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Which lateral clavicle fractures can be treated by an arthroscopic-assisted endobutton procedure? An analysis of risk factors

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Abstract

Introduction Arthroscopy-assisted treatment of lateral clavicle fractures with coracoclavicular stabilization and an endobutton device have gained popularity over recent years. There is little evidence to support which types of lateral clavicle fractures are suitable for this treatment. The primary aim of this study was to evaluate the clinical und radiological outcomes of this treatment and to identify which fracture types are suitable. The secondary outcome was to evaluate potential risk factors for complications

Material/methods A retrospective single center review of 20 unstable lateral clavicle fractures treated with an arthroscopy-assisted CC stabilization technique and Endobutton device between September 2012 and August 2016. The functional outcome was evaluated using Constant and DASH Scores, VAS and SSV.

Results Between September 2012 and August 2016, 20 patients were treated using this method (average age 45 years; male: female ratio 14:6). The DASH Score was on average 2.0 (0–9.82) and the Constant Score on average 81.8 points (range 68–93) with an average difference between the affected and the unaffected side of 4.1 points (range 0–15). Six patients had nonunion fractures of which two needed revision.

Conclusions Our study shows that arthroscopy-assisted CC stabilization using an endobutton technique delivers good functional results. Highly lateral unstable clavicle fractures seem to be especially suitable for this surgical technique. There was a high number of delayed unions. Analysis of risk factors showed that early mechanical stress, a lateral clavicular fragment larger than 3 cm and a time delay to surgery could be risk factors for nonunions.

Keywords Lateral · Clavicle · Fracture · Arthroscopic · Nonunion · Risk factors

Introduction

Clavicle fractures account for 2–5% of all fractures in adults [1]. Approximately 12–25% involve the lateral clavicle [1]. The mechanism of accident usually involves direct impact on the shoulder [2]. Neer's classification is commonly used to classify lateral clavicle fractures [3]. In this classification, one can differentiate between stable and unstable fractures [3, 4]. In the case of stable Neer type I and III fractures, nonoperative therapy is recommended [5, 6]. Neer type II fractures are characterized by disruption of the coracoclavicular ligaments from the medial clavicular shaft [3]. There is no consensus on what the best treatment is for unstable lateral clavicle fractures (Neer type II). High nonunion rates between 22–40% have been described with nonoperative treatment [2, 7, 8], although up to 80% of these are asymptomatic [7].

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Various different surgical procedures have been described to treat this type of fracture, including plate or hook-plate fixation, CC screws, Kirschner wire fixation and different suture and sling techniques [9–14].

Recently, arthroscopic techniques have been described mainly for Neer type II fractures with CC stabilization [5, 6, 15, 16]. The first published studies showed promising results [6, 15–21], however, these case series were small and the patient collectives were highly selective. The question is whether single arthroscopic CC stabilization with an endobutton device without fixation of the fracture can achieve fracture healing with a good clinical outcome in diverse patient collectives. Repeated radiological examinations and current Shoulder-Scores were used as evidence. In addition, risk factors were evaluated for unsatisfactory results, such as fracture pattern, older age, comorbidities, sex or smoking status.

Methods

This article was written in accordance with the STROBE statement [22].

Patients

The study is a retrospective case analysis of all patients with an unstable lateral clavicle fracture treated with an arthroscopy-assisted endobutton device, at a level one trauma center in Switzerland. All patients operated for a clavicle fracture between September 2012 and August 2016 were extracted using our digital OP-Controlling System. The next phase selected those with an unstable lateral clavicle fracture (Type II) according to the Neer's classification who were treated with this method. Patients who were operated outside of this study period or who had open surgery were excluded.

Surgical technique, rehabilitation and follow-up

All operations were carried out in the beach-chair position with general and regional anesthesia. Shoulder arthroscopy was performed using posterior, anterolateral and anterior portals. After performing a diagnostic tour to detect additional pathologies, the anterolateral and anterior portals were placed under direct vision. The scope was then placed in the anterolateral portal to open the rotator interval and clean the inferior coracoid arch and the coracoid base. The drill guide was placed through the anterior portal. A 2 cm skin incision was subsequently made over the lateral clavicle without exposure of the fracture. With a drill guide (Arthrex, Naples, USA), a 3 mm hole through the clavicle medial to the fracture and centrally in the shaft, close through the base of the coracoid was performed. The implant was inserted in a retrograde manner through the anterior portal. The reduction was controlled under fluoroscopy using an AP and tangential view. The implants used were *DogBone Button* or *TightRope Button* (Arthrex; Napels, USA).

Postoperative therapy included physiotherapy-guided early functional passive shoulder mobilization up to the horizontal level for 2 weeks. Subsequently, active-assisted shoulder mobilization was applied for up to 6 weeks after surgery. The shoulder was immobilized between sessions in a 15° abduction brace.

Radiological follow-up was performed on postoperative day 1, and 6 and 12 weeks and 1 year after surgery.

Data analyses

Using our routine clinical and radiological follow-up, data were extracted from the electronic patient files. After both written and oral informed consent, all patients agreed to their data being used for research purposes including this manuscript. At the final follow-up visit, Constant and DASH Scores were collected in the outpatient department. The abduction force was measured using an Isobex isometric dynamometer. In addition, a Visual Analog Scale (VAS) and the Subjective Shoulder Value (SSV) were collected during the last follow-up. Factors such as fracture pattern, age, side of injury, smoking status, vascular disease and diabetes were determined at the time of the trauma. The intensity of trauma was classified into high- or low-energy trauma on the basis of the Advanced Trauma Life Support (ATLS) criteria [23]. The time between injury and surgery was recorded in days. Time to radiological bone healing was recorded in months during routine follow-up. Radiographic union was defined as bridging bone on a minimum of three cortices in anteroposterior and tangential radiographic views. Nonunion was defined as standard plain radiographs not showing fracture union 1 year after surgery. Incisional surgical site infections (SSI) were assessed and classified according to the definition of the Centers of Disease Control (CDC) as superficial incisional SSI or deep incisional SSI [24]. Frozen shoulder was defined as a pattern of limited joint mobility in external rotation, (passive and active ROM less than 50% of the unaffected side) over at least 4 months [25].

Occupation was divided into physical work or office work and the duration until full working capacity was recorded. Cases where revision surgery was required were documented. In those patients with follow-up less than 12 month, the functional Scores were not collected.

Statistical analysis

All data were recorded and analyzed using SPSS version 21 (IBM Corp). Calendar calculations were performed and mean values and mean variations were calculated (Tables 1,

Table 1 Patients' data

	Unit	Quantity	Range
Patients	*n*	20	
Age	Year	45	26–74
Gender	Female/male	6/14	
Side	Right/left	8/12	
Fracture type	Neer type, 2a/2b	9/11	
Delay to OP	Days	5.7	1–21
Return to work	Month	2.7	1.3–4.9
Radiological follow-up	Month	11.5	3.3–16.8
Clinical follow-up	Month	17.5	8.5–49.9
Nonunion	*n*	6	
Reoperation	*n*	5	
Revision	*n*	2	
Vascular disease	*n*	2	

2, 3). Additional statistical analysis was not performed due to the low number of cases.

Results

Between September 2012 and August 2016, 217 patients with clavicle fractures underwent surgery. Twenty-eight of those were lateral clavicle fractures, including 21 Neer type II fractures. These 21 were treated with the DogBone or TightRope Implant (Arthrex, Naples, FL, USA) in 20 cases arthroscopically and in one patient using open surgery (this patient was not included in the study).

Patient demographics

Patient demographics are presented in Table 1. None of the patients had intra-articular lesions requiring treatment in the same operation. The predominant causes of injury were bike accidents ($n=13$) followed by ordinary falls ($n=5$), skiing ($n=1$) and a motorbike accident ($n=1$).

Table 2 Patient-reported outcome scores in patients with healed fractures ($n=12$)

Variable	Score reference		Value
	Range	Best	Mean ± SD (range)
Constant Score	0–92 (side difference)	0	4.1 ± 4.4 (0–15)
DASH Score	0–100	0	2.0 ± 2.9 (0-8.8)
VAS	0–10	0	0.4 ± 0.9 (0–3)
SSV	0–100	100	96.8 ± 4.6 (90–100)

Table 3 Patient-reported outcome scores in patients with nonunion ($n=3$)

Variable	Score reference		Value
	Range	Best	Mean ± SD (range)
Constant Score	0–92 (side difference)	0	10.0 ± 8.9 (0–17)
DASH Score	0–100	0	2.4 ± 1.9 (0.9–4.5)
VAS	0–10	0	0.7 ± 1.2 (0–2)
SSV	0–100	100	91 ± 14.4 (75–100)

Follow-up

The median clinical follow-up was 18.7 months (range 12–50) in the group with fracture consolidation. In the group with nonunion, the median clinical follow-up was 14 months (range 4–24). Of the six patients with a nonunion, three completed the DASH and the Constant Scores as shown in Fig. 1.

Radiological outcomes

Among the 20 patients radiologic fracture, healing of at least three cortices was observed in 13 cases after a median of 7.2 months (range 2.7–18.2). In one case, the first radiologic follow-up was performed after 18.2 months.

One patient was lost to follow-up before fracture healing was observed. His last clinical and radiological follow-up was 4 months after surgery. It is not known whether bone healing took place (Fig. 1, left row). Six patients had nonunion fractures (33%), two symptomatic patients underwent revision surgery as shown in Figs. 1 and 2.

Functional outcome

In the group with fracture healing, 11 of 13 patients completed DASH and Constant Scores. Their Constant Score was on average 81.8 (range 68–93) points. The other outcomes are summarized in Table 2. The outcomes from three of six patients with nonunion is detailed in Table 3.

Complications

Six nonunions were reported, two of which were treated with revision surgery and four were oligo symptomatic. The nonunion was stabilized with a lateral clavicular plate after debridement of fibrotic tissue in the fracture gap without bone grafting. Subsequent bone healing was reported in both cases. No surgical site infections were reported. Two patients had delayed wound healing. One patient had superficial localized wound revision due to keloid. Two patient developed frozen shoulder which was treated conservatively and fully resolved.

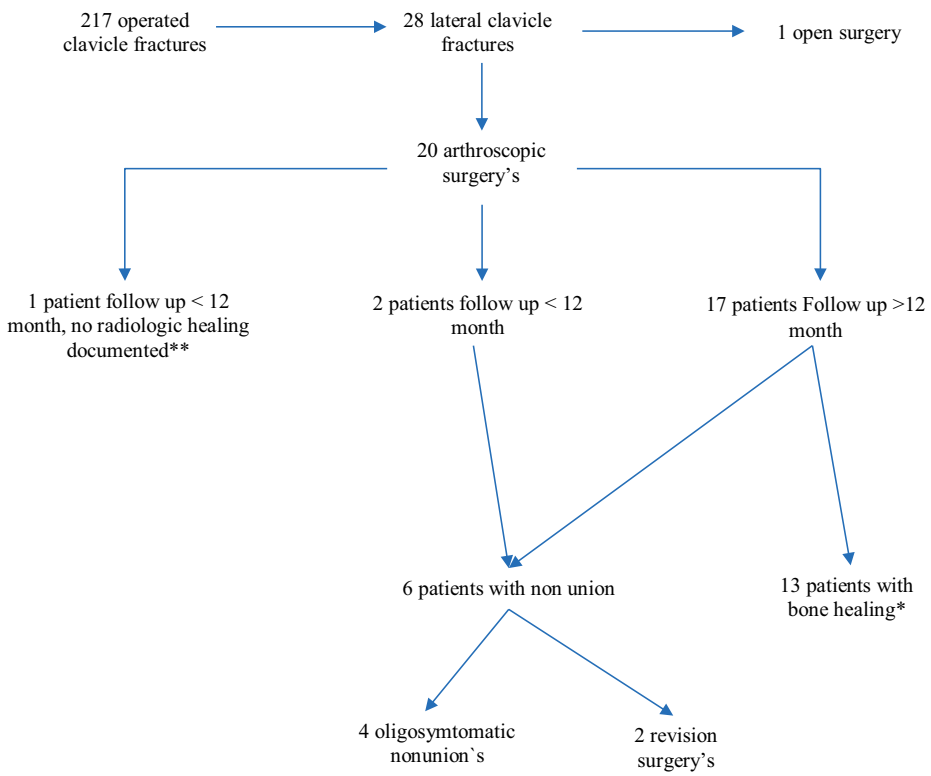

Fig. 1 Composition of cases with surgically supplied clavicle fracture

*The clinical outcome of those patients ist shown in Tab. II
**The last clinical und radiological follow up was four month after surgery. It is not known if bone healing took place

Two female patients felt discomfort because of the implant on top of the clavicle, these implants were removed under local anesthesia 1 year after surgery.

Analysis of risk factors

One patient with delayed union was a smoker, one patient stated that she fell twice during the first 6 weeks after surgery onto her operated shoulder. In one case, the operation was 21 days after trauma and the implant failed after 12 weeks. In three patients, a larger lateral fragment was present so that the DogBone had to be positioned more than 33 mm (33–53) medial to the AC joint on the clavicle. In hindsight, these patients may not have had an indication for this technique because the fractures were located too far medial. Two of them were revised with supplementary plate osteosynthesis. An overview of the risk factors we analyzed is given in Table 4.

Discussion

Our results show that the arthroscopic surgical technique and reduction using DogBone or TightRope Buttons deliver good functional results in people of all ages with unstable lateral clavicle fractures according to the Neer classification system [3].

In the literature, nonunion rates between 20–30% are described with conservative therapy [3, 7, 26]. The meta-analysis by Oh JH et al. (2011) showed that among 425 patients with Neer Type II fractures, nonunion was observed in 33% of 60 patients after conservative treatment and a non-union rate of 1.6% of 365 patients after surgical treatment. The surgical technique used was coracoclavicular stabilization, hook plate, intramedullary fixation, interfragmentary fixation and K-wire plus tension band wiring [8].

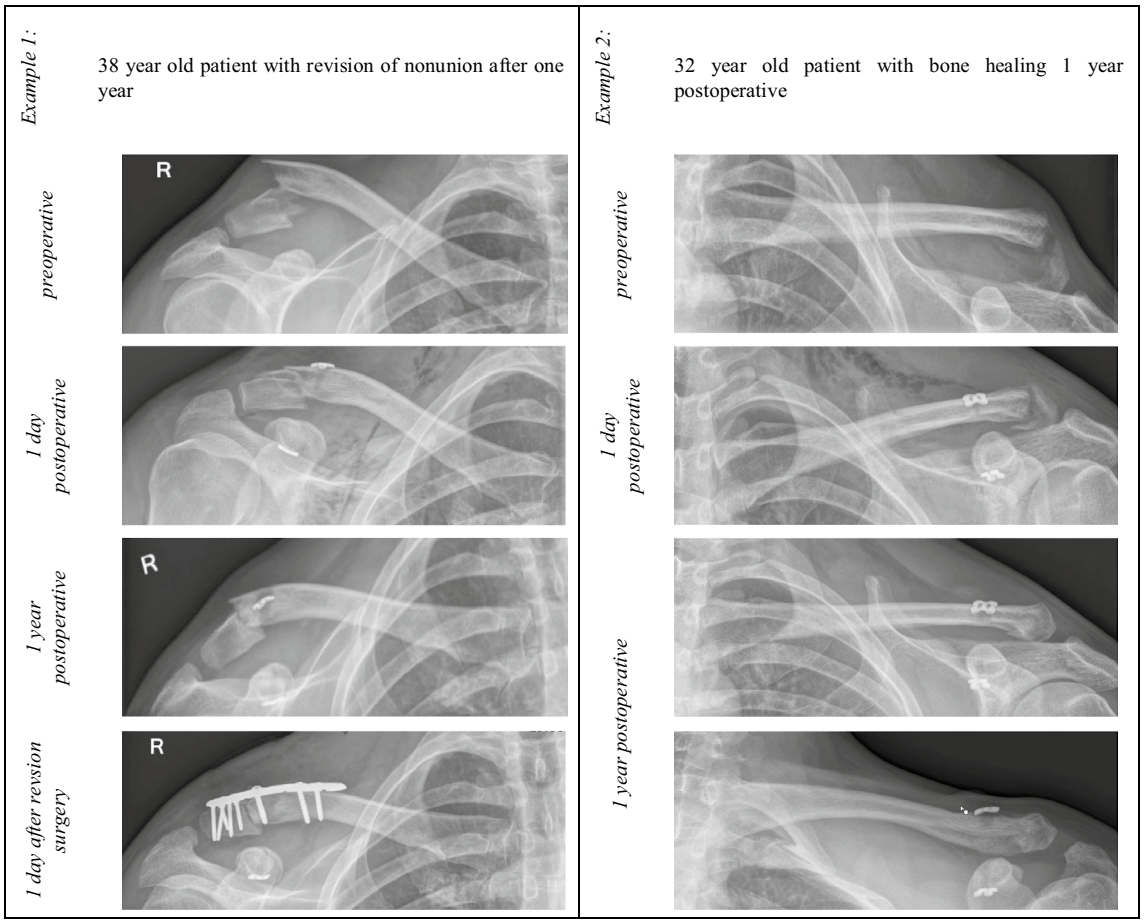

Fig. 2 Case presentation of two patients with unstable lateral clavicle fracture

Table 4 The list shows patient specific date, adverse event and the estimated reason in context of nonunion

No.	Gender, age	Adverse event	Suggested reason	Treatment
1	Female, 53 years	Loss of reduction after 3 months and nonunion	Delay of treatment, operation after 21 days	Conservative, since asymptomatic
2	Female, 50 years	Loss of reduction after 3 months and nonunion	Non-compliance, high activity level, to more falls within 6 weeks, DogBone too medial	
3	Male, 57 years	Asymptomatic nonunion	Biology impaired because of antecedent clavicle fracture, nicotine abuse	
4	Female, 34 years	Asymptomatic nonunion	Wrong indication for operation, fracture too medial	
5	Male, 73 years	Implant failure 3 days after surgery, painful nonunion 3 months after revision surgery	Reoperation due to technical failure, DogBone too medial, fracture too medial	revision surgery with supplementary plate osteosynthesis
6	Male, 38 years	Nonunion after 1 year, pain during physically demanding activities	Wrong indication for operation, fracture too medial	

There are only few studies using our technique in the literature. Two authors have also reported nonunions with arthroscopic fixation and a comparable surgical technique [16, 17]. In our patient collective, six nonunions (33%) occurred. Two were symptomatic and required revision surgery. Our case series was too small to perform a statistical analysis of risk factors. We assume that an early increase in activity may be a risk factor as our patients received early functional passive shoulder mobilization, whereas other authors described immobilization for

1–4 weeks after surgery [15–17]. One patient fell twice within the first 6 weeks after the operation and finally developed a nonunion.

Motta et al. excluded all patients with a delay between accident and surgery of more than 10 days [15]. The reason for this exclusion criteria was not given. We had two patients in whom surgery was delayed by 12 and 21 days, respectively. One of these developed a nonunion. A delay in treatment could therefore be a contraindication for this type of operative fixation.

In our opinion, only very lateral unstable clavicle fractures are suitable for this surgical technique. In hindsight, three patients may not have had an indication for DogBone stabilization because the fractures were too medial, i.e., with a lateral fragment larger than 3 cm. We will therefore now treat patients shown in "Example 1 in Fig. 2" with plate osteosynthesis. The stability of the DogBone and TightRope Button system may decrease in more medially located fractures because the direction of tension is more oblique and therefore might allow more movement. Moreover, it becomes increasingly difficult to position the drill guide, since it interferes with the patient's head due to the tilting required to reach the coracoid. We therefore believe that plate fixation should be the preferred method in cases with a larger lateral fragment that fit a plate and several screws medial to the acromioclavicular joint. Comminuted fractures close to the AC joint where proper screw placement is not possible in the lateral fragment showed good bone healing without development of nonunions. Therefore, we believe this technique may be particularly useful as an alternative to hook-plate fixation without involving the AC joint where it may be associated with a less risk of impairing the supraspinatus tendon and the acromion. In addition, removal of implants is less likely to be necessary, which may deliver cost savings.

In a recent study, Cho et al. described a series of 18 patients with Neer type II fractures treated with DogBone and a single incision at the lateral clavicle [17] without arthroscopic guidance. He reported good clinical outcomes and only one nonunion (5%). A possible reason for the lower nonunion rate could be the loss of fracture hematoma due to dilution in our arthroscopic technique. The importance of the pro-osteogenic early hematoma is widely accepted [27, 28].

The detection of concomitant intra-articular injuries in the arthroscopic technique is said to be one of the advantages [15]. In our patient group, no intra-articular injuries were detected, so there were no therapeutic benefits for our patient group in this respect. In contrast to open techniques, arthroscopy allows for more precise tunnel placement in the clavicle and the coracoid and requires less deltoid detachment. However, shoulder arthroscopy may be associated with a higher risk of frozen shoulder.

This study has several limitations such as the retrospective study design, the absence of a control group, the short minimal follow-up of 12 month and the limited number of cases. Consequently no statistical analysis could be performed. Since there were several months between the radiological follow-up (maximum 18.2 month), the time of fracture healing could not be determined exactly.

The strength of the presented study is the fact that the majority of patients with unstable type II clavicle fracture were treated with this surgical procedure between 2012 and 2016 at our hospital. Additionally, there was only limited patient selection as a diverse range of patients of different ages and sex were operated.

Conclusions

Despite the larger number of nonunions, our study shows good functional outcomes. The method seems suitable for highly lateral unstable clavicle fractures which do not allow adequate screw fixation even when using new lateral anatomic clavicle plates. The surgical technique presented therefore adds to the current treatment portfolio. Fractures with large lateral fragments suitable for stable screw fixation, and a delay in surgery appear to negatively influence the outcomes when using this technique. Immediate functional aftercare should be critically evaluated.

This case series does not support the potential benefit of diagnosing additional intra-articular lesions. The high number of delayed unions however warrants further analysis, and future research should focus on this topic.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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