Lateral closing isosceles triangular osteotomy for the treatment of a post-traumatic cubitus varus deformity in children

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Aims
Cubitus varus is the most common late complication of a supracondylar fracture of the humerus in children. Correction can be performed using one of a number of techniques of osteotomy but each has disadvantages. We describe a new technique for correcting post-traumatic cubitus varus using a lateral closing wedge isosceles triangular osteotomy.

Patients and Methods
A lateral closing wedge isosceles triangular osteotomy was performed in 25 patients (15 male and ten female with a mean age of 9.5 years (6 to 12)) between May 2010 and April 2013. All patients had cubitus varus secondary to malunion of a supracondylar fracture, with good function of the elbow and a full range of movement. The osteotomy lines were marked on the bone with an isosceles triangular template made before surgery, after which the osteotomy was performed leaving the medial cortex intact. Fixation was performed using two lateral 2 mm Kirschner (K)-wires and patients were immobilised in an above-elbow plaster. By six to eight weeks callus was present and the wires and cast were removed. Patients were reviewed at four and six weeks, three, six and 12 months and then every two years until skeletal maturity. Clinical and radiographic outcomes were categorised as excellent, good or poor.

Results
A total of 23 patients had an excellent and two had a good outcome at a mean final follow-up of 3.4 years (two to four). The mean post-operative carrying angle in the corrected elbow was 11.7° (7° to 18°). One patient fell, displacing the osteotomy, and needed revision of the fixation. No patient had a nerve injury.

Conclusion
A lateral isosceles triangular osteotomy and with K-wire fixation is a practical, effective, reliable, safe and simple method of correcting post-traumatic cubitus varus in children. It has inherent stability and excellent cosmesis without prominence of the lateral condyle.

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A cubitus varus deformity is the most common late complication after a supracondylar fracture of the humerus in children.1 Although this deformity rarely results in a functional deficit, it is poorly tolerated aesthetically and several forms of corrective osteotomy have been used to improve the appearance of the elbow.2-3,11 Traditional approaches include a straight or step-cut lateral closing-wedge osteotomy, a transverse or oblique medial opening-wedge osteotomy and a dome osteotomy,6,12-15 each having both advantages and disadvantages. Because it is the simplest method of correction, a lateral closing-wedge osteotomy has been used most commonly, but it has many technical pitfalls.16 Complications include prominence of the lateral condyle, instability and difficulty in correcting internal rotation.8,12,13,17,18 Removal of a large wedge in children with a severe deformity can produce a pronounced step at the lateral side of the osteotomy due to mismatch in the diameter of the proximal and distal fragments (Fig. 1).19 While a dome osteotomy8,9,19,21 may achieve a better cosmetic result, most techniques necessitate the use of the triceps-splitting posterior approach which may result in a decreased post-operative range of movement (ROM)8,9,19,20,22. Good functional and cosmetic results have been reported after several other osteotomies but many of the techniques described are complex and technically challenging.1,7,9,11,21,23-27
A good corrective approach should be simple, safe and technically sound, and should be able to give near-normal cosmesis and excellent function. We describe a new technique, a lateral closing-wedge isosceles triangular osteotomy, which is designed to correct the varus deformity while avoiding the complications of traditional techniques.

**Patients and Methods**

Between May 2010 and April 2013, following ethical approval, 25 patients underwent a lateral closing isosceles triangular osteotomy for a cubitus varus deformity resulting from malunion of a supracondylar fracture of the humerus. There were 15 male and ten female patients with a mean age of 9.5 years (6 to 12); the right elbow was involved in 17/25 patients (70%, Table I). Patients underwent surgery if the deformity had persisted for > two years and if the varus angle was > 15°, without a noticeable internal rotation deformity. All patients had good function of the elbow with a full range of movement (ROM) prior to surgery.

Pre-operative anteroposterior radiographs of both upper extremities are assessed to confirm the angle of the bone

Table I. Humerus-elbow-wrist (HEW) angle; difference, pre-operative and post-operative details of range of movement (ROM), time to union, and follow-up time and details of current surgical procedure

<table>
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<tr>
<th>No</th>
<th>Gender</th>
<th>Pre-operative HEW (°)</th>
<th>At follow-up HEW (°)</th>
<th>Pre-operative f/e (°)</th>
<th>Post-operative f/e (°)</th>
<th>Union time (wk)</th>
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Results expressed as per Oppenheim’s criteria
* obstetric brachial plexus palsy at the same side
f/e, flexion and extension
cuts and templates are created to determine the dimensions of the osteotomy (Fig. 2). The humerus-elbow-wrist (HEW) angle is determined in both arms as described by Oppenheim et al.  

The procedure is performed under general anesthesia using a tourniquet. A 4 cm to 6 cm longitudinal incision is made over the lateral distal humerus and the interval between the brachioradialis and triceps muscles is developed. The distal humerus, including the coronoid fossa, is exposed circumferentially by subperiosteal dissection. The lines of the osteotomy are marked using the template. The distal line (BO) is made 1 cm proximal to the coronoid fossa to allow clearance of the fossa in flexion and extension. The osteotomy is made, taking care to preserve the medial cortical hinge, and is closed and fixed using two 2 mm Kirschner (K)-wires which are passed from lateral to medial and left proud of the skin (Fig. 3). Following fixation, the carrying angle is determined using a goniometer and the ROM is compared with the contralateral side to ensure that full flexion and extension are maintained. Stability of the construct is confirmed by taking fluoroscopic views under valgus and varus stress. Following closure, a long-arm cast is applied with the elbow at 90°, and the forearm in neutral rotation.

All procedures were carried out by a single senior surgeon (GN). Radiographs were taken six to eight weeks post-operatively to confirm the formation of callus, and the cast and pins were removed. While most children do not require formal physiotherapy, we generally educate the parents on how to exercise the elbow. The patients were reviewed at four and six weeks, three, six and 12 months later and then every two years until skeletal maturity. Outcomes were categorised as excellent, good or poor according to Yun’s criteria (based on Oppenheim’s criteria). Post-operative clinical assessment included the carrying angle, the ROM of both elbows, and the incidence of complications. Radiographic examination included anteroposterior and lateral radiographs to determine the HEW angle, degree of union and the extent of prominence of the lateral condyle.

Results
A total of 23 patients (92%) had excellent results, and two (8%) had good results at a mean follow-up of 3.4 years (2 to 4). All the osteotomies had healed at the time of the first follow-up appointment at six to eight weeks. Prior to surgery, the mean HEW angle was -18.5° (-29° to -15°) in the affected elbow, compared with 8.5° (5° to 15°) in the contralateral elbow. Following surgery, the mean angle in the corrected elbow was 11.7° (7° to 18°), representing a mean correction of 30.2° (24° to 47°). There was one major complication requiring revision surgery. This patient fell following surgery, removing the pin and displacing the osteotomy. A full recovery was made after revision surgery and the patient was then classified as excellent. A total of seven patients (28%) had a minor complication; three had a pin site infection and four had extensive scarring. None had evidence of nerve injury.

Discussion
A lateral closing wedge osteotomy for correction of cubitus varus deformity is popular due to its simplicity, and its reliability in achieving an adequate correction with a low rate of complications. However, by producing fragments of unequal widths, a lateral bony prominence is present in between 42% and 47% of patients. In the technique described here, the use of an isosceles triangular osteotomy
eliminates this problem by equalising the two sides of the osteotomy, so that they match exactly when the osteotomy is closed without disrupting the medial periosteal hinge (Figs 4 and 5). Preservation of the medial hinge provides stability to the construct which, with the large area of bony contact at the site of the osteotomy, allows fixation with two lateral wires. Other techniques with less inherent stability require fixation with plates and screws which require a further anaesthetic to remove. While fixation was lost in one patient, this followed trauma. In most patients, considerable callus formation was observed after four to five weeks of immobilisation and the K-wires could be removed at six to eight weeks, allowing early mobilisation, contributing to the good outcome. A further advantage of this technique is the use of a direct lateral approach. The avoidance of a triceps splitting approach reduces the incidence of post-operative stiffness, and the use of a lateral approach and lateral wires means that the ulnar nerve was not put at risk.

We have shown excellent results with few complications. No patient had limitation of movement, none had lateral bony prominence and there were no neurovascular complications. To our knowledge, this is the first description of the use of this osteotomy for the treatment of cubitus varus.

Cubitus varus is a complication of supracondylar fractures of the humerus in childhood, arising as a result either of inadequate reduction, loss of reduction during healing, or disturbance of growth due to a physeal injury. Correction is mainly indicated for cosmetic reasons but some patients may have symptoms such as pain, ulnar nerve dysfunction or a snapping sensation during movements of the elbow.

In addition to a medial opening wedge, many other types of osteotomy have been described to produce an adequate correction whilst avoiding the creation of a lateral bony prominence. Step-cut osteotomies, dome osteotomies and lateral closing wedge techniques with medial translation of the distal fragment can be used to decrease the lateral prominence, however, these approaches are more complex than lateral closing wedge osteotomy, are technically demanding and produce relatively unstable constructs. Using a lateral closing wedge with medial displacement of the distal fragment can improve the cosmetic outcome, but involves disruption of the medial periosteal hinge, reducing the stability of the construct.

Typically, the deformity in cubitus varus is 3D and characterised by extension, internal rotation and varus angulation of the distal fragment. We used an osteotomy which was designed to correct the deformity mainly in the coronal plane alone. This method can be modified to correct an extension deformity simultaneously, but is not designed to correct an internal rotation deformity. The need for rotational correction is controversial. Multiplanar osteotomies may result in poor healing due to the small area of bone contact at the osteotomy site, and we believe, on the basis of the evidence available, that cubitus varus may be satisfactorily corrected using a uniplanar osteotomy.

The main limitations of this technique, in common with other approaches, are that it cannot correct severe internal rotation deformities and that it is associated with scarring on the lateral aspect of the elbow. The only patients in our study who did not achieve improved cosmesis were those with considerable scarring. Whilst a good, sustained improvement in alignment of the elbow was achieved, not all patients were followed to skeletal maturity.

This study has shown that a lateral isosceles triangular closing wedge osteotomy with K-wire fixation is a practical, straightforward, reliable and effective method of correcting cubitus varus in children after malunion of a supracondylar fracture. It results in excellent cosmesis without prominence of the lateral condyle, and has a low rate of complications. Studies with a larger sample size and longer follow-up will be necessary to assess the long-term efficacy of this technique.
Take home message:
The study proposed is a practical, effective and simple method of correcting post-traumatic cubitus varus in children.

Author contributions:
Y. Su: Collected the data, Performed the statistical analysis, Drafted the manuscript.
G. Nam: Study conception, Participated in its design and coordination, Helped to draft the manuscript.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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References