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An alternative fixation method for the treatment of unstable distal clavicle fractures: locked distal radius plate

Distal klavikula ayrışmalı kırıkları için yeni bir tespit yöntemi: Kilitli distal radius uç plağı

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Amaç: Ayrışmalı distal klavikula kırıkları için uygulanan cerrahi tedavinin komşu eklem hareketlerinde kısıtlamaya yol açmaması gerekir. Bu çalışmada, ayrışmalı klavikula distal uç kırıklarında kilitli distal radius uç plağı kullanarak uyguladığımız cerrahi tedavinin sonuçları değerlendirildi.

Çalışma planı: Çalışmada, ayrışmalı klavikula distal uç kırığı nedeniyle açık düzeltme ve kilitli radius distal uç plağı ile tedavi edilen ardışık 14 hasta (11 erkek, 3 kadın; ort. yaş 30±9; dağılım 19-51) incelendi. Bir hastaya daha önce başka bir merkezde K-teli ve gergi bandı yöntemiyle cerrahi uygulanmış ve kaynama sağlanamamıştı. İki olgu dışında, ameliyata kadar geçen süre ortalama 5.3 gündü (dağılım 1-17 gün). Yeni kırıklar Neer sınıflamasına göre 10 olguda tip II, üç olguda tip III olarak sınıflandırıldı. Omuz muayenesi ve işlevsel değerlendirme ameliyat sonrası 3, 6 ve 12. aylarda yapıldı. İşlevsel değerlendirmede Değiştirilmiş Omuz Puanı ve Constant omuz puanı kullanıldı.

Sonuçlar: Tüm olgularda ameliyat sonrası altıncı haftada omuz ekleminde tam hareket açıklığı elde edildi. On ikinci aydaki değiştirilmiş omuz puanı ortalaması 18.7±1.5, Constant omuz puanı ortalaması 95.4±3.0 bulundu. Hiçbir olguda plak vida yetersizliği, düzeltme kaybı, yara açılması veya enfeksiyon gibi komplikasyonlarla karşılaşılmadı.

Çıkarımlar: Distal radius kilitli plağı, seçilmiş distal klavikula taze kırıkları ve kaynamamalarında, cihazın çıkarılması gerekmeden, erken dönemde aktif omuz hareketlerine izin verebilecek bir tespit sağlamaktadır. Bu teknik kullanılarak mükemmel klinik sonuçlar elde edilebilir.

Anahtar sözcükler: Kemik plağı; kemik vidası; klavikula/yaralanma/cerrahi; kırık tespiti, internal/enstrümantasyon; omuz kırığı/cerrahi; omuz eklemi.

Objectives: Optimal surgical fixation method for displaced distal clavicle fractures should not impose limitations on neighboring joint movements. We evaluated the results of surgical treatment of displaced distal clavicle fractures using locked distal radius plates.

Methods: Displaced distal clavicle fractures of 14 consecutive patients (11 men, 3 women; mean age 30±9 years; range 19 to 51 years) were treated using open reduction and locked distal radius plates. Before final fixation, one patient underwent K-wire fixation with tension band at another center, resulting in nonunion. Except for two cases with late presentation, the mean time to surgery was 5.3 days (range 1 to 17 days). According to the Neer classification, fresh fractures were type II in 10 patients and type III in three patients. Shoulder examinations and functional evaluations were made at 3, 6, and 12 months postoperatively. Functional assessment included the Modified Shoulder Rating Scale and Constant score.

Results: All patients achieved full range of motion of the shoulder at six weeks postoperatively. The mean modified shoulder score was 18.7±1.5 and the mean Constant score was 95.4±3.0 at 12 months. None of the patients developed implant failure, loss of reduction, skin breakdown, or infection.

Conclusion: In selected acute fractures and nonunions of the distal clavicle, excellent clinical results are easily achievable with locked distal radius plate fixation because it allows early shoulder movements without necessitating implant removal.

Key words: Bone plates; bone screws; clavicle/injuries/surgery; fracture fixation, internal/instrumentation; shoulder fractures/surgery; shoulder joint.

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A clavicle fracture is common traumatic injury that comprises 44% of shoulder girdle injuries and 5% of all skeletal injuries . Fractures of the clavicle are classified by Allman according to its localization as middle, distal and medial third fractures. Being second in the frequency of occurrence after middle third, distal end fractures comprise approximately 10 to 15% of clavicle fractures.[1-3] Distal end clavicle fractures are further classified by Neer into three types as; minimally displaced type I with intact coracoclavicular ligament complex, displaced type II with ruptured coracoclavicular ligament complex and type III fracture extending into the acromioclavicular joint surface.[4]

Weight of the arm, pectoralis major, pectoralis minor, latissimus dorsi, trapezius and scapular motions act on the fracture site to impair union in displaced fractures. Non operative treatment results in high delayed or non union rate of approximately 50%.[4] Many authors advocated primary surgical treatment of displaced injuries . Direct fracture repair with or without coracoclavicular ligament complex repair [2, 3], k-wires and tension band wiring [5], transacromial pinning [4, 6], coracoclavicular screws [4, 6], intramedullary fixation with various implants [7, 8], coracoclavicular ligament complex reconstructions with various methods and hook plating [9, 10] are major techniques that had been used for the surgical treatment of distal end clavicle fractures. However, many of these techniques have potential or proven disadvantages such as pin migration, screw breakage, rotator cuff irritation and rupture, infection, osteomyelitis, refracture, osteoarthritic changes, and ankylosis. No single method has been found to be the best surgical option.

When surgery was indicated, a fixation method that does not involve any joints other than fracture itself may be the best treatment option for distal clavicular fractures. To overcome the disadvantages of previously described methods we proposed a new fixation technique. The objective of this study is to describe a new operative treatment technique, which uses fixed angle distal radius plate-screw construct in a consecutive patient series with short term follow up.

Patients and methods

Between March 2005 and June 2007 fourteen patients underwent surgical treatment for distal clavicular fractures. Eleven out of fourteen was men. Surgery was performed for thirteen acute fractures and one non union; which was operated on by using transacromial Kirchner wires and cerclage technique four months before the admission. All patients were operated on in beech chair position with the involved extremity draped free. Fracture ends were debrided and direct reduction was performed. Fixed angle

Table 1. Modified Shoulder Rating Scale for Distal Clavicle Fractures[6,11]

Category	Points
Maintance of reduction	
Reduced	4
Subluxed (1–2 mm)	2
Dislocated (.3 mm)	0
Range of motion	
Full	2
Mild limitation	1
Marked limitation	0
Muscle strength	
Normal	2
Nearly normal	1
Abnormal	0
Pain	
None	4
With strenuous activity	3
With moderate activity	2
With mild activity	1
All the time	0
Subjective weakness	
None	2
With strenuous activity	1
All the time	0
Change in occupation	
Same or more strenuous	2
Less strenuous	0
Patient satisfaction	
Yes	2
No or unsure	0
Complication	
None	2
Minor/resolved	1
Major/affected outcome	0
Resulting and overall rating	
Excellent	18-20
Good	15-17
Fair	12-14
Poor	<11

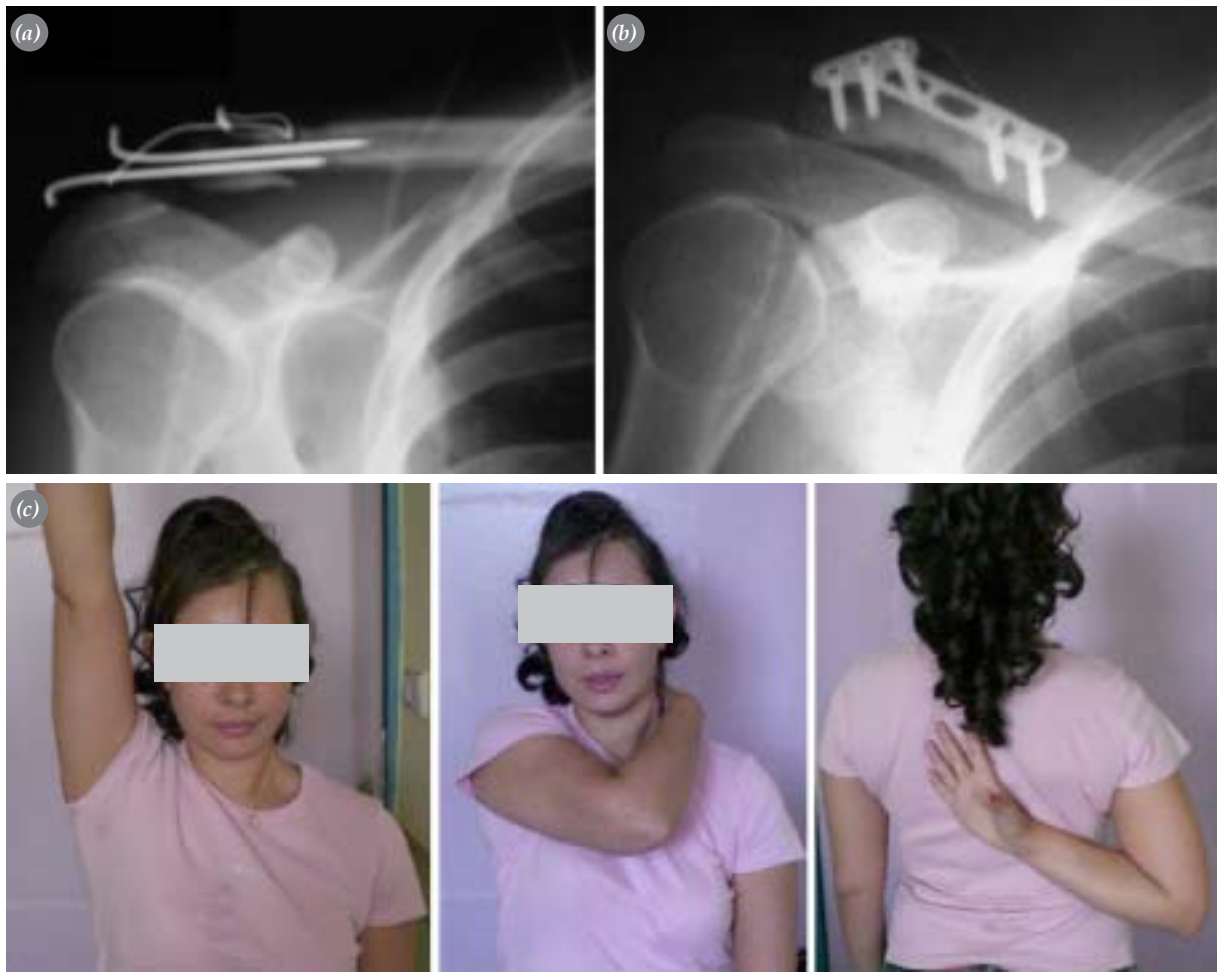

Figure 1. Thirty six years old female medical dentist was involved in a car traffic accident and sustained a displaced right clavicle distal end fracture. Operative treatment by using open reduction and K wire-cerclage wiring technique was performed at a different hospital. After four months she admitted to our department with pain on shoulder motions and skin irritation due to protruding K wires and cerclage knot. Clinical examination revealed decreased shoulder motion in all directions and tenderness on palpation over the prominent implant. Direct X-rays revealed, defective fracture healing at the fracture site and loosening of wires **(a)**. Operative treatment was advised. After implant removal fracture site was debrided and fixed with fixed angle distal radius plate. No bone grafting was performed. Fracture united uneventfully **(b)**. Three months postoperatively patient was completely pain free with full range of motion **(c,d** and **e)**.

distal radius plate (Synthes GmbH, Switzerland) was then applied onto the distal clavicle so that the T-piece sits on the lateral fragment and at least two screws are used to fix the medial fragment. Coracoclavicular ligament was repaired by direct sutures of the torn parts in nine and reconstructed by using Teflon band in one patient.

Rehabilitation protocol was the same for all patients and included immediate active range of motion dictated by patients' pain tolerance. After achieving full range of motion, strengthening exercises were initiated, usually at about two weeks in most of the cases. Functional and radiological examinations were performed by an independent observer at three, six and twelve months postoperatively. Modified Shoulder Score [6, 11] and Constant Shoulder Score [12] were used to evaluate the patients' functional status. Mean age was 29,8 ± 8,7 years (range 19-51). Trauma mechanism was simple fall in six, sporting injuries in four, traffic accidents in three and fall from height in one case. Mean injury severity score was 10,8 ± 6,4. Mean time between trauma and surgical treatment in our department was 15,3 days. However, when we

Figure 2. 27 years old male construct worker fell from eight meters and admitted to our emergency department. Clinical examination and direct X rays revealed bilateral distal clavicular fractures, right midclavicular displaced fracture **(a)** and left humerus shaft fracture. Segmental right clavicula was fixed by using 3,5 mm fixed angle reconstruction plate-screws for midshaft portion and 2,7/3,5 mm angular stable distal radius plate-screws for the distal end fracture and healed without complication **(b)**. At three months he had pain free full range of motion **(c, d** and **e)**.

excluded two patients with previous history of conservative treatment in one case and surgical treatment in one other mean time before our surgery drops to 5,3 ± 4,9 days (range 1-17).

Results

Mean of injury severity score was 10,8±6,4. All patients achieved full range of motion at six weeks postoperatively (Figures 1-3). Mean modified shoulder score was 18,7±1,5 and mean Constant score was 95,4±3,0 at twelve months. No implant failure, loss of reduction, skin breakdown or infection was observed in this series. Big scar was caused cosmetic complaint in one case in which segmental clavicular shaft fracture was treated with plate and screws necessitating a big transverse incision. Patients did not report any complaints related to rotator cuff during the mean follow-up of 22 months (range 14-28).

Discussion

The rarity of the lateral clavicular fractures and the lack of results of patient series treated with a particular method account for the fact that no single technique has become generally accepted [13] Many of the proposed techniques have potential or proven disadvantages. Techniques using internal fixation that includes rigid fixation between the clavicle and coracoid or between the clavicle and acromion are doomed to fail, because they interfere with the normal rotational movement of the clavicle in relation to the coracoid and acromion. Therefore, the metallic fixation should be removed before full mobilization is started if such internal fixation had been used. Direct repair of the fracture with wires or other suture materials was reported to yield excellent results.[2, 3, 14, 15] However, applicability of this technique is mostly limited to fracture types that are not comminuted or long ob-

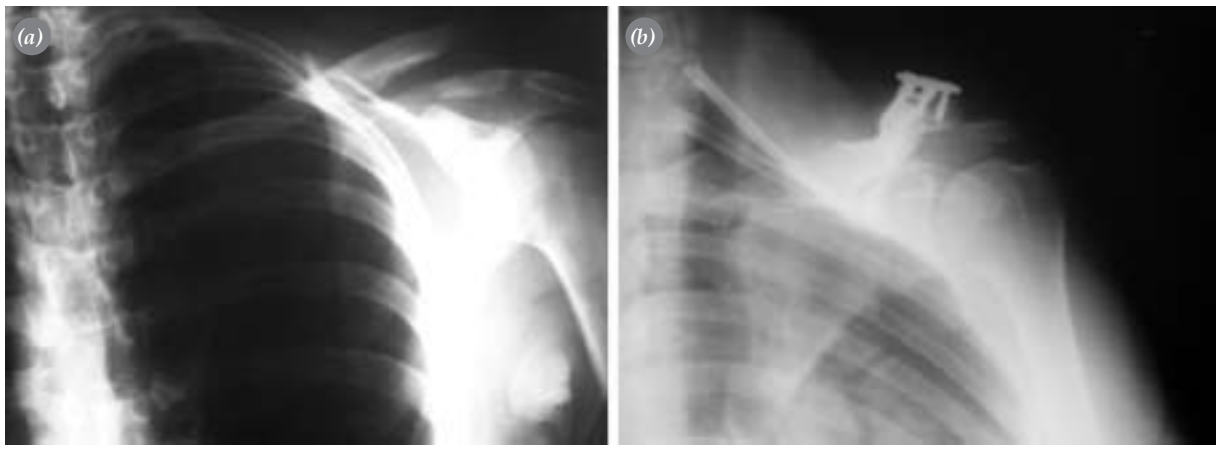

Figure 3. (a) Type II lateral end clavicle fracture which occurred after a simple fall, **(b)** Oblique X-ray showing healed fracture, relation of lateral clavicle to acromion and position of the plate.

lique in shape. The latter is not a common pattern. Transacromial wires alone are known to have a high rate of nonunion and infection.[16] Potentially fatal and seriously disabling complications that prohibit the utilization of this technique have been reported as well.[17, 18] Specially designed hook plates proposed in the last decade improved the initial stability of the fracture. However, later reports showed increased incidence of complications such as subacromial impingement, rotator cuff ruptures, acromion fractures, acromial osteolysis and pain originating from the hook hole enlargement.[9, 10, 19]

We propose that the technique presented in this study provides rigid fixation of the distal clavicle fracture itself and also does not limit the motion of neighboring joints. When reviewed the early outcomes of patients treated with this technique, the advantage of early rehabilitation without limitation of range of motion was obvious. On the other hand, if techniques that consist of fixation between the clavicle and coracoid or between the clavicle and acromion were chosen, shoulder motions would be restricted until the fracture union and removal of the implants and thereby would interfere with early return to activities of daily living. Failure to understand the complex three dimensional clavicular motion [20, 21] and anatomy [22, 23] and beginning full range of motion before the implant removal usually results in implant breakage or more seriously fracture of the anchorage points .

Small size of the lateral fragment in distal clavicle fractures makes its sufficient stabilization with classical plate screws designs technically very difficult. Remembering the bony anatomy of the clavicle the concave angle of 143±8,1 degrees and superior bow of 5,1±5,9 millimeters at the lateral clavicle within the five centimeters from the acromial end make it extremely difficult to find an implant that provides both sufficient fracture stabilization and ease to fit to the anatomy considering the shape of the distal end of the clavicle. Additionally, an average of 11,4±1,6 millimeters superior-inferior thickness at the acromial end precludes secure purchase of conventional cortical screws. To overcome such difficulties we propose a technique which utilizes the locking distal radius T plate. As described above the surgical technique is simple: T part of the plate sits on the lateral fragment and usually three hole longitudinal part on the medial fragment. Application of fixed angle screws which are locked onto the plate increases the rigidity of the construct and accommodates the forces generated by the free motion of shoulder in our cases until fractures unite. Although there is a specifically designed lateral clavicular plate still commercially available on the market we are not aware of any study reporting the results of its use. Very recently Kalamaras and coworkers [24] published a smaller series comprised of nine lateral clavicular fractures treated with 2.7mm locked distal radius plate. Their results were very similar to ours in respect to Constant scores and union. However, they immobilized their patients during first six weeks after the operation and allowed only range of motion exercises. They also recommended bending the plate ends on the lateral fragment to angle screws into the clavicle and probably also to prevent soft tissue irritation since these five hole T plates have longer T portion than the antero-posterior dimensions of the clavicle. In our series we used 3.5mm implants with

three holes on T portion and we did not it necessary to bend any part of the plate in none of the cases. If plate protrudes from the margins of the lateral fragment we recommend placing it posteriorly to prevent anterior soft tissue problems. Additionally, we initiated immediate full range of motion exercises and as patients pain tolerate they discontinued the sling immobilization in our series in contrast to prolonged immobilization policy in shoulder sling of Kalamaras and coworkers. In our opinion fixation with locked plates provides enough and secure stability which permit early unprotected motion.

In spite of excellent and encouraging early results, our study also has some limitations. Lateral fragment should be large enough to accept the T-part of the plate. In cases with very small lateral fragment or too much comminution the risk of hindering the secure fixation is high. Despite the well known disadvantages, acromioclavicular hook plates or other techniques which surgeon is familiar with may be a better choice. The described method of fixation, like all other plating techniques, needs relatively wider exposure and dissection. Although we did not remove any implants in this series, metallic implants sometimes need to be removed if they cause irritation or if there is a demand on behalf of the patient. Last, this series includes a relatively small number of patients and the method was not compared with another method prospectively to investigate if the outcomes are superior.

In conclusion, we propose an alternative fixation technique for the treatment of selected lateral end clavicular fractures and non unions. Main advantage of this new technique is that it enables initiation of early active unlimited motion. Also it does not require a second operation for implant removal before the initiation of full range of motion exercises. In this study, excellent results are easily achieved without major complications at short term follow up.

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