Congenital elbow luxation in the dog

SARAH A. BINGEL AND WAYNE H. RISER*

Department of Anatomy, College of Veterinary Medicine, Washington State University, Pullman, Washington 99163, and *Department of Pathobiology, School of Veterinary Medicine, University of Pennsylvania, 3800 Spruce Street, Philadelphia, Pennsylvania 19174

ABSTRACT

Anatomical and pathological descriptions of five congenital elbow luxations and subluxations in three dogs were based on palpation, radiographs, gross dissection and in one dog, surgical correction. The primary defect in all five joints was hypoplasia, or aplasia, of the medial collateral ligament. The osseous deformities consisted of outward rotation of the proximal ulna, hypoplasia, or aplasia, of the coronoid process, anconeal process and radial notch and a shallow trochlear notch. The proximal ulna was rotated approximately 40-45°. The olecranon was deviated laterally and dorso-cranially. The syndrome was compared with the deformities of congenital luxation of the radial head in children. An embryonic pathogenesis for congenital elbow luxations in dogs was hypothesized.

INTRODUCTION

Congenital elbow luxations in dogs are not uncommon even though they have received limited attention in the literature. The syndrome is usually recognized by the owner when the pup is 3-6 weeks old and is observed to be lame or not bearing weight on one or both forelimbs.

Fox (1963) reported a case of bilateral congenital luxation of the elbows associated with multiple congenital skeletal anomalies in a Wirehaired Fox Terrier. Fox (1964) again reported congenital elbow luxations in achondroplastic breeds associated with congenital luxations of the shoulders and hips (polyarthrodysplasia). Filipo (1965) pictured one case of congenital elbow luxation in a puppy but did not specify its age, breed or sex. Campbell (1969) reported that in a survey of non-fracture injuries involving the canine elbow, 17% were due to congenital luxations and that they occurred principally in the small breeds such as Pekingese,
Shetland Sheepdog and Yorkshire Terrier. The deformity varied from lateral displacement of the radius and ulna with aplasia of the anconeus, to medial or lateral bowing of the radius. There was no evidence of hereditary predisposition.

Campbell (1971) described congenital subluxation of the elbow in the same breeds. The degree of deformity varied from mild subluxation of the head of the radius with only a mild lameness to severe distortion of the joint, bowing of the leg, aplasia of the anconeal process and complete inability to extend the elbow during attempted weight bearing.

Pass & Furguson (1971) surveyed elbow dislocations in dogs and reported three congenital dislocations in a total of fifteen cases. In two of them the dislocations were bilateral. They also reported five cases of dislocation of the radial head, one of which was congenital.

Grøndalen (1973) described three Afghan Hound littermates with congenital elbow deformities characterized by incongruity of the joint surfaces of the radius, ulna and humerus. Two of them had bilateral involvement. A calcified joint mouse was found in the cranial aspect of the joint space of both elbows in a fourth littermate.

Stevens & Sande (1974) pictured a case of congenital elbow luxation involving a 3-month-old Japanese Spaniel and described congenital luxations of the radial head in a 3-month-old male Golden Retriever, a 3-month-old male Retriever × Setter cross (bilateral involvement) and a 2-year-old female Doberman Pinscher (bilateral involvement).

In children, congenital luxation of the head of the radius has been well documented (Caravias, 1957; Crockshott & Omololu, 1958; Kelikian, 1974). The osseous deformities associated with the condition are consistent. Other congenital anomalies of the elbow do occur but are rare. McGavian (1913) described a case of bilateral congenital dislocation of the radius and ulna in a newborn infant. Mead & Martin (1963) reported a mother and three siblings with aplasia of the trochlea and humero-ulnar dislocation. Luxation of the radial head in children was also frequently observed as a part of various multiple skeletal anomalies and connective tissue disorders (Kelikian, 1974).

It is the purpose of this paper to describe three additional cases of congenital elbow luxations in dogs and to discuss the similarities with the conditions reported in children.

CASE REPORTS

Two 8-week-old male Miniature Poodles, littermates, were presented with bilateral elbow deformities (cases 1 and 2). The left elbows of both pups were carried slightly flexed and abducted. Both pups had not borne weight on their left forelimbs since birth. In both left elbows the radial head was lateral to the lateral humeral epicondyle and the proximal portion of the ulna was rotated about its axis and lying lateral to the radial head. The olecranon was deviated laterally and dorsocranially
such that the triceps tendon appeared like a bow string on the lateral aspect of the brachium. The olecrans of the right ulnas were likewise deviated laterally and dorsocranially. Both right elbows were crepitant, although each possessed a full range of pain-free motion. One pup which subsequently died of distemper also had bilateral medial patellar luxation with marked rotational deformity of the right tibia. The other pup underwent surgical reduction of the left elbow. Craniocaudal and lateral radiographs of the elbows of both dogs (Figs 1 and 2) were made.

![Fig. 1](image1.jpg) ![Fig. 2](image2.jpg)

**Fig. 1.** Antero-posterior radiograph of the left elbow case 1. Note the very narrow radial neck and abnormally shallow trochlear notch on the ulna.

**Fig. 2.** Antero-posterior radiograph of the left elbow case 2. There is complete luxation of the elbow. The radial neck is narrowed and the trochlear notch misshapen and shallow.

*Case 1. Male Miniature Poodle* (age at time of death 9 weeks)

Upon detailed gross dissection, numerous deviations from the normal origin and insertion of skeletal muscles at the elbows were found.

The right proximal ulna was rotated laterally, approximately 40°, causing the trochlear notch to articulate with the lateral aspect of the medial humeral condyle (Fig. 3). The lateral aspect of the trochlear notch and adjacent portion of the ulna articulated with the lateral humeral condyle. The trochlear notch was shallow and irregular. It contained a small area of fibrous tissue replacing the normal
articul cartilage. The coronoid process was hypoplastic. The radio-ulnar articulation was distorted because of the rotational deformity of the proximal ulna and a shallow radial notch. The lateral humeral condyle was flattened caudally. The annular ligament was present. A short hypertrophied lateral collateral ligament inserted onto the distal one-half of the lateral border of the trochlear notch and the lateral aspect of the radial neck (Fig. 4). The medial collateral ligament was hypoplastic and could not be distinguished from the thickened joint capsule. The olecranon was rotated laterally and angled craniodorsally. All other structures were normal.

Fig. 3. Medial view of the right elbow case 1 after removal of the joint capsule. Note rotation of the articular surface of the trochlear notch and prominent lipping on the medial side of the trochlear notch. The medial collateral ligament could not be distinguished from the thickened joint capsule.

Fig. 4. Antero-posterior view of the right elbow case 1. Note the hypertrophied lateral collateral ligament (arrow) inserting on the lateral aspect of the trochlear notch. The trochlear notch is shallow and rotated laterally.

The luxated left ulna could not be reduced even after removal of the muscle groups. A dense hypertrophied lateral collateral ligament rendered the ulna almost immobile (Fig. 5). No medial collateral ligament was present. The lateral collateral ligament inserted onto the lateral aspect of the distal half of the trochlear notch and the lateral aspect of the radial neck. The annular ligament was present. The radio-ulnar articulation was distorted by rotation of the proximal ulna and the flattened radial notch. The coronoid process was aplastic. The anconeal process was absent. The trochlear notch was shallow and the olecranon deviated laterally and dorsocranially. Both humeral condyles were hypoplastic compared to those of the right humerus. The olecranon fossa was very shallow and the trochlear foramen absent.
FIG. 5. Lateral view of the left elbow case 1, gross specimen. Note the short thickened lateral collateral ligament (arrow) and presence of a mass of dense fibrous connective tissue attached to the trochlear notch immediately adjacent to the lateral collateral ligament. No medial collateral ligament was present.

Case 2. Male Miniature Poodle (age at the time of surgery 10 weeks)

Open reduction was performed via an incision on the lateral aspect of the left elbow immediately caudal to the displaced ulna. The joint capsule was incised caudal to the ulna. Both humeral condyles were hypoplastic and the olecranon fossa was shallow. No medial collateral ligament was present. The trochlear notch was shallow and the olecranon was deviated laterally and dorsocranially. The coronoid process was aplastic and the radial notch flattened. The annular ligament was present. The articular surface of the radial head appeared normal. The hypertrophied lateral collateral ligament prevented reduction of the ulna.

The ulna was accidentally fractured distal to the trochlear notch during attempted reduction. The lateral collateral ligament was incised at its attachment to the ulna and the proximal ulnar fragment de-rotated. The luxated radial head reduced spontaneously and appeared stable. The elbow was placed in a neutral position and two 0.045 inch Kirschner wires were inserted just distal to the olecranon on the caudal ulna at an angle into the humeral condyles to transfix the proximal ulnar fragment into correct anatomical position. Excess joint capsule was removed from the medial aspect of the joint. The joint capsule was sutured with 000 chromic gut using a vertical mattress pattern. The capsule was allowed to remain open laterally. The incision was closed routinely. A well padded Orthoplast (Johnson and Johnson, New Brunswick, New Jersey) splint was applied over the shoulder and around the chest to immobilize the entire left forelimb. The carpus was flexed slightly and the central two digital pads remained exposed for weight bearing. The dog tolerated the splint very well and was extremely active. Radiographic
examination 5 weeks after surgery revealed adequate formation of callus at the fracture. Eight weeks post-operatively the splint and wires were removed. Full extension of the elbow was present but only about 15–20° of flexion. Fourteen weeks post-operatively flexion had increased to about 35° and, by 5 months, to 45° without pain or crepitus. The radial head became subluxated at 5 weeks post-operatively. However, the dog showed no sign of pain and only a slight limp. The proximal radial physis was irregular; it fused at 6 months of age, approximately 6–8 weeks earlier than the left proximal radial physis.

Case 3

An 8-week-old small male mixed Terrier dog was presented with multiple congenital deformities of the right forelimb. It would not bear weight on the limb. The elbow was flexed and slightly abducted. The radial head was easily palpated cranial to the lateral humeral condyle. The ulna was rotated and luxated laterally. The limb was divided into the radial and ulnar rays from the elbow through the digits (Figs 6 and 7). Those digits which were part of the ulnar ray exhibited marked flexure contracture. Polydactyly was present. The puppy appeared normal in all other respects. Antero-posterior and lateral radiographs of both forelimbs were made. Ossification of the right humeral condyles was delayed when compared to the left. Both humeri were of equal length. The radius was displaced cranially.

Fig. 6. Lateral radiograph of the right elbow, case 3, 8-week-old mixed Terrier. The limb is divided into radial and ulnar parts from the elbow distally.
The right radial epiphysis was hypoplastic and the radius was 0.8 cm shorter than the left radius. The distal physes and epiphyses were normal. The right ulna was rotated, luxated, and was 1.4 cm shorter than the left ulna. There was delayed ossification of the distal ulnar epiphysis.

When the dog was 14 weeks old a right forequarter amputation was performed. Gross dissection of the amputated forelimb revealed multiple skeletal muscle deformities. The fourth digit of the radial ray was supernumerary. The olecranon was deviated laterally and slightly craniodorsally. There was approximately 40–45° rotation of the entire proximal ulna. The trochlear notch was shallow and articulated with the lateral aspect of the medial humeral condyle. The anconeal process was normal. No radial notch was present and there was aplasia of the coronoid process. The medial collateral ligament was indistinguishable from the thickened joint capsule. The joint capsule was markedly thickened ventrally and was attached circumferentially to the neck of the radius. The lateral collateral ligament was present and hypertrophied. No annular ligament was present. The caudal aspect of the radial neck was grooved as a result of articulating with the lateral condyle of the humerus. A dense fibrous band was present (Fig. 8). It was bifurcated proximally. One portion originated from the thickened ventral joint
capsule; the other originated from the medial border of the proximal radius just below the physis. It inserted at the lateral aspect of the distal radial epiphysis and the palmar fascia of the proximal carpal bones. It was bound to the periosteum of the radius through its distal half by fascial sheets. A thin short ligament was present, originating from the cranial aspect of the lateral humeral condyle and inserting at the caudolateral radial neck. Two extra muscles were present. One acted as an extensor of the digits of the ulnar ray while the other acted as a flexor of the digits of the radial ray. The radial ray contained the radial carpal bone and the first, second and third carpal bones. The ulnar ray contained the ulnar, accessory and the fourth carpal bones.

DISCUSSION

Congenital elbow luxations and subluxations in dogs constitute a distinct pathological entity apart from the other elbow deformities such as ununited anconeal process, ununited medial condyle, patella cubiti and luxations secondary to premature closure of the growth plates at either the proximal or distal radius or ulna. Gross dissection and surgical and radiographic observations have made it possible to suggest an embryological pathogenesis for congenital elbow luxations and subluxations.

Embryologically, joints are formed from a solid core of mesenchymal cells termed the blastema, in the centre of the developing limb bud. These mesenchymal
cells differentiate into chondrocytes which secrete a supporting matrix around themselves and then undergo hypertrophy. A pressure gradient is built up in the matrix which causes the chondrocytes to be arranged in arcades. Cells which remain between two arcades occupy the area termed the interzone. This is the area of presumptive joint formation. The mesenchymal cells in the interzone are avascular but do not undergo chondrification. At this point, two critical events occur.

(1) A capillary penetrates the interzone, stimulating the adjacent chondrocytes to secrete lysosomal enzymes which digest all unwanted material, forming a series of clefts. These clefts coalesce to form the joint cavity. The remaining mesenchymal cells in the interzone become vascularized and differentiate to form the synovial membrane and all intra-articular ligaments. The fibroblasts adjacent to the interzone produce a dense collagen network which becomes the joint capsule.

(2) During formation of the joint cavity, motion must occur. This required concomitant development of skeletal muscles (Gardner, 1963; Trueta, 1968; Mankin, Radin & Rosenberg 1975). Events leading to the development of the early joint cavity and ultimately the shape of the joint surfaces are under genetic control and occur spontaneously (Mankin et al., 1975).

It was the opinion of the authors that congenital elbow luxations and subluxations result from a failure at the stage of formation of the intra-articular ligaments. The medial collateral ligament either failed to develop or was hypoplastic, thus permitting rotation of the proximal ulna and subluxation or luxation of the radial head, the ulna, or both. This was also accompanied by a functionally hypoplastic annular ligament which allowed subluxation of the radial head. The flattened or shallow radial notch accentuated the instability of the radial head. Hypoplasia or aplasia of the coronoid process was a constant feature. Hypoplasia or aplasia of the anconeal process was present in 4 of the 5 elbows studied and has previously been reported as having been a variable feature in congenital elbow subluxations (Campbell, 1971). It was unclear if this represented a primary or a secondary defect.

Hypertrophy of the lateral collateral ligament was probably secondary to hypoplasia of the medial collateral ligament and the presence of a weak annular ligament. When there has been an initial error in embryonic development, the organism attempts to reproduce as nearly as possible the normal condition. This may be accomplished by multiple changes in associated structures (O’Rahilly, 1951). In the cases discussed, the compensatory anatomical changes resulted in rotation of the proximal ulna and in some, luxation. Tension of the triceps tendon on the developing olecranon became distorted and caused the apophysis to be deformed.

The instabilities created by hypoplasia or aplasia of the ligaments permitted incongruous joint surfaces to articulate. Abnormal wear of the joint surfaces resulted since the trochlear notch and olecranon fossa had failed to develop normally. This was of course impossible when the ulna was rotated or luxated.
The altered stress patterns which resulted from joint incongruities while the limbs were bearing weight, as occurred in cases of subluxation of the radial head, resulted in further distortion of the articular cartilage and eventually in osteoarthritis.

The delayed ossification of the humeral condyles and distal ulnar epiphysis and the shortening of the radius and ulna observed in case #3 was probably secondary to disuse.

The skeletal muscle anomalies observed in these dogs were secondary to the osseous defects. In spite of the distortion, the muscles had origins close to their normal sites. Carter (1951), studying the bone-muscle relationship in 'luxate mice', stated that when the osseous element on which a muscle inserted was absent, the muscle would insert on the nearest appropriate skeletal element to retain its extensor or flexor function. Also, supernumerary unspecialized digits tended to acquire a normal unspecialized muscle supply. Morris (1971), studying congenital skeletal limb malformations in non-human primates, observed that although the bones that normally served as sites of insertion for certain muscles were present, the muscles showed abnormal insertions. He attributed the difference between his observations and those of Carter (1951) to genotypic variation of the species or a second pathway of embryonic development. Case 3 contained examples of both types of muscle insertions.

A possible hereditary basis of congenital elbow luxations and subluxations was suggested by the following: (1) there was a high incidence of bilateral involvement (cases 1 and 2; Pass & Ferguson, 1971; Grøndalen, 1973; Stevens & Sande, 1974); (2) more than one animal in a litter was affected (cases 1 and 2; Grøndalen, 1973); (3) the embryonic stage at which the failure occurred was genetically controlled, and (4) the condition occurred in some animals possessing multiple soft tissue and skeletal anomalies. Breeding experiments should be conducted to clarify this point.

In the normal dog, the medial collateral ligament has been reported to be weaker than the lateral (Miller, Christensen & Evans, 1964; Sisson & Grossman, 1975). Perhaps this rendered it more vulnerable to injury or developmental agenesis. The interpretation of hyperplasia of the lateral collateral ligament was based on comparison with ligaments from several normal adult medium-sized dogs.

Congenital luxation of the radial head in children was reported to occur during the phase of joint formation and differentiation (Swanson, Barksy & Entin, 1968). Our observations of these canine elbows suggested a similar phenomenon.

Case 3 represented incomplete fusion of the embryonic rays of the forelimb. In human embryos, three parallel developmental areas form in the limb bud and coalesce to form the hand and forearm. The radial ray contains the radius, associated carpal and metacarpal bones and phalanges of the first digit. The medial ray contains the carpal and metacarpal bones and phalanges of the second digit. The ulnar ray contains the ulna, the carpal and metacarpal bones and phalanges
of the third, fourth and fifth digits (Kanavel, 1932; Entin, 1960; Kelikian, 1974). It appeared, however, that in this dog the medial and radial elements fused normally to form the radial ray, whereas the ulnar ray remained a separate entity. The radial ray in this dog contained the radius, radial carpal bone, and the first, second and third carpal and associated metacarpal bones and phalanges as would be found in the first three digits of a normal dog. The ulnar ray contained the ulna, ulnar, and accessory carpal bones and the fourth carpal bone plus the metacarpals and phalanges of the normal fourth and fifth digits plus an extra digit which lacked an associated carpal bone.

A thick fibrous band was in the position normally occupied by the ulna. It has been reported that in hemimelia in children such fibrous bands are found filling the defect and supporting the musculature (Freund, 1936; Kelikian, 1974).

The elbow defect in this case included an aplastic annular ligament and hypoplasia of the medial collateral ligament which was indistinguishable from the thickened joint capsule. As a result of failure of fusion of the radial and ulnar rays, the interosseous membrane was also absent. The ligamentous defects in the elbow of this dog were the same as in cases 1 and 2 but were believed to represent a more advanced stage combined with the failure of fusion of the radial and ulnar rays.

Surgical stabilization of the subluxated radial head can be obtained by placing a lag screw from the caudal ulna into the proximal radius. This should have been done in case 2 in order to maintain an anatomical reduction.

The osseous defects of congenital luxation of the radial head in children were hypoplasia or aplasia of the capitulum (lateral condyle) of the humerus, partly defective trochlea, prominent ulnar epicondyle, absence of the lesser sigmoid cavity (radial notch) on the radial aspect of the proximal ulna, undersized radial head bearing a dome-shaped articular surface and a comparatively long radius which bypassed the level of the elbow joint (Kelikian, 1974). In the dogs described by Stevens & Sande (1974) some correlation may be found in the osseous deformity of the lateral humeral condyles and radius with the most constant feature of human cases, the underdeveloped capitulum. However, the observations of Grøndalen (1973) and Campbell (1969, 1971) do not mention hypoplasia of the lateral humeral condyle. Defective trochleas and aplasia of the radial notch were observed in the elbows we studied. It would seem, therefore, that some correlations probably exist between human and canine congenital elbow luxations and subluxations. However, no documentation could be found concerning the integrity of the ligaments of the elbow in human radial head luxations. Additional detailed gross or surgical dissections of canine elbow luxations should be performed.

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