar ostectomy. C and D. Medio-lateral and cranio-caudal radiograph of left antebrachium after partial ulnar ostectomy, cuneiform radial osteotomy and LCP system

Fig 4: A. Frontal view of forelimbs showing bilateral valgus deformity of the forelimbs and external rotation of the carpal joint and paw at the time of presentation. B. Frontal view of forelimbs after 60th day of 2nd corrective surgery

Conclusion

In the study, we reported performing bilateral ulnar ostectomy and left radial cuneiform osteotomy along with LCP system for stabilization of the left radius. No complication related to the surgical procedure and the implant was observed in the study. So, based on our findings we can conclude that ulnar ostectomy and radial cuneiform osteotomy with LCP system provides sufficient biomechanical support, aids in remodeling of the radius and also helps in correction of the antebrachium growth deformity due to unsynchronized growth of radius ulna as a result of premature closure of the ulnar growth plate.

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