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Klinik Çalışma

Outcome of olecranon osteotomy in the trans-olecranon approach of intra-articular fractures of the distal humerus

Distal humerusun intraartiküler kırıklarının transolekranon yaklaşımında olekranon osteotomisinin sonuçları

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BACKGROUND

The trans-olecranon approach has been suggested to improve the visualization of complex intra-articular distal humerus fractures. Significant osteotomy complications have prompted a search for alternative approaches. The purpose of this series was to study the outcome of the olecranon osteotomy in terms of union and complications and the ultimate outcome of the fracture.

METHODS

Ninety-four patients with intra-articular fractures of the distal humerus (type C3) were treated by open reduction and internal fixation using the trans-olecranon approach. The patients were followed from 6 to 48 months, with an average follow-up of 24 months.

RESULTS

All osteotomies united in an average of 11 weeks (range, 8-20 weeks). There was no non-union, although union was delayed in four osteotomies, which all healed by 20 weeks without any intervention. The most frequent complication in this study was symptomatic osteotomy fixation in 19% of patients, all of whom underwent a secondary procedure for the removal of the implant after the osteotomy had united. Seventy-one percent of the unsatisfactory results were seen in those patients who had symptomatic olecranon fixation.

CONCLUSION

Despite a few manageable complications, the trans-olecranon approach is essential for the adequate visualization and fixation of the complex fracture of the distal humerus. Adequate fixation of the osteotomy is essential to prevent complications and achieve a satisfactory outcome.

Key Words: Distal humerus; trans-olecranon approach; intra-articular fractures; outcome.

AMAÇ

Transolekranon yaklaşımının, kompleks intraartiküler distal humerus kırıklarının vizüalizasyonunu artırdığı ileri sürülmüştür. Ortaya çıkan önemli osteotomi komplikasyonları, alternatif yaklaşımlara yönelik arayışa girilmesine neden olmuştur. Bu seride, kaynama, komplikasyon ve kırığın nihai neticesiyle ilgili olarak olekranon osteotomisinin sonuçları değerlendirildi.

GEREÇ VE YÖNTEM

İntraartiküler distal humerus kırığı (tip C3) bulunan 94 hasta, transolekranon yaklaşım kullanılarak açık redüksiyon ve internal fiksasyon yöntemiyle tedavi edildi. Hastalar, 6. aydan 48. aya kadar takip edildi ve ortalama takip 24 ay oldu.

BULGULAR

Bütün osteotomiler, ortalama 11 haftada (dağılım, 8-20 hafta) kaynadı. Herhangi bir girişimde bulunulmaksızın 20. haftaya kadar iyileşen dört osteotomide kaynama gecikmekle birlikte, hiçbir kaynamama olayı yaşanmadı. Bu çalışmada en çok sıklıkla karşılaşılan komplikasyon, hastaların %19'unda gerçekleştirilen semptomatik osteotomi fiksasyonu oldu. Bu hastaların tamamında, osteotomi kaynadıktan sonra implantın çıkartılması için sekonder bir prosedür uygulandı. Tatmin edici olmayan sonuçların %71'i, semptomatik olekranon fiksasyonu uygulanan hastalarda görüldü.

SONUÇ

Bazı tedavi edilebilir komplikasyonları olmasına rağmen, transolekranon yaklaşımı, kompleks distal humerus kırığının yeterli vizüalizasyonu ve fiksasyonu için kaçınılmazdır. Osteotominin yeterli fiksasyonu, komplikasyonların önlenmesi ve tatmin edici sonucun alınması için elzemdir.

Anahtar Sözcükler: Distal humerus; transolekranon yaklaşımı; intra-artiküler kırıklar; sonuç.

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Intercondylar fractures of the distal humerus constitute about 2% of all fractures.[1] The intricate anatomy of the region, complex fracture patterns and limited bone stock for fixation make these fractures a treatment challenge, and open reduction and internal fixation remains the standard of treatment.[2-6] Various operative approaches have been recommended, including triceps splitting, triceps reflecting and trans-olecranon approaches.[7-9] Cassebaum[8] introduced the transverse olecranon osteotomy for enhancing the visualization of the articular surface of intra-articular fractures of the distal humerus. Problems with fixation of the osteotomy and high complication rates have led to various modifications, including extra-articular olecranon osteotomy and chevron intra-articular osteotomy. Chevron intra-articular osteotomy has inherent rotational and translational stability and increased osteotomy surfaces for better healing and lower complication rates.[4,10] The intra-articular olecranon osteotomy provides better visualization of complex intra-articular fractures, enabling accurate reduction and fixation.[11,12] Significant complications like delayed union, non-union, symptomatic olecranon fixation, and secondary procedures for removal of symptomatic hardware have been reported with the use of the trans-olecranon approach.[2-5,11,13] Alternative approaches like triceps splitting and triceps reflecting are advocated to eliminate the complications inherent to olecranon osteotomy; however, reflecting the triceps mechanism from the proximal ulna or distal humerus does not offer the same degree of visualization of the fracture anatomy since the olecranon process remains intact. Wilkinson and Stanley[12] demonstrated that the median exposures of the articular surface after triceps splitting, triceps reflecting and olecranon osteotomy were 35%, 46% and 57%, respectively.

MATERIALS AND METHODS

From January 2002 to May 2007, 94 patients with intra-articular fractures of the distal humerus were treated in our department by open reduction and internal fixation using the trans-olecranon approach. There were 39 (41%) male and 55 (59%) female patients; mean age at presentation was 51.6 years, ranging from 17 to 90 years. Mode of injury was falls in 56 (60%), road traffic accidents in 31 (32%) and direct hit in 7 (8%) patients. The fracture was classified as per AO/OTA classification. There were 30 (32%) type C1, 39 (41%) type C2 and 25 (27%) type C3 fractures. Sixty-eight (72.3%) fractures affected the right side and 26 (27.7%) the left side. Sixteen fractures were type 1 compound. Skeletally immature patients, poly trauma patients, patients with head injury or compound fractures of type 2 or higher, and patients with ipsilateral proximal ulnar fractures were excluded from the study. All patients were operated within five days of admission; average injury-surgery interval was 3.87 days. Anteroposterior and lateral pre-operative radiographs, including traction films, to delineate fracture anatomy were taken to frame an operative plan.

Operative Technique and Follow-Up

The surgery was performed as per AO technique, under tourniquet and in prone position using regional anesthesia in 67 and general anesthesia in 27 patients. Chevron intra-articular osteotomy with apex downwards was made 2-3 cm below the tip of the olecranon at the bare area, if visible, after reflection of capsular attachments from the sides of the olecranon; the bare area corresponds with the deeper part of the sigmoid notch, which is devoid of articular cartilage.[9] The osteotomy was made with an oscillating saw, but not through the subchondral bone. The terminal part of the osteotomy was completed by a thin osteotome, by fracturing through the osteochondral surface, which leaves an irregular osteochondral surface that can accurately interdigitate at the time of fixation, assisting in reduction and enhancing stability.[2,9] The triceps muscle was elevated from the medial and lateral inter-muscular septum and the fracture exposed. After the fixation of the fracture, the osteotomy was reduced and fixed with a 4.5 or 6.5 mm cancellous screw 60 to 100 mm in length and was reinforced with dorsal ulnar tension band wiring. The stability of the osteotomy construct was achieved by the screw diameter engaging the endosteal bone and indirectly by slight bending of the screw in the curvature of the proximal ulna.[9] Post-operatively, the limb was immobilized in a long-arm crammer-wire splint. Range of motion exercises were started from the first post-operative day. The splint was removed for the day and was reapplied at night, till the wound healed and sutures were removed, when the splint was discarded.

Patients were followed regularly for the six months, with a maximum follow-up of 48 months and average follow-up of 24 months. Five patients were lost to follow-up before 3 months. Regular checkups were done at 1 week, 3 weeks, 6 weeks, 12 weeks, and at 6-month intervals after discharging

Fig. 1. **(a)** Pre-operative anteroposterior and lateral radiograph. **(b)** Post-operative radiograph at 6 months showing union of fracture and osteotomy.

the patient from the hospital. At each visit, anteroposterior and lateral radiographs were taken and assessed for the adequacy of the reduction, loosening of implant and progression of the union. Range of motion, functional status of the patient, complaints of pain and complications, if any, were noted. Final assessment was done at the end of 6 months using the scoring system of Caja and Morani et al.[14]

Statistical Analysis

Data was described as mean±SD and percentages. Various complications of osteotomy were categorized under the heading of complications present or absent for the subjects who completed their follow-up. All clinical and radiological parameters were analyzed and the results were obtained by Mann-Whitney U test, chi-square test and odds ratio analysis. Statistical significance was met at a 95% confidence interval.

RESULTS

All of the olecranon osteotomies united in 8-20 weeks (Figs. 1, 2). The average healing time was 11 weeks. There was no non-union of any osteotomy, although there was delayed union in four (4.5%) osteotomies, all of which healed uneventfully by 20 weeks without any intervention. Minor complications occurred in some patients. Ulnar nerve palsy was seen in one patient, due to pressure on the nerve caused by a backed out screw, which resolved once the screw was removed. Superficial wound infection was seen in 8 (8.5%) patients; there was no deep infection. Prominent proximal ulnar implant was seen in 23 (26%) patients, which was symptomatic in 17

Fig. 2. **(a)** Pre-operative anteroposterior radiographs of a type C2 fracture. **(b)** Image at 8 weeks post-operatively showing united osteotomy.

Table 1. Effect of olecranon osteotomy on the clinical and radiological outcome

Parameter	No. of patients (%)
Total no. of patients	94
Patients completing follow-up	89
Pain	
No pain	60 (67.4)
Occasional pain	26 (29.2)
Activity-related mild pain	3 (3.4)
Range of motion (ROM)	
Full ROM	22 (24.7)
ROM more than functional range	60 (67.4)
ROM less than functional range	7 (7.9)
Activity level	
As prior to trauma	80 (89.9)
Diminished	6 (6.7)
Interrupted	3 (3.4)
Radiological quality of the surgical reduction	
Articular surface step >1 mm	28 (31.5)
Articular surface diastases >1 mm	33 (37)
AP carrying angle malalignment >10º	12 (13.5)
Heterotrophic ossification >10 mm	17 (19)
Complications related to osteotomy	
Prominent olecranon screw	23 (25.9)
Painful bursa over screw head	17 (19.1)
Secondary procedure for removal of symptomatic osteotomy fixation	29 (32.6)
Delayed union	4 (4.5)

(19%) patients because bursa had formed over the screw head. All 17 patients underwent a secondary procedure for removal of the osteotomy fixation, excluding another 12 (13%) patients who underwent removal of total implants including the osteotomy fixation. The mean time for removal of proximal ulnar implant was 7.2 months (range, 4 to 18 months). The mean radiological score was 15 out of 20 points. Pain was seen in 20 (22%) patients. In 17 (19%), pain was because of bursa over the olecranon screw; the other 3 (3%) had occasional activity-related pain. Eighty-two (92%) patients had range of motion more than functional range.[15] Eighty patients (90%) had activity equalling the level prior to injury (Tables 1, 2). Thirty-six (40.4%) patients were graded as excellent (90-100 points), 40 (45%) as good (75-85 points), 10 (11.2%) as fair (50-65 points), and 3 (3.4%) as poor (<50 points). The patients with delayed union of the olecranon osteotomy had a 2.7 times higher chance of developing heterotrophic ossification of more than 10 mm (odd ratio [OR] 2.7). All the unsatisfactory results (average and poor) were seen in those patients who developed complications related to the olecranon osteotomy (p=0.000, OR 103.2).

DISCUSSION

Intercondylar fractures of the distal humerus are difficult to treat because of the nature of the injury and intricate anatomy of the region. The recommendations for treatment range widely from essentially no treatment to open reduction and extensive internal fixation.[1,2,8,9] Conservative treatment has largely been abandoned because of its unsatisfactory results.[1,16] The aim of operative treatment of intra-articular distal humeral fractures is anatomic reduction and rigid fixation to allow early range of motion and finally to restore the pre-fracture function.[4,16,17] The anatomic reduction of articular fragments is difficult due to the poor visualization because of the extensor mechanism and intact olecranon process, which is hocked over the trochlea. Direct visualization of the fracture is enhanced by mobilizing the extensor mechanism, which is further enhanced by osteomatising the olecranon process, as has been demonstrated in cadaveric experiments.[12] Olecranon osteotomy has been reported to have inherent complications that range from increasing surgical time, delayed union, non-union (10%), malunion, prominent hardware (25%), secondary procedures for removal of hardware (13%), and the problem of non-union repair.[15,18] The purpose of this study was to evaluate the outcome of chevron olecranon osteotomy in terms of union, complications, adequacy of surgical reduction of fracture, and ultimate functional outcome. Credited to MacAusland, the trans- olecranon approach was popularized by Cassebaum.[8] There have been several modifications to the technique, notably, the chevron intra-articular olecranon osteotomy. While providing similar exposure of the articular surface, the chevron osteotomy increases rotational and translational stability of the osteotomy apart from increasing contact surface area for bony union as compared to transverse osteotomy.[2,4,9] The chevron olecranon osteotomy was used in the operative management of all the intra-articular fractures of the distal humerus in our study. To determine whether this exposure facilitated anatomic reduction of the articular surface, pre- and postoperative radiographs were analyzed as per the radiological criteria of Caja and Morani et al.[14] Satisfactory results were found in most of the patients, and the adequacy of the surgical reduction was gauged from the average radiological score of 15 out of 20 points. Similar observations were recognized by other authors.[2,17] Despite being used in more severe and comminuted fractures, the olecranon osteotomy has been shown to lead to less stiffness and

Table 2. Baseline characteristics in relation with complications of the olecranon osteotomy

	Yes		No		Result
	n	%	n	%	
Age					
≤ 45	12	32.4	25	67.6	**OR=1.1**
> 45	18	34.6	34	65.4	p=0.830 (NS)
Gender					
Male	14	35.9	25	64.1	**OR=1.2**
Female	16	32.0	34	68.0	p=0.701 (NS)
Pain					
No	20	33.3	40	66.7	**OR=1.05**
Occasional	9	34.6	17	65.4	p=0.919 (NS)
Activity-related	1	33.3	2	66.7	
Range of motion					
Full	10	31.3	22	68.8	**OR=1.3**
More than functional	18	36.0	32	64.0	p=0.828 (NS)
Less than functional	2	28.6	5	71.4	
Activity					
Normal	26	32.5	54	67.5	**OR=1.7**
Interrupted	2	66.7	1	33.3	p=0.506 (NS)
Diminished	2	33.3	4	66.7	
Articular surface step > 1 mm					
Present	8	33.3	16	66.7	**OR=0.98**
Absent	22	33.8	43	66.2	p=0.964 (NS)
Articular surface diastases > 1 mm					
Present	9	28.1	23	71.9	**OR=0.67**
Absent	21	36.8	36	63.2	p=0.406 (NS)
Carrying angle malalignment >10º					
Present	5	41.7	7	58.3	**OR=1.5**
Absent	25	32.5	52	67.5	p=0.533 (NS)
Heterotrophic ossification >10 mm					
Present	9	52.9	8	47.1	**OR=2.7**
Absent	21	29.2	51	70.8	p=0.064 (NS)
Result					
Satisfactory	16	21.3	59	78.7	**OR=103.2**
Not satisfactory	14	100.0			p=0.000 (Sig)

increased range of motion of the elbow compared to splitting or reflecting the extensor mechanism, thus enhancing the functional outcome. [2,17]

The most frequently cited complications associated with olecranon osteotomy are non-union and symptomatic prominent hardware.[3,4] Henley[4,5] noted a 23% complication rate related to olecranon osteotomy. Difficulties with union were identified in 10.3% of patients, with remaining complications associated with symptomatic internal fixation. All the complications in the study occurred in those osteotomies that were fixed with K-wire tension band technique. McKee et al.[6] noted 27% required re-operation for removal of symptomatic internal fixation. Gofton et al.[10] reported non-union in 2 of 22 olecranon osteotomies. One osteotomy was secured with an intramedullary screw and tension band wiring and the second was secured with K-wires and tension band technique. John and Rosso[18] noted non-union in two osteotomies out of 49 patients, and they advised chevron olecranon osteotomy and tension band wiring for fixation of osteotomies to overcome the problem. Holdsworth[11] observed three delayed unions of olecranon osteotomies, but all three were transverse osteotomies as compared to chevron osteotomies.

Many methods have been advocated for the fixation of the olecranon osteotomies in an effort to overcome the problems of union.[1-3,5] One of the methods is unicortical K-wires and tension band wiring. This

method of fixation has been reported to be associated with higher incidence of non-union and wire migration.[1,3,5] Another method is an intramedullary screw and dorsal ulnar SS-wire construct. When comparing this method with K-wire/tension band technique, intramedullary screws offered improved osteotomy fixation and were less likely to back out and create symptomatic prominence.[2] In this study, there was no non-union of any olecranon osteotomy, although delayed union occurred in four osteotomies that subsequently healed without intervention by 20 weeks. All the osteotomies in our series were fixed with a 4.5 or 6.5 mm cancellous screw based on the intra-medullary diameter of the proximal ulna. The screw diameter strongly engages the endosteum and the hold is increased indirectly by the curvature of the proximal ulna, which is further enhanced by the dorsal ulnar tension band wiring. This type of construct has less chance of non-union, as has been proven from this study. Another major complication reported with the use of olecranon osteotomy is a secondary procedure for removal of symptomatic implant.[2] Ring et al.[19] noted a 13% removal rate of solely symptomatic proximal ulnar wires and a total of 27% wire removal rate, including those removed in conjunction with another elbow procedure. Ulnar nerve injury is reported in 7 to15% of patients.[20] In our study, 17 (19%) patients had symptomatic olecranon fixation and needed an elective procedure for its removal. Out of the 14 unsatisfactory results, 10 (71.4%) were those who had prominent symptomatic olecranon fixation. Thus, careful fixation of the osteotomy is mandatory for the satisfactory outcome of these fractures.

Despite a few manageable complications, olecranon osteotomy is useful in visualization of more complex articular injuries and allows accurate reduction.[2] Symptomatic olecranon fixation remains a consistent but manageable problem, particularly when compared with complex reconstructive issues of high energy malunited distal humerus fractures as a result of inadequate articular visualization.

In conclusion, intra-articular fractures of the distal humerus are difficult to treat. Exposure is enhanced by olecranon osteotomy, which facilitates adequate reduction and stable fixation, leading to a better outcome. Symptomatic olecranon fixation remains a consistent but manageable problem, particularly when compared with complex reconstructive issues of high energy malunited distal humerus fractures as a result of inadequate articular visualization.

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