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Clavicular tunnel widening after acromioclavicular joint reconstruction: comparison between single and double clavicular tunnel techniques

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Acromioclavicular joint (ACJ) reconstruction using artificial ligaments is a common surgical treatment for Rockwood grade III or higher injuries. These techniques use bone tunnels in the clavicle and coracoid to insert the Tightrope implants. This multicenter retrospective study compares long term radiographic follow up of clavicular tunnel widening in two groups of patients with high-grade ACJ injury who underwent reconstruction using two different surgical techniques. The first group of 23 patients underwent an arthroscopic single clavicular tunnel ACJ reconstruction. The second group of 23 patiënts underwent an open double clavicular tunnel reconstruction. Inclusion criteria are Rockwood grade III or higher injury and minimum 18 months of follow-up. Exclusion criteria are distal clavicle fracture and additional stabilization techniques. Radiographic results were measured on anteroposterior shoulder radiographs taken at the first and last follow-up. Clavicular tunnel widening is the main outcome measurement. Secondary outcomes are heterotopic ligament calcifications, migration of buttons, tunnel fracture and loss of acromioclavicular reduction. The mean clavicular tunnel widening in the single clavicular tunnel technique is 1.91 mm. In the double clavicular tunnel technique, the widening of the medial tunnel is 2.52 mm and 3.59 mm in the lateral tunnel. The difference in widening between the single tunnel and the lateral tunnel is significant (p=0.003). A very clear observation on all follow-up X-rays was a reorientation of the clavicular tunnels towards the coracoid. The double clavicular tunnel technique has more tunnel widening in both tunnels compared to the single bundle technique.

Keywords: trauma, shoulder, acromioclavicular joint, tunnel widening, surgical treatment.

INTRODUCTION

Numerous open or arthroscopic surgical techniques have been described to treat Rockwood grade III or higher acromioclavicular joint (ACJ) dislocations[1]. Many of them use one or multiple tunnels to anatomically restore the coracoclavicular interval and show good results, but there is still no gold standard[2-6]. Although these techniques have high success rates, they may carry an increased risk of clavicle fractures, which has been attributed to the number and size of the tunnels[7-10]. Other radiologic findings and complications after ACJ reconstruction with coracolavicular ligament reconstruction are loss of reduction, widening of the coracoclavicular distance, distal clavicular osteolysis and tunnel widening. Tunnel widening may increase the risk of postoperative fractures and complications[6,11-14.] Some studies suggest that the direction and angulation of the clavicular tunnel is related to the loss of reduction[6,15]. The aim of this study is to investigate whether there is more widening of the clavicular tunnels in a double clavicular tunnel technique compared to a single clavicular tunnel technique. Our hypothesis is that there is more widening in the double tunnel technique due to a more angulated direction of the clavicular tunnels and the tendency of the TighTrope to reorientate towards the coracoid.

MATERIAL AND METHODS

Approval for the study was obtained from the local ethics committee. In this retrospective cohort study we compare postoperative clavicular tunnel widening in two different acromioclavicular joint reconstruction techniques. The first group consisted of 23 patients who underwent a single clavicular tunnel arthroscopic ACJ reconstruction between 2010 and 2017. All surgeries were performed by two senior surgeons. The second group consisted of 23 patients, who underwent an open ACJ reconstruction between 2016 and 2021 by two senior surgeons in a second hospital. Inclusion criteria for both groups were ACJ luxation Rockwood grade III or higher, age older than 18 years and a minimum follow-up of 18 months. Exclusion criteria for both groups

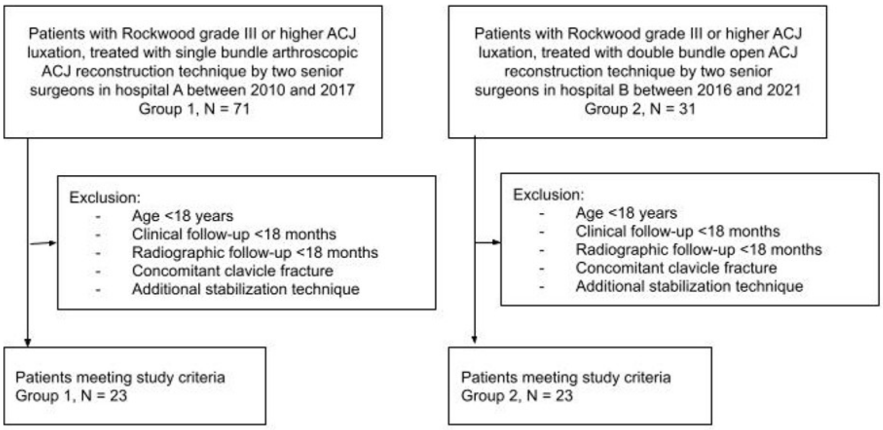

Figure 1. — Flowchart.

Table I. — Comparison between the two groups concerning age at surgery, time between trauma and surgery in days, follow-up after surgery in months, measurements of the tunnels at the most wide part of the tunnels at immediate postoperative X-ray and at follow-up, mean widening of the tunnel. SD = standard deviation.

Patient demographics	**Group 1 (N=23)**	**Group 2 (N=23)**
Mean age ± SD (in years)	42 ± 12	44 ± 12
Mean time to surgery ± SD (in days)	44 ± 82	23 ± 34
Mean follow-up ± SD (in months)	61 ± 21	35 ± 13
Side (Richt)	1.09	2.29

were distal clavicle fracture and additional stabilization techniques (e.g. concomitant Weaver-Dunn) at the time of operation. We made anteroposterior radiographs of both shoulders on week two postoperative and on their last follow-up.[1] Informed consent was given by all patients (Fig. 1, Table I).

The technique used in the first group was an arthroscopic single clavicular tunnel ACJ reconstruction using the Arthrex (Arthrex, Naples, FL, USA) AC TightRope Technique. The AC TightRope consists of an oblong coracoid button and a round clavicle button, connected to each other by a number 5 FiberWire loop through a tunnel in the coracoid and one aligned tunnel in the clavicle. All operations were performed in beach chair position. Intra-articular pathologies were documented, and treated where indicated, during an initial arthroscopy. Through an anterolateral working portal, we freed the lateral and medial borders of the base of coracoid using an ablation device. Next, a transportal guide with a mounted 2.4 drill sleeve was placed and a small incision was made two to three cm medial to the ACJ. Under direct arthroscopic vision with an aiming device, a tunnel was drilled through the clavicle and coracoid process with a 2.4 guide pin and a 4.5mm cannulated drill. With the cannulated drill in place, we removed the guide pin, passed a suture passing wire through the drill and retrieved it with a suture retriever through the anterior portal. After removing the drill, the TightRope system was shuttled through the clavicular and coracoid tunnel under arthroscopic vision to ensure that the coracoid button was well seated beneath the coracoid. Lastly the ACJ was manually reduced and the TightRope was tightened and tied.

The second group underwent an open ACJ reconstruction using the Arthrex Twin Tail TightRope Technique. The Twin Tail TightRope has two oblong clavicle buttons connected to one oblong coracoid button by a number 5 FiberWire. With this technique the coracoclavicular ligament is anatomically reconstructed. This open technique was performed in the beach chair position. The approach was made by a 4 cm horizontal incision anterior to the distal clavicle. With sharp dissection, the ACJ, distal clavicle and coracoid process were visualized. First a centered coracoid tunnel was drilled using a 4.5mm drill. Next the clavicular tunnels were drilled at approximately 2.5 and 4 cm medial to the AC joint. The coracoid button was then passed through the coracoid tunnel and the clavicular buttons were passed using a suture passing wire. While manually holding the reduction, the Tightrope device was tightened and tied.

Both groups received an adduction sling for three weeks. Immediate postoperative automobilization of hand, wrist and elbow was recommended. Passive and gradual active range of motion of the shoulder was allowed from day 1 postoperative. The adduction sling was discarded from week 3. Strength training was allowed from week 6 postoperative. If necessary, additional physiotherapy was started after three weeks.

Anteroposterior radiographs of both shoulders were taken on week two postoperative and on their last time

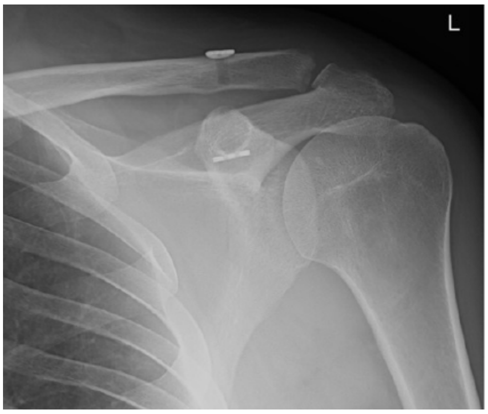

Figure 2a. — Two weeks postoperative X-ray of single clavicular tunnel technique.

Figure 2b. — X-ray of single clavicular tunnel technique at least 18 months follow-up.

Figure 3a. — Two weeks postoperative X-ray of double clavicular tunnel technique.

Figure 3b. — X-ray of double clavicular tunnel technique at least 18 months follow-up.

follow-up[1]. The tunnel width of the clavicular tunnels measured on the radiograph at two weeks postoperative is used as a reference for assessing tunnel widening at later follow-up time. The minimum width of the clavicular tunnels is 4.5 mm due to the drill size used in both techniques.

The main outcome measurement is tunnel widening of the clavicular tunnels. Tunnel widening was assessed by measuring the clavicular tunnel diameter in mm on the most wide part of the tunnel and comparing the first postoperative follow-up at two weeks, with the latest follow-up X-ray. Clavicular tunnel widening was defined as the difference in millimeters between the first postoperative (Fig. 2a, Fig. 3a) and most recent follow-up X-ray (Fig. 2b, Fig. 3b). Measurements were done independently by two investigators and the mean of the independent measurements was used. Secondary outcomes observed on X-ray are, heterotopic ligament calcification, migration of buttons and loss of acromioclavicular reduction. We defined loss of reduction of the acromioclavicular joint as widening of the ACJ width with 50 or more percent compared to the contralateral side.

The Tukey test was used for pairwise comparison of both groups comparing number of patients included, age at time of surgery, heterotopic ligament calcification, migration of clavicular button, migration of coracoid button, loss of reduction and clavicular fracture. With the one-way ANOVA test we compared the mean tunnel widening between the single tunnel of the TightRope technique, the medial tunnel of the Twin Tail technique and the lateral tunnel of the Twin Tail technique. The Tukey test was used for pairwise comparison. The mean widening of the single tunnel was compared to the mean widening of the medial tunnel and lateral tunnel of the Twin Tail technique.

RESULTS

Both groups were comparable in number (group 1 N = 23, group 2 N = 23) and mean age at time of surgery (42 years and 44 years respectively). Mean time to surgery after trauma was 44 days (group 1) and 23 days (group 2) and the mean follow-up time in months was 61 and 35 respectively, with a minimum follow-up of 18 months in both groups.

At the most recent follow-up, X-ray measurements of the width of the single clavicular tunnel (group 1) at the widest point of the tunnel varied between 3.71 mm and 9.2 mm. Resulting in a widening of the tunnel ranging between -0.79 and 4.70 mm at the widest point comparing the most recent postoperative X-ray to the

Table II. — Mean tunnel widening between earliest and latest postoperative follow-up, measured at the most wide part of the clavicular tunnel. SD = standard deviation, 95% CI = 95% confidence interval.

Tunnel widening	Group 1 single tunnel	Group 2 medial tunnel	Group 2 lateral tunnel
Earliest postoperative follow-up (mm)	4.5	4.5	4.5
Lates postoperative follow-up (mm) + SD 95% CI	6.41 ± 1.36 5.85 to 6.97	6.99 ± 1.39 6.42 to 7.56	8.06 ± 1.76 7.34 to 8.78
Mean tunnel widening (mm) + SD 95% CI	1.91 ± 1.36 1.35 to 2.47	2.52 ± 1.38 1.96 to 3.0	3.56 ± 1.75 2.85 to 4.28
Mean tunnel widening (%)	42%	56%	79%

two weeks postoperative X-ray (4.5mm). The average widening of the single clavicular tunnel was 1.91 mm (42%). Group 2 had a medial and a lateral clavicular tunnel. At the most recent follow-up X-ray, the medial tunnel width measurements varied between 4.34 mm to 10.26 mm. Widening of the medial tunnel ranged between -0.16 mm and 5,76 mm with an average widening of 2.52mm (56%). The measurements of the width of the lateral clavicular tunnel from group 2 varied between 4.01 mm and 11.79 mm. Widening of the lateral tunnel ranged between -0.49 mm and 7.29 mm with an average of 3.56 mm (79%). The mean widening is lowest in the arthroscopic single bundle technique (1.91 mm) and higher in both clavicular tunnels of the open double bundle technique. The medial tunnel had a mean widening of 2.52 mm and the lateral tunnel had a mean widening of 3.56 mm. The difference in widening between the single tunnel and medial tunnel is not significant (p=0.387), the difference between the single tunnel and the lateral tunnel is significant (p=0.002). A very clear observation on all follow-up X-rays was a reorientation of the clavicular tunnels towards the coracoid. (Table I)

The following secondary outcomes were observed on follow-up X-rays: heterotopic ligament calcification, loss of reduction of the acromioclavicular joint, migration of the button and fracture through the tunnel. Loss of reduction was seen in 22% to 30% of the patients in the first and second group respectively. The migration of the clavicular button was only seen in the lateral tunnel of the Twin Tail technique where in two cases the button sunk into the tunnel for a maximum of 2 mm. Migration of the coracoid button was observed in both techniques, probably due to uncentered drilling of the coracoid. In one case there was a fracture through the medial tunnel of the Twin Tail technique after a new trauma with direct impact on the ipsilateral shoulder (Table II).

DISCUSSION

The aim of this study was to investigate whether the double clavicular tunnel technique for ACJ reconstruction is more prone to clavicular tunnel widening than the single clavicular tunnel technique. These techniques only stabilize in the coronal plane and there was no additional anteroposterior stabilization in either of the techniques. Our study has the biggest population to compare two acromioclavicular reconstruction techniques for tunnel widening in the current literature.

Various studies have shown that an increase in the diameter and the number and position of the drilled holes is linked to an increased risk of coracoid process and clavicle fractures[7-10,16]. More recently, the phenomenon of tunnel widening of the clavicular tunnels has gained attention and could attribute to an increased risk of loss of reduction and clavicle fractures[2]. Recent clinical studies however do not support a relationship between tunnel widening and loss of reduction or clinical outcome[12-14]. Studies investigating this phenomenon detected a tunnel widening in up to 100% of the patients, with a mean increase in tunnel diameter of 18-66%[12-15]. In our study, the mean increase in tunnel size was 46% in the single clavicular tunnel group and 56% to 79% for the medial and lateral tunnel respectively in the double clavicular tunnel group. There was only a statistically significant difference in tunnel widening between the single clavicular tunnel and the lateral tunnel in the double clavicular tunnel technique. The increased widening over time seen for the lateral tunnel is consistent with the current literature and is attributed to lower bone mineral density of the distal clavicle[2,13].

Dalos D. et al showed that clavicular tunnel widening mostly occurs in the inferior part of the tunnel and the superior part of the coracoid[12]. The diameter of the tunnel increases the further away from the fixation point, suggesting a three dimensional windshield-wiper effect of the fixation device. The windshield

Table III. — Secondary outcomes found on latest follow-up X-rays

Secondary outcomes	Group 1 (N=23)	Group 2 (N=23)
Heterotopic calcification	4 (17%)	6 (26%)
Loss of reduction	5 (22%)	7 (30%)
Migration of clavicular button	0 (0%)	2 (9%)
Migration of coracoid button	3 (13%)	3 (13%)
Clavicle tunnel fracture	0 (0%)	1 (4%)

wiper effect supports our theory that the orientation of a clavicular tunnel straight above or in line with the coracoid tunnel is important to minimize clavicular tunnel widening.

Seo JB et al. proved the importance of the angle between the clavicular tunnel and the coracoid tunnel as they found a significantly higher clavicular tunnel widening when the tunnels were made before reduction of the ACJ as the the angle of the clavicular and coracoid tunnel variates before and after reduction[15]. The angle of the clavicular tunnels in a double bundle technique towards the coracoid tunnel is always bigger than the angle in a single bundle technique using an aiming device. This was consistent with our findings, especially the lateral clavicular tunnel in the Twin Tail technique.

This study showed a significant difference in the tunnel widening between the 2 techniques. We did not see a significant difference in secondary outcomes between both techniques (Table III). Thus we could not prove correlation between progressive tunnel widening and an increased risk of loss of reduction or increased risk for fractures.

Our study has limitations. Our measurements were made on plain anteroposterior radiographs at the latest postoperative follow-up, the time between first postoperative X-ray and latest X-ray was not standardized resulting in a wide range of follow-up time. Further, the measurements could have been more precise with CT scan. This is, however, more expensive and is associated with higher exposure of radiation. Furthermore we did not have clinical scores to correlate our radiological results to clinical findings.

CONCLUSION

Our study compares a single bundle AC TightRope technique to a double bundle Twin Tail TightRope technique. Our study confirms our hypothesis that the double bundle technique is more subject to osteolysis due to the windshield wiper effect resulting in clavicular tunnel widening. The single bundle technique had a mean clavicular tunnel widening of 1.91 ± 1.36 mm, the medial tunnel of the double bundle technique had a mean clavicular tunnel widening of 2.52 ± 1.38 mm and the lateral tunnel of the double bundle technique had a mean clavicular tunnel widening of 3.56 ± 1.75 mm.

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