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A New Technique of Step-cut Osteotomy for Cubitus Varus in Children

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Abstract Design concept of the author's modified step-cut osteotomy comes from both step-cut and dome osteotomies ; in that the configuration of osteotomy is that of the step-cut though in a reversed fashion, while medialization of the distal fragment is from the dome osteotomy. Since 1993, twenty-two children with cubitus varus deformity were operated by this osteotomy. Their average age was 9.4 (range, 2 to 15) years. Preoperative carrying angle was varus 19° (range, 5° to 35°) in average. In at least one-year follow-up, all patients were satisfied with the nearly normal correction of carrying angle (<5° difference from the normal arm) without any unsightly lateral condylar prominence. In three children, sagittal angulation (one anterior, two posterior) was noted postoperatively, but subsequently remodeled until the last follow-up. There was no fixation failure or loss of preoperative motion. Complications were two ; a transient ulnar neurapraxia, and an intraoperative step-cut spike fracture in an osteogenesis imperfecta patient. This technique was excellent to achieve an accurate correction of carrying angle for cubitus varus deformity in the skeletally immature patients.

Introduction

Cubitus varus is one of the most common complications of the supracondylar fracture with an incidence varying from 9 to 57%[1]. Although this deformity rarely limits function, the awkward "gunstock" appearance is usually unacceptable to both the child and the parents. A variety of corrective osteotomies for this deformity have been described. The three most popular techniques include a simple lateral closing wedge osteotomy[2)7)8)], a dome osteotomy[4)], and a step-cut osteotomy[3)]. Most of them had significant complications such as stiffness, nerve injury, fixation failure with an overall rate approaching 25%. Since 1993 the author employed a osteotomy technique which is a modification of the step-cut osteotomy with medial translocation of the distal fragment and rigid internal fixation[10)]. The technique of osteotomy and the results are reported.

Materials and Methods

From 1993 to 2003, twenty-two skeletally immature children (19 boys and 3 girls) with an average age of 9.4 years (range, two to 15 years) were treated by the modified step-cut osteotomy for correction of cubitus varus

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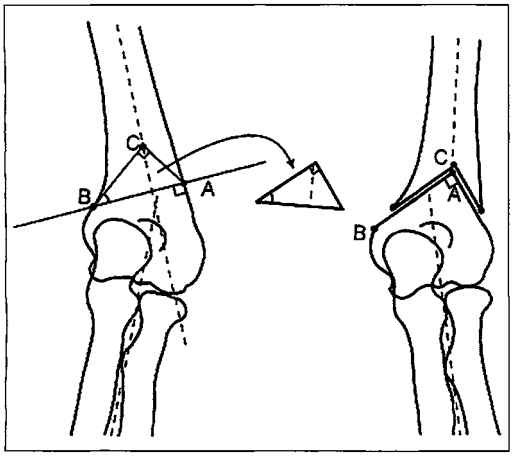

Fig. 1. Schematic drawing of the preoperative plan : the line AB is 1 cm above olecranon fossa, and perpendicular to the lateral supracondylar ridge. Angle ABC is the angle to be corrected. After removal of the rectangle ABC, the distal fragment is translocated medially and proximally so that the point A meets the point C.

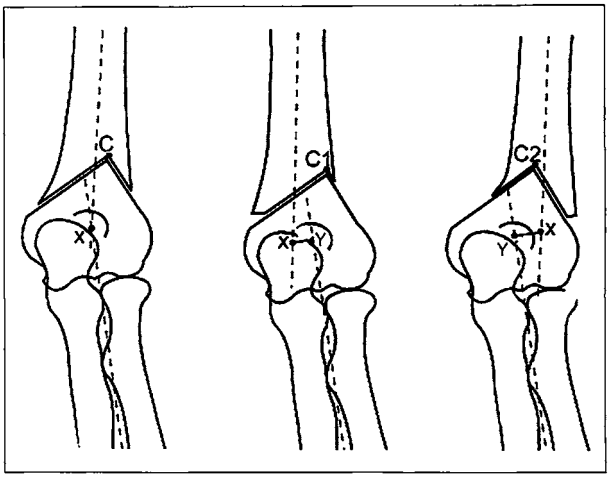

Fig. 2. Determining the point C. In ideal correction without prominence(left), both humeral and forearm axis meet at point X, which is determined from the opposite normal elbow. Correction with lateral prominence(center) ; and correction with medial prominence(right). Point Y is determined by a perpendicular line from the point X to the longitudinal axis of forearm. Distance between points X and Y is the amount of medial or lateral translation.

deformity. The causes of deformity were supracondylar fracture in eighteen, lateral condylar fracture in two, entire distal humeral physis fracture in one, and medial condylar fracture in one. They were operated on by the osteotomy at an average of 2.9 years(range, 1 to 5 years) after the injury. The average length of the follow-up was 16 months(range, 12 to 36 months).

The carrying angle was measured from the long axis of the humerus and the midline of the forearm in full extension and supination. Radiographically, the humeral-elbow-wrist(HEW) angle was determined according to Oppenheim et al[7]. The average HEW angle on the affected side was varus 19°(range, varus 5° to 35°), while that on the normal side was valgus 7°(range, valgus 4° to 15°). The difference in the HEW angle between two upper extremities determined the angle to be corrected, which was 22° (range, 15° to 40°)in average. Preoperative sagittal angulation in the lateral radiograph was found in six patients. All were posterior angulation with the average amount of 18° (range, 10° to 25°).

1. Preoperative planning : Prior to the surgery, paper tracing is made to determine the exact template for the osteotomy(Fig. 1). Osteotomy line AB is made 1 cm above the olecranon fossa, and perpendicular to the lateral supracondylar ridge, which is almost straight in cubitus varus deformity. The angle to be corrected(angle ABC)is depicted at the medial corner above the osteotomy line AB. Determination of the point C of the rectangular triangle ABC is critical to obtain the exact amount of medial translation of the distal fragment(Fig. 2). From the normal side the intersection point(X)between humeral and forearm axis is found, which is usually at the olecranon fossa. From the point X a perpendicular line is drawn toward the forearm axis, and the inter-

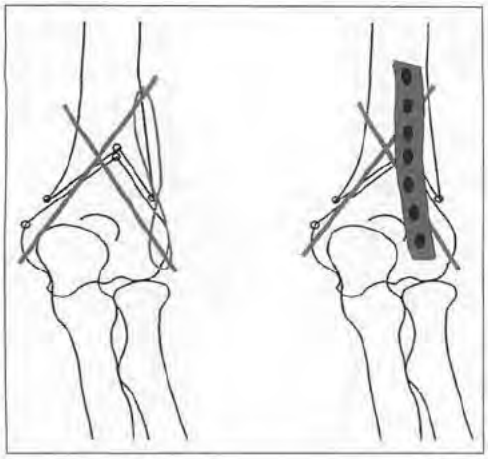

Fig. 3. Fixation of the osteotomy Two K-wires is used in a crossed fashion. Lateral tension band wiring is added in the skeletally immature(left) ; while DCP is placed posterolaterally in the mature bone (right).

Fig. 4. Preoperative photo(A) and anteroposterior radiograph (B)of the typical cubitus varus deformity in a 10 year old boy. Result at one year reveals excellent correction in the radiograph(C)and photo(D).

section is the point Y. With adequate medial translation of the distal fragment the point Y meets the point X. In this position the rectangular apex of triangle is the point C. From the point C the line CA is drawn perpendicular to the line BC. Cut out the rectangular triangle ABC. Finally, the distal fragment is translocated proximally and medially for the rectangle-cut lateral corner(point A) of distal fragment to meet the rectangular point C of proximal fragment.

2. Osteotomy technique : The surgery is performed with the patient in a lateral decubitus position. A posterolateral approach to the distal humerus is employed along the lateral margin of triceps muscle. Triceps muscle is preserved and retracted medially without violating elbow joint capsule. The entire posterior aspect of the distal humerus is subperiosteally exposed. This area is flat enough, which is good to depict the osteotomy line according to the template. With the completion of osteotomies a temporary fixation with two K wires is done in a crossed fashion. The medial pin is inserted from the lateral supracondylar ridge of the proximal fragment. Adequacy of correction is checked grossly and fluoroscopically in both coronal and sagittal planes. Additional tension band is made on the lateral aspect (Fig. 3) Bone graft to the osteotomy gap is sometimes done using the excised rectangle bone fragment. Postoperatively, a posterior slab splint is applied for one to two weeks, after which active motion is started.

Results

The average postoperative HEW angle in the twenty-two patients was valgus 7°(range, 5° to 14°), and there was no loss of correction during the follow-up. By the Oppenheim et al. 's criteria[7] of within 5° of the contralateral normal elbow, excellent correction in coronal plane was obtained in all patients. Lateral condylar prominence, the distance XY as measured in Fig. 2, was within 5 mm in all patients. Sagittal angulation in the postoperative radiograph was found three cases(two residual posterior angulation, one anterior angulation due to overcorrection). They were all within 10° and remodeled until the last follow-up.

Preoperative range of motion was rapidly restorated after the surgery usually within three to four weeks. At the last follow-up no

patient showed a loss of preoperative range of motion. All osteotomies healed rapidly to return to normal activity within three months. Two patients had postoperative complications. One patient had a transient ulnar neurapraxia. It was spontaneously resolved with observation. The other complication was an intraoperative undisplaced fracture of the step-cut spike in a osteogenesis imperfecta patient. It did not limit the start of elbow motion, and healed unequivocally.

Final results were graded by the method modified from criteria of Oppenheim et al[7]. Excellent result included if the coronal and sagittal plane corrections are within 5° of the normal elbow ; the lateral condylar prominence within 5 mm ; maintenance of preoperative elbow motion ; and no perioperative complications. A good result is a valgus elbow, within 10° sagittal angulation ; within 10 mm lateral condylar prominence ; and with motion to within 10° of the preoperative level. A poor result reflected any perioperative complication ; residual varus ; more than 10° sagittal angulation ; more than 10 mm lateral condylar prominence ; or loss of greater than 10° of elbow motion. Based on these criteria, eighteen patients had excellent results ; two, good due to sagittal angulation but nicely remodeled at follow-up ; and two, poor due to complications that were not serious to resolve spontaneously. All patients and their parents were satisfied with the final result.

Discussion

A variety of osteotomies including three major types have been proposed to correct the cubitus varus deformity. A lateral closing wedge osteotomy is the simplest and the most popular one. But the incidence of significant complications (residual varus deformity, loss of fixation, delayed or nonunion, infection, nerve palsies, or necessity of reoperation) reaches 24 to 47%[2)3)7)], so that this technique is called "deceptively simple." Another problem is the lateral condylar prominence. Wong et al.[9] wrote that even with adequate restoration of the carrying angle and preservation of elbow motion after closing wedge ostetomy they experienced poor cosmetic results because of a prominence in the lateral condylar region. In their opinion the prominence is inherent in the design of the osteotomy. Hinging on the medial cortex while closing the osteotomy effectively shifted the distal fragment laterally. Levine et al.[6] commented the importance of medial displacement of the distal humeral fragment to diminish the prominence of the lateral humeral condyle. They wrote that medial displacement disrupts the medial periosteum and creates an unstable environment for fixation. Dome osteotomy, popularized by Japanese surgeons[4], involves making the osteotomy in the shape of a dome. It helps correct the residual prominence of the lateral condyle by allowing it to be rotated in both coronal and horizontal rotational planes. DeRosa and Graziano[3] have described an interlocking step-cut osteotomy that can be secured with a single, laterally based screw. They reported the single screw provided adequate fixation. Their one poor result, however, occurred when this lateral spike of the distal fragment fractured as the screw was being inserted to result in a loss of fixation. There was no comment about the lateral condylar prominence in their article.

The author's modified step-cut osteotomy is a combination of the original step-cut

osteotomy in its configuration and the dome osteotomy in its concept to prevent lateral condylar prominence. The differences in the osteotomy technique from the original step-cut are that the step-cut is made on the proximal fragment of the first osteotomy line ; and that the distal fragment is translocated medially and proximally to prevent the lateral condylar prominence. The advantages of rectangled step-cut roof are that the configuration of osteotomy is securer than the dome ; and that the degree of medial translation can be exactly measured by preoperative paper tracing. The fixation by two crossed pins and additional lateral tension band is rigid enough to permit early elbow motion. Additional tension band to the lateral pins was also advocated by Laupattarakasem and Mahaisavariya[5].

This osteotomy corrects both coronal and sagittal planes. There is some controversy as to whether the medial rotation should be corrected at the same time. Reports on the dome osteotomy believe that it was essential to correct horizontal rotation as well to decrease the lateral condylar prominence[4]. However, Oppenheim and coworkers[7] found that the complication rate was increased in their series when rotational correction was attempted. The author believes the correction of medial rotation is not necessary if coronal and sagittal plane corrections are adequate. Medial rotation of the distal humerus is easily adapted from the shoulder joint.

From ten-year experience of the modified step-cut osteotomy, a satisfactory outcome can be expected by this procedure in most of the cubitus varus deformity. Careful preoperative planning and special attention to surgical details are required to obtain an ideal result.

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