REVIEW ARTICLE

Cubitus Varus Deformity Correction by Surgical Methods

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Abstract

Cubitus varus deformity is the most common late complication of supracondylar fractures in children. Various methods of osteotomy have been proposed for the treatment of this deformity. This study details the surgical technique and advantages and complications of the 4 most commonly used techniques of cubitus varus correction in paediatric group. Specifically, the lateral closing-wedge osteotomy, step-cut osteotomy, dome osteotomy, and multiplanar osteotomy. Each technique shown to have its own advantage and complications, no technique was shown to significantly affect the surgical outcome. We recommend that surgeon should choose surgical technique most suited to deformity of the patient.

Key words: Cubitus Varus deformity, Supracondylar fractures, Osteotomy

Journal of Green Life Med. Col. 2020; 5(2): 75- 79

Introduction:

Average carrying angle is 6°-14° with more angle in girls than in boys.[1] Any reduction in the normal carrying angle of the elbow produces cubitus varus deformity, which is the common late complication of supracondylar fracture in children.[1, 2] Incidence of this deformity varying from 4% to 58%.[3, 4] It is a triplaner deformity consisting of varus angulation in coronal plane, internal rotation in axial plane, and extension in the sagittal plane.[5]

Pediatric cubitus varus is considered a cosmetic problem with minimal loss of motion although the arc of motion maybe altered to increase hyperextension and decreased elbow flexions.[5-7] Remodeling of the very young, skeletally immature elbow may restore loss of elbow flexion.[8] Even in the absence of functional problems, which are mostly late sequelae, parents are often dissatisfied with the appearance of their child's arm and request treatment. [5]

In recent times, there is growing awareness of long-term complications of cubitus varus deformity that appears in the adult. These are Postero-lateral rotational instability, Ulnar neuropathy, Progressive varus of the ulna.[5, 7]

For correction of cubitus varus, there is different surgical techniques and complications after correction is also not uncommon.[5-8] In this review, most common type of osteotomies to correct this deformity will be described to understand advantages and complications of each methods.

Biomechanical & morphological alterations

O'Driscoll et al[9] reported 25 adult elbows with cubitus varus who developed symptomatic posterolateral rotatory instability (PLRI) decades after their initial injury. Varus malalignment of the upper extremity leads to medial displacement of the mechanical axis of the upper extremity. With time, increased attenuation of the lateral elbow ligament complex combined with increased external rotation of the ulna leads to PLRI and radial head sublaxation. Surgical treatment consisted of lateral ulnar collateral ligament (LUCL) reconstruction, distal humeral osteotomy, or a combined LUCL reconstruction with distal humeral osteotomy.

Ulnar nerve palsy has been reported in conjunction with cubitus varus.[10-12] It is thought that internal rotation deformity of the distal humerus in conjunction with distal fibrosis and entrapment of the nerve cause traction injury. In these cases, ulnar nerve transposition is recommended in conjunction of with corrective osteotomy. [7]

Snapping of the medial portion of the triceps may occur from the medial displacement of the triceps as wee as the internal rotation of the distal humerus.[7]

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Received: 18.03.2020 **Accepted:** 18.04.2020

It is hypothesized that the medial over pull of the triceps leads to bony morphologic changes, which is turn leads to progressive varus of the ulna. These include trochlear overgrowth posteriorly, capitullum overgrows distally, and diameter of the radial head enlarges. The ulna shifts to a more distal and medial position accompanied by increased external rotation and flexion. Thus, there is a progressive varus of the ulna.[7]

Surgical correction

There are multiple reported techniques for the correction of cubitus varus – [5-7]

A. Lateral closing wedge osteotomy

B. Step-cut osteotomy

C. Dome osteotomy

D. Computer aided multiplanar osteotomy

E. External fixation with distraction osteogenesis.

Additional lateral ulnar collateral ligament (LUCL) reconstruction has been described in conjunction with distal humerus osteotomy to correct PLRI and cubitus varus in adult.[9, 13, 14]

A. Lateral wedge osteotomy

The lateral close wedge osteotomy is most commonly used for cubitus varus because of its ease and simplicity.[15] Siris first described a lateral close wedge osteotomy for cubitus varus in 1939.[5] In 1959 French recommended a modification of the technique, along with simultaneous correction of internal rotation via the preservation of medial cortical and periosteal hinge, and fixation with two offset screws and tension band.[16]

The principle behind close wedge osteotomy is to plan a distal cut parallel to the joint line and a proximal cut perpendicular to the long axis of the humerus.[6] Some surgeons prefer to completely cut the medial cortex, where others have recommended leaving a medial cortical hinge. Leaving an intact medial cortex allows lesser fixation methods such as pins.[17]

When pin fixation is planned, it is helpful to first place 2 Kirscher wires in the lateral condyle distally, so that when the wedge is removed, the pins can be driven across the osteotomy site. If additional fixation is required, third wire or a lateral plate can be used. Plate fixation may have an advantage over pin fixation is allowing earlier mobilization, but it requires a more extensive dissection and is more technically demanding.[6]

B. Step-cut osteotomy

The concept of a step-cut osteotomy arose combat the lateral condylar prominence. A paratricipital or olecranon osteotomy approach is used to allow wide exposure of the distal humerus. A close wedge osteotomy is performed. The inferior margin of the triangle is made parallel to the joint line 0.5cm above the olecranon fossa. The second line is drawn from medial distal to proximal lateral to make the desired angle of correction. The inferior margin is equal in length to the second line. Next from lateral end of second line a third perpendicular line is drawn distally meeting the first line. This outlined triangle is now removed. A triangular notch of bone is resected from the proximal fragment to match the distal fragment. The horizontal correction of distal fragment is completed by translating distal fragment on the proximal fragment. This translation step-cut is modification of the traditional step-cut described by De Roza and Graziano where the distal fragment having a lateral spike is fixed to the proximal fragment.[6, 18]

Another modification of the traditional step-cut osteotomy is the spike translation modification step-cut osteotomy. Here a notch is made in the proximal fragment to accommodate the distal fragment spike. It is more difficult to perform spike osteotomies on smaller and younger paediatric patients. Spike osteotomies require a large bone resection compared with translation step-cut osteotomies and lateral-closing wedge osteotomies. [6-18]

C. Dome osteotomy

The dome osteotomy is more technically demanding than either the lateral wedge or the step-cut osteotomy.[19] The dome osteotomy avoids the lateral prominence produced by lateral closing-wedge osteotomy.[6] The lateral condylar prominence is decreased because the axis of rotation for the dome osteotomy is at the centre of the distal humerus, obviously the need for the lateral translation. In addition, rotational deformity can be corrected.[20]

The centre of dome osteotomy (point A) is the point at which the midline axis of the humerus intersect with the upper margin of the olecranon fossa (Figure 1). From point A, the base segment line AB is marked perpendicular to the midline axis of the humerus. Line AB´ is then drawn parallel to the distal humeral articular surface. The length of AB´ determines the radius of the dome osteotomy. The area of dome osteotomy is marked with K-wires and drilled with 3-0 cannulated drill bit. A osteotome of a oscillating saw is used to finish the dome. Point B´ on the distal fragment is rotated to point B to correct the deformity and fixed with K-wires. In older children and teenagers, distal humeral plates are used.[6]

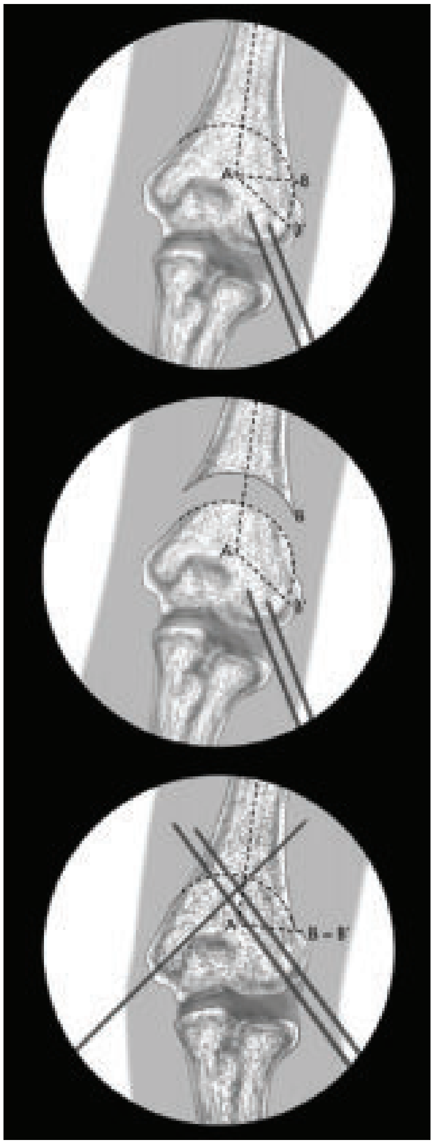

Fig.-1: *The dome osteotomy. Point A marks intersection of midline axis of humerus with olecranon fossa. AB is drawn parallel to the distal humeral joint line, so that angle BAB' marks the angle needed for correction. The dome then drawn with line AB' as its radius. After dome osteotomy is completed, distal humerus is rotated so that Band B' are in same point. Reproduced from Bauer et al.*[6]

Eamsobhana and Kaewpornsawan performed a double dome osteotomy to address both the coronal and sagittal plane deformities in cubitus varus.[21] The first dome osteotomy was at the apex of the olecranon fossa with the center if the dome aligned with the humeral midline axis. The second dome osteotomy was also at the apex of the olecranon fossa, but with the centre of the dome aligned with the midline axis of the ulna. The 2 domes overlap, creating 2 semicircular wedges for removal. After bone removal, the osteotomies are translated so the humeral axis is aligned with the ulnar axis, thus correcting the varus and extension deformities. [6, 21]

D. Computer aided multiplanar osteotomy

Multiplanar osteotomies can accurately correct not only varus deformity, but also the extension and internal rotation that are part of the cubitus varus deformity, improving both appearance and function. [22]

Rotational deformity is difficult to understand through conventional radiographs, and so accurate planning of multiplanar osteotomies require a preoperative CT scan.[6, 22] The surgeon can work with either implant company or software company to generate a 3-D model for the radius, ulna and humerus. The entire affected arm and the healthy humerus are superimposed to determine the correction of the deformity. On the basis of this model, the surgeon can create patient-specific cutting guides as well as custom surgical fixation devices. [6]

The surgical template is placed in contact with the distal humerus. K-wires are inserted into the bone to hold the guide in place. An oscillating saw is used to perform the planned osteotomies, through slits in the guide. The bone wedges removed. The K-wires on the proximal fragment as guides for rotation and translation of the distal fragment. The K-wires on the distal fragment are positioned until it aligns with the proximal wires for complete correction. Different types of fixation can be used such as K-wires, tension band wires, standard plates and screws, or custom devices. [6, 22]

Discussion:

Three recent review literatures, no single technique was found to be safer or more effective than any other.[5-7] And also indications for which technique to select are unclear, and it is even uncertain whether correction of the internal rotation deformity is necessary for a successful result.[23] Estimated overall rate of good to excellent results was 87.8% and complication rate of 14.5% have been reported in a meta-analysis, which include nerve injury, residual deformity, loss of fixation, infection and unsightly scarring.[5] Corrective osteotomy in the distal humerus for paediatric group is less technically demanding surgery when compared with adolescents and adults.[7]

Complex multiplanar osteotomy found to have lowest overall complications.[5, 6] In one review study[5], they found 9.4% of patients treated by this technique reported complications. This technique corrects accurately varus deformity, and also extension and internal rotation. But this technique has some drawbacks. The major issues are access and cost effectiveness. A bilateral CT scan with corrective software and cutting templates is required, which may not be readily available. Another issue is whether the correction of internal rotation deformity even necessary.[6] Some author suggested that excessive internal rotation may be related to the development of tardy ulnar nerve palsy, others have suggested that internal rotation correction does not affect the outcome of cubitus varus corrections.[6,23] Although multiplanar osteotomies have the potential to correct cubitus varus with fewer complications, the difficulty of obtaining custom surgical guide templates for each patient prevent this from currently becoming the gold standard.[5-7]

Lateral close wedge osteotomy is the most popular technique due to its simplicity, ease and reproducible.[6,7,24] This technique is less technically demanding and to have a decreased risk of nerve injuries compared with others.[6,7] Complications from lateral wedge osteotomies are reported between 14% and 53%.[6] The main drawback of this technique is that prominence of the lateral condyle is not addressed with this method. Loss of correction when Kirscher wires alone are used for fixation, is another complication. Oppenheim et al.[17] described other complications such as unacceptable scarring, neuropraxia, and sepsis in 24% of cases.

Step cut osteotomy was developed to address lateral condylar prominence and other complications of lateral closing wedge osteotomy.[6] But both the translational and spike-modified step-cut osteotomies have complications to consider. For the translational step-cut osteotomy, Davids et al.[25] reported a complication rate of 19%, consisting of transient nerve palsy and loss of fixation. These complications did not occur in the series of cases by Moradi et al.[18] It is more difficult to perform spike osteotomies on smaller and younger pediatric patients. Also, spike osteotomies require a larger bone resection compared with translational step-cut osteotomies and lateral closing-wedge osteotomies.[6]

With both the single and double dome osteotomies, lateral condylar prominence is less likely, while providing a large surface area for fixation and healing.[6,21] In addition, rotational deformity can be corrected.[6] High patient satisfaction with appearance has been reported.[21] However, it is more technically demanding.[19] other complications included transient radial nerve palsy, superficial infection, and excessive derotation.[21] One series found a higher rate of radial nerve palsy using the posterior triceps-sparing approach.[6] Similarly, Raney et al.[26] noted similar overall rates of complications with both lateral and posterior approaches but associated a higher rate of nerve palsies with the posterior approach.[6]

A study by Solfelt et al.[5] found although an estimated overall poor surgical outcome rate of 12.2% and a complication rate of 14.5% across all osteotomy classes is higher than is desirable, many authors pointed out that a complication does not necessarily equate to a poor functional result or decreased patient satisfaction. Patients were reported to appreciate improvements in cosmesis, even when there was some residual deformity.[5] Nerve injury found to be the most feared complication of supracondylar osteotomy, at a rate of 2.5% across all osteotomy techniques. But fortunately, patients can be counselled that most nerve injuries are transient.[5]

It has been found that most common indication for surgery was cosmetic deformity, and there was absence of functional problem prior to surgery.[5] Nevertheless, Oppenheim et al.[17] found that total pre-operative range of elbow movement in the affected limb was often less than that of the normal side. This suggest that functional limitations secondary to cubitus varus are either underreported or are unrecognised in children.

Conclusion:

There are multiple types of osteotomies exist to correct cubitus varus deformity in children, and no gold standard surgical technique has been found. Each method has its own advantage and complications. Further research requires consideration for a simple and effective surgical technique with minimal complication and maximum patient satisfaction. We recommend that surgeons performing a surgical correction of cubitus varus deformity, be aware of the potential complications and adequately counsel the patient regarding the probability of complications and choose the technique most suitable to the age and deformity of the patient.

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