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3-Year results of arthroscopic management of lateral clavicle fractures

Case series and literature review

Approximately 15–18% of all fractures of the clavicle affect the lateral segment [1]. The most common mechanisms of injury include falls on the shoulder itself, as well as falls on the outstretched arm, both resulting in a transmission of forces [2]. Previous studies have shown that the majority of fractures were a direct result of falls on the affected shoulder (87%; [2]). A large variety of interventional techniques were discussed over the past few years; however, this discussion did not help to establish a “go-to” approach thus far [3].

Despite its clinical relevance, to date there is no uniform treatment concept for the lateral fracture of the clavicle. The past couple of years have seen a shift of focus toward the additional addressing of the coracoclavicular (CC) ligament [4]. Similar to instabilities of the acromioclavicular (AC) joint, conventional hook plates and later locking plates were the state of the art for fractures of the lateral clavicle. Furthermore, more minimally invasive techniques were described over the past couple of years for both pathologies [5–8].

The aim of our study was to evaluate the outcomes of lateral clavicle fractures that were treated with a Dog Bone implant (Arthrex, Naples, FL, USA). To our best knowledge there is currently no published literature focusing exclusively on this implant. In the past, arthroscopic-assisted procedures often used an implant referred to as “TightRope” (Arthrex). It contains two oblong buttons connected

with one long polyethylene wire (FiberWire, Arthrex). The Dog Bone implant has two dog-bone-shaped implants creating a major area of support. It is loaded with two 2-mm-wide rigid polyethylene tapes as suture material. The greater area of support has the aim of decreasing the number of coracoid break-outs, while the two fiber tapes help to prevent wire insufficiencies.

The aim of this study was to evaluate the subjective satisfaction of patients and to analyze the radiological and functional outcomes. Furthermore, we compared our results with those in recent publications. By comparing the data collected with the recent literature, we aim to determine whether an arthroscopy-only augmentation of the CC ligament is a sufficient alternative.

Methods

Between 2013 and 2015, a series of ten patients, who presented with an unstable fracture of the lateral clavicle (Jäger and Breitner IIA/Neer IIB) and were treated with an isolated arthroscopic-assisted CC double-button augmentation (Dog Bone, Arthrex), were retrospectively followed up. In addition, a clinical evaluation of the functional outcome was performed. The relevant scores included the active-assisted range of movement, the Subjective Shoulder Value (SSV), age- and sex-adjusted Constant–Murley Score (CMS), Taft Score, American Shoulder and Elbow Score (ASES), the Nottingham Clavicle

Score (NCS), as well as the Visual Analogue Scale (VAS). Furthermore, a radiological analysis was performed regarding the CC distance, clavicular tunnel widening, heterotopic ossification, and bony healing.

Operative technique

The patient is placed in a “beach chair” position. After marking the anatomical landmarks, a stab incision is performed at the level of the dorsal “soft spot” of the shoulder. An arthroscopic trocar is then used to insert and position the arthroscope, in order to visualize the shoulder joint. Following this an antero-inferior portal is used to perform a conventional shoulder arthroscopy, which has the aim of identifying any potential accompanying pathologies. A lateral transtendinous viewing portal is established in an outside-in technique. From this lateral view an arthroscopic depiction of the coracoid arch is made. This is then followed by a second stab incision above the clavicle, more accurately above the medial fracture fragment, with the aim of positioning the aiming device in the direction of the transclavicular and transcoracoid drill holes.

A cannulated 2.4-mm drill is used to perform the vertical transclavicular–transcoracoid drilling, which has its exit point at the level of the coracoid base in a central position. This surgical step is visualized both arthroscopically and radiologically. The trocar is then removed

Table 1 Indication and treatments for patients undergoing revision in the single Dog Bone cohort

Patients	Indication	Treatment
Patient 1	Material irritation/ Tenderness on palpation	Open removal clavicular Dog Bone
Patient 2	Material irritation/ Tenderness on palpation	Open removal clavicular Dog Bone, surgical removal of a clavicular suture granuloma
Patient 3	Painful subcoracoid bursa	Arthroscopy-assisted complete removal, arthroscopic removal of the subcoracoid bursa
Patient 4	Bony non-union	Revision surgery with angle-stable anatomical locking plate and an additional coracoclavicular augmentation
Patient 5	Bony non-union	Revision surgery with angle-stable anatomical locking plate and an additional coracoclavicular augmentation

Table 2 Summary of the clinical outcome measures for the single Dog Bone approach

Clinical score	Single Dog Bone procedure
SSV (0–100 pt)	86.67 ± 6.9 pt
Constant Score (0–100 pt)	93.3 ± 3.7 pt
Taft Score (0–12 pt)	10.83 ± 0.4 pt
ASES Score (0–100 pt)	87.18 ± 5.58 pt
NCS (0–100 pt)	76.3 ± 6.9 pt
VAS	0.83 ± 0.65 pt

SSV Subjective Shoulder Value, *pt* points ASES American Shoulder and Elbow Score (ASES), NCS Nottingham Clavicle Score, VAS Visual Analogue Scale

from the cannulated drill, followed by a nitinol suture passer that is inserted into the subcoracoidal space through the drill and retrieved via the antero-inferior portal. The drill is then removed. The limbs of a FiberTape and a TigerTape (both Arthrex) are clipped into the slots of the later subcoracoidal button. Following this, the open endings of the tapes are shuttled through the transclavicular and transcoracoidal drill holes using the nitinol suture passer and the button is placed under the base of the coracoid. The retrograde passage of the first button should be guided via the antero-inferior portal using a grasping forceps. A second button is then inserted, which is supported just above the clavicle. The repositioning of the clavicle is visualized by fluoroscopy only and the FiberTapes are fastened with six to eight knots. The knot conglomerate is flattened alongside the clavicle and the deltoid–trapezoid fascia is closed accurately over the knots and the clavicle washer in order to prevent soft tissue irritation. The subcutaneous tissue and skin are closed in standardized fashion.

Postoperative management

Similar to previous studies concerning AC joint instabilities that were conducted at our center, the shoulder of patients who received treatment was protected in a sling for 6 weeks [9]. During the first 3 weeks, patients were allowed to only passively move the affected joint up to a flexion and abduction of 45°. From week 4 onwards, patients performed active-assisted motion leading up to a flexion and abduction of 45° and 60° in week 5 and 6, respectively. Free motion was allowed from week 7 on [9].

Statistical analysis

Statistical analysis was performed using Microsoft Excel 2013 (Redmond, WA, USA) and GraphPad Prism 6 (GraphPad Software, San Diego, CA, USA). The results were interpreted in a descriptive fashion, followed by Shapiro–Wilk normality test, which led to a nonparametric analysis with the Kruskal–Wallis test regarding the CC distance. Statistical significance was set at $p < 0.05$. The variables

are presented as means, standard deviations, and ranges.

Results

Patient population

Eight of the ten patients who received the described intervention participated in the study (the response rate was 80%). One patient had left Germany and another did not agree to participate in this study. The cohort comprised three female and five male patients. The mean age of the patients was 33.1 years (± 11.4) with an average postoperative follow-up time of 36.6 months (± 14.3). All of the eight patients had received medical specialist operative care.

All of the fractures were classified as a Jäger and Breitner type IIA/Neer IIB. All patients were right-handed. With regard to the mechanism of injury, all patients had a direct impact injury of the affected shoulder. The mean operation time of the isolated arthroscopic augmentation of the CC ligaments amounted to 52 ± 21 min (range: 29–90 min). Three patients (37.5%) had an accompanying pathology of the affected shoulder: (a) One patient had fraying of the labrum and pulley complex, as well as the long biceps tendon, which was addressed with an arthroscopic debridement. (b) An articular partial rupture of the supraspinatus tendon (Ellman A1) with fraying of the superior glenohumeral ligament (SGHL) and an additional SLAP I lesion were identified in another patient, which were also addressed with an arthroscopic debridement. (c) The third patient presented with an accompanying partial rupture of the subscapularis tendon (SSC; Fox–Romeo 2), which was reconstructed with a suture anchor.

Material was removed in five of the patients. **Table 1** illustrates the indication and measures of the respective removal of material. A radiological non-union was identified in four patients (50%). Of these, two were symptomatic and required revision surgery with an angle-stable anatomical locking plate and an additional CC augmentation.

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3-Year results of arthroscopic management of lateral clavicle fractures. Case series and literature review

Abstract

Background. In 18% of clavicular fractures, the lateral part is affected. Recently, a variety of surgical techniques have been discussed. This study aimed to analyze clinical and radiological results of a consecutive case series with arthroscopy-only coracoclavicular stabilization in unstable lateral clavicle fractures of Neer type IIB, utilizing a double-button fixation technique.

Methods. Between 2013 and 2015 we followed up ten patients who exclusively had an arthroscopically assisted augmentation of the coracoclavicular ligaments using a double-button fixation (Dog Bone, Arthrex, Naples, FL, USA). Radiological scores and functional outcome measures were evaluated: Subjective Shoulder Value (SSV), Constant–Murley Score

(CMS), Taft Score (TF), ASES Score (ASES), Nottingham Clavicle Score (NCS), and a Visual Analogous Scale (VAS).

Results. Eight of ten patients (5 males, 3 females; 80%) had follow-ups 37 ± 14 months postoperatively. The mean age was 32.4 ± 11.6 years and the mean operation time was 53 ± 21 min. Clinical examination showed a CMS of 91.9 ± 7.9 points (pt), a TF of 10.5 ± 1.1 pt, and an NCS of 76.5 ± 15.3 pt. The VAS score was 0.7 ± 1.5 pt with an average SSV of 83.1 ± 13.4 pt and an ASES of 87.0 ± 12.5 pt. In three cases (37.5%) a concomitant intra-articular pathology was found. Radiological analysis showed a preoperative CC distance of 19.7 ± 3.3 mm, a postoperative distance of 6.9 ± 3.0 mm and 12.0 ± 4.9 mm at follow-

up. The clavicular drill hole widened from 3.0 ± 0.4 mm postoperatively to 6.0 ± 1.5 mm at follow-up; 50% of cases had radiological signs of bony non-union, two of which were symptomatic and received revision surgery. **Conclusion.** The solely arthroscopic double-button technique shows good clinical results. Although not symptomatic in all cases, the non-union rate is quite high. Thus, this technique should be reserved for special cases with small lateral fragments where anchoring techniques are not an option.

Keywords

Fractures · Collar bone · Arthroscopic double-button technique · Bony non-union · Arthroscopic surgery

3-Jahres-Ergebnisse der allein arthroskopisch assistierten Versorgung lateraler Klavikulafrakturen in Doppelbutton-Technik. Fallserie und Vergleich der Literatur

Zusammenfassung

Hintergrund. Von allen Klavikulafrakturen betreffen 18% das laterale Segment. Verschiedene Operationstechniken wurden kontrovers diskutiert, ohne dass sich ein Goldstandard etabliert hat. Ziel dieser Fallserie war die Bewertung der klinischen und radiologischen Ergebnisse einer allein arthroskopisch assistierten Doppelbutton-Technik zur korakoklavikulären Stabilisierung instabiler lateraler Klavikulafrakturen vom Typ IIB nach Neer.

Methodik. Von 2013–2015 wurden 10 Patienten mit einer instabilen lateralen Klavikulafraktur (Jäger/Breitner IIA/Neer IIB) mit arthroskopisch assistierter Augmentation der korakoklavikulären Bänder nachuntersucht (Dog Bone, Fa. Arthrex, Naples/FL, USA). Hierbei wurden neben einer radiologischen Auswertung folgende Scores erhoben: Subjective Shoulder Value (SSV), alters- und geschlechtskorrigierter Constant–Murley-

Score (CMS), Taft-Score (TF), ASES Score (ASES), Nottingham Clavicle Score (NCS) und eine visuelle analoge Schmerzskala (VAS).

Ergebnis. Nachuntersucht werden konnten 8 von 10 Patienten der konsekutiven Serie (5 männlich/3 weiblich, 80%) bei einem mittleren Follow-up von 37 ± 14 Monaten und einem durchschnittlichen Patientenalter von 32,4 (±11,6) Jahren. Die Op.-Dauer betrug im Durchschnitt 52 ± 21 min. In den klinischen Untersuchungen zeigten sich ein CMS von 91,9 ± 7,9 Punkte (Pt.), ein TF von 10,5 ± 1,1 Pt. und ein NCS von 76,5 ± 15,3 Pt. Der VAS-Score betrug 0,7 ± 1,5 Pt. bei einer SSV von 83,1 ± 13,4 und einem ASES von 87,0 ± 12,5. In 3 Fällen (37,5%) wurde eine intraartikuläre begleitende pathologische Veränderung festgestellt, welche jeweils einzeln angegangen wurde. In der radiologischen Auswertung lag präoperativ ein korakoklavikulärer (CC-)Abstand von 19,7 ± 3,3 mm,

postoperativ von 6,9 ± 3,0 mm und in der Nachuntersuchung von 12,0 ± 4,9 mm vor. Der klavikuläre Bohrkanal erweiterte sich von postoperativ 3,0 ± 0,4 mm auf 6,0 ± 1,5 mm in der Nachuntersuchung. In 50% der Fälle zeigte sich radiologisch eine Pseudarthrose, 2 davon waren symptomatisch und wurden revidiert.

Schlussfolgerung. Bei guten klinischen Resultaten sollte aufgrund einer relativ hohen Pseudarthroserate die alleinige Doppelbutton-Technik ausgewählten Fällen mit kleinem lateralem Fragment (funktionelle Schulterreckgelenksprengungen) ohne Möglichkeit einer sonstigen suffizienten Implantatverankerung vorbehalten bleiben.

Schlüsselwörter

Frakturen · Schlüsselbein · Arthroskopische Doppelbutton-Technik · Pseudarthrose · Arthroskopische Chirurgie

Clinical scores

The clinical examination showed a CMS of 91.9 ± 7.9 points (pt; range: 77–100 pt), a TF of 10.5 ± 1.1 pt (range: 9–12 pt), as well as an NCS of 76.5 ± 15.3 pt (range: 52–98 pt). The VAS score was 0.7 ± 1.5 pt (range: 0–4 pt) with an average SSV

of 83.1 ± 13.4 pt (range: 70–100 pt) and an ASES of 87.0 ± 12.5 pt (range: 64.9–100 pt; **Table 2**). The mean absence time from work was 52 ± 47 days.

Radiological analysis

The radiological analysis showed a preoperative CC distance of 19.7 ± 3.3 mm (range: 15.7–24.3 mm), an immediately postoperative distance of 6.9 ± 3.0 mm (range: 5.8–11.5 mm), and 12.0 ± 4.9 mm (range: 5.8–20 mm) at follow-up (**Fig. 1**).

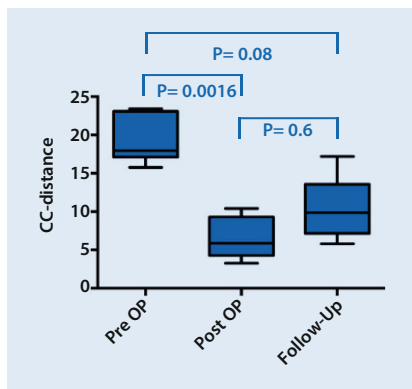


Fig. 1 ▲ Coracoclavicular distance (CC distance) following isolated arthroscopic Dog Bone repair

There was a significant reduction in the CC distance from pre- to immediately postoperative ($p=0.0016$), without a significant loss of reduction from immediately postoperative to the follow-up ($p=0.6$). A statistical trend toward a reduced CC distance from the pre- to immediately postoperative measurements was observed ($p=0.08$). The initial postoperative drill hole width was 3.0 mm (range: 2.7–4 mm), while a width of 5.9 mm (range: 3.6–7.8 mm) was measured in the follow-up group. Thus, the mean difference between the postoperative and follow-up groups was 2.9 mm, which was found to be statistically significant at $p=0.0003$ (■ **Fig. 2**).

Heterotopic ossification

Heterotopic ossification was present in 75% of all patients who were treated with the suture button-tape system.

Bony consolidation

Radiologically confirmed non-union was present in 50% of cases, of which two patients were asymptomatic and a further two required revision surgery as illustrated earlier (■ **Fig. 3**).

Discussion

The main findings of this study were firstly the high rates of bony non-union after treatment with the double-button fixation technique. The radiological analysis showed reduced bony consolidation and a 50% incidence of pseudarthrosis.

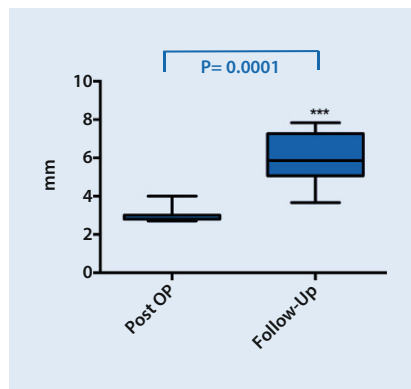


Fig. 2 ▲ Surgical drill hole width at follow-up in the single Dog Bone cohort

However only two of four patients were clinically symptomatic.

Secondly, we found a statistical trend ($p=0.08$) toward a reduced CC distance at follow-up in patients who were treated with a double-button technique. Interestingly, the immediately postoperative CC distance increased (6.9 ± 3.0 mm) compared with the follow-up group (12.0 ± 4.9 mm). No cases of coracoidal break-outs or migration of the buttons were observed. A rupture of the polyethylene tapes was most likely the reason for the secondary loss of reduction.

Management of lateral fractures of the clavicle is still subject to debate, as various studies could not come to a consensus. Takase et al. addressed the conoid ligament in their case series of seven patients with an artificial ligament (Smith & Nephew, Andover, MA, USA) through a 4.7-mm drill hole fixed to the coracoidal side with an Endobutton (Smith & Nephew) and a spiked washer screw to the clavicular side. All seven patients achieved bony union and excellent-to-good results in the radiological and clinical follow-up [5]. In 2007, Qureshi et al. described a solely arthroscopic procedure without a clavicular screw leading into the aforementioned TightRope system [10].

Motta et al. employed a first- and a second-generation TightRope construction, using a 4-mm drill hole and fixation via a 6-mm or 10-mm button on the clavicular side. A total of 14 patients (50% follow-up rate) were included in the follow-up. Radiological union was recorded in 13 cases after 1 month and excellent results in the 2-year follow-up ([6];

■ **Table 3**). Loriaut et al. used a comparable surgical approach to Motta et al. with 17 patients (81% follow-up rate; [6, 8]). Although results showed one bony non-union, excellent surgical outcomes regarding the CMS and QuickDASH Score were achieved. Kraus et al. enhanced the TightRope technique with an additional interfragmentary cerclage [7]. They enrolled 20 patients with two bony non-unions and good results in the SSV and the Constant Score. All aforementioned studies used general shoulder scores such as the UCLA, Constant, or SSV.

Most recently, Kuner et al. illustrated their case series, which included 20 patients with a median follow-up time of 18 months. Besides the comparable clinical results (■ **Table 3**), they reported a bony non-union in seven cases, resulting in two revision surgeries [11].

Furthermore, the group analyzed potential risk factors for a delayed union or non-union and concluded that the following are potential risk factors leading to bony non-unions:

- Size of the lateral fragment
- Delayed surgical procedure
- Smoking
- Recurrent trauma

Regarding the size of the lateral fragment, Kuner et al. describe 33 mm (33–53 mm) as a potential cut-off value leading to a bony non-union [11]. In our case series one of the two patients needing revision surgery had a lateral fragment measuring 33 mm (■ **Fig. 3**).

Furthermore, one can hypothesize, in the case of a fracture fixation with the single Dog Bone system, that only a relative interfragmentary stability can be achieved. This may lead to persistent motion in the fracture area, thus resulting in non-union. Biomechanical studies concerning this issue are not yet published to the best knowledge of the authors of this study.

Although only two of the four cases were symptomatic, it should be noted that the primary aim of a reposition and fixation is not to cause the patients more problems through the development of a non-union. A comparison to Charles Neer's main point of criticism concern-

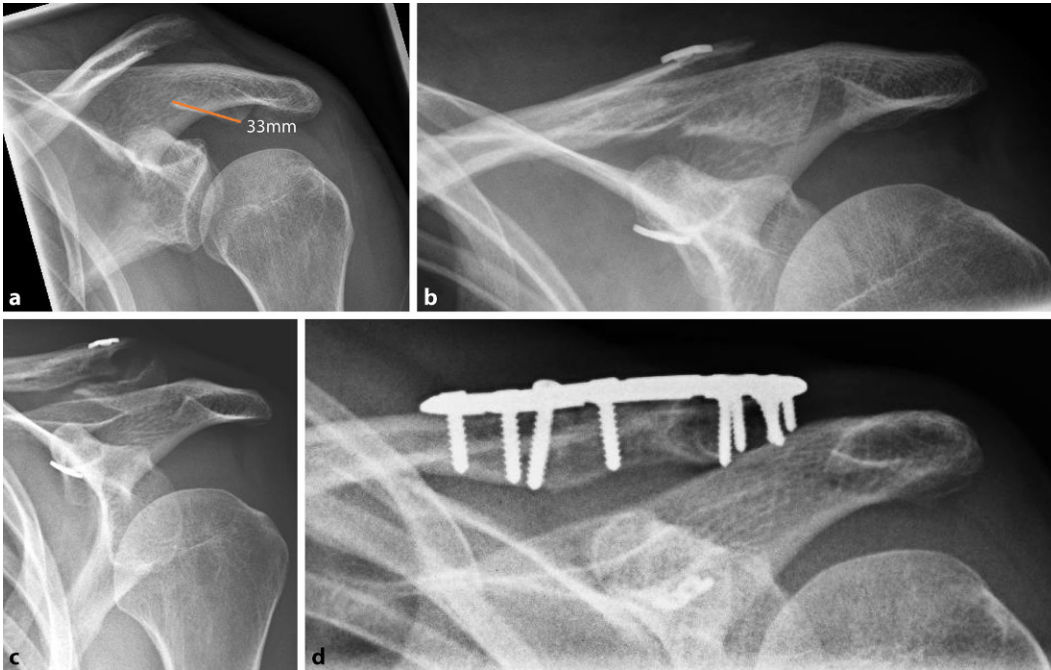


Fig. 3 ◀ **a** Lateral clavicle fracture (Jäger and Breitter IIA/Neer IIB). The lateral fracture fragment measures 33 mm. **b** Postoperative X-ray after solely arthroscopy-assisted single Dog Bone procedure. **c** Radiological 1-year follow-up with further radiological signs of a clinically symptomatic pseudarthrosis. **d** Revision with an arthroscopy-assisted hybrid approach consisting in a locking plate and coracoclavicular stabilization with a Dog Bone



Fig. 4 ▲ **a** Lateral clavicle fracture (Jäger and Breitter IIA/Neer IIB). **b** Postoperative X-ray after solely arthroscopy-assisted single Dog Bone procedure. **c** Radiological 3-year follow-up after implant removal

ing the incidence after conservative management is important: 12 patients in his patient group were treated in a conservative manner, of whom eight presented with delayed bony healing and four with a manifest pseudarthrosis [12]. Therefore, the isolated single Dog Bone procedure does not set itself apart.

In a comparable study, Kraus et al. evaluated 20 patients with similar fracture entities (Neer type II), in which an isolated arthroscopic CC ligament augmentation was performed [7]. A key technical difference was an interfragmentary cerclage utilizing a FiberTape (Arthrex). The results of Kraus et al. indicated a CMS of 95.1 pt, as well as an SSV of 88.7% with a bony consolidation rate of 90% (18 of 20; [7]).

The study of Kraus et al. [7] did not compile AC-specific scores, such as the NCS and the TF, as well as other radiological parameters, including the drill hole width. The CS and SSV values are comparable to our results (CS, 93.3 ± 7.9 pt/SSV, 83.13 ± 13.4 pt). Relevant differences were found regarding bony consolidation, where a 50% (4/8) incidence of pseudarthrosis was found in our patient population.

In the past, recurrent complications were observed in clavicular button procedures. Similar to Kraus et al., three patients in our case series showed clinical symptoms of material irritation, resulting in the removal of the implant. Motta et al. and Loriaut et al. described one case of superficial infection each [6, 8]. One can therefore assume that this

observation is similar to those made in arthroscopic-assisted AC joint stabilizations, where there is material irritation due to the rather thin soft tissue composition of the shoulder girdle. Newly approved knotless low-profile buttons for the clavicles could be a solution.

The advantages of the single Dog Bone method were found to be:

- A short procedural time
- A relatively easy surgical technique
- The possibility of detecting and the direct management of accompanying pathologies

The average operation time in our case series was 52 min, making the operation time itself rather short. The benefits associated with short operations are: reduction of infection rates, shorter time

Table 3 Review of the literature regarding a solely double-button fixation in lateral clavicle fractures

Study	Implant	Baseline characteristics	Clinical results	Complications
Kuner et al. [2019] [11]	DogBone Button or TightRope Button, (Arthrex; Naples, FL, USA)	n = 20 Case series Level IV Follow-up 18 months	DASH: 3.2 ± 6 pt CS: 94.8 ± 9.9 pt	7 bony non-unions 2 delayed wound healings 1 superficial infection
Kraus et al. [2015] [7]	Single TightRope second-generation, (Arthrex) Neer IIB	n = 23 Case-Series Level IV Follow-up 23 months	CS: 88.7(64–99) pt SSV: 95.1% (60–100%)	30% CC ossifications 10% concomitant injuries 1 loss of reduction 1 implant irritation 10% asymptomatic non-union
Loriaut et al. [2013] [8]	Single TightRope second-generation, (Arthrex) Neer IIB	n = 21 Case series Level IV Follow-up min. 2 years	QuickDASH: 3.2 ± 6 pt CS: 94.8 ± 9.9 pt VAS: 0.5 ± 1.2 pt	3 complications: 1 capsulitis 1 bony non-union 1 ACJ arthritis
Motta et al. [2013] [6]	Single TightRope first- and second-generation, (Arthrex) Neer IIB, IIB, V	n = 14 Case series Level IV Follow-up min. 2 years	CS: 95 ± 1 pt SST: 12 ± 0 pt	1 superficial infection

CS Constant Score, SSV Subjective Shoulder Value, SST Simple Shoulder Test, pt points, CC coracoclavicular, ACJ Acromioclavicular joint
Values are all arithmetic means ± standard deviation,

in the “beach chair” position, a shorter duration of anesthesia, and finally an economic benefit [13].

What should be noted in particular, however, is the fact that accompanying pathologies can be addressed straight away, and thus the surgical technique sets itself apart from isolated fixed-angle plate osteosyntheses.

In our patient population we evaluated and addressed 37.5% of accompanying pathologies. This is comparable to a study conducted by Beirer et al., who performed a diagnostic arthroscopy in every fracture of the lateral clavicle included in their study [14]. Accompanying pathologies were found in 46.4% of cases [14]. In 28.6% of these cases the accompanying pathologies were diagnosed and treated accordingly. In the final analysis, a distinct injury pattern cannot be seen. However, there seems to be an increased incidence of injuries affecting the anterosuperior rotator cuff and the SLAP complex.

Nevertheless, the studies illustrated here indicate a range of accompanying pathologies in 25–46% of cases, which need to be detected and addressed to prevent further damage (▣ Fig. 4; [14, 15]).

Limitations

A limitation of this study is its small population, making it underpowered. The

small population size is the result of a low incidence of this fracture type [1]. Further limitations are its retrospective design and a missing group to compare it with.

The advantages of the single Dog Bone procedure include the short procedure time, the direct addressing of accompanying pathologies, the and relatively low procedural cost. These need to be weighed against potential disadvantages such as the bony non-union.

Owing to high postoperative rates of non-union, our institution moved away from using isolated CC ligament augmentation for fractures of the lateral clavicle in primary care. Although the current evidence is limited, our preferred method is a hybrid approach, containing a locking plate and an arthroscopic-assisted CC augmentation.

Practical conclusion

- The solely arthroscopic double-button technique shows good clinical results.
- Although not symptomatic in all cases, the non-union rate is quite high.
- Therefore, the double-button technique should only be reserved for a few special cases with small lateral fragments (functional acromioclavicular joint separations) where

anchoring techniques are not an option.

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Compliance with ethical guidelines

Conflict of interest. H. Lill is consultant with Arthrex (Naples, USA) and DePuy Synthes (Umkirch, Deutschland). R.-O. Dey Hazra, R. Blach, A. Ellwein, and G. Jensen declare that they have no competing interests.

This retrospective study was performed after consultation with the institutional ethics committee (Medizinische Hochschule Hannover Nr. 7503) and in accordance with national legal requirements.

All procedures performed in studies involving human participants or on human tissue were in accordance with the ethical standards of the institutional and/or national research committee and with the 1975 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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