NON-UNION OF FRACTURES OF CLAVICLE
Klavikula kırıklarında psödoartroz

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Özet

Amaç: *Bu çalışmada,klavikula pseudoartrozu nedeniyle kemik grefti ile birlikte tedavi ettiğimiz, Dinamik Kompresyon Plakları (DCP) ile tesbit uygulanan 15 ve Low-contact Dinamik Kompresyon Plakları (LC-DCP) ile tesbit edilen 19 hastanın sonuçlarını retrospektif olarak karşılaştırmayı amaçladık.*

Hastalar ve Yöntem: *DCP ile 11 atrofik ve dört hipertrofik pseudoartroz tedavi edilirken,13 atrofik ve altı hipertrofik pseudoartrozuna LC-DCP ile tesbit yapıldı.Hastaların günlük aktiviteleri ve ameliyat sonrası yaşam kalitesi Disabilities of the Arm, Shoulder and Hand (DASH) sorgulaması ile değerlendirildi. DCP ile tedavi edilen grupta ortalama takip süresi 6.2 yıl (2-10 yıl) ve LC-DCP ile tedavi edilen grupta ise ortalama 3.4 yıl (2-6 yıl) idi.*

Bulgular: *DASH fonksiyon/semptom skoru DCP ile tdeavi edilen grupta 9.2±2.0 puan iken LC-DCP ile tedavi edilen grupta 8.7±1.1 puan idi.*

Sonuç: *Klavikula pseudoartrozlarının tedavisinde otojen kemik grefti ile birlikte LC-DCP ile tesbit başarılı bir tedavi yöntemidir.*

Anahtar Kelimeler: *Kemik grefti, Pseodoartroz,Klavikula*

Abstract

Purpose: *The aim of this retrospective study was to compare the results of the techniques of dynamic compression plating (DCP) or low-contact dynamic compression plaques (LC-DCP) applied to patients for internal fixation and bone grafting of non-union of the clavicle.*

Patients and Methods: *There were 11 atrophic and four hypertrophic non-unions in the DCP treated group and 13 atrophic and six hypertrophic non-unions in the LC-DCP treated group. The patients' everyday activities and general post-operative quality of life were estimated with the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. The average follow-up period of the cases treated with DCP was 6.2 years (range 2-10 years) and that of the cases treated with LC-DCP was 3.4 years (range 2-6 years).*

Results: *In the group treated with DCP the mean DASH function/symptom score was 9.2±2.0 points. Mean DASH function /symptom score was 8.7±1.1 points in the group treated with LC-DCP.*

Conclusion: *We conclude that the use of an LC-DCP with autologous bone-grafting is a reliable method of treating ununited fractures or non-unions of the clavicle.*

Key Words: *Bone grafting; Clavicula; Pseudoarthrozis*

Fractures of the clavicle are common injuries, accounting for 5% to 10% of all cases of adult skeletal trauma (1,2). Despite this, non-unions and symptomatic malunions following clavicular fractures are uncommon. When these complications occur, however, they may be associated with a pattern of disability that includes not only pain but also impairment of upper extremity function (3-5). In addition ,deformity at the fracture site can result in local compression of the brachial plexus or subclavian vessels (1,3,4). Factors predisposing to non-union of the clavicle include high energy trauma, degree of displacement, lateral third fractures, soft tissue interposition and re-fracture (1,2,6).

Various surgical procedures have been proposed for the treatment of un-united fractures of the clavicle. There is controversy concerning the management of symptomatic non-union of the clavicle (7-9). The treatment options include excision of the site (4,10) and intramedullary fixation, (11,12) interfragmentary screw fixation,

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AO dynamic compression plating (DCP), reconstruction plate(6,13-16), and 3.5 mm low–contact dynamic compression plate (LC-DCP)(17) with various combinations of cortical (2) or cancellous autograft(1,2,10) or sculptured tricortical iliac graft (18).

We undertook this retrospective study to review our experience of dynamic compression plating and the results of using LC-DCP for internal fixation and bone grafting of non-union of the clavicle.

MATERIALS AND METHODS

From August 1990 to March 1999, 32 adult patients with an ununited fracture of the clavicle were treated at our institution; 15 with 3.5mm AO DCP and 19 with titanium 3.5mm LC-DCP (Synthes®). Proximal and distal end clavicular non-unions were excluded from our study because of being anatomically unfit for plate fixation.

The patients treated with dynamic compression plating ranged in age from 19 to 66 years (mean 39 years), with a male to female ratio of 4:1.The patients treated with LC-DCP ranged in age from 22 to 66 years (mean 42 years), with a male to female ratio of 3:1 .The causes of the initial fracture were sport injuries in 9 patients, motor vehicle accidents in 17, and a fall in the case of six patients. The mean interval between fracture and surgery for a delayed union or non-union was 10.2 months (mean 4 to 26 months) in the group treated with DCP, and 11.4 months (mean 3 to 19 months) in the group treated with LC-DCP. There were 11 atrophic and four hypertrophic non-unions in the DCP treated group and 13 atrophic and six hypertrophic non-unions in the LC-DCP treated group.

Preoperatively, all patients complained of pain from motion at the fracture site with use of the ipsilateral shoulder. Five patients complained of paresthesias in the distal part of the extremity with extreme abduction or flexion. Twelve patients complained of a clicking sensation with motion of the arm. Ten patients also had limitation of shoulder motion.

The site of non-union in 19 patients was the middle third of the clavicle and in the other 13, the lateral third. On all roentgenograms, the primary displacement equaled the clavicular thickness or was greater. The mean displacement of the bone ends was 9 mm (DCP) and 11 mm (LC-DCP) . Preoperative planning in cases of non-union was executed with the aid of anteroposterior radiographs which show both clavicles. This establishes the extent of shortening and the length of an intercalary bone graft should it be needed to restore clavicular length. Each fixation was supplemented with cancellous bone from the iliac crest. All operations were performed under general intubation anesthesia, and the affected shoulder was elevated. An incision was made along the longitudinal axis of the bone centred over the site of the lesion. Careful dissection, preferably with loupe magnification was performed to identify and safeguard branches of the supraclavicular nerves that traverse the surface of the clavicle. The site of the non-union was then exposed subperiosteally. Sclerotic bone ends were excised and the medullary canals of both fragments opened up in cases of non-union. After reduction of the fracture, a 3.5 mm DCP (7 or 8 holes) was bent to the contours of the serpentine architecture of the clavicle. The design features of the LC-DCP permit multiplanar bending to occur at any point in the plate rather than through the screw holes. Depending on the extent of the gap that existed, an appropriate type of bone graft was harvested from the iliac crest. A large defect was spanned using a sculptured tricortical graft (18). In a total of 14 of the cases in both groups, soft tissue interposition was observed between the fracture ends during the operation.

Postoperatively, the affected shoulder was immobilized with a sling. The sling was removed for short periods of passive shoulder pendulum and overhead elbow–flexion (without resistance) range-of-motion exercises, which was continued until fracture union was observed. Thereafter, progressive strengthening exercises were permitted, although full overhead activities were not resumed

until sound healing was observed both clinically and radiologically, which usually occurred six to eight weeks postoperatively. A return to all occupational duties and recreational pursuits was usually possible by three months after reconstruction. We defined bony union as no pain or tenderness over the fracture site and the complete disappearance of the bony gap or solid callus connecting the fracture fragments on plain films(21).

The patients' everyday activities and general post-operative quality of life were estimated using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire (19,20). The DASH function/symptom questionnaire is composed of thirty questions. The alternatives given for each question range from one to five points, one being the best outcome, and five the worst. The DASH score is calculated by subtracting 30 from the patients' total points, then dividing this number by 1.20 (©IWH & AAOS & COMSS 1997). In both groups union periods were measured and the DASH scores calculated. Student's t test was used to compare the two groups and p< 0.001 was considered significantly different.

RESULTS

Twenty–nine patients were followed for at least two years. The other three patients could not be contacted. Thirteen of these cases were from the group treated with AO DCP and 16 were from the group treated with LC-DCP. The average follow-up period of the cases treated with DCP was 6.2 years (mean 2 -10 years) and that of the cases treated with LC-DCP was 3.4 years (mean 2 - 6 years).

For DCP cases, 12 achieved solid union, with a union rate of 92.3% (12 of 13) and a union period of 11.9±2.3 weeks (Table 1). For LC-DCP treated group, both clinical and radiological union was achieved in all cases with a union period of 9.2±1.7 (p< 0.001)(Table 1). All these patients also had a normal range of motion of the ipsilateral shoulder. The ipsilateral shoulder and elbow range of motion were usually satisfactory regardless of their status preoperatively. No significant differences were noted. No postoperative problems with wound healing or infection occurred.

All neurologic complaints resolved after operation. Complications in cases of DCP included three superficial infections and one non-union (with implant failure). This patient was treated with sculptured tricortical iliac bone grafting with LC-DCP. His shoulder movement was limited. This patient's shoulder was successfully manipulated under general anesthesia. The patient's shoulder abduction is limited at present (160º), but this limitation does not cause any problems in his daily living. Two patients noticed persistent numbness at the donor site of the bone graft from the iliac crest. It was not sufficiently troublesome to then warrant any treatment.

In the group treated with DCP the mean DASH function/symptom score was 9.2±2.0 points (0 points representing the best possible result and 100 points representing the worst possible result). The mean DASH function /symptom score was 8.7±1.1 points in the group treated with LC-DCP (p>0.05) (Table 1). There was no statistically significant difference between the results of the two groups. The optional module was answered by three patients: one tennis player who was treated with LC-DCP and two basketball players who were treated with DCP. The findings were then investigated. The tennis player and one of the basketball players stated that they suffered from mild shoulder pain following heavy exercises during the first year after treatment although this pain did not prevent them from doing sport activities, and this complaint then disappeared. Both the patients' everyday activities and the range of motion categories were almost normal. Overall, the long-term outcome was excellent.

Twelve patients in the DCP groups and all patients in the LC-DCP groups were unable to work prior to surgery. One patient failed to return to work postoperatively due to implant failure. The average time before returning to work was 6.9 (2-14) weeks (DCP) and 6.1 (1-11) weeks (LC-DCP) following

surgery. Three patients in the DCP group and 3 patients in the LC-DCP group had mild discomfort from their scar. At the most recent follow-up examinations, two patients had mild symptoms, such as occasional pain with changes in the weather. These patients had no complaints after removal of the implants. Five DCP and two LC-DCP were removed because of cosmesis (Figure

Table 1. *The comparison of statistical results of the DASH function score and union durations in the patients treated with DCP and LC-DCP*

	DCP Group[x]	LC-DCP Group[xx]	P
DASH Ouastionnare (point) [xxx]	9.2 ± 2.0	8.7 ± 1.1	> 0.05
Union time (week)	11.9 ± 2.3	9.2 ± 1.7	< 0.001

[x] Dynamic Compression Plate
[xx] Low Contact-Dynamic Compression Plate
[xxx] Disabilities of the Arm,Shoulder and Hand (DASH) 0,is the best outcome and 100 is the worst

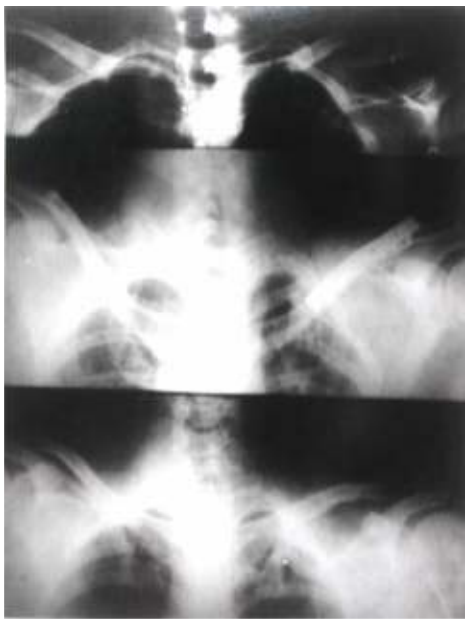

Figure 1. *The roentgenorams of a 44-year patient with a middle clavicular non-union who was treated with DCP. The roentgenograms were obtained prepoeratively, in the postoperative 6th year, and after removal of the implant.*

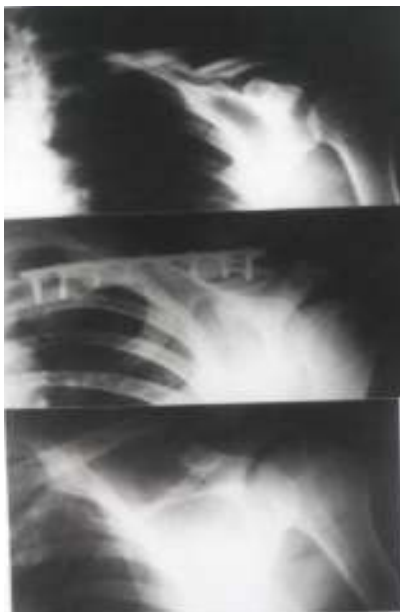

Figure 2. *The roentgenorams of a 37-year patient with a clavicular non-union who was treated with LC-DCP. The roentgenograms were obtained prepoeratively, in the postoperative 4th year, and after removal of the implant.*

1,2).

DISCUSSION

Factors favoring fracture healing are smaller gap, adequate stability, and sufficient nutrition supply (1,2). Although movement of the glenohumeral joint will also create a half–displacement of the scapulothoracic joint, which in turn introduces clavicular movement(2), clinically, the stability of the fracture fragments seems to be sufficient.

The clavicle has an integral role not only in the mechanism of the pectoral girdle but also in the function of the upper extremity. Non-union of a fracture of the clavicle might cause considerable functional deficit (4). Non-union is considered to be present when there is little or no progression of clinical or radiographic healing at a minimum of 16 weeks after injury (1,2).

Most closed fractures of the clavicle are managed conservatively and often unite with some shortening (1,2,8). The reasons for the development of a clavicular non-union have yet to be clearly defined. Wilkins and Johnston (5), in an analysis of clavicular non-unions, suggested that the severity of initial trauma and the extent of displacement of the fracture fragments are the most significant factors predisposing to non-union. Some of the non-unions in their study developed in the presence of a comminuted fracture, a fracture that was widely displaced, or associated trauma to the thorax, spine, or ipsilateral extremity. Other studies support the severity of the initial trauma and the extent of fracture–fragment displacement as the most important factors that might lead to failure of union(4-6). None of these studies has implicated such elements as soft-tissue interposition and inadequate immobilization as important risk factors. All patients in our series had marked initial displacement. The deformity characteristically seen is that of the apex pointing superiorly due to the weight of the arm tilting the lateral fragment downwards(4). Based on our surgical findings, we think that soft–tissue interposition may be a major contributing factor in fractures that fail to heal. This mechanism is probably the cause of atrophic non-union. In our study, 14 of the cases had soft tissue interposition between fracture ends.At the same time, all of these cases had atrophic non-union and distant fracture ends.

Malunion of the clavicle seldom presents a problem. However, shortening can result in abduction weakness (10). This has been attributed to restriction of the scapula in an adducted position by the shortened clavicle. The use of an intercalated sculptured tricortical bone graft as described by Seiler and Jupiter (18) is an excellent means of reconstituting clavicular length. The graft is sculptured to create large cancellous pegs at each end, which plug into the prepared medullary canals of the clavicle, maximizing stability of the graft during plate fixation.

Several methods of internal fixation have been utilized in the past. These include screws and onlay bone grafting (5), threaded intramedullary pins (8,1,12), plates and screws (6,3-16). Intramedullary pinning may be combined with cancellous bone or onlay iliac-crest grafting (11), but this is difficult because the pin has to pass through the thin atrophic ends of the bone close to neurovascular structures. Such pinning may cause distraction, and migration of the thin Kirschner wires is common. Wilkins and Johnston (5) reported a 75% incidence of complications in their series of patients whose fractures were managed with intramedullary fixation.

The clavicle has a complex S-shape:–a combination of two curves, a medial half that is convex forwards and a lateral half that is convex backwards. At either end the clavicle is firmly tethered by ligaments or muscular attachments (4,17,18). The apical deformity of a clavicular non-union tends to be directed superiorly, creating a pre-existing tension and compression surface of the clavicle.because of this, we favour application of a plate to the superior, or tension, surface when possible; by doing so, the forces of distraction acting on the bone will be converted into compressive forces, optimizing skeletal stability and promoting healing. Satisfactory clavicular fixation

has also been reported with semitubular, reconstruction, and standard dynamic compression plating (6,13-16). Since 1994, our preference has generally been to use the LC-DCP which offers several advantages in this situation(17,18). The LC-DCP enables further refinement in the implementation of well-established principles of plating. It boasts technical features of value in any location: the structured undersurface enables the preservation of blood supply to plated bone segments, and avoidance of stress risers produced at implant removal. Union occurs earlier in the cases treated with LC-DCP than in those treated with DCP because the periosteum is not removed from the clavicle while placing the plate in LC-DCP ($p<0.001$).The titanium used is twice as flexible as steel, thus rendering it less prone to fatigue failure when used to span a defect(22). The uniform stiffness of the implant facilitates precise contouring in all planes to accurately match the unique anatomy of the clavicle. Furthermore, since there is no solid central section, screw placement into the intercalated bone graft is easier. In addition ,the screw holes permit compression in either direction to enhance graft incorporation on both its surfaces (17,22). Due to LC-DCP uniform bending stiffness, easier contouring of the plate in multiple planes is permitted. This is of considerable importance in the clavicle with its complex three-dimensional shape. In fixation applied with dynamic compression plates, the surgeon may need to bend the plate because the plate cannot match the unique anatomy of the clavicle. The plate may not exactly gain the shape to match the anatomy of the clavicle even if it is considerably bent. This case causes stress both on the plate and the bone. Screw loosening or plate breakage may occur because of stress. In one of our cases treated with DCP, screw loosening and hence loss of reduction occurred. The LC-DCP was sufficiently rigid to permit early rehabilitation and rapid return of shoulder mobility without fear of disruption of the construct. There was no evidence of screw loosening or plate breakage in any instance . Union was successful in all other cases.

In both of the groups, answers to the DASH questionnaire varied with respect to the patients' occupations. Although the DASH function /symptom score was lower in the group treated with LC-DCP, there was no statistically significant difference between the two groups. In sense of union, the results of the group treated with LC-DCP was statistically significant compared with those of the group treated with DCP ($p>0.05$),(Table 1). However, the patients who did sport activities stated that they sometimes had mild complaints during the first year following treatment, and that these complaints disappeared later.

We suggest that the use of an LC-DCP with autologous bone-grafting is a reliable method of treating ununited fractures or non-unions of the clavicle.

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