ARTICLE IN PRESS

Acta Orthopaedica et Traumatologica Turcica xxx (2016) 1–5

Contents lists available at ScienceDirect

Acta Orthopaedica et Traumatologica Turcica

journal homepage: https://www.elsevier.com/locate/aott

Treatment of post-traumatic elbow deformities in children with the Ilizarov distraction osteogenesis technique

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A R T I C L E I N F O

Article history:
Received 30 May 2016
Received in revised form
19 August 2016
Accepted 23 August 2016
Available online xxx

Keywords:
Cubitus varus
Cubitus valgus
Distraction osteogenesis
Ilizarov technique

A B S T R A C T

Objective: The present study assessed functional and radiographic outcomes of distraction osteogenesis treatment of post-traumatic elbow deformities in children.
Methods: Eight children were treated between 2008 and 2013 for post-traumatic elbow deformities using distraction osteogenesis. Mean age at time of operation was 10.9 years. Six patients had varus and 2 had valgus deformity. Magnitude of correction, fixator index, complications, carrying angle, and elbow range of motion were assessed. Functional results were graded according to protocol of Bellemore et al.
Results: Mean follow-up was 43 months. Mean preoperative varus deformity in 6 patients was 29.2° and valgus deformity in 2 patients was 28.5°. Preoperative flexion and extension of elbow were 123.8° and −10.6°, respectively. Mean carrying angle was 9° valgus at last follow-up. Mean flexion and extension were 134.4° and −6.0°, respectively. Change in carrying angle was statistically significant ($p = 0.002$). There were 2 grade 1 pin tract infections and 1 diaphyseal fracture of humerus. Functional outcome was rated excellent in 7 patients and good in 1 patient.
Conclusion: Ilizarov distraction osteogenesis is a valuable alternative in treatment of elbow deformities in children. The surgical technique is simple and correction is adjustable. Gradual correction prevents possible neurovascular complications and minimally invasive surgery produces less scarring. Compliance of patient and family is key factor in the success of the outcome.
Level of evidence: Level IV, therapeutic study
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Introduction

Fractures of distal humerus constitute approximately 10% of all childhood fractures.[1] Cubitus varus and valgus deformities are frequently encountered as sequela of malunion after supracondylar fracture and nonunion of lateral condyle fracture (9–58%).[2] Varus angulation, extension, and internal rotation deformity with accompanying flexion contracture or hyperextension of elbow may occur after supracondylar fracture, and nonunion of lateral condyle fracture may present with cubitus valgus deformity and tardy ulnar palsy.

Cosmetic deformity or functional impairment may be indication for corrective surgery. Anatomy of distal humerus with open growth plates requires detailed 3-dimensional planning of complex geometrical osteotomies and it is usually hard to achieve stable fixation between poorly apposed thin bony fragments.[3] Acute correction and fixation with plates, K-wires, or unilateral or circular external fixators have been the established methods of treatment.[4–6] However, acute correction may result in over or undercorrection, neurological deficit, or poor cosmetic appearance. Loss of fixation may cause recurrence of deformity and elbow contracture due to prolonged immobilization.

Distraction osteogenesis has several advantages in deformity surgery such as providing adjustable, 3-dimensional correction, stable fixation, and allowing immediate range of motion (ROM) with less soft tissue damage and scar formation.[4] The aim of this study was to assess functional and radiographic outcomes of

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Peer review under responsibility of Turkish Association of Orthopaedics and Traumatology.

http://dx.doi.org/10.1016/j.aott.2016.08.019
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Please cite this article in press as: Özkan C, et al., Treatment of post-traumatic elbow deformities in children with the Ilizarov distraction osteogenesis technique, Acta Orthop Traumatol Turc (2016), http://dx.doi.org/10.1016/j.aott.2016.08.019

distraction osteogenesis using a hybrid frame with short oblique osteotomy to treat post-traumatic elbow deformities in children and to define the technique and possible complications.

Patients and methods

Records of 8 children (5 female and 3 male) treated for post-traumatic elbow deformities between 2008 and 2013 using distraction osteogenesis with a minimum of 2 years follow-up were evaluated retrospectively after ethical board approval and receiving written, informed consent from parents of the patients. Mean age at time of operation was 10.88 years (range: 4–15 years), while mean age at the time of initial trauma was 5.38 years (range: 2–14 years). Six patients had varus deformity after supracondylar fracture of humerus, and 2 had valgus deformity with accompanying nonunion of lateral condylar fracture of humerus. One patient with cubitus valgus deformity had been previously operated on at another medical center; all remaining deformities were sequelae of nonsurgical treatment. Coronal plane deformity exceeding 10° was indication for corrective surgery. Carrying angle of both sides, flexion and extension of elbow, and forearm rotation were measured with goniometer clinically and noted. Anteroposterior and lateral radiographies of both elbows were obtained for preoperative planning. Lateral condyle prominence index (LCPI) was calculated preoperatively from radiographic images and at last follow-up using method described by Wong et al.[7] Magnitude of deformity and degree of correction were calculated in reference to carrying angle of contralateral side.

Surgical technique

All operations were done in supine position with arm on radiolucent table under general anesthesia and without tourniquet application. Ilizarov frame assembly consisted of 2 full rings. Distal ring was positioned at level of epicondyle and proximal ring was located above level of olecranon fossa. The 2 rings were angulated at predetermined angle and were connected by 2 parallel hinges located at apex of deformity on either side of distal humeral cortex or farther in a distractive position to allow open wedge correction. Oblique plane deformity planning was conducted for 1 patient with accompanying posterior angulation. K-wires and Schanz screws were placed parallel to distal ring and elbow joint from medial and lateral epicondylar area, aligned in approximately 30° angle to each other. Ulnar nerve was protected from iatrogenic damage with use of mini-incision. Offset Schanz screws were placed on proximal ring from anteromedial and anterolateral cortex above level of radial nerve. An additional proximal half-ring was used in 3 patients to support the system. Short, oblique osteotomy proximal to olecranon fossa was performed with stab incision using multiple drilling technique. Contralateral cortex was left intact. Opening of osteotomy site and future correction were checked intraoperatively under fluoroscopy. System was locked, and active and passive elbow ROM exercises were allowed in early postoperative period (Fig. 1).

Postoperative care and evaluation

Calculation for deformity correction was done according to method described by Herzenberg and Waanders.[8] Distraction was initiated after 5 days at a rate of 4 full turns/day. Once symmetrical correction to carrying angle of contralateral side was achieved, hinges and motor unit were removed, and the 2 rings were connected with straight rods. Anterior portion of distal full ring was cut with Gigli saw to allow full flexion of elbow. Radiographs were taken at this stage, and again at 4, 8, and 12 weeks postoperatively. Fixator was removed after radiographic union of osteotomy site under general anesthesia and no protective brace was added. Magnitude of correction, fixator index, complications, carrying angle, and elbow ROM were assessed. Functional results were evaluated at last follow-up visit and were graded as excellent, good, or poor according to protocol of Bellemore et al.[9] An excellent result was defined as loss of carrying angle of 5° or less, and loss of range of flexion and extension of 10° or less. A good result was loss of carrying angle between 6° and 10°, and loss of flexion and extension of 20° or less. Difference in carrying angle greater than 10°, or range of flexion and extension limited by more than 20° was considered poor result.

Statistical analysis

Statistical Package for Social Sciences (SPSS) software version 16.0 (SPSS Inc., Chicago, IL, USA) was used for data analysis. Paired sample t-test was used to assess changes in carrying angle and elbow flexion and extension from preoperative measurement to last follow-up. $P < 0.05$ was considered statistically significant.

Results

Mean follow-up was 43 months (range: 24–65 months). Demographic data of patients, side of deformity, hand dominance, preoperative varus and valgus deformity, and carrying angle are summarized in Table 1. Mean preoperative varus deformity in 6 patients was 29.16° and 1 patient had accompanying extension deformity of 55°. Mean valgus deformity in the remaining two patients was 28.5°.

Preoperative and postoperative ROM, carrying angle, complications, and functional results are summarized in Table 2. Mean preoperative flexion and extension of elbow were 123.75 ± 17.68° and −10.63 ± 8.63°, respectively. None of the patients had limitation of forearm rotation. Mean time for correction was 4.5 weeks and fixator index was 13.25 weeks. Mean carrying angle was 9 ± 3.2° of valgus at last follow-up. Mean flexion and extension ROM at last follow-up were 134.38 ± 4.95° and −6.0 ± 5.15°, respectively. Change in the carrying angle was statistically significant ($p = 0.002$), while no significant change occurred in flexion and extension of elbow ($p = 0.109$ and 0.110, respectively).

Mean LCPI was +0.0375 (between −0.25 and +0.14) preoperatively, and was corrected to mean of +0.02 (between −0.18 and +0.16). Prominent lateral condyle was seen in 1 patient.

Regarding complications, there were 2 grade 1 pin tract infections treated with appropriate dressing and oral antibiotic, and 1 diaphyseal fracture of humerus at proximal Schanz screw insertion caused by forceful manipulation during physiotherapy after removal of fixator. Circular external fixator was reapplied until solid union of fracture was achieved. No neurovascular complications occurred. Functional outcome was rated excellent in 7 patients, and good in 1 patient. Clinical and radiographic views of 2 patients each treated for cubitus varus and valgus deformity are provided in Figs. 2 and 3, respectively.

Discussion

There is limited number of studies reporting good results in treatment of post-traumatic elbow deformities with distraction osteogenesis.[1,4,10,11] Success of the technique is associated with facilitated planning and application of 3-dimensional correction without complex geometrical osteotomies. Furthermore, gradual correction avoids possible neurovascular complications, while stable fixation allows early ROM exercises. It is usually hard to achieve stable fixation of corrective osteotomy because of small

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