



Primary versus revision arthroscopically-assisted acromio- and coracoclavicular stabilization of chronic AC-joint instability

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Abstract

Background A gracilis tendon autograft with TightRope-augmentation can be used for arthroscopically-assisted acromioclavicular (AC)- and coracoclavicular (CC-)stabilization of chronic bidirectional AC-joint instability after failed primary treatment. The impact of failed initial treatment on postoperative outcome is unclear. Hence, the purpose of this study was to evaluate it.

Methods Twenty-seven of 38 patients suffering from chronic AC-joint instability after either failed conservative (group 1) or surgical treatment (group 2) treated in the above-mentioned technique were finally included in this study. The Subjective Shoulder Value, the Constant Score, the Taft Score and the Acromioclavicular Joint Instability Score were used for clinical evaluation. Bilateral anteroposterior stress radiographs and bilateral Alexander views were obtained for radiological evaluation.

Results 14 patients of group 1 [3f/11m; median age 47.6 (range 20.9–57.4) years] could be evaluated after a median follow-up of 24.3 (range 20–31.2) months and 13 patients of group 2 [6f/7m; median age 44.9 (range 24.9–61.0) years] were available after a median follow-up of 28.8 (range 20–33) months. Comparison of clinical score results revealed no significant differences between both groups. The median CC-difference showed no significant difference between the groups [group 1 0.8 (0–10.5) mm, group 2 0.9 (0–4.3) mm].

Conclusion AC- and CC-stabilization of chronic bidirectional AC-joint instability using a gracilis tendon autograft with TightRope-augmentation can be recommended after failed conservative and surgical treatment.

Study design Retrospective cohort study; Level of evidence III.

Keywords Chronic acromioclavicular joint instability · TightRope · Gracilis tendon autograft · Prior treatment

Introduction

Neglected or underestimated acute injuries to the acromioclavicular (AC)-joint, as well as failure of previous treatment may result in chronic AC-joint instability [9, 20]. These instabilities often pose a challenge regarding treatment.

Chronic AC-joint instability predisposes for a symptomatic scapula dyskinesia or SICK scapula syndrome (“scapular malposition, inferior medial border prominence, pain and malposition, and dyskinesia of scapular motion”) [8].

Various open surgical techniques for the stabilization of chronic AC-joint instability are reported in the literature [2, 15–17, 19, 21, 24]. With the development of minimally-invasive surgical techniques AC-joint stabilization can nowadays be performed via an arthroscopically-assisted approach [11–14, 27]. A combined vertical and horizontal high-grade instability requires coracoclavicular (CC-) and AC-augmentation to provide a stable construct [10, 28]. The aim of anatomic stabilization using a free tendon graft is to recreate the biomechanics of the AC-joint and the shoulder girdle.

Multiple minimally-invasive procedures using tendon grafts showed promising results [12–14, 27]. Especially in

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patients after failed surgical repair, however, revision surgery is challenging, since a higher rate of complications is expected due to preexisting drill holes or altered anatomy after clavicle resection.

The impact of prior treatment on postoperative outcome is not yet described in literature. Therefore, the aim of this study was to compare clinical and radiographic results of patients who underwent arthroscopically-assisted AC- and CC-stabilization using a free gracilis tendon autograft and synthetic augmentation after failed surgical treatment, to those undergoing the procedure as primary surgery after failed conservative treatment (Fig. 1) [13, 27].

We hypothesized that patients undergoing the procedure as a revision would show worse results than patients after failed conservative treatment.

Materials and methods

Patients

From November 2007 until September 2014, 38 patients [10f/28m; median age 43.2 (range 18–64) years] with a chronic bidirectional AC-joint instability were treated in a combined coraco- and acromioclavicular stabilization

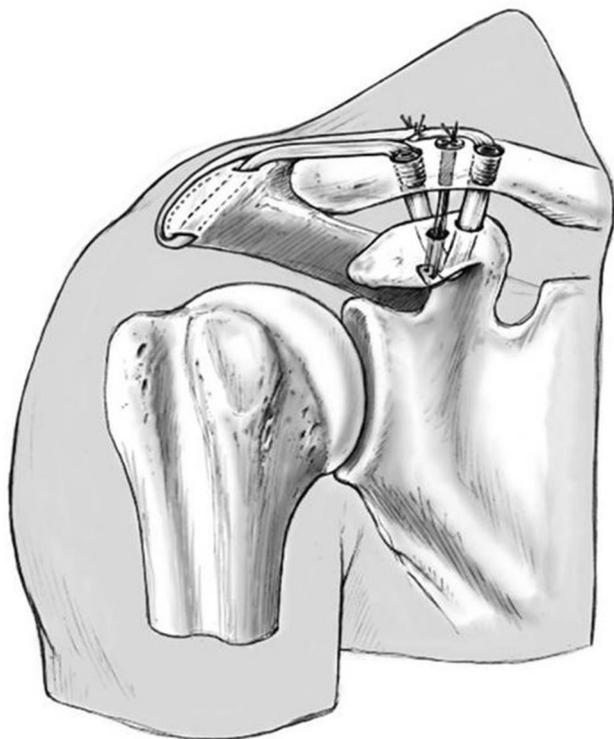


Fig. 1 Arthroscopically-assisted acromio- and coracoclavicular stabilization with a free tendon autograft and Single-TightRope augmentation [6]

technique using a gracilis tendon autograft with TightRope augmentation (Arthrex, Naples, FL, USA). All patients with chronic AC-joint instability after failed conservative treatment, as well as failed surgical stabilization were included in this non-randomized retrospective case series. Informed consent was obtained from all individual participants included in the study. Exclusion criteria were: AC-joint dislocations of the contralateral side, clavicle fractures altering the CCD ($n = 1$) and any history of cerebral seizure condition ($n = 1$). All patients had ongoing pain affecting their daily activities and quality of life after continuous physiotherapeutic treatment for 3–6 months prior to the operation.

Clinical and radiologic examination

The diagnosis of a chronic AC-joint dislocation is made by history, clinical examination and radiographic evaluation. All patients underwent a clinical examination of both shoulders. Additionally, the Subjective Shoulder Value (SSV), the Constant Score (CS), the Taft Score (TF) and the Acromioclavicular Joint Instability Score (ACJI) were obtained for clinical evaluation [4, 7, 26, 29]. Radiologically, bilateral anteroposterior stress radiographs were used for assessment of vertical stability.

Bilateral Alexander views were obtained for evaluation of dynamic posterior translation (DPT) [1, 22]. A stable AC-joint is defined as a clavicle that is in line with the acromion. The clavicle is partially translated if the difference to the acromion is less than one clavicle shaft width. If the difference is equal to or more than one width, complete DPT is present. Besides that, the mediolateral position of clavicular drill tunnels (CLm = medial clavicular drill tunnel, CLtr = TightRope drill tunnel; CLl = lateral clavicular drill tunnel) and their width at three predefined positions were measured (CLm1–3; CLtr1–3; CLl1–3) at the stress radiographs for the evaluation of potential drill hole enlargement after time.

Surgical technique

Under general anaesthesia and preoperative antibiotics, the patient was placed in the beach-chair position. A tourniquet was applied to the ipsilateral leg after full relaxation of the patient. Next, the arm, shoulder and ipsilateral leg were prepped and draped in a sterile fashion. First, the tendon graft was harvested from the pes anserinus. Usually, a length of approximate 24 cm of the tendon is suitable for CC- and AC-reconstruction. The tendon was prepared on a separate table and cleared of muscle fibres and soft tissue. A baseball stitch was applied to both ends of the tendon using a FiberWire No. 2. A pretensioning of the tendon was performed. The tendon width was measured to determine the required diameter of the drill holes.

After the diagnostic arthroscopy via a standard posterior portal, an anteroinferior working portal and a lateral viewing portal were established in an outside-in-technique. The arthroscope was switched to the lateral portal and the subcoracoid space was prepared using an electrothermic device via the anteroinferior portal. Special care has to be taken to visualize both the lateral and the medial border of the coracoid process, to place the drill holes correctly. Hence, a 2–3 cm sagittal incision approximately 3 cm medial of the AC-joint was established. In cases of prior surgery, an existing incision was used. The skin, subcutaneous tissue and the deltotrachezoidal fascia were incised. With the use of a small periosteal elevator the clavicle was cleared of remaining soft tissue. Next, the marking hook of an anterior cruciate ligament (ACL) drill guide was placed under the base of the coracoid to establish the medial coracoclavicular drill hole. The drill sleeve of the ACL drill guide was positioned superior on the clavicle. All K-wire placements and drillings were performed under arthroscopic visualization and image-intensifier control. The medial transclavicular-transcoracoidal drill hole was established in line with the former conoid ligament (Fig. 2a). First, a 2.0 mm K-wire was placed and then overdrilled using a 4.5 mm cannulated drill bit transclavicular and a 4.0 mm cannulated drill bit transcoracoidal. The K-wire was removed and a nitinol suture passing wire was inserted at the clavicular incision and retrieved via the anteroinferior portal (Fig. 2b). The drill bit was removed. A second transclavicular-transcoracoidal drill hole 1 cm laterally to the first one was established in the same technique using a 4.0 mm cannulated drill bit for Tight-Rope augmentation (Fig. 3a, b).

A transclavicular drill hole was established 1 cm laterally to the second one for later graft insertion. Again, a nitinol suture passing wire was introduced. At first, the TightRope device was shuttled through the transclavicular-transcoracoidal drill hole and the AC-joint was reduced by tightening the sutures of the TightRope device.

One limb of the prepared tendon was shuttled through the medial drill hole and retrieved at the anteroinferior portal using the nitinol wire (Fig. 4a). The leading end was then pulled through the lateral transclavicular drill hole via the remaining nitinol wire and retrieved at the clavicular incision (Fig. 4b). Both ends of the tendon were secured intraosseously using a 4.0 × 10.0 mm Tenodesis screw (Arthrex, Naples, FL, USA, Fig. 4c).

Next, the drill holes for the AC-stabilization were established. Therefore, a 1.25 mm K-wire was placed transacromially via the lateral portal and anterosuperiorly of the AC-joint (Fig. 5a). The K-wire was overdrilled using a 2.7–3.5 mm cannulated drill bit, depending on the tendon diameter (Fig. 5b). The K-wire was removed and a nitinol wire with its loop leading was introduced and retrieved via the clavicular incision (Fig. 5c). The long limb of the

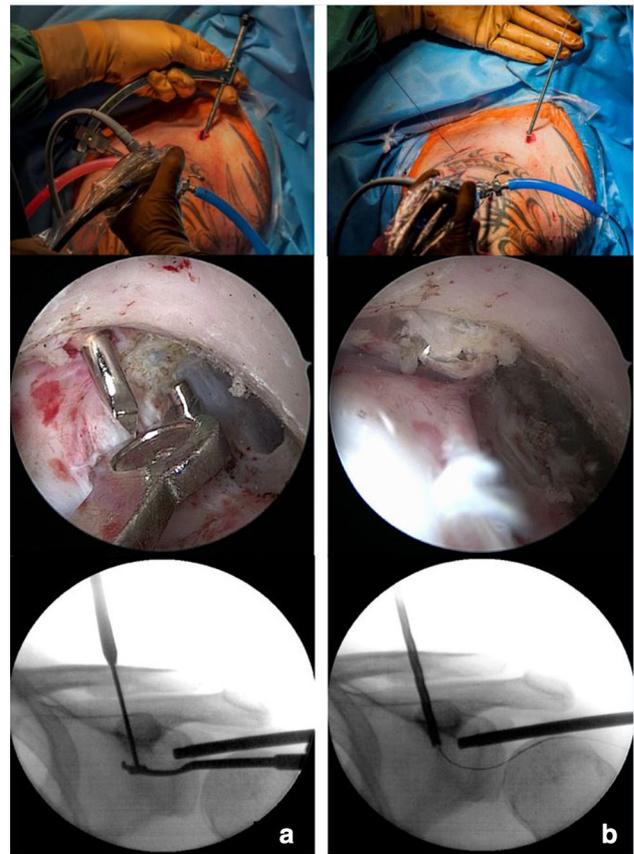


Fig. 2 Establishment of the first transclavicular and transcoracoidal drill hole: First, a 2.0 mm K-wire is placed transclavicular and transcoracoidal (a). After overdrilling of the K-wire using a 4.0 mm cannulated drill bit it is removed and a nitinol suture passing wire is introduced and retrieved via the anteroinferior portal (b)

tendon was then attached to the loop of the nitinol wire, pulled through the acromion and shuttled back subcutaneously (Fig. 6a, b).

Hence, the tendon ends were knotted. The superior incision including the deltotrachezoidal fascia was closed in two layers. The arthroscopic portals were closed in a standard fashion.

Rehabilitation protocol

The patients were placed in an abduction brace (Orthosoft, Laboratorium Ortho-Soft, Montpellier, France) for 8 weeks. In the first 2 weeks, only elbow, wrist and hand mobilization was allowed. During the 3rd week, passive flexion and abduction of the shoulder were limited to 45°. In the following 3 weeks, passive range-of-motion was allowed up to 90° of flexion and abduction. From week 9 on free passive range-of-motion was allowed and active-assisted movement was commenced. Patients were advised to avoid carrying heavy weights or movements like a forced adduction of the arm in

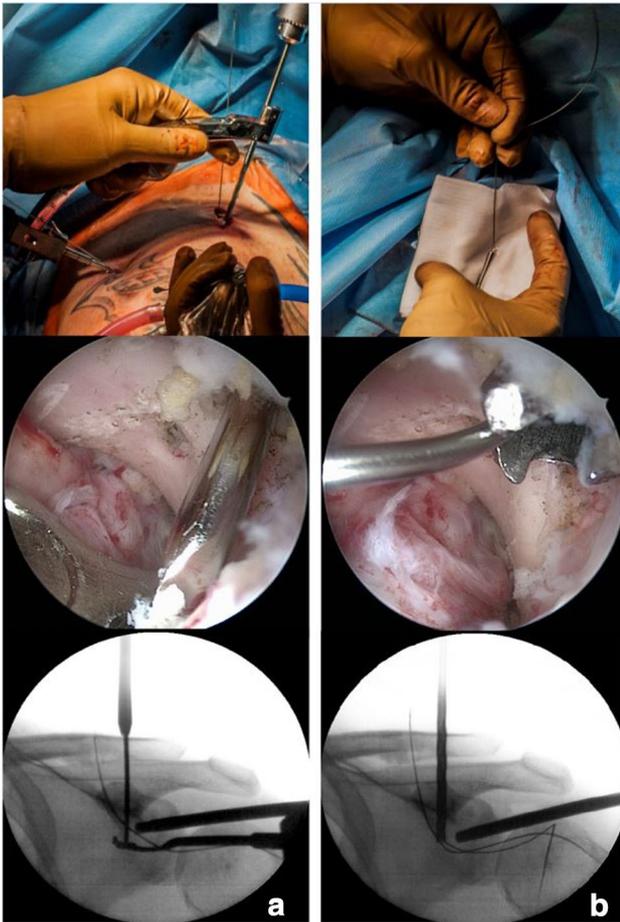


Fig. 3 Establishment of the second transclavicular and transcoracoid drill hole in the same fashion

the horizontal plane until up to 12 weeks after surgery. After 12 weeks, muscle strengthening exercises were initiated.

The local ethical committee of the Charité Universitaetsmedizin Berlin approved the study protocol (EA4/044/17).

Statistics

Statistical analysis was performed using SPSS version 16.0 (SPSS Inc, Chicago, Illinois). The Kolmogorov–Smirnov test was used on all data to test for normal distribution. Metric data was compared using the Student-test. The results of the CS, TF, SSV and ACJI were correlated using Pearson’s correlation coefficient and compared employing the Mann–Whitney *U* test. Descriptive results are demonstrated as the median (range).

The level of significance was defined as $p < 0.05$.

Results

Preoperative assessment

All of the 38 patients enrolled in this study had a symptomatic chronic AC-joint instability. From those 17 patients had a Rockwood type V instability, 19 patients a type III and 2 patients a type II. All of these patients presented with a clinically and radiographically bidirectional instability of the AC-joint in the vertical and horizontal plane. In 19 patients, prior conservative treatment (group 1) and in another 19 patients surgical treatment (group 2) failed. Prior failed surgery of patients consisted of hook plate fixation ($n=9$), Single-TightRope stabilization ($n=3$), Single-TightRope stabilization with a free tendon graft ($n=1$), minimally invasive acromioclavicular joint repair (MINAR)-technique ($n=1$), lateral clavicle resection ($n=3$), polydioxanesulfate (PDS)-cerclage ($n=2$) stabilization, transfixation with Kirschner



Fig. 4 The first limb of the prepared tendon is shuttled via the nitinol wire in the first drill hole (a). The remaining limb is then pulled through the third, transclavicular drill hole via the third nitinol wire (b). Both ends of the tendon are secured using a BioTenodesis screw (c)

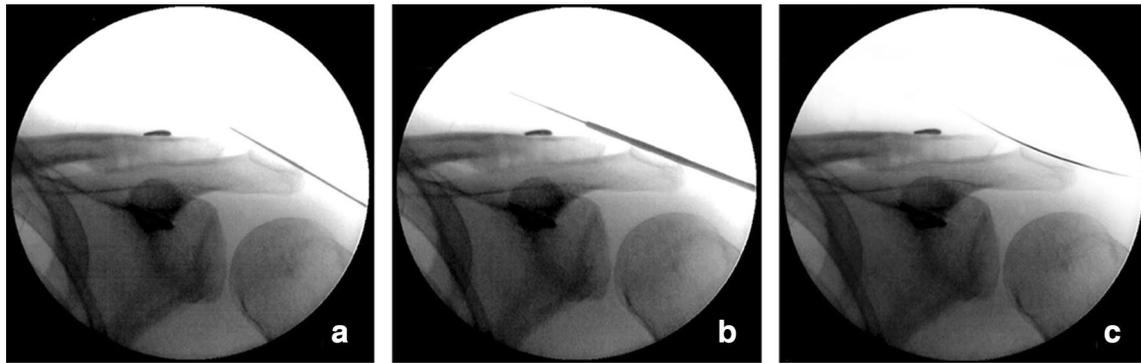
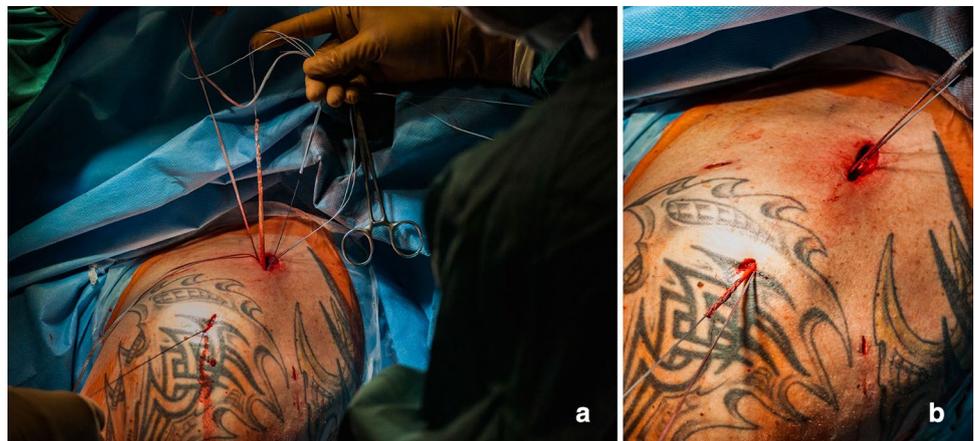


Fig. 5 AC-stabilization: a 1.25 mm transacromial K-wire is placed via the lateral portal superior of the AC-joint (a). The K-wire is overdrilled using a 2.7–3.5 mm cannulated drill bit, depending on the ten-

don width (b). The K-wire is removed and a nitinol wire, with its loop leading, is introduced and retrieved via the superior incision (c)

Fig. 6 The long limb of the tendon is then attached to the loop of the nitinol wire (a), directed through the acromion and returned subcutaneously (b)



wires ($n = 1$) and coracoacromial ligament transfer ($n = 1$). Four patients had multiple prior surgeries. One patient had a second hook plate fixation after failed initial hook plate fixation. One patient underwent lateral clavicle resection two times. Two patients had multiple revisions due to local postoperative infection.

Clinical results

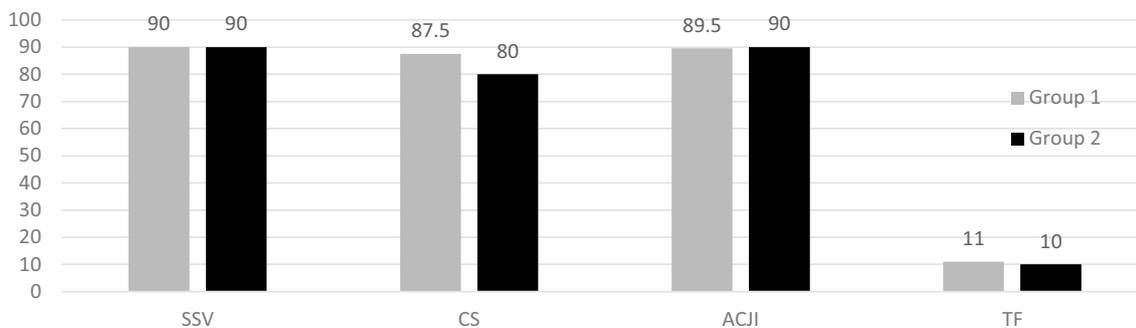
After a median follow-up of 25.2 (range 20–37.2) months 27 patients were available for follow-up (71%). Six patients refused to participate in the follow-up examination as they claimed to have no complaints and did not see a necessity for the examination. Six patients could not be contacted via telephone, mail or their health insurance company. Unfortunately, one patient died unrelated to the surgery before the 24 months follow-up. Regarding primary treatment, 14 patients had prior conservative [group 1; 3f/11 m; median age 47.2 (range 20.9–57.4) years] and 13 had prior surgical repair [group 2; 6f/7 m; median age 44.9 (range 24.9–61) years].

Group 1: Patients with failed prior conservative treatment

After a median follow-up of 24.3 (range 20–31.2) months patients in group 1 reached 87.5 (range 62–97); contralateral 90 (range 80–100) points in the CS, 90 (range 50–100) % in the SSV, 11 (range 7–12) points in the TF and 89.5 (range 34–100) points in the ACJI (Table 1). The median range-of-motion on the affected side was 180° (range 150°–180°) in flexion, 180° (range 150°–180°) in abduction, 80° (range 30°–90°) external rotation in 0° abduction.

Eleven patients (78.6%) had a cosmetically satisfying result without subjective asymmetry. Three patients (21.4%) had a slight objective asymmetry between both clavicles without subjective complaints. The three patients with both, an objective and subjective asymmetry, had a pain-free and nearly full range-of-motion. Two patients had occasional pain during overhead activities. The remaining patients were pain-free. One patient had tenderness-to-palpation over the AC-Joint and the TightRope-buttons.

After 2 years, the median coracoclavicular distance on the affected side [11.1 (range 7.3–24.1) mm] was significantly higher than on the contralateral side [9.55 (range

Table 1 Score results

CS Constant Score, $p=0.47$; SSV Subjective Shoulder Value, $p=0.83$; TF Taft Score, $p=0.68$; ACJI Acromioclavicular Joint Instability Score, $p=0.83$; pts points

5.1–12.1 mm] ($p < 0.05$) (Fig. 7a). Regarding DPT in the bilateral Alexander-views ten patients showed a stable AC-joint. In three patients, partial and in one case a complete DPT was observed (Fig. 7b).

Coracoclavicular ossification was found in one patient, which was not related to clinical symptoms or inferior results.

Regarding drill tunnel placement, the distance from the lateral clavicular edge was found to be 41.2 (range 34–47) mm for the CLm, 25.9 (range 19–33) mm for the CLtr and 13.0 (range 10–21) mm for the CLI. After 24 months, an increase in drill tunnel width regarding the graft passage (CLm1 = 5.0 mm, CLm2 = 6.9 mm, CLm3 = 7.1 mm; CLtr1 = 3.6 mm, CLtr2 = 4.0 mm; CLtr3 = 5.0 mm; CLI1 = 5.7 mm; CLI2 = 5.9 mm, CLI3 = 5.3 mm) was

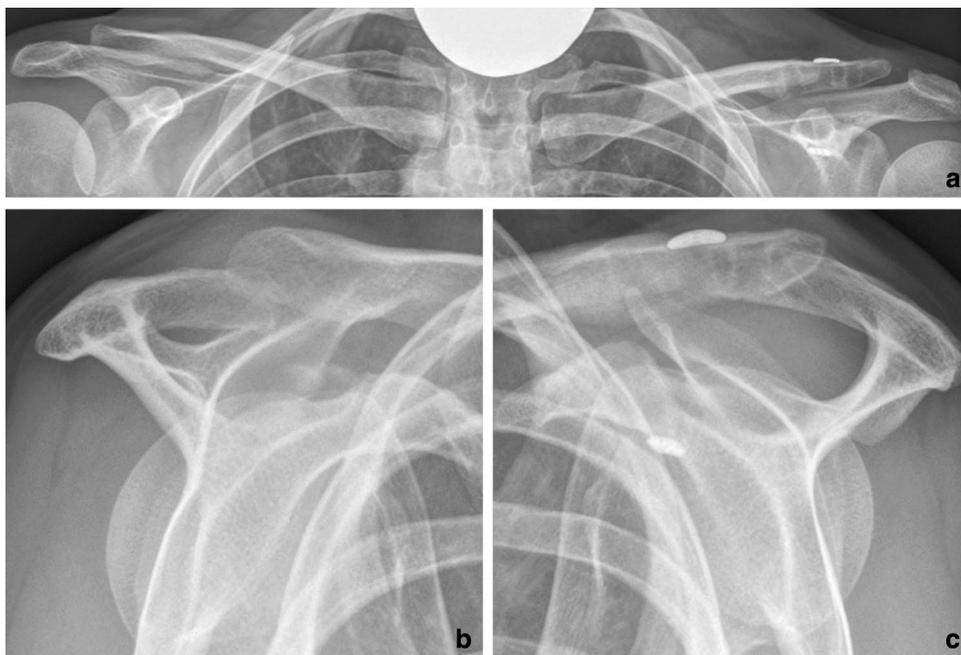
observed. But only Clm2 and Clm3 showed a statistically significant increase ($p < 0.05$).

One patient (7.1%) required revision surgery for vertical and horizontal AC-joint stabilization using semitendinosus graft. Three patients (21.3%) experienced minor complications. A secondary shoulder stiffness was treated successfully by oral cortisone. In one case a recurrent vertical instability was treated conservatively, this patient achieved 95% in the SSV at the follow-up. One patient experienced persisting hypesthesia at the graft harvesting side without signs of neuropathy.

Group 2: Patients with failed prior surgical treatment

The median follow-up was 28.8 (range 20–33) months. The median CS was 80.0 points (range 47–100; contralateral 87.5

Fig. 7 Bilateral anteroposterior (a) and horizontal stress views (b, c) 2 years after surgical repair



(range 83–100), $p > 0.05$), the median SSV was 90.0 (range 50–98) %, the median TS was 10.0 (range 7–12) points and the median ACJI was 90.0 (range 48–100) points (Table 1). This group reached 180° (range 140°–180°) in flexion, 180° (range 80°–180°) in abduction and 75° (range 30°–80°) in external rotation.

Twelve (92.3%) of the remaining patients had no subjective asymmetry and a cosmetically satisfying result. Four patients (30.8%) had an objective difference between both clavicles without subjective complains. One patient with an objective and a subjective asymmetry experienced occasional pain at rest, the other one was pain-free and had a full range of motion. Two patients had occasional pain with strenuous overhead activities. Two patients had tenderness-to-palpation over the AC-joint.

After 2 years, there was no significant difference between the median coracoclavicular distance of the affected side and the contralateral side [10.1 (range 6–18) mm versus 9.1 (range 6–14) mm] (Fig. 7a). The median CC-difference was 0.95 (0–4.3) mm. In group 2 eleven patients showed a stable AC-joint on bilateral Alexander views (Fig. 7b). Two patients displayed a partial and no patient a complete DPT. One patient had ossification in the line of the former conoid ligament without clinical impact regarding pain or range of motion.

In this group, the distance from the lateral clavicular edge was for the CLm 39.4 (range 34–47) mm, for the CLtr 24.8 (range 22–33) mm and for the CLI 14.3 (range 10–24) mm regarding to drill tunnel placement. After the mean follow-up also in this group an increase in drill tunnel width regarding the graft passage (CLm1 = 5.2 mm, CLm2 = 6.3 mm, CLm3 = 6.5 mm; CLtr1 = 3.7 mm, CLtr2 = 4.2 mm; CLtr3 = 6.0 mm; CLI1 = 5.4 mm; CLI2 = 5.8 mm, CLI3 = 6.1 mm) was found, the enlargement was also only significant for CLm2 ($p < 0.05$) and CLm3 ($p < 0.05$).

Two patients (15.4%) required revision surgery [combined open-arthroscopic debridement, lavage and implant removal ($n = 1$), combined open-arthroscopic transfer of the coracoacromial ligament with Single-TightRope augmentation and lateral clavicle resection ($n = 1$)]. Only one patient (7.6%) presented a minor complication: a recurrent vertical instability, which was treated conservatively. The patient was subjectively satisfied and reached 80% in the SSV.

Comparison of the groups

Subjective asymmetry and pain did not correlate with the type of prior treatment. There was no statistically significant difference between group 1 and group 2 and no significant side difference regarding the range of motion. Comparison of the clinical score results, regarding the CS, the SSV, the TF, revealed no significant differences between the groups. Furthermore, the radiologic evaluation did not show any

statistically significant differences between the two groups (CCD 11.1 mm versus 10.1 mm, CC difference 0.8 mm versus 0.9 mm). There was no difference in drill tunnel placement between both groups. The Tight-Rope drill tunnel showed no significant enlargement. Enlargement did not differ significantly between both groups. In total, there was a coneshaped enlargement in the medial and a more equally distributed enlargement in lateral drill tunnels. A medial enlargement correlated significantly with a lateral enlargement for CLm3 and CLI 3 ($p < 0.05$). The mediolateral position or a drill tunnel enlargement was not associated with inferior clinical results or a pronounced vertical or horizontal translation of the AC-joint. The rate of complications requiring revision was 7.1% in group 1 and 15.4% in group 2. This difference was not statistically significant. However, revision surgery was performed in two patients of group 2 and only one patient of group 1. Furthermore, three patients suffered from tenderness to palpation over the AC-joint in group 2 and none in group 1.

Discussion

The most important finding of this study is that we found no inferior clinical results in patients that underwent prior surgical treatment, therefore, our hypothesis has to be rejected. The treatment of chronic high-grade acromioclavicular instability can be challenging. In many patients stabilization with a free tendon graft is a secondary procedure after failed early surgical repair with a possibly higher risk of complications. Therefore, surgical intervention remains an individual decision. In chronic situations a conservative treatment over 6 months with strengthening of scapula-stabilizing muscles that aims to normalize scapular movement and kinesis should be taken into consideration [3, 8, 23].

Surgical treatment should focus on the severity of the instability. Low-grade chronic instabilities with degenerative AC-joint pathologies as the main factor causing symptoms can be treated sufficiently with careful arthroscopic lateral clavicle resection [13]. Care needs to be taken to avoid excessive bone resection and consecutive damage to the coracoclavicular ligament complex. Isolated vertical instabilities may be treated with open or arthroscopic transfer of the coracoacromial ligament with or without additional synthetic augmentation using a pulley-like implant [11, 14, 31]. However, in high-grade bidirectional instability biomechanical properties of the CA-ligament do not allow for a sufficient stabilization of the AC- and CC-ligament complex [30]. Besides, exclusive synthetic augmentation in the chronic situation is not feasible as biologic healing capacity does not resemble the acute setting. Therefore, biologic augmentation is advocated. The gracilis and semitendinosus tendon have been described to resemble the biomechanical properties of

the native coracoclavicular ligaments [5]. Results of open stabilization are promising. To preserve the tendon graft in the early phase of healing a synthetic augmentation may be added to the technique. An additional acromioclavicular placement of the graft provides horizontal stability. This has been shown biomechanically by Shin et al. in a cadaveric study [28]. The authors found that a simultaneous acromioclavicular–coracoclavicular reconstruction technique using a single free tendon graft provided anatomic reconstruction of the conoid, trapezoid, and superior and inferior acromioclavicular ligaments with a significantly greater ultimate load, deformation at ultimate load, and energy absorbed at ultimate load than after coracoid cerclage reconstruction. They concluded that this technique may also reduce postoperative subluxation. Recently, some technical notes using a gracilis tendon graft for AC and CC-stabilization with synthetic augmentation were published [18, 25]. So far, no results of an arthroscopically-assisted CC- and AC-stabilization using a gracilis tendon graft and a synthetic augmentation with a pulley-like implant have been published. First, the clavicle is reduced using a single TightRope and then the AC Joint is finally stabilized by recreating the anatomic situation with the gracilis graft. We believe that the tendon also needs a protection during the healing and remodeling process which is given by a synthetic augmentation. We found good clinical and radiographic results with an acceptable revision rate in this challenging patient group. It might be assumed that synthetic augmentation leads to stiffness of the acromioclavicular joint. To our knowledge, no study ever investigated the biomechanics of a CC- and AC-stabilization using a tendon graft with synthetic augmentation. However, even though such a biomechanical investigation might add valuable information, it would not allow statements about biomechanical properties after the healing and remodeling process. Reflecting our results, we do not believe that the augmentation is too stiff. We still observed cases of partial or complete DPT. Prior treatment had no significant impact on clinical or radiographic results including clavicular drill tunnel position and enlargement. These findings are consistent with those published by Fauci et al. [6]. The influence of the tunnel position and the enlargement on the clinical outcome is nearly unknown. We assumed that the enlargement is higher in patients with existing drill tunnels in the coracoid, which were used again. We found a significant enlargement of clavicular graft tunnels. The TightRope drill hole showed no significant enlargement. The difference in the shape of the medial (cone-shaped enlargement) and the lateral (equally distributed enlargement) graft passage drill hole could be due to a “wind-shield wiper effect” medially and a more equally distributed force in the lateral drill hole as the lateral part of the gracilis tendon was used for the AC-stabilization. Lateral tension in the AC-cerclage-construct might, therefore, lead to the equal enlargement shape of the

lateral drill hole. However, there is no clinical relevance, but we think it is an interesting finding.

This study has some limitations. First, it is a small patient cohort operated on over a long time period without a control group. However, these chronic high-grade instabilities are rare diagnosis and careful consideration is necessary to indicate surgery in this challenging patient group. Besides, all patients received a trial period of physiotherapy for 3–6 months prior to this surgery and suffered from ongoing symptoms. Second, a direct comparison between prior conservative and surgical treatment is difficult as patients received different surgical techniques with and without coracoclavicular drill tunnels. In addition, group two was a heterogeneous with regards to prior surgical procedures. However, this resembles clinical routine as various surgical techniques exist for stabilization of the AC-joint. Another limitation is the retrospective study design and the loss-to follow-up rate.

Conclusion

The results of this study suggest that arthroscopically-assisted AC- and CC-stabilization with a free gracilis tendon autograft and synthetic augmentation can be considered as a suitable treatment option for both failed conservative and surgical treatment.

Compliance with ethical standards

Conflict of interest The authors would like to state that no outside funding or grants were received that assisted in this study. Natascha Kraus, Carmen Hann, Nina Maziak and Marvin Minkus, their immediate family, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article. Markus Scheibel received consultant payments from Arthrex Company related to this work.

Ethical statement This study was approved by the local ethical committee (EA4/044/17).

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