

## Case Report

# Stairstep Osteotomy for the Treatment of Radial Shortening and Forelimb Deformity in a Dog

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## Abstract

A case of radius shortening in an 11-month old female Fox Terrier referred to Veterinary Teaching Hospital of University of Camerino, Italy. Radiographic and tomographic examinations suggested a traumatic premature closure of distal and proximal physis of radius, resulting in a lateral and caudal radial shortening of 2.98 mm and moderate angular deformity in the proximal radius. Stairstep osteotomy of the radial diaphysis was performed to re-establishing the length of the bone and the elbow congruence. The distraction was obtained by temporary linear external skeletal fixation and the osteotomy was synthesized by using of a 2.4 locking compression plate applied to the cranial aspect of radius. This is the first description of sagittal sliding osteotomy used to correct both limb deformity and radial shortening.

**Keywords:** Radius shortening; Radioulnar incongruence; Homeroulnar subluxation; Premature closure of physis; Lengthening radius; Stairstep osteotomy

## Introduction

The normal anatomical development of the forelimb depends on synchronous growth rates of radius and ulna. A discrepancy in the growth rate or a complete closure of one or more of the physis can result in shortened angulated limbs, elbow and carpal joints incongruity and secondary osteoarthritis [1].

Symmetric or asymmetric premature closure of the radial physis is a congenital or acquired condition that can affect the radius of young dogs [2,3]. These conditions are less common than the premature closure of the distal ulnar physis [2-4]. In a report, O'Brien et al. [1] have observed an 11% incidence of distal closure and a 6% incidence of proximal physis closure of radius among all cases of forelimb growth arrest.

The premature closure of either physis of the radius, with the premature closure of the proximal one being rarer than the distal one [1], results in radial shortening and the bone remains usually straight if the closure is symmetrical. If the premature closure of the physis is localized in an eccentric area it usually results in some degree of angular deformity [3,5,6].

When the distal radial physis is symmetrically impaired, the amount of elongation of the radius slows dramatically [4,6]. Symmetrical closure of the distal radial physis is not often associated with angular deformity although carpal varus and inward rotation of the paw may result [7].

The radius provides the major weight-bearing surface of the elbow joint (75% to 80%) [8], but the radial shortening produces an intra-articular space between the radial head and the capitulum. The humeral trochlea displaces cranially and puts pressure on the coronoid process of the ulna [4,6]. In particular, Preston and colleagues concluded that a radioulnar step may concentrate physiologic forces on the elevated lateral edge of the medial coronoid process thus resulting in fragmentation [9].

If the radioulnar angulation doesn't concur, the rapidity of the degenerative process requires a surgical intervention in order to re-establish the congruency of the elbow joint, maintain the bone alignment and restore the limb to a functional position [4,5,10]. Rapidity and severity of osteoarthritis onset depend on patient's age and lifestyle [11].

Early surgical intervention is recommended in dogs with physeal injuries to minimize angular limb deformities [12,13].

There are different therapeutical options for the radial shortening taking into consideration the severity of the condition and also the age of the patient, since an additional surgical correction may be needed in animals treated at a young age that haven't still completed their growth [14].

Elbow incongruence is corrected by re-establishing the length of the radius, acutely or gradually, or by shortening the ulna [4].

## Case Presentation

An 11-month-old female Fox Terrier dog breed has been referred to Veterinary Teaching Hospital of the University of Camerino, Italy. Anamnestic data report an ulnar greenstick fracture treated conservatively with a Robert-Jones bandage, 4 months prior and intermittent right forelimb lameness. Gait evaluation revealed a shortened stride in ambulatory phase and moderate head "bob" on trot and varus angulation of the elbow and valgus of the carpi during station. Orthopedic examination revealed mild generalized right forelimb muscle atrophy and pain on flexion and extension of the elbow joint with mild limitation of the elbow range of motion. Campbell's test of the elbow was weakly positive and valgus and varus stress did not elicit elbow instability.

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Radiographic and tomographic examinations were taken. Mediolateral and craniocaudal radiographic projections of the right radio-ulnar display a symmetric premature closure of the distal radial physis and asymmetric premature closure of the proximal radial physis, which were results in incongruities of the caudal and lateral radial head and a moderate valgus of the proximal anatomical radial angle (aMRPRA 90°) (Figure 1A and B) [15,16].

CT was performed on a single-slice helical CT-scanner (CT/e General Electric single-slice computed tomography

scanner) with a slice thickness of 1 mm. Images of the forelimbs were acquired in sternal recumbency with the elbow joints flexed to approximately 90 degrees. Joint incongruence was evaluated using a duplicated circle superimposition technique in sagittal CT slice (Figure 2A and B) [17-20]. The 3D reconstruction was used to obtain proximal and distal anatomical articular angle. The elbow incongruence was found to be 2.98 mm, the aMPRA and aLDRA were respectively 90° and 86° (Figure 2).



**Figure 1:** A) Craniocaudal radiographic projection. Moderate valgus of the proximal radius. B) Mediolateral radiographic projection. Incongruities of the caudal and lateral radial head.

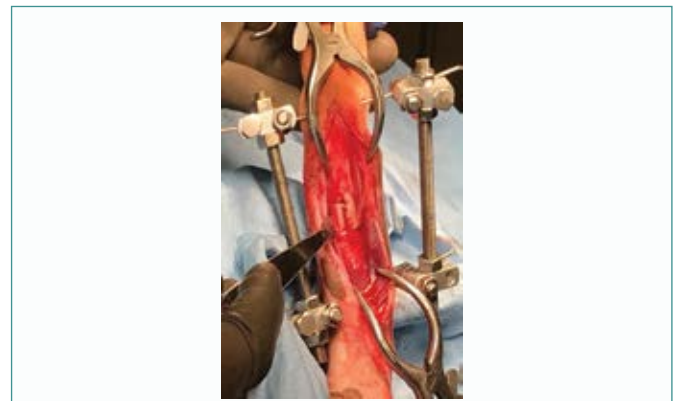


**Figure 2:** A) 3D reconstruction. B) Joint incongruence evaluated by duplicated circle superimposition technique in sagittal CT slice.

The patient underwent an acute radial elongation to restore congruency of the elbow and the correct frontal proximal alignment (83° aMPRA). The anesthesia protocol consisted of premedication with dexmedetomidine (2 µg/kg, Intramuscularly [IM]), and methadone (0.2 mg/kg Intramuscularly [IM]). General anaesthesia was induced with propofol (2 mg/kg - 4 mg/kg Intravenously [IV]) and maintained with inhalational anesthesia with isoflurane. The affected limb was

clipped from the dorsal ridge of the scapula to the level of the mid metacarpi. A 4% chlorhexidine gluconate cleanser with a minimum contact time of 5 minutes was used for the preliminary surgical site preparation. In theatre, the dog was positioned in dorsal recumbency, and the right limb was suspended from a ceiling-mounted hook. A veterinary technician performed the final skin preparation with sterile gloves, sterile gauze sponges, and a 4% chlorhexidine gluconate cleanser before application of an alcoholic chlorhexidine gluconate spray (0.5%). Cefazolin (22 mg/kg IV) was administered approximately 30 minutes before the first incision, and administration was repeated every 90 minutes throughout general anesthesia.

Stairstep frontal osteotomy was performed through craniolateral approach to the proximal-midshaft of the radius. Two pins were applied to the radius, proximally pin was inclined as joint reference angle to obtain during distraction a correction of the valgus; the two pins were connected with 2 bars, medially and laterally, building a bilateral uniplanar external fixator. The temporary linear external skeletal fixation was used to distract segments of the radius and to obtain a correction of the proximal joint angle after osteotomy. A stair-step osteotomy of the radial diaphysis was created with an oscillating saw using a narrow saw blade (Figure 3).



**Figure 3:** Intraoperative images. Stairstep osteotomy of the radial diaphysis and distraction by using a temporary linear external skeletal fixation.

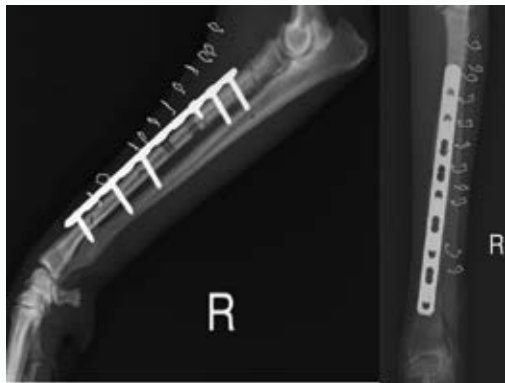
The osteotomy was performed above the radial insertion of interosseous ligament. The radial segments were distracted for 3 mm according to preoperative measurements by using the external fixator, until the head of the radius was placed in the correct relationship with the capitulum and the coronoid process. This relationship was established by intraoperative radiographs and reproducing preoperative measurements during distraction with an orthopedic ruler. The radial proximal and distal segments were stabilized by an LCP Synthes 2.4 mm (Locking Compression Plate) and 6 locked screws used as a neutralization plate applied to the cranial aspect of the radius (Figure 4). The temporary external fixator was removed, and the soft tissues were routinely sutured.

A soft padded compressive bandage was applied for 24-48 hours to minimize swelling after surgery.

Methadone at 0.1 mg/kg was administered intravenously as needed for 24 hours postoperatively to provide analgesia. In the hospital was administered anti-inflammatory therapy (Carprofen 2 mg/kg, bid), and ranitidine (2 mg/kg, BID) intravenously.

The dog was discharged from hospital after 24 hours with medical prescription of anti-inflammatory and analgesic therapy. The client was instructed to limit the motion of dog, only walking at leash was

allowed. Exercise was then gradually reintroduced, depending on the dog's clinical progress and radiographic assessments.



**Figure 4:** Post-surgery mediolateral and craniocaudal radiographs.

X-ray evaluation at 60 days postoperatively revealed healing of the osteotomy of the radius and a thinning of the ulna due to the stress protection for the locking implant. The implant was subjected to a dynamization (Figures 5A and 6A) and after 90 days was completely removed (Figures 5B and 6B). On orthopedic examination, gait evaluation revealed a mild right forelimb lameness and visual inspection detected mild bilateral carpal valgus more pronounced in the right limb. The range of homolateral elbow motion was improved and pain on palpation was absent on flexion and extension. There was pain on flexion of carpal joint and Campbell's test of homolateral carpus was positive. Radiographs showed stress protection of the bone and plate and screws were removed. X ray examination shows a better congruency of the elbow (1 mm) with a good improvement of the anatomical medial proximal radial angle ( $84^\circ$  aMPRA), with a mild worsening of distal varus of the distal radius (Figures 7A-D).



**Figure 5:** A) Patient at 60 days postoperatively. B) 90 days postoperatively.

## Discussion

Acute elongation of the radius with sagittal sliding osteotomy is a good strategy technique for radial shortening in adult dogs, in particular in those with less severe radio-ulnar step. A literature doesn't currently propose a guideline to govern the surgical choice on the need for a gradual correction with respect to the acute one. Choices are based on the surgeon experience; this case illustrates the successful use of acute one-stage radial elongation to manage radial shortening in a patient with a reduced potential growth [4].

Acute elongation technique choice was based on surgeon selection of the patient and for the slight radioulnar step incongruence detected.



**Figure 6:** A) 60 days postoperative mediolateral radiography: screws removal. B) 90 days postoperative mediolateral radiography: implant removal.



**Figure 7:** A,B) Improvement of aMPRA and mild worsening of distal varus of the radius. C,D) Improvement of congruency of the elbow.

Use of the internal fixation with locking plate leading less discomfort after surgery with good stability of the osteotomy [4].

Treatment of radial shortening, in skeletally mature dogs can be alternatively performed by ulnar osteotomy, which provide acute restore of mild incongruence preserving the load sharing bone [9,20]. The advantage of this technique is that proximal segment of ulna is compressed to distal segment during weight bearing and the radial head will find its own position relative to the humeral trochlea. If limb length is sufficient for reasonably good function, ulnar shortening is probably to prefer, because if is completed in a proximal to the interosseous ligament and in a dynamic fashion achieves good stability without rigid fixation [21]. However, ulnar osteotomy is not useful to manage forelimb deformity in young-adult or adult dog.

Although the incongruity was mild, preoperative planning showed a proximal valgus of radial head due to asymmetrical physis closure and radial lengthening method was necessary to restore limb alignment. Distraction osteogenesis can be used to treat the lengthening of the antebrachium and also correcting angular deformity [22,23].

This technique allows some adjustability during continued growth, so it has advantages in the young animals [24]. Treatment of radial shortening in skeletally mature dogs can be performed with any of the gradual dynamic lengthening procedures, which would be particularly advantageous if the length discrepancy of the radius is very large and it is a feasible option for stretching the soft tissues joining the two bones [4].

Burton et al. [19] affirmed that acute distraction of radial segments allows a precise control over the obtained congruity, a reduced incidence of delayed healing or non-union, and a reduced morbidity associated to the use of external fixator in a gradually distraction.

To the best of our knowledge, this is the first description of sagittal sliding osteotomy used to correct both limb deformity and radial shortening. This surgery resulted in satisfactory forelimb function up to the 24 hours postoperative follow-up. No major complications were encountered. The mild lameness due to implant discomfort was completely resolved after removal. Postoperative X-ray examination displayed an improvement of proximal alignment with a mild worsening of valgus of anatomical lateral distal radial angle, without clinic significantly.

Removing the internal implants was necessary to resolve ulna resorption due to stress protection. The excessive implant's stiffness compromised biomechanical loading of the bone results from an imbalance in bone homeostasis leading to predominant osteoclastic activity [25]. Bone resorption following plating of the radius is reported more often in small breeds dogs than in large breed dogs [26,27]. Recently, Böttcher and Eljack reported a correlation between an axially shortened radius and severe medial compartment elbow disease. The acute and accurate lengthening of the radius in dogs with a short radius may permit an immediate abaxial shift of load through the humeral trochlea from the medial coronoid process to the radial head, reducing the severity of medial compartment change that may subsequently develop [28]. Treatment of the elbow incongruence and bone lengthening were necessary to obtain a functional forelimb and prevent or slow down the progression of degenerative joint disease.

## Conclusion

This report confirms that the acute re-establishment of the radial length by sagittal sliding osteotomy is an effective treatment strategy and that it is a successful technique even for the correction of angular deformity.

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