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Original Article

Post-traumatic acromioclavicular instability reconstruction with coracoacromial ligament and conjoined tendon: A preliminary report

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ABSTRACT

Background: Many surgical techniques have been proposed to treat acromioclavicular (AC) injuries; however, anatomic coracoclavicular (CC) reconstructions with local tissue grafts have not been reported in previous studies. The aim of this study was to investigate early outcomes of this innovative technique.
Methods: Between 2004 and 2011, 15 patients with post-traumatic AC instability underwent anatomic reconstructions by two surgeons at our institution. Nine patients were treated with local tissue grafts, and these included six patients who underwent double-bundle reconstructions and three who underwent single-bundle reconstructions. The remaining six patients were treated with free tendon grafts. The clinical outcomes of the Constant scores and the radiographic results of the CC distance were further analyzed.
Results: In patients who underwent reconstructions with local tissue grafts, those treated with double-bundle and selective-bundle reconstructions had an average postoperative Constant score of 89.0 ± 11.5 and 71.7 ± 38.4, respectively. In patients who underwent reconstructions with free tendon grafts, the average score was 73.0 ± 29.4. There was no statistically significant difference among the three reconstruction procedures. Only one patient showed residual AC separation on plain-film radiography.
Conclusion: This innovative technique provided clinical and radiographic results that were comparable to those achieved with free tendon grafts. This procedure can be an alternative surgical option for treating AC joint instability.

1. Introduction

The Weaver-Dunn and modified Weaver-Dunn procedures, which involve coracoacromial (CA) ligament transfer into the medullary canal, have been the most popular surgeries for acromioclavicular (AC) injuries.[1–8] Other local tissue grafts, such as those involving conjoined tendons, result in similar ultimate tensile strengths in biomechanical studies and serve as an alternative tissue option in studies of nonanatomic reconstruction.[9–11]

Anatomic coracoclavicular (CC) reconstructions with free tendon grafts have been shown in biomechanical studies to provide more resistance to translation force.[12,13] This technique has resulted in promising clinical results and has become popular in recent years.[14–17]

Although numerous surgical techniques have been proposed for treating AC injuries, anatomic reconstructions with local tissue grafts have not been reported in previous studies. We developed this innovative procedure, which involves transferring the CA ligament and conjoined tendon to anatomic tunnels, in order to combine the advantages of local tissue transfer and anatomic reconstruction. The purpose of this study was to investigate the early results of this procedure and to compare it with the results of anatomic reconstructions with free tendon grafts.

2. Materials and methods

2.1. Patient data

The Rockwood classification was used to assess the AC injuries. Types I and II were low-grade injuries. The CC interspace increases in Types III and V were 25–100% and 100–300%, respectively; Type

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IV included posterior displacement, and Type VI included inferior displacement.[18] Surgical indications were: (1) acute Rockwood Type IV, V, or VI AC injuries; (2) chronic Rockwood Type III, IV, V, or VI AC injuries with failed conservative treatment; (3) distal clavicle nonunion; or (4) failure of prior surgery for AC dislocation. Patients with cervical disorder, open fractures, or neurovascular injuries were excluded.

Between 2004 and 2011, 15 patients (12 men and 3 women; mean age 47.5 years, range 19.7–82.4 years) with AC instability underwent CC reconstructions that were performed by two surgeons at our institution. All 15 patients were included in this study and were followed up for a mean duration of 24.4 months (range 8.8–93.1).

The mechanisms of AC injury included falls (3 patients), traffic accidents (11 patients), and contusion during work (1 patient). We classified AC instability according to the Rockwood system. One patient was Type II, four patients were Type III, two patients were Type IV, and eight patients were Type V (Table 1). Six of the 15 patients had concomitant injuries, including intracranial hematomas, ipsilateral hip and femoral shaft fractures, rib fractures, radial head fractures, and metatarsal fractures.

Twelve patients underwent primary CC reconstruction surgery, and these included 10 patients with AC separation and two with a distal clavicle nonunion and a high-riding clavicle. Three patients who had failures of a prior CC screw fixation at other institutions visited our hospital and underwent revision CC reconstruction surgery. The interval between injury and index surgery at our institution was 145 (range 3–730) days (Table 2).

All patients were treated surgically by one of the two surgeons (Chen A.C. and Chan Y.S.) with either local tissue transfers or free tendon grafts. The donor tissue for reconstruction included nine patients with local tissue grafts (6 cases of both CA ligament and conjoined tendon transfer, 2 cases of CA ligament transfer, and 1 case of conjoined tendon transfer) and six patients with free tendon grafts (4 cases of ipsilateral semitendinosus tendon, 1 case of palmaris longus, and 1 case of flexor carpi radialis due to an unavailable palmaris longus). Six of nine patients with local tissue grafts and all six patients with free tendon grafts underwent double-bundle reconstruction. The remaining three patients with local tissue grafts underwent selective-bundle reconstruction (2 cases of trapezoid ligament reconstruction and 1 case of conoid ligament reconstruction).

Nine patients were augmented with a hook plate, and six patients with Mersilene tape or nonabsorbable sutures. Eleven of the total 15 patients had AC arthrosis and underwent distal clavicle excision (Table 2).

Table 1
Patient information.

Patient	Sex	Age (y)	Injury	Side	Dx[|]	RW	Polytrauma[#]
01	M	67	TA	R	AC	V	—
02	M	37	Fall	R	AC	IV	Rib fracture
03	M	42	TA	R	AC	V	—
04	M	62	TA	L	AC	V	—
05	M	49	Fall	L	AC	V	ICH, hemopneumothorax
06	F	37	TA	R	AC	V	Hip and femoral fracture
07	F	22	TA	R	AC	V	Metatarsal fracture
08	M	51	TA	L	AC	IV	Rib fracture
09	M	26	TA	R	Clavicle	III	—
10	F	51	TA	R	AC	II	—
11	M	56	TA	R	AC	III	—
12	M	65	TA	L	AC	III	—
13	M	40	TA	R	AC	V	Radial head fracture
14	M	48	Cont	L	AC	III	—
15	M	85	Fall	L	Clavicle	V	—

AC = acromioclavicular injury; Clavicle = distal clavicle fracture; Cont = direct blunt contusion; Dx = diagnosis; ICH = intracranial hemorrhage L = left side injured; R = right side injured; RW = Rockwood classification; TA = traffic accident.

2.2. Surgical technique of local tissue grafting

In patients with AC arthrosis, 5–8 mm of the distal clavicle were resected. The dissection was performed meticulously in order to evaluate the injury severity of the conoid and trapezoid ligaments. In the patient with complete tears of both the conoid and trapezoid ligaments, a double-bundle reconstruction was performed. If either the conoid or the trapezoid ligament had a sprain or partial tear injury, the sprained or partially torn ligament was preserved and selective-bundle reconstruction performed on the completely torn ligament. We used the CA ligament and conjoined tendon for trapezoid and conoid ligament reconstruction, respectively. The CA ligament was detached without bone chips, and the lateral half of the conjoined tendon was split and harvested 5 cm distal to the coracoid. Great care was taken to avoid musculocutaneous nerve injury.

Based on the bony landmarks described by Harris and Salzmann, the anatomic insertion sites of the conoid and trapezoid ligaments were identified.[19,20] There should be a 20–25-mm distance between the two tunnels in the clavicle, and a 10–12-mm distance in the coracoid. The anatomic ligament tunnels were created using 3-mm drills, and the grafts were passed through the bony tunnels (Fig. 1). The reduction was performed, and the grafts fixed with nonabsorbable sutures. Reconstruction was augmented with a hook plate if patient consent was obtained. If the patient declined implant treatment, augmentation with Mersilene tape or nonabsorbable sutures was the alternative method used (Fig. 2).

2.3. Surgical technique of free tendon grafting

The tendon was harvested with a closed-loop tendon stripper and prepared with nonabsorbable sutures. The clavicular and conoid insertion sites of the conoid and trapezoid ligaments were identified, and the anatomic tunnels drilled. After passage through drill holes in the coracoid, the graft was passed through the bony tunnels in the clavicle (Fig. 3). The reduction was performed, and the graft fixed with nonabsorbable sutures. The reconstructed ligaments were protected with a hook plate, Mersilene tape, or nonabsorbable sutures.

2.4. Postoperative treatment and follow-up

Postoperatively, patients were immobilized in a sling for 6 weeks. Patients were immediately allowed passive pendulum exercise in the first 2 weeks. Closed-chain passive exercise was initiated in the 3rd postoperative week. Following removal of the sling, the passive overhead stretching was continued and active motion added in the 7th week. Full active shoulder motion was allowed 3 months postoperatively. Surgery for removal of implant was suggested, and most plates were removed at around 3–4 months from the index surgery.

Data regarding the patients' profiles, injury mechanisms, graft source, methods of reconstruction, and complications were collected. The average follow-up duration was 24.4 months. The functional outcomes were assessed with Constant scores.[21] The results were also assessed by anteroposterior and axillary view radiographs of the shoulder. The CC distance was measured in order to evaluate the displacement preoperatively, postoperatively, and at the final follow-up examination.

2.5. Statistical analysis

ANOVA was used to determine whether there was a significant difference in the Constant scores among the reconstruction techniques. Unpaired t tests were used to compare the outcomes

Table 2
Clinical course.

Patient	Interval* (d)	Prior surgery**	OP-1			OP-2	F-U (month)	Score
			Graft	Donor tissue	Aug			
01	150	CC	Free	ST	Hook	Removal of TBW	14	100
02	30	—	Free	ST	Suture	—	21	55
03	45	—	Free	ST	Hook	Removal	11	100
04	205	—	Free	ST	Hook	—	9	96
05	79	—	Free	PL	Hook	Removal	11	55
06	254	—	Free	FCR	Hook	Removal	10	32
07	3	—	Local	CA & Conj	Suture	—	35	84
08	50	—	Local	CA & Conj	Hook	Removal	31	93
09	730	—	Local	CA & Conj	Hook	Removal	20	94
10	75	CC	Local	CA & Conj	Hook	Removal	14	100
11	21	CC	Local	CA & Conj	Suture	—	93	95
12	150	—	Local	CA & Conj	Suture	—	14	68
13	10	—	Local	CA	Hook	—	35	87
14	180	—	Local	CA	Suture	—	15	100
15	195	—	Local	Conj	Suture	—	36	28

Aug = augmentation of fixation; CA = coracoacromial ligament; CC = coracoclavicular screw; Conj = conjoined tendon; FCR = flexor carpi radialis tendon; F-U = follow-up; Free = free tendon graft; Hook = hook plate; Local = local tissue transfer; OP-1 = first operation at our institution; OP-2 = second operation at our institution; PL = palmaris longus tendon; Score = Constant score; ST = semitendinosus tendon; Suture = Ethibond suture and Mersilene tape; TBW = tendon band wire.

* Interval: interval between injury and surgery.

** Prior surgery at other institutions.

between different augmentation methods. The confidence level was assumed to be 95%, and significance was set at $p < 0.05$.

3. Results

3.1. Clinical outcomes

At the final follow-up examination, the average Constant score of all 15 patients was 79.1 ± 25.2, and the average score of each assessment was 12.4 ± 3.8 for pain, 16.9 ± 3.2 for activities of daily living, 33.6 ± 10.2 for movement, and 16.3 ± 9.9 for strength.

In six polytrauma patients, the average Constant score was 67.7 ± 24.0. In nine patients with isolated AC joint injuries, the average score was 86.8 ± 24.3. The final Constant score of the patient with a Type-II injury was 100. The average score was 89.3 ± 14.4 in patients with Type-III injuries, 74 ± 26.9 in patients with Type IV, and 72.8 ± 30.1 in patients with Type V.

In the local tissue graft group, patients with double-bundle reconstructions had an average Constant score of 89.0 ± 11.5, and patients with selective-bundle reconstructions had an average Constant score of 71.7 ± 38.4. In the free tendon graft group, the average Constant score was 73.0 ± 29.4. There were no significant differences among the three reconstruction methods ($p = 0.500$). The average score for the patients with hook plate augmentations was 84.1 ± 24.1, while the average score for patients augmented with Mersilene tape or nonabsorbable sutures was 71.7 ± 27.2. No significant difference between the augmentation methods was noted ($p = 0.368$).

Seven patients with hook plate augmentations underwent a second procedure for removal of the implant. One patient fell onto his ipsilateral shoulder before implant removal and was diagnosed with an acromion fracture. He underwent a second surgery for removal of the plate and fracture fixation with a tension-band wire.

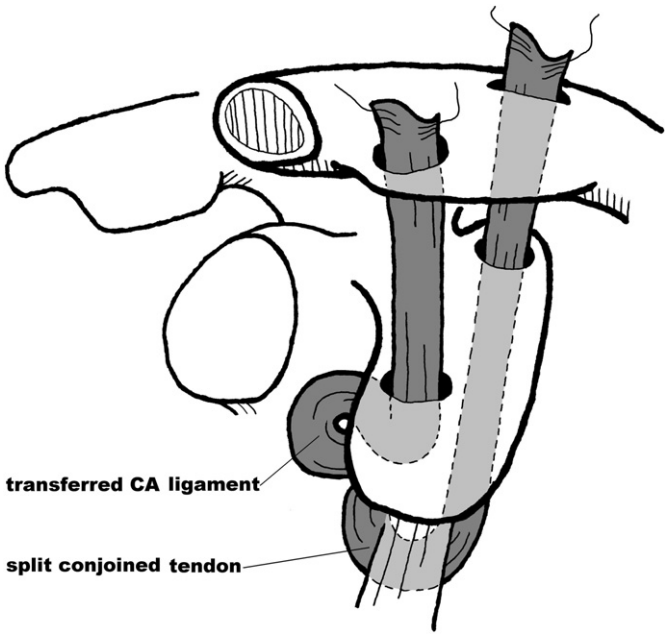

Fig. 1. The procedure for the coracoacromial ligament and split conjoined tendon transfer through the coracoid and clavicular tunnels, respectively.

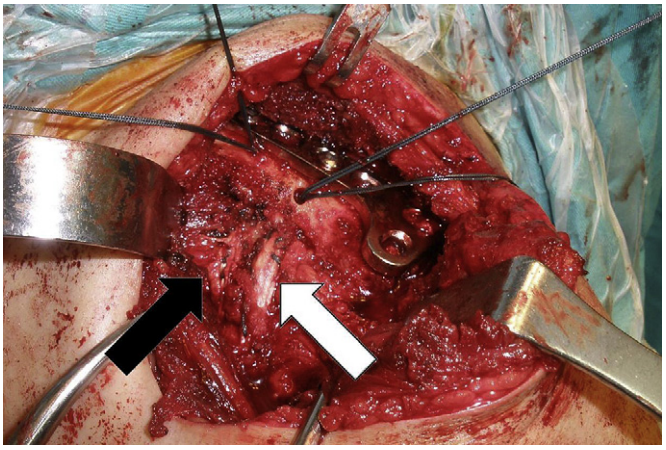

Fig. 2. Intraoperative photo showing trapezoid reconstruction with the CA ligament (white arrow) and conoid reconstruction with the split conjoined tendon (black arrow).

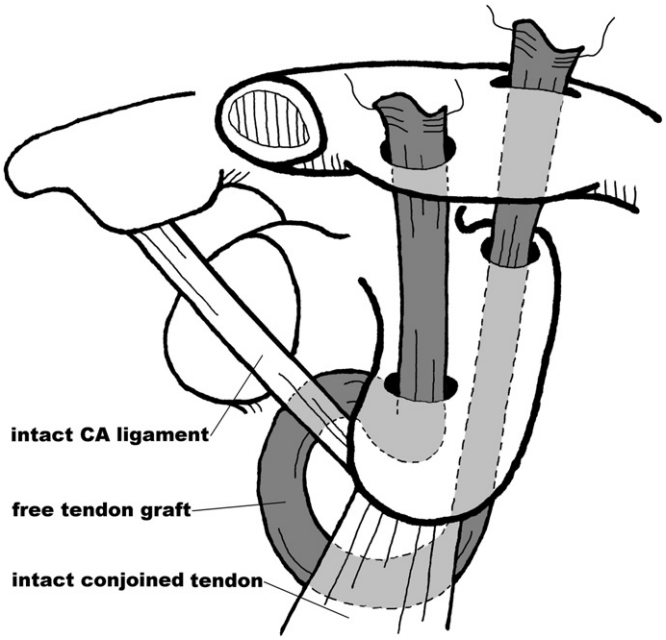

Fig. 3. The procedure of free graft transfer using a semitendinosus graft through the coracoid and clavicular tunnels.

3.2. Radiographic outcomes

The average CC distance in all patients decreased from 17.7 ± 5.6 mm preoperatively to 8.7 ± 4.5 mm at the final follow-up examination (Fig. 4). A loss of reduction was observed in the anteroposterior view in one patient who underwent selective-bundle reconstruction. There was no subluxation observed in the axillary view.

3.3. Complications

One patient had a stitch abscess at the donor knee. The patient was treated with oral antibiotics and recovered well.

Two patients had asymptomatic subacromial erosions of the hook plate. One plate was removed, and the other patient did not undergo surgery due to personal factors.

4. Discussion

AC instability usually is related to direct or indirect trauma. In our series, traffic accidents were the dominant mechanism. Six polytrauma patients had worse Constant scores than patients with isolated AC joint injuries, and this finding was compatible with previous reports.[22] In addition, we found that the higher the Rockwood type in the preoperative radiograph, the worse the Constant score at the final follow-up examination. There was a trend toward poor final results for high-grade AC dislocations.

The modified Weaver-Dunn procedure was developed because of the inferior biomechanical properties of the original Weaver-Dunn procedure.[4–8] Weinstein presented a modified method that involved additional CC fixation,[4] while Tienen presented a CA ligament transfer that was combined with AC fixation.[5] Some authors advocated reconstruction with alternative local tissue. Vargas presented a technique that utilized the short head of the biceps,[23] and Jiang presented a reconstruction method with conjoined tendon transfer into the stump of the clavicle, which showed reliable clinical results.[10,11]

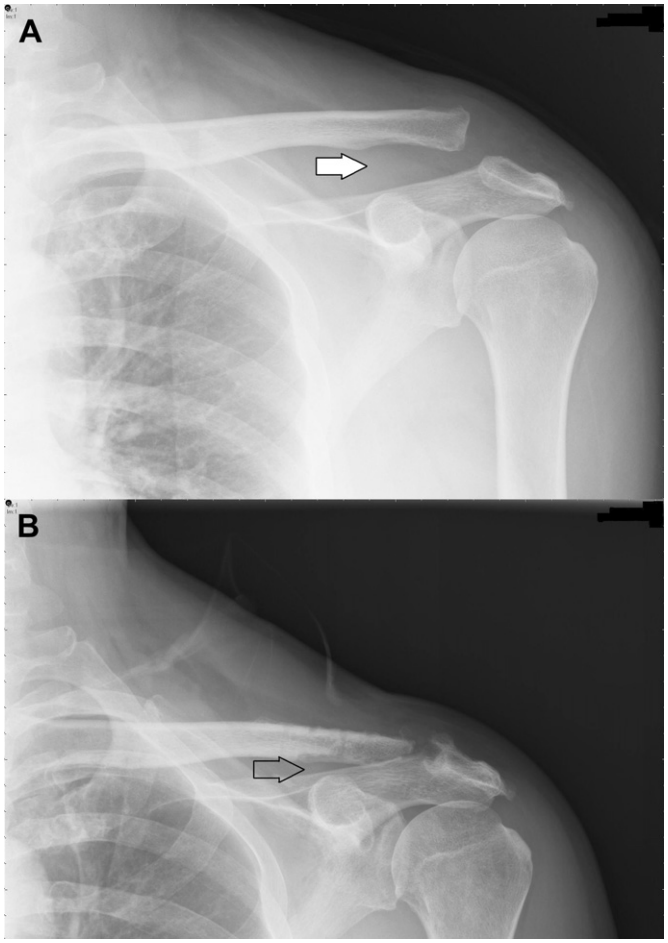

Fig. 4. (A) A 50-year-old man experienced a traffic accident and suffered a right acromioclavicular separation. (B) A postoperative radiograph conducted 1 year after a double-bundle reconstruction with local tissue transfer showing good acromioclavicular alignment. The coracoclavicular distance decreased from 18 cm preoperatively (white arrow) to 5 cm postoperatively (hollow arrow).

Anatomic reconstruction has been advocated in recent years.[12–17] Mazzocca et al emphasized the importance of anatomic graft reconstruction,[12] and Thomas et al reported that anatomic reconstructions with free tendon grafts had superior results compared to the four alternative treatments.[13]

Anatomic CC ligament reconstructions using free tendon grafts can provide better resistance to translation; however, additional incisions are required to harvest the free tendon grafts. Therefore, we developed this innovative technique of anatomic reconstruction with local tissue grafts in order to preserve the biomechanical properties of anatomic reconstruction and to avoid additional donor-site complications.

At the final follow-up examination, patients who had double-bundle reconstructions with local tissue grafts had an average Constant score of 89.0 points, patients who had selective-bundle reconstructions with local tissue grafts had an average score of 71.7 points, and the free tendon graft group had an average score of 73.0 points. There was no significant difference among the three reconstructive methods ($p = 0.500$). The outcomes of the local tissue grafts in the anatomic reconstructions were comparable to the clinical outcomes of the free tendon grafts. The radiographic results showed one case involving a loss of reduction in the group of selective-bundle reconstructions with local tissue; therefore, we recommended double-bundle reconstructions whenever equivocal quality of the residual ligament bundle was noted.

The hook plate could provide relatively easier surgical technique and lower risk of implant migration. Compared with CC sling, the hook plate had stiffness more similar to the normal physiologic state of the AC joint.[24] The drawbacks of retaining the plate included subacromial irritation and osteolysis. Some authors do not recommend augmentation with a hook plate because of the risks of joint damage and subsequent operation[8]; even so, erosion of the distal clavicle could still occur after the use of nonabsorbable materials, such as Mersilene tape or sutures.[17] Surgery for removal of implant was suggested at our institution, but there were still some patients who declined a second procedure, especially patients who had good life quality with minor symptoms of impingement. In the present study, two cases with hook plate fixation had asymptomatic subacromial erosions. One plate was removed 3 months after the index surgery, and both patients recovered well. Both hook plates and nonabsorbable sutures had satisfactory results (84.1 vs. 71.7 points), and there was no statistically significant difference ($p = 0.368$).

Although the overall outcomes were satisfactory, the scores of the strength assessment at the final follow-up examination were not as good as in other studies. This may be partially attributed to the relatively old age of our patients, and the Constant score allocates a large proportion of the score to strength.[21] When compared to other studies, Fraschini reported the average age of patients at the time of surgery was 31 years.[17] Boström Windhamre et al reported that the mean ages of each study group were 37, 42, 40, and 36 years, respectively.[8]

This study had a number of shortcomings, including a relatively small sample size with short-term reports. Larger comparative investigations are necessary to clarify further the advantages of anatomic bundle reconstructions as well as the long-term effects of the different graft options.

In conclusion, anatomic CC reconstructions with local tissue grafts provided encouraging early clinical and radiographic results. With feasible augmentation, this technique can be an alternative surgical option to treat post-traumatic AC instability.

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