SUPRACONDYLAR OSTEOTOMY WITH ILIZAROV FIXATION FOR ELBOW DEFORMITIES IN ADULTS

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Stable fixation after a corrective supracondylar osteotomy in adults is difficult because of the irregularity of the area of bony contact, displacement of the fragments, the predominance of cortical bone, and the need for early mobilisation.

We have used the Ilizarov apparatus for fixation in 15 patients who were treated by complex osteotomies with displacement of fragments for cubitus varus or valgus. Most patients with cubitus varus required medial displacement with rotation of the distal fragment. Those with cubitus valgus required lateral shift of the distal fragment to reduce the medial prominence of the elbow that would otherwise result.

All osteotomies united within the expected time without loss of correction, despite early mobilisation. Complications related to the fixation were few and had resolved at the long-term follow-up.

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Cubitus varus or valgus is a common complication of supracondylar or lateral condylar fractures of the humerus. Operation is often required to improve the appearance in cubitus varus and to correct tardy palsy of the ulnar nerve in cubitus valgus. Many methods have been described to fix the fragments after a corrective osteotomy. In children, French’s technique using Kirschner wires or screws is adequate.1 In adults, however, plate fixation is difficult and often inadequate, especially when displacement or rotation of the distal fragment is required after supracondylar osteotomy to reduce a prominent lateral condyle in cubitus varus or a prominent medial condyle in cubitus valgus.

The use of a monolateral external fixator for stabilisation of the fragments after closing or open wedge osteotomies for the treatment of cubitus varus in children has been described by King and Secor2 and Levine, Horn and Pizzutillo,3 but there are no reports of the use of this technique in adults. The method gives acute correction of three-dimensional deformities and allows early movement of the elbow after surgery, without the risk of loss of correction. Our aim was to evaluate the results and complications of the supracondylar closing wedge osteotomy in the treatment of elbow deformities in which the Ilizarov apparatus was used for stabilisation.

PATIENTS AND METHODS

We studied eight patients with cubitus varus and seven with cubitus valgus. There were nine men and six women with a mean age of 22 years (15 to 41). The average interval between the fracture and the corrective osteotomy was ten years. Seven patients had cubitus varus after malunion of a supracondylar fracture and one developed the deformity after a lateral condylar fracture with hypoplasia of the trochlea. Valgus deformities occurred after Milch type-II lateral condylar fractures of the distal humerus in four patients, Milch type-I fractures in one and dislocation of the radial head in two. All patients with cubitus valgus had tardy palsy of the ulnar nerve.

In the patients with cubitus varus we used a closing lateral wedge valgus osteotomy with medial displacement of the distal fragment (Fig. 1) and in those with cubitus valgus, a closing medial wedge varus osteotomy with lateral shift of the distal fragment (Fig. 2). Excision of the radial head was required in two patients with cubitus valgus after long-standing, unreduced dislocations. Loose bodies were removed from two elbows.

Outcome scores were based on the evaluation of the carrying angle determined by measuring the humeral-elbow-wrist (HEW) angle pre- and postoperatively, the range of elbow movement and the presence or absence of complications.
Operative technique. We made an incision approximately 5 cm proximal to the tip of the olecranon along the centre of the triceps and continued it medially to the olecranon for approximately 3 cm. This part of the incision allowed exposure of the ulnar nerve, so that it could be isolated and transposed anteriorly. It was dissected to just above the muscular branch of the flexor carpi ulnaris, placed subcutaneously, and sutured to the biceps fascia. The triceps was then split longitudinally to expose the distal humerus. Using fluoroscopy, a reference wire was inserted from the medial to the lateral epicondyle, parallel to the distal articular surface of the humerus. Laterally, this wire must be inserted into the centre of the capitulum. It should be posterior to the transposed ulnar nerve to avoid tethering...
during elbow movement. An Ilizarov full, half, or, more recently, a 5/8th ring, was attached to this wire and tensioned to between 100 and 130 kg. Two more wires were inserted, one proximally and one distally, to the reference wire (Fig. 3). These were placed at an angle of 20 to 30° to each other in the coronal plane, and were anchored and tensioned on the distal ring. A proximal ring was connected temporarily to this distal ring with two threaded rods and conical washers, at a level about 3 cm above the proposed site of osteotomy.

The proximal fragment was fixed with two half pins. The first was inserted into the posterior aspect of the humerus through the split in the triceps muscle, the second into the anterolateral aspect of the humerus perpendicular to the first, between the biceps and the triceps. With the proximal ring in a plane perpendicular to the humeral shaft and the distal ring parallel to the distal articular surface, when assembled they reflected the degree of the elbow deformity. Lateral or medial closing wedge osteotomies were then performed between the rings at the supracondylar level 3 cm above the superior margin of the olecranon fossa. The required wedges were calculated preoperatively on tracings of the radiographs.

After completing the osteotomy, the rods connecting the two rings were removed and the fragments were manually reduced using the rings as levers. Medial displacement with or without lateral rotation of the distal fragment was performed to reduce a lateral condylar prominence in cases of cubitus varus. Excessive rotational correction reduced the bony contact at the osteotomy site and therefore the maximum rotation was limited to 20 to 30° to avoid problems of union. In cubitus valgus, lateral displacement of the distal fragment was required to reduce the medial condylar prominence.

After the reduction, four threaded rods and conical washers were used to connect the two rings. Excessive displacement during the correction resulted in the need to use small plates for offset connection of the two rings. The stability of the construct was checked while putting the elbow through the maximum range of movement possible with the frame in position.

Active and passive exercises began within one week of the operation. Union was evaluated clinically and radiologically after temporary removal of the connecting rods, which would otherwise overlap the osteotomy site and preclude adequate radiography. The Ilizarov apparatus was removed after confirmation of union.

RESULTS

All the osteotomies united. The mean duration of fixation was 10.6 weeks (8 to 13). The mean follow-up was 3.5 years (1 to 6). The mean preoperative HEW angle was –24° (–18 to –30) in cubitus varus and 34° (22 to 45) in cubitus valgus. The mean desired HEW angle was 9° in cubitus varus and 11° in cubitus valgus with reference to the unaffected side (Table I). The mean final HEW angle attained was 5° in cubitus varus and 4° in cubitus valgus. The HEW angle differed between the normal and affected sides by 4° in cubitus varus and 7° in cubitus valgus due to slight over- or undercorrection.

Symptoms of tardy palsy of the ulnar nerve improved within six weeks of surgery in all the patients. All but two patients either retained their preoperative range of movement or had improved movement after the procedure.

We graded our results as excellent, good, or poor based on a protocol modified from Bellemore et al.1 An excellent result had a difference of HEW angle from the normal side of 5° or less, loss of flexion or extension by 10° or less, and no complications. A good result had a difference in HEW angle of between 6 and 10°, loss of flexion or extension of 20° or less, and minor complications without any residual effects. The result was regarded as poor when there was a difference of HEW angle greater than 10°, reduction of flexion or extension greater than 20°, and complications with permanent residual effects. We had ten excellent, three good, and two poor results. All patients were satisfied with the cosmetic appearance of the elbow.

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**Fig. 3a** – Anteroposterior diagram showing the placement of three wires in the distal fragment of the humerus, two half-pins in the proximal fragment, and the site of the closing wedge osteotomy. The proximal half-pin must be inserted perpendicular to the axis of the humeral shaft. **Fig. 3b** – Diagram showing the lateral view of the elbow and half-pin placement. The reference wire should be placed through the centre of the capitulum and trochlea. The distal half-pin is placed posteriorly, perpendicular to the axis of the humeral shaft. **Fig. 3c** – Diagram showing medial translation of the distal fragment of the humerus, with 10° of valgus.
Complications. Complications included temporary palsy of the radial nerve in one patient, pin-track infection in five, overcorrection of valgus in one, refracture in one, and reduction in the preoperative range of flexion in three.

The patient with palsy of the radial nerve had a concomitant pin-track infection. The offending wire was replaced with a half pin at a new site which gave improvement over the following three weeks. In the five patients with pin-track infection this occurred at the site of half-pins in three and was treated by local injection of antibiotics in one and by removal of the half-pin in two. In the other two patients the infection developed at the wire site; one wire was replaced by a half-pin and the other was removed.

Overcorrection of a valgus deformity to 3° of varus occurred in one patient who had a preoperative flexion contracture of 30°. A complex osteotomy was performed to correct not only the valgus displacement but also the pre-existing flexion contracture which had made initial assessment of the correction difficult. The result was classified as good.

Three patients had a reduction in the range of flexion from 10 to 20° after the procedure. Two of these had pin-track infections which probably restricted flexion exercises, and resulted in the decreased flexion. These results were classified as good. The other patient with cubitus valgus had a 20° flexion contracture for which she had an extension osteotomy. This caused a change in the arc of motion, correcting the flexion contracture but restricting the final 20° of flexion. This result was classified as poor since the patient complained of difficulty in washing her face and feeding herself due to terminal loss of flexion.

One refracture occurred after removal of the frame, due to overenthusiastic mobilisation by the patient to regain flexion. The fracture was treated by a long arm cast in extension, and healed in four weeks. The result was classified as poor because the resulting HEW angle, when compared with the normal side, was greater than 10°.

The poor results in two patients were correlated with the complications of loss of full flexion after removal of the apparatus. Full flexion was impossible because of the distal full ring, and this complication was not anticipated or recognised during treatment with the Ilizarov apparatus. The maintenance of the final arc of flexion during treatment is important in order to obtain a good functional result. Using a 5/8th distal ring prevents this complication (Fig. 4).

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<th>Desired HEW (degrees)</th>
<th>Final HEW (degrees)</th>
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* humeral-elbow-wrist angle (Carring angle)
† arc of elbow motion

Fig. 4

Photograph showing flexion of the elbow with the use of a 5/8th ring distally.
Prominence of the lateral condyle remained in two patients with cubitus varus due to partial correction of the displacement. Complete correction would have resulted in loss of contact between the two fragments. Partial correction was also responsible for a minor malalignment of the axes of the humerus and the ulna in two patients with cubitus valgus.

DISCUSSION

Prominence of the lateral condyle has been reported as a complication of supracondylar osteotomy for cubitus varus.\textsuperscript{1,4} Previous authors\textsuperscript{3,5,6} have described surgical techniques for medial translation of the distal fragment to avoid this complication. Milch\textsuperscript{7} suggested that angular correction and lateral shift of the distal fragment were required to avoid prominence of the medial condyle after supracondylar osteotomy for cubitus valgus occurring after a Milch type-II lateral condylar fracture. Loss of correction is common when Kirschner wires or screws are used due to the narrow contact area after displacement and correction of the rotation. In children, remodelling and the sequelae of epiphyseal damage continue to have an effect on the position as growth progresses and further surgical procedures may be necessary. After sound union in adults, the alignment is unlikely to change.

The use of the Ilizarov apparatus for fixation of unstable fragments after correction osteotomy for complex deformities has definite advantages. No loss of correction or problems of union were observed in our series and all the osteotomies united within 12 weeks. Limiting the fixation to the area of the osteotomy site without involving the elbow allows the patient to begin early postoperative movement. The apparatus which we used is light and restricted to a short segment of the arm; it does not hinder shoulder mobility.

We recommend the routine use of carefully placed half-pins in the proximal fragment to avoid damage to the radial nerve, but in the distal fragment we suggest the use of wires. The distal humerus is predominantly cortical and is flattened anteroposteriorly, making it difficult to introduce the half-pin. There is also considerable soft-tissue movement around the wire in the distal fixation site during elbow movement which predisposes to pin-track problems. Wires may be replaced by half-pins if necessary and these may also be used for fixation of the distal fragment. In infection of these large-diameter pin-tracks, replacement is difficult as there is not enough adequate bone stock in the small distal fragment.

Transposition of the ulnar nerve was carried out in all cases. While it is routinely performed in cubitus valgus, we also recommend it in cubitus varus. It assists the passage of wires since the nerve is exposed and isolated and remains in view during their insertion. Transposition is also advisable to avoid the complications of kinking or of becoming trapped within the osteotomy site. The use of carbon-fibre rings greatly improves radiography of the fragments for postoperative assessment. An assembly with a 5/8th ring distally allows full flexion of the elbow and accelerates rehabilitation.

In several cases, we observed marked reduction in the contact area between the two fragments, which was further reduced when we attempted complete correction of the rotation and the element of displacement of the deformity. This may, to some extent, be remedied by keeping the distal limb of the line of the wedge osteotomy oblique to the distal humeral articular surface. Shortening the humerus and trimming the proximal fragment for an improved contact area may also be necessary.

\textbf{Conclusions.} We have used the Ilizarov external fixator for stabilisation of complex osteotomies around the elbow with good results. No loss of correction was observed despite early mobilisation of the elbow, and all osteotomies united within the expected time period. There were few complications and none was permanent, with no problems at long-term follow-up.

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\textbf{REFERENCES}