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Arthroscopic coracoclavicular button fixation versus anatomic locking plate fixation for unstable distal clavicular fractures

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Hypothesis: Neer type II distal clavicle fractures are unstable and associated with high nonunion rates. The aim of this retrospective study was to compare the clinical and radiographic outcomes of anatomic locking plate fixation and arthroscopic coracoclavicular button fixation for unstable distal clavicle fractures.

Methods: Forty-seven patients with Neer type II distal clavicle fractures were treated surgically using either anatomic locking plate fixation (group 1, n = 20) or all arthroscopic coracoclavicular button fixation (group 2, n = 27) between 2012 and 2019 in 2 centers. Clinical and radiographic outcomes after an average follow-up period of 49 months for group 1 and 32 months for group 2 were assessed using the American Shoulder and Elbow Surgeons Shoulder score, Constant-Murley score, visual analog scale score and X-rays.

Results: At the final follow-up, the mean American Shoulder and Elbow Surgeons Shoulder score, Constant-Murley score, and visual analog scale score for group 1 and group 2 were 92.5 ± 3.9 (range 88.3-98.3), 93.6 ± 4.0 (range 90-100), and 0.6 ± 0.6 (range 0-2) and 95 ± 3.3 (range 86.6-100), 96.2 ± 3.0 (range 88-100), and 0.4 ± 0.5 (range 0-1), respectively ($P = .32$, $P = .15$, and $P = .59$, respectively). At the final follow-up, acceptable reduction and bone healing were achieved in all patients. All patients in both groups were able to resume work as well as sports activities. Postoperative complications included 1 case of acromioclavicular joint arthritis and 1 case of screw penetration in group 1 and 2 cases of coracoid process fracture that did not require additional surgery in group 2. Five patients underwent hardware removal owing to skin irritation and dissatisfaction with the cosmetic appearance in group 1.

Conclusion: Both distal anatomic locking plate fixation and arthroscopic coracoclavicular button fixation provide satisfactory functional and radiological outcomes. Both procedures can be used to treat distal clavicle fractures because they have a minimal risk of complications and present similar, high union rates.

Fractures of the distal third of the clavicle affect the coracoclavicular (CC) ligaments are less common than midshaft fractures and are usually secondary to direct high-energy shoulder trauma.[25] Neer classified distal clavicle fractures into 5 types based on their relation to the CC ligaments.[15] In this classification system, types 1 and 3 are considered to be stable fractures and are generally treated conservatively.[17] Detachment of the CC ligaments (conoid and trapezoid ligaments), which ensures the stability of the medial fragment, causes Neer's type 2 fractures to be unstable. Surgical treatment is recommended for these fracture types owing to the 22%-50% nonunion rate after conservative treatment and to prevent other complications, such as shoulder asymmetry, malunion, nonunion, and permanent pain; however, which fixation method yields the best outcomes remains a matter of debate. Hook plates, conventional plates, Kirschner wires (K-wires), a single cortical screw, anatomic locking plates (LPs), and arthroscopic-assisted coracoclavicular button (CB) systems have been used for the surgical treatment of distal clavicle fractures.[3,6,7,11,15,16,18,20,23,24]

Anatomic LPs have multiple locking screws on the lateral end, and these screws have various configurations to maximize screw

Institutional review board approval was obtained from Bezmialem Vakif University (No:2019/6293).

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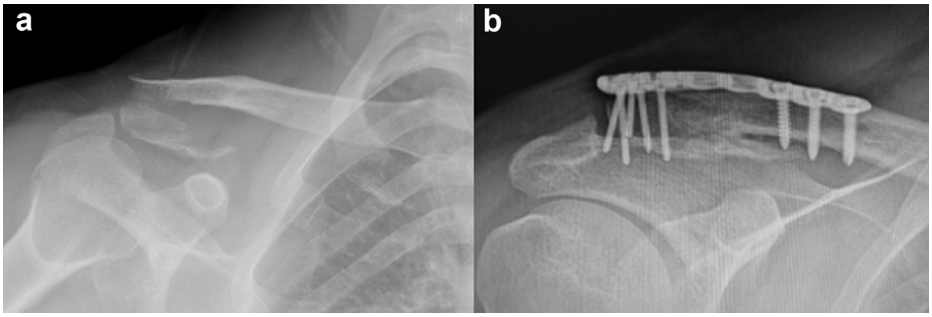

Figure 1 A 36-year-old patient underwent secondary surgery due to dissatisfaction with the cosmetic appearance and screw penetration. Preoperative (**a**) and 1-year postoperative (**b**) anteroposterior X-ray views of the patient.

purchase on distal fragments. Compared with hook plates, anatomic LPs have a relatively low profile and do not interfere with the acromioclavicular joint.[1,2,10] In a few case series, it has been shown that anatomic LPs provide effective fixation in the treatment of unstable Neer's type 2 fractures, and satisfactory results are obtained.[1,2,10] Open reduction and anatomic LP fixation techniques are simple, and every surgeon with experience in basic fracture surgery can successfully fix these rare fractures. However, plate removal is indicated after union is achieved owing to screw penetration into the acromioclavicular joint or subacromial space and for cosmetic reasons. All arthroscopic CB fixation systems were developed for acromioclavicular dislocations and are used for fixation of distal clavicle fractures, and successful results have been reported.[7,16] The potential advantages of the technique are minimal invasiveness, no need for implant removal, and avoidance of disruption of the delicate subacromial space.[5,7] However, arthroscopic surgery requires surgeon experience and training.

The aim of this retrospective study was to compare the clinical and radiographic outcomes of anatomic LP fixation and indirect reduction with an arthroscopic CB system for unstable distal clavicle fractures. Our hypothesis was that all arthroscopic CB fixation would result in satisfactory functional outcomes and better radiological union and lower complication rates than anatomic LP fixation.

Material and methods

After obtaining institutional review board approval (IRB: 2019/6293) from Bezmialem Vakif University (Istanbul, Turkey), the data of 70 patients who underwent surgery for unstable distal clavicle fractures between 2012 and 2019 were retrospectively reviewed. We divided the patients into 2 groups based on the fixation method used: patients in group 1 were treated with distal clavicle anatomic LP fixation (Acumed, Hillsboro, OR, USA) and those in group 2 were treated with an arthroscopic CB system (TightRope system, Arthrex, Naples, FL, USA, and Endobutton, Smith & Nephew, Andover, MA, USA).

Patients who had a multifragmentary clavicle fracture (n = 6) or other fracture types (type I and III) (n = 4) were diagnosed with an additional pathology (glenohumeral, rotator cuff, labral, or biceps tendon injury) during the arthroscopic intervention (n = 4), were treated with open reduction and K-wire fixation (n = 1) (pediatric patient) or a hook plate (patients who had both unstable distal clavicle and coracoid fractures) (n = 4), or were lost to follow-up (n = 4) were excluded from the study. Forty-seven patients with Neer type II fractures who were older than 18 years of age had no concomitant shoulder pathologies and continued their follow-up visits regularly for more than 1 year were included in the study. The patients who met the inclusion criteria were divided into the LP (group 1; n = 20) and CB system (group 2; n = 27) groups.

Surgical techniques

Anatomic locking plate

With the patient in a beach-chair position, a standard superior approach to the clavicle was used. Fracture reduction was performed under direct visualization, and the initial reduction was held with K-wires. Then, the distal clavicle anatomic LP was placed on the reduced clavicular fracture, with locking screws secured into the distal fragment (Fig. 1). Care was taken not to violate or span the acromioclavicular joint during plate fixation. All operations were performed by 2 senior authors (KB, AE) in different university hospitals.

All arthroscopic CB

The procedure began with the patient in the beach-chair position, and anatomic landmarks were marked. The glenohumeral joint was entered through a standard posterior portal and evaluated for concomitant intra-articular pathologies. The anterolateral portal was used as an imaging portal to increase visualization of the coracoid process. Initially, the midpoint of the coracoid was identified percutaneously with a spinal needle; thereafter, the coracoid was punctured with a 2.4-mm guide wire, and a tunnel was opened with a 4-mm drill through the guide wire. A carrier rope was passed through the suture carrier and removed through the posterior portal. Under fluoroscopic visualization, clavicular drilling was performed percutaneously with the 2.4-mm guide wire from the medial (approximately 3-4 cm medial to the AC joint) aspect of the fracture line. Then, under arthroscopic inspection of the guide wire, the tunnel was enlarged with a 4-mm drill. A 2-cm incision was made over the clavicular tunnel, and the suture was passed through the carrier tunnel. The upper portion of the ropes was pulled up, and the CB was added to the system and passed under the coracoid, which was then checked via arthroscopy. Reduction was performed under fluoroscopy, the system was fixed, with nodes on another button placed on the clavicle, and the procedure was terminated (Fig. 2). All operations were performed by 2 senior authors (KB, AE) in 2 different university hospitals.

Postoperative rehabilitation

The same postoperative rehabilitation program was used for both groups. Immobilization was achieved with a shoulder-arm sling for 4 weeks postoperatively. Shoulder pendulum exercises were performed on postoperative day 1. At the end of the 4th week, the sling was removed, and shoulder range-of-motion exercises were allowed until 6-8 weeks. Active assisted exercises were started after obtaining radiological union at 6-8 weeks postoperatively, and active strengthening exercises were given after the 3rd month. Routine clinical and radiological follow-up examinations were performed by the senior authors (KB and AE) at 2 weeks, 6 weeks, 3 months, and 1 year.

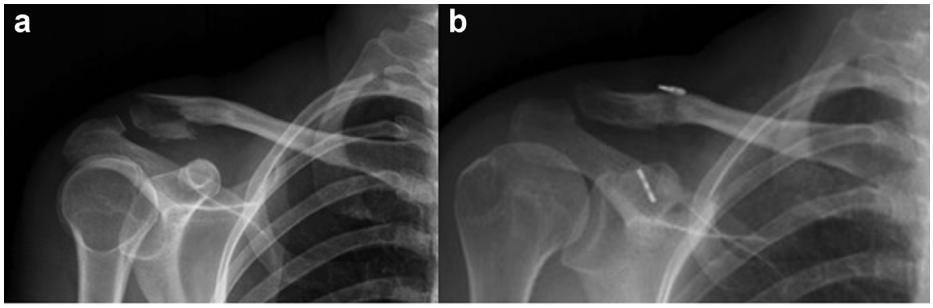

Figure 2 (**a** and **b**) Preoperative and 6-month postoperative anteroposterior X-ray views of a 34-year-old female patient.

Clinical and radiological assessment

The Constant-Murley score, American Shoulder and Elbow Surgeons Shoulder score, and visual analog scale score were used to evaluate the clinical results of the patients. An evaluation of the time to fracture union was performed based on conventional shoulder anteroposterior and axillary radiographs obtained during the follow-up period. Informed consent was obtained from all patients, and the described research adhered to the tenets of the Declaration of Helsinki.

Statistical analysis

First, a Kolmogorov-Smirnov test was used to determine which variables should be included in the data analysis and whether the data for the variables were normally distributed, but the data were not normally distributed. Therefore, nonparametric tests were used. The Mann-Whitney U test was used to compare continuous variables between groups. The Wilcoxon signed-rank test was used to compare continuous variables between groups. The chi-square and Fisher's exact tests were used to compare categorical variables between the 2 groups. The median (1st quartile [Q1]-3rd quartile [Q3]), mean ± standard deviation, frequency, and percentage were reported as descriptive statistics. The statistical analyses were performed using SPSS, version 22 (SPSS Statistics for Windows, Released 2013; IBM, Armonk, NY, USA).

Results

Patient demographics and clinical outcomes are reported in Tables I and II and summarized as follows. In total, 47 patients were included in the study, 8 (17%) were women and 39 (83%) were men. The dominant arm was affected in 68% of the patients. There was a significant difference in follow-up period between the 2 groups ($P = .019$). The mean duration of hospitalization before surgery was 2 ± 0.8 days (range, 1-5). The mechanisms of injury for patients were as follows: falls from standing height (LP n = 11, CB n = 16), traffic accidents (LP n = 5, CB n = 5), bicycle accidents (LP n = 1, CB n = 2), and sports injuries (LP n = 3, CB n = 4).

Return to daily living activities and full range of motion of the affected shoulder were achieved in 6 to 12 weeks in all patients. At the final postoperative evaluation, the mean American Shoulder and Elbow Surgeons Shoulder score, Constant-Murley score, and visual analog scale score were 92.5 ± 3.9 (range, 88.3-98.3), 93.6 ± 4.0 (range, 90-100) and 0.6 ± 0.6 (range, 0-2), respectively, for group 1 and 95.0 ± 3.3 (range, 84.9-100), 96.2 ± 3.0 (range, 88-100) and 0.4 ± 0.5 (range, 0-1), respectively, for group 2 (Table II). There were no statistically significant differences between the preoperative and postoperative values of any of the scores in either of the groups (Table II).

Neither group had instances of nonunion, malunion, or late union during the follow-up period. Postoperative complications were reported in 2 patients in group 1 (LP): acromioclavicular joint osteoarthritis developed after 1 year in 1 patient and screw penetration developed in 1 patient. Five patients experienced skin irritation and were not satisfied with the cosmetic appearance, and secondary surgeries were required to remove the hardware at the 9th, 13th, and 15th months (Fig. 1).

In group 2 (CB), there were no intraoperative complications; however, coracoid process fractures that did not require additional surgical intervention were observed in 2 female patients (7.4%) at 2 and 3 weeks postoperatively (Fig. 3). The sling was used for a longer duration to avoid fracture displacement, and in both cases, complete healing of the coracoid fracture was observed without loss of reduction after 6 weeks. In 2 patients, complete removal of the implant was required owing to skin irritation at 9 and 13 months postoperatively. No complications were observed in the remaining patients during the follow-up period.

Discussion

The main finding of this study was that all arthroscopic CB stabilization and anatomic LP fixation procedures for unstable Neer type II distal clavicle fractures achieved similar, satisfactory outcomes at a minimum 1-year follow-up. Patient functional recovery was high, and complication rates were low for both groups.

Neer type II distal clavicle fractures are usually seen in young populations and are inherently unstable and associated with a high rate of nonunion (range, 25%-44%) with conservative treatment.[15,21-23] The paucity of studies concerning conservative treatment, the tendency for displacement to occur, the higher risk of nonunion, and the small number of patients included in previous studies make surgical treatment a reasonable option.[15,26,28] However, the most appropriate surgical technique remains controversial.[12]

LP and hook plate (HP) fixation systems are widely used for the treatment of distal clavicle fractures.[9] Although successful and similar fracture union rates have been reported for LPs and HPs, HP complications have been reported relatively frequent and include impingement, implant failure, acromial fracture, rotator cuff tears, hook migration, and the necessity of implant removal.[5,8,29]

In a systemic review and meta-analysis conducted by Vannabouathong et al[27] on distal clavicle fractures, LPs yielded better functional and radiological outcomes than HPs, CC suturing alone, K-wires with or without tension bands, and conservative treatment. Boonard et al[4] reported that LP and CC fixation were associated with higher clinical scores than other techniques, and when comparing the complication rates, LP fixation was the most effective technique for unstable distal clavicle fractures, followed by CC fixation, HP fixation, tension band fixation and transacromial pinning. In another study by Tan et al,[26] HPs were removed in 65% of patients between 3 and 14 months postoperatively because of functional limitations, and the authors reported that 74% of patients in the same group had mild to severe shoulder pain.

Table I
Patient demographics and clinical results

	Age (y)	Sex (n [%])		Follow-up (mo)	Time to union (week)	Time from injury to surgery (d)	Complication
		Female	Male				
Group 1 (ALP)	35 ± 10.5	5 (25)	15 (75)	49.6 ± 21.6	10.9 ± 1.1	1.9 ± 1.6	ACJ osteoarthritis (n = 1) Screw penetration (n = 1)
Group 2 (CB)	33.7 ± 9.6	3 (11)	24 (89)	32.4 ± 9.2	9.7 ± 1.7	2.3 ± 2.1	Coracoid process fracture (n = 2)
P value	n.s.	n.s.		.019	n.s.	n.s.	n.s.

CB, coracoclavicular button; LP, locking plates.

Table II
Clinical outcomes after surgery: ASESs, Constant-Murley scores and VAS scores

	Group 1 (LP)		Group 2 (CB)		*P* value
	Mean ± SD	Median (Q1-Q3)	Mean ± SD	Median (Q1-Q3)	
ASES	92.5 ± 3.9	93.2 (89.9-96.1)	95 ± 3.3	96 (92.5-98)	.32
Constant	93.6 ± 4.0	94.9 (91.6 + 96.6)	96.2 ± 3.0	98 (94-98)	.15
VAS	0.6 ± 0.6	8 (7-9)	0.4 ± 0.5	0 (0-1)	.59

ASES, American Shoulder and Elbow Surgeons Shoulder score; CB, coracoclavicular button; LP, locking plates; VAS, visual analog scale.

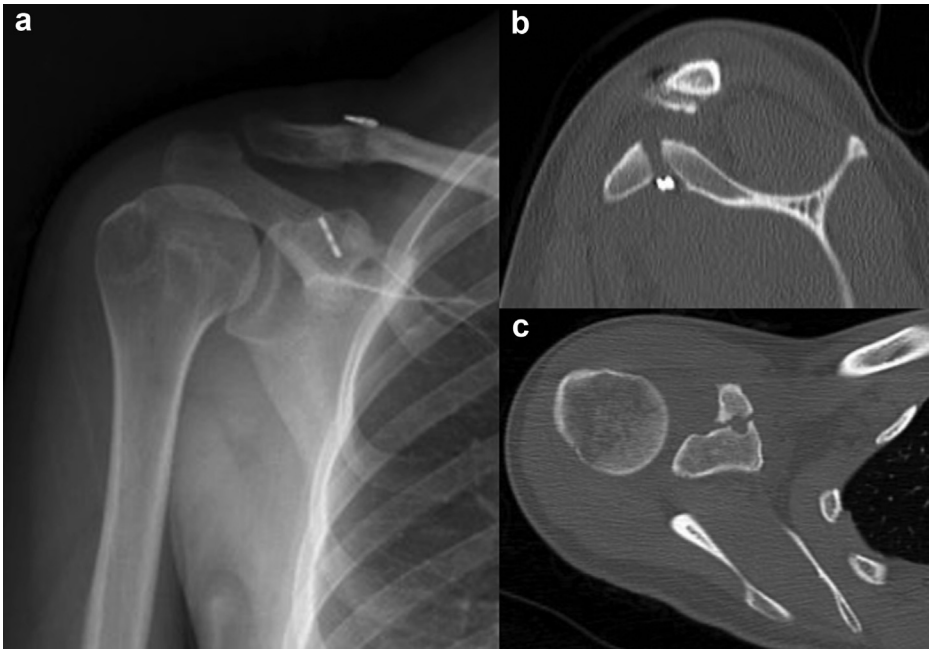

Figure 3 Anteroposterior X-ray (**a**) and CT (sagittal [**b**], axial [**c**]) views of the patient who had coracoid fracture at the postoperative third week. CT, computed tomography.

In a meta-analysis performed by Oh et al[18] involving 425 Neer type II distal clavicle fractures, 162 patients were treated with a HP, and a significantly higher complication rate was reported for patients who received HPs (40.7%). The most common complications were subacromial impingement (18.5%) and plate migration (9.3%). Zhang et al[29] compared the efficiency of LP and HP fixation and found no significant difference between the union rate and Constant-Murley score. However, LPs facilitated the return to work better than HPs and had a significantly lower rate of complications (5.6% vs. 23.3%) and hardware removal. In our study, clinical and radiological union was achieved in all patients, no intraoperative or perioperative complications were observed for either group, and similar successful functional results were achieved.

Arthroscopic fixation techniques for distal clavicle fractures have been developed in recent years, and their popularity has increased as satisfactory clinical and radiological results have been achieved. The minimally invasive arthroscopic technique was first described by Nourrissat et al in 2007.[16] They used FibreTape (Arthex, Naples, FL, USA), which was passed through a tunnel in the coracoid process and sutured onto the superior side of the clavicle, for final fixation. However, no clinical or radiological results were reported in their study. Owing to the rarity of unstable distal clavicle fractures, only a few studies, with small sample sizes, have been reported in the literature; the first results from 4 patients were reported by Pujol et al, [19] and there were no complications and encouraging clinical and radiological results. Motta et al[14] treated 14 patients with arthroscopic stabilization using TightRope and reported that all fractures had healed without limitations in range of motion or loss of reduction. In another study performed by Loriaut et al, [13] 21 patients were treated with an arthroscopic double button (TightRope), and satisfactory results were achieved. Only 3 complications (14.2%) were encountered in the study: 1 case of nonunion (due to implant failure), 1 case of transient adhesive capsulitis, and 1 case of symptomatic acromioclavicular joint osteoarthritis.

Sautet et al[25] treated 14 patients with arthroscopic subcoracoid sutures and a clavicle button. They reported only 1 case of late union and no complications, but the implant was removed from 2 patients owing to skin irritation. Zheng et al[30] treated 15 patients with TightRope and reported that TightRope fixation provided sufficient stability for Neer's type II fractures and achieved satisfactory clinical and radiological outcomes. They reported only 1 peri-implant coracoid fracture as a complication. Similarly, in our study, coracoid process fracture was seen in 2 patients (7.4%), and no additional surgery was required. Owing to skin irritation, complete removal of the implant was required at 13 months postoperatively in 1 young, frail female patient.

There are a few limitations to our study. This was a retrospective study, and no comparison was made with other treatment methods, such as K-wires, HPs, or tension bands. Patients could not be evaluated with advanced radiological examinations (computed tomography or magnetic resonance imaging), and only X-rays were used.

Conclusion

Both distal anatomic LP fixation and all arthroscopic CB fixation provide satisfactory functional and radiological outcomes. Both procedures minimize the risk of complications and present similar, high union rates. In the future, prospective randomized studies on this subject could provide clear information on the selection of the appropriate surgical method.

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