

Case Report Surgery



Single oblique osteotomy for correction of congenital radial head luxation with concurrent complex angular limb deformity in a dog: a case report

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ABSTRACT

A 5-month old Shih Tzu was diagnosed with congenital elbow luxation and uniapical complex angular deformity of the radius. Single radial oblique and dynamic ulnar osteotomies were performed, using patient-specific 3D-printed osteotomy guide. External skeletal fixation was maintained for three weeks to prevent re-luxation of elbow joint. Three months after the surgery, objective gait analysis indicated markedly improved limb function. In addition, radiograph showed improved congruity of elbow joint and appropriate bone healing. In dogs with congenital radial head luxation and concurrent complex angular deformity, a single oblique osteotomy might be a viable option to preserve bone length and correct the luxation of elbow joint.

Keywords: Elbow; luxation; radial head; single oblique osteotomy; congenital

INTRODUCTION

Congenital radial head luxation has been reported in small dogs. Most owners recognize the problem between the ages of 3 and 5 months [1]. Clinical signs include forelimb lameness, pain, reduced range of elbow motions, swelling, and angular limb deformities [2,3]. Radiographic findings include radial head caudolateral dislocation, with concurrent angular limb deformities affecting the radius and ulna [3,4]. Treatment options include conservative management and surgical treatment. Surgical treatment is indicated in patients with pain and lameness, while conservative management may be indicated in patients with mild clinical signs. In such patients, surgical intervention may be advisable to prevent lameness, persistent deformities, and osteoarthritis secondary to the radial head luxation [5]. Open reduction and temporary transarticular pinning [6], closing wedge osteotomy of proximal radius [7], gradual traction using external skeletal fixation (ESF) [5], radial head osteotomy

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Conflict of Interest

The authors declare no conflicts of interest.

Author Contributions

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[8], and arthrodesis have all been reported as optional surgical approaches. However, to date no standard surgical technique has been established.

Single oblique osteotomy (SOO), as a surgical technique for simultaneous correction of a uniapical angular and torsional deformity of the long bone while maintaining osseous contact and avoiding bone loss was recently reported in a dog [9]. The purpose of this case report is to describe SOO, followed by temporary ESF, for congenital radial head luxation with concurrent complex angular limb deformity of the antebrachium.

CASE PRESENTATION

A 5-month-old, 3.1 kg, intact male Shih Tzu was presented with right lateral elbow prominence and right forelimb lameness, with no history of trauma. When manipulating the joint, crepitus and decrease in range of motion were noted. On radiographs, the radius of the affected leg was shorter than normal and the radial head was luxated caudolaterally (**Fig. 1**). The ulna was also confirmed to be bowed. Proximal and distal radial growth plates were open. Based on the examination, congenital radial head luxation was diagnosed.

Computer-Assisted 3D Surgical Planning and Patient-Specific 3D-Printed Surgical Guide

For preoperative planning, bilateral transverse forelimbs CT scans were obtained, with slice thickness of 0.5 mm, mA = 200, and kVp = 120. The CT scans were converted to 3D surface models using a 3D modeling software (Mimics Innovation Suite 20, Materialise NV, Leuven, Belgium). The distal portion of the affected radius was superimposed to the mirror surface model of the contralateral normal radius to determine characteristics of the deformity, using a mesh handling computer-aided design (CAD) software (Meshmixer 3.2, Autodesk, Inc., USA) (**Fig. 2**). Comparison with the contralateral radius revealed a uniapical angular limb deformity with 15-degrees valgus and 5-degrees procurvatum. There was also a 40-degrees external torsion of the proximal radius, according to proximal physeal landmarks suggested by Meola et al. [10]. Since the radius was already short and the angular limb deformity was complex and included torsion, a SOO technique was recommended. Following this technique, we could minimize reduction in bone length and increase its contact surface. The true magnitude of the angulation was 16 degrees at the 30-degree oblique to the frontal plane. The orientation of SOO was determined as described by Kim et al. [9]. The orientation of SOO was calculated to be 22 degrees from the bisector plane (transverse plane) on the convex surface in the oblique angulation plane. A virtual SOO surgery of the 3D printed bone model predicted satisfactory alignment of the right radius, with a length discrepancy between the radii. Patient-specific surgical guides (PSG) were designed, using Mesh-handling CAD software. The guide consisted of a slot for osteotomy and holes to affix it to the bone with 1.1 mm Kirschner wire (**Fig. 1**). These would also aid reduction and placement of the 2.0 locking compression plate. A SOO procedure was rehearsed, using the 3D printed models and the PSG, and the bone plate was pre-contoured.

Surgery

The planned SOO procedure was performed, followed by open reduction of the radial head (**Fig. 2**). Craniomedial approach was performed. Branches of the cephalic vein were identified, the radius was exposed, and the PSG was applied to it. However, it was difficult to mount the guide in the correct position because of the guide's length and disturbance of soft

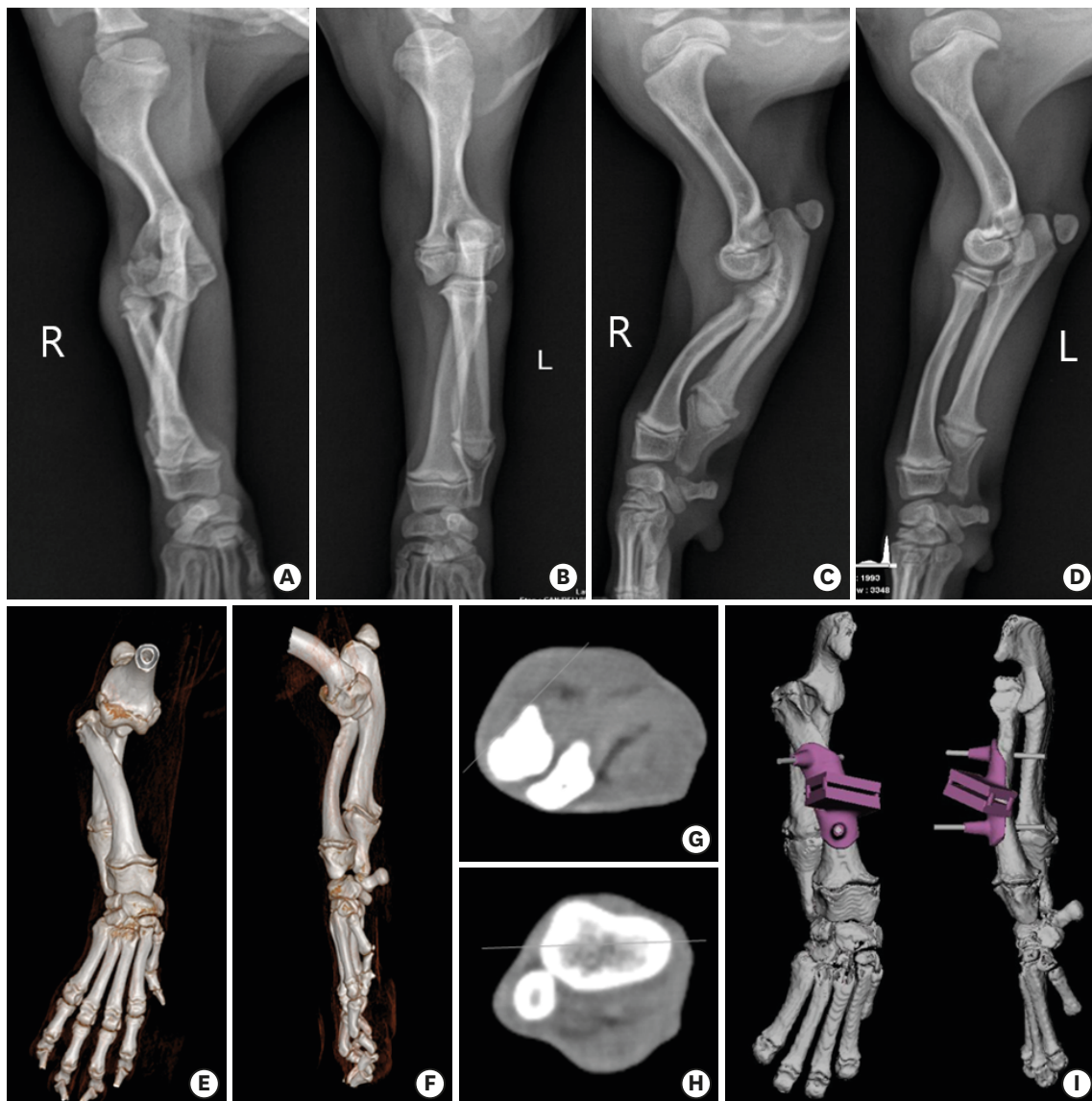


Fig. 1. Radiographic images of both forelimbs and surgical planning before surgery. Orthogonal radiographs of the bilateral elbow joints (A-D). (A, C) Note the caudolateral radial head luxation of the affected forelimb. Computed tomography reconstruction of the limb's angular deformity and measurement of torsional deformity (E-H). Illustration of a 3-D reconstructed bone and surgical guide model, used for preoperative surgical plan (I).

tissue. It was therefore possible to attach the guide to the correct position only after using a lateral approach. 1.1 mm k-wires were used to fix the surgical guide through the proximal and distal fixation holes. Ulnar osteotomy was performed at the level of the SOO. After the guide was removed, the angular and torsional deformities were simultaneously corrected by externally rotating the distal segment. The osteotomy was stabilized with the pre-contoured bone plate. Subsequently, the radial head was reduced and temporary ESF was placed. After copious flushing with saline, the wound was closed in a routine manner.

Postoperative care and follow up

The temporary ESF was maintained for 3 weeks. Three-month postoperative radiographs showed complete healing of the SOO, with synostosis between the radius and ulna, and improved elbow congruity (**Fig. 2**). Symmetry index and weight distribution of peak vertical

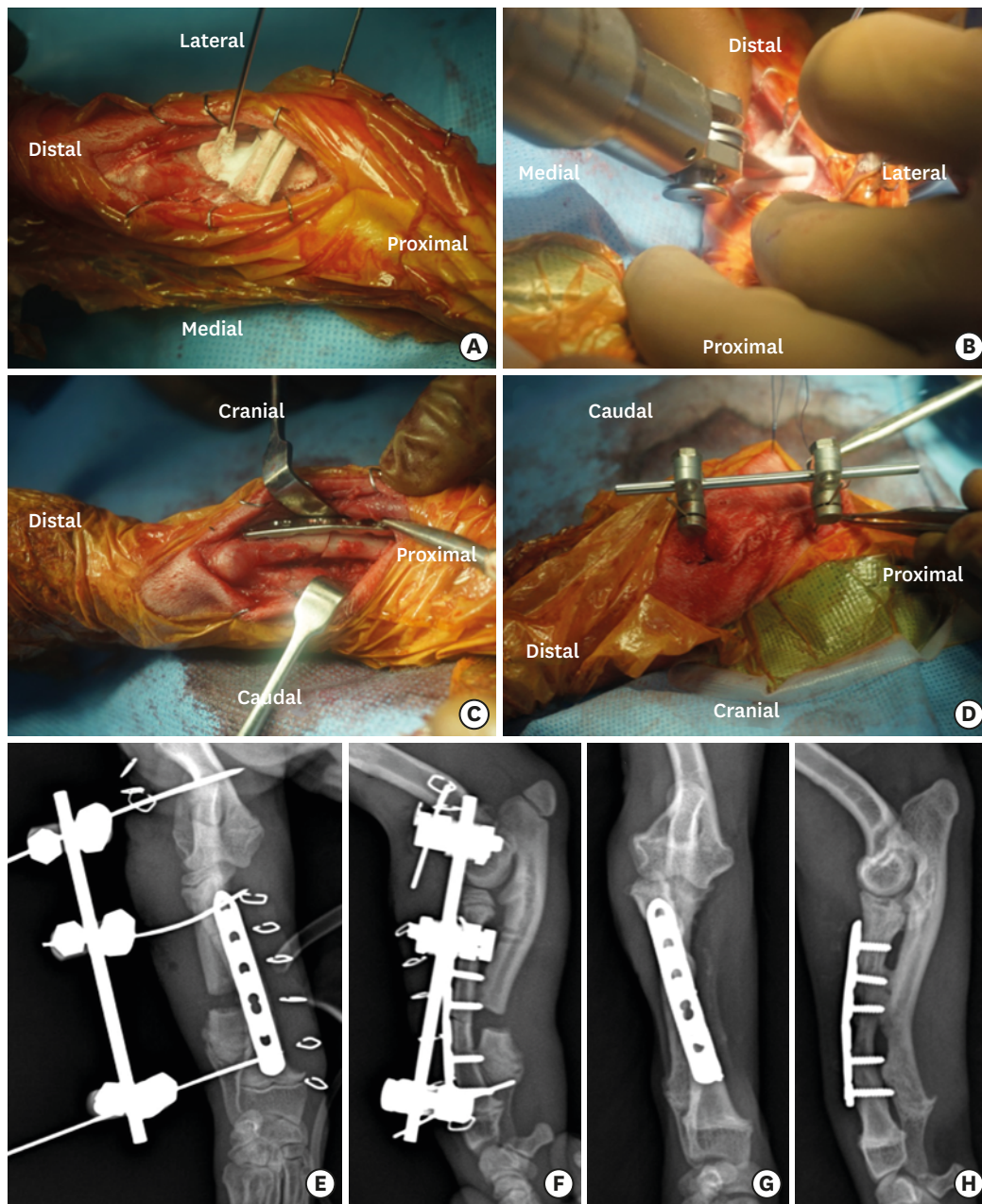


Fig. 2. Intraoperative photographs and postoperative radiographs. (A-D) Reduction of the radial head has been achieved with a single oblique osteotomy technique, followed by immobilization, using temporary external skeletal fixation. Radiographic images immediately postoperative (E, F) and 3 months later (G, H).

force and vertical impulse were measured on a pressure sensor walkway (Walkway, Tekscan Inc., USA) at 3 weeks, 7 weeks and 3 months after surgery and data were analyzed using a repeated measures ANOVA, with a post hoc Sidak multiple comparison test. Objective gait analysis revealed improvement in the symmetry index and weight distribution during the three months since the surgery (**Fig. 3**).

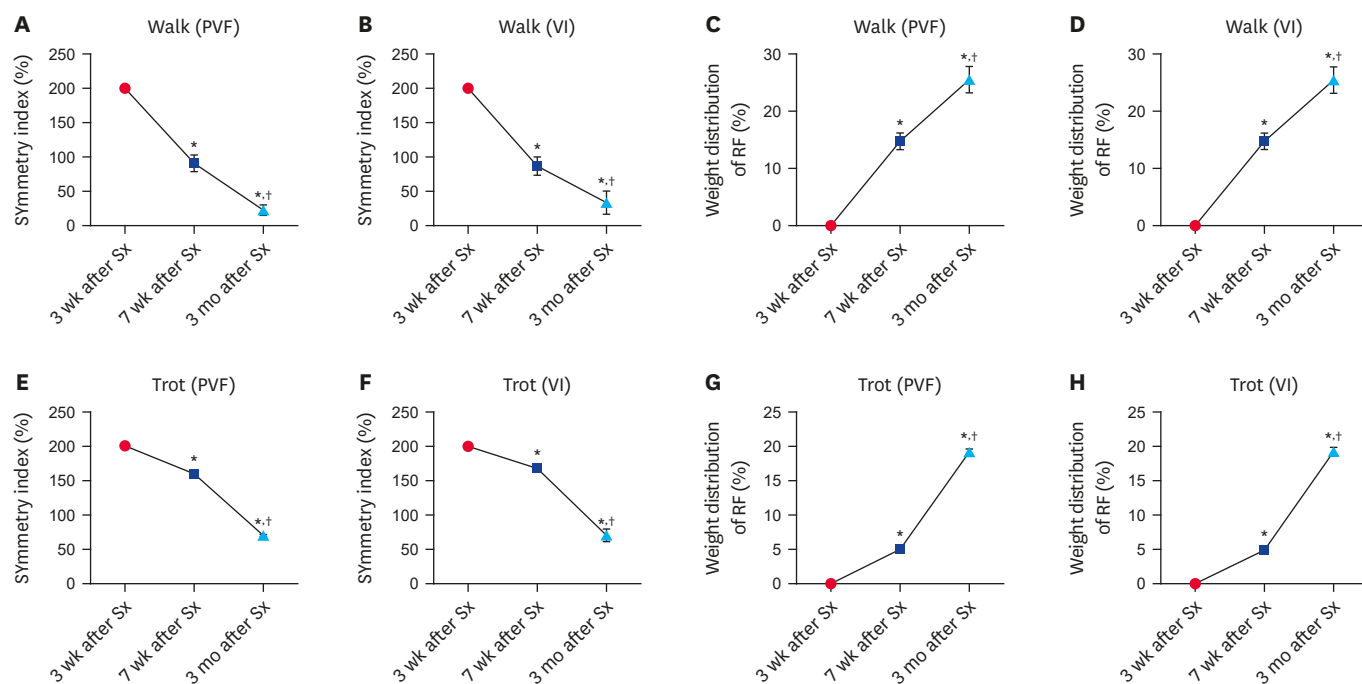


Fig. 3. Gait analysis on pressure sensor walkway. Forelimb symmetry indices and weight distribution at 3, 7, and 12 weeks after surgery revealed a tendency to restore function of the right forelimb. (A, C, E, G) PVF; (B, D, F, H) VI. PVF, peak vertical force; VI, vertical impulse; RF, right forelimb. *Significant change from 3 weeks after surgery; †significant change from 7 weeks after surgery.

DISCUSSION

In this case report, the patient had a congenital radial head luxation with complex angular limb deformity of the radius. These were treated by a SOO technique and temporary transarticular ESF. SOO is an effective technique to surgically correct angulation and torsion simultaneously. It has the advantage of maintaining osseous contact and allowing rigid internal fixation without bone loss [9]. However, surgical planning is considered complex, and accurate execution of the planning is challenging [11]. For the case reported here, surgical planning was done by computer-assisted 3D modeling and characterization of the deformities. In addition, because of the complexities of planning, virtual surgery was performed. As a complex surgery, PSG was used to achieve accurate outcome. Improvements in surgical accuracy with PSG have been reported in several case series [12-14].

To date, there is no ideal treatment for radial head luxation and no evidence that surgical intervention is better than conservative treatment when clinical signs are mild. However, early surgical intervention is likely to slow the progression of osteoarthritis, and to improve limb function. Moreover, it is reported that if the radial head is reduced before the age of 5 months, remodeling of the articular cartilage is more likely to occur, than if later reduction is performed [3,7]. Therefore, it was decided to perform the surgery after consultation with the owner, and considering the following: anomalies in the affected limb as well as osteoarthritis and lameness were already present and were likely to progress; age of the dog was at the optimal operation time's upper limit. Based on radiographic assessment 3 months after surgery, congruity of the elbow joint was good. In addition, considering the absence of lameness and pain, timing, when the patient is 5 months old, can be considered appropriate for reduction of the radial head.

Many surgical procedures have been reported to correct congenital elbow luxation. Closing wedge osteotomy is the most commonly reported method. However, it causes bone loss and shortening in the radius' length. Furthermore, it needs larger ulnar osteotomy due to the shortened radius. SOO, however, requires smaller ulnar osteotomy because it has no bone loss and the radius is not shortened. However, the effect of length change caused by closing wedge osteotomy has not been evaluated. Moreover, correction by closing wedge osteotomy can only correct procurvatum/recurvatum and varus/valgus, so that after correction, the radial head might still be externally rotated, even if its head had been reduced. On the other hand, not only SOO corrects procurvatum/recurvatum and varus/valgus, but it also corrects torsion deformity. By correcting torsion, SOO may provide better congruity than after closing wedge osteotomy. This can be confirmed by the significantly improved congruity noted on the radiographs.

Temporary elbow joint immobilization seems to be necessary to prevent re-luxation of the radial head, caused by the tendency of the soft tissue to return to its original position. Approaches such as transarticular pinning, capsulorrhaphy, and collateral ligament tightening/prosthetic collateral ligament have been previously reported [15]. However, external support, such as a modified external skeletal fixator, might be useful to minimize joint damage. In this case, immobilization was performed for three weeks, using temporary ESF. There was no re-luxation of the radial head after its removal. Furthermore, objective gait analysis showed improvement in weight bearing following the procedure. However, outcome could not be directly compared with other case reports since use of such objective data has not been reported before.

In dogs with congenital radial head luxation concurrent with angular bone deformity and torsion, SOO technique might be a viable option to preserve bone length and correct the luxation of the elbow joint. However, given that this is a single case report with short-term follow-up, more reports or clinical trials, with long-term follow-up, are needed to reach more conclusive recommendations.

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