



Chronic acromioclavicular separation: The medium term results of coracoclavicular ligament reconstruction using braided polyester prosthetic ligament

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Summary In this series, we treated chronic acromioclavicular disruption with an artificial coraco-clavicular ligament made from braided polyester (The Nottingham Surgilig). The ligament has a loop at each end and is passed around the coracoid process, threaded through itself, then passed around the posterior aspect of the clavicle and finally anchored to it with a bone screw.

Eleven men with an average age of 39 underwent this procedure. Three patients had previously been operated on using the Weaver–Dunn procedure which had failed. All eleven patients have been reassessed clinically and radiographically at an average of 55 months. Using the Imatani evaluation score, 10 patients achieved a good/excellent result with the mean Constant score being 92. One patient had fracture of the base of the coracoid after heavy lifting in the early postoperative period which resulted in a poor outcome. Two patients needed an additional operation. In one the lateral end of the clavicle was excised together with removal of the fixation screw, and in the other a subacromial decompression was carried out.

The Nottingham Surgilig is a useful alternative for the treatment of chronic acromioclavicular separation, especially in revision reconstruction when the coracoacromial ligament is no longer available.

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Introduction

Disruption of the acromioclavicular joint (ACJ) represents about 3–5% of shoulder girdle injuries and the majority of these acromioclavicular injuries can be successfully treated by simple, non-operative means, particularly in cases of partial disruption.^{14,15} However, there remain a significant number of patients who are dissatisfied with the results of conservative management, especially those who are required to use their arm in an overhead position or for demanding activities. The treatment of complete ACJ dislocation is still controversial.^{5,6,16}

More than 60 different surgical procedures as well as a variety of conservative measures have been suggested for treatment of this injury.¹⁵ Delbet carried out the first coracoclavicular reconstruction using a single strand of silver wire looped under the coracoid and through a drill hole in the clavicle and most of the coracoclavicular fixations described in the literature have been modifications of Delbet's original procedure.⁸ However, simple coracoclavicular circlage causes anterior subluxation of the distal clavicle with malreduction of the ACJ and synthetic material such as wire may wear through the bone and result in failure of reduction.⁵ The use of a Bosworth screw requires a second procedure to remove the screw to avoid breakage or migration.⁶ Although good results have been reported with Weaver–Dunn coracoacromial ligament transfer,¹⁷ this coracoacromial ligament is not always available, and this procedure by necessity disrupts the coracoacromial arch.

Woven polyester ligaments have been used previously to reconstruct ligaments in the knee joint because of the material's ability to provide a scaffold for tissue ingrowth and its adequate mechanical properties.^{3,4,9–12,14} Recently this braided polyester material has been modified into a purpose made ligament with loops on both ends to reconstruct the disrupted coracoclavicular ligament.

In this report, the authors describe a method of reconstruction of the coracoclavicular ligament for chronic symptomatic dislocation of the ACJ using this new ligament and report the medium term results of reconstruction.

Materials and methods

Thirteen patients with chronic complete ACJ dislocation treated by this method were retrospectively reviewed. Two patients were lost to follow-up, and the remaining eleven patients were evaluated clinically and radiologically. All were male with an average age of 39 years (range, 20–61) at the time of the

operation. Eight injuries were to the dominant extremity and the right side was involved in seven.

Four patients were injured during a fall, three from bicycle accidents, two during sports activities and two during motor vehicle accidents. All were chronic injuries and the average interval from injury to operation was 18 months (range, 3–36 months). Nine of the injuries were classified as Rockwood grade¹⁴ III and one as grade IV and one as V.

After the initial injury, six patients were treated in a sling, three had a Weaver–Dunn procedure (cases 2, 6, 11), and two did not have any treatment. However, all of these patients continued to suffer from residual shoulder pain, discomfort, weakness and clicking. They all presented to us with obvious deformity of the ACJ and radiographs showed superior migration of distal clavicle above the level of the superior surface of acromion. The length of the non-operative treatment in these patients varied from 9 to 36 months with a mean of 14.4 months, which included anti-inflammatory medication and strengthening exercises (Table 1).

A purpose made braided polyester prosthetic ACJ ligament (Nottingham Surgilig, Surgicraft, Redditch, UK) [Fig. 1] was used in the reconstruction. All operations were performed by two senior authors.

Operative technique

All operations were performed under general anaesthesia with the patient in the deckchair position. A sagittal skin incision was made from the superior margin of the clavicle just medial to the ACJ down to the level of the coracoid process. The deltoid muscle was split in line with its fibres and the trapezius deltoid interval was incised to expose the clavicle and 5–10 mm of its distal end was excised. A curved guide instrument was passed from medial to lateral

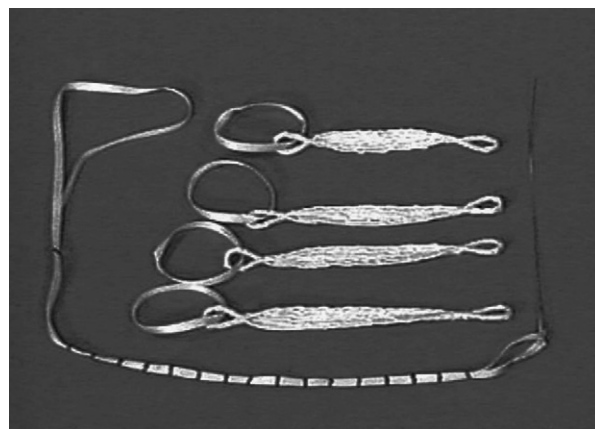


Figure 1 Polyester prosthetic ligament (Surgilig, Surgicraft, Redditch, UK) of different length and the Surgilig length gauge with metal lead.

Table 1 Summary of the patients

Case	Age	Side/ dominance	Cause of injury	Rockwood's grade	Initial treatment	Interval (months)	Occupation	X-ray evaluation	Follow-up (months)	Imatani score	Constant score	Complications and further surgery
1	39	L/ND	Judo	5	Sling	10	Engineer	Minor S/L	50	100	98	No
2	36	R/D	Fall	3	Weaver— Dunn (2)	18	Van driver	Loss of reduction	80	60	64	# Of coracoid
3	46	L/ND	RTA	3	Sling	12	Civil servant	Minor S/L	48	90	97	Calcification of CC ligament
4	61	R/D	Fall	3	Sling	18	Car park attendant	Moderate S/L	60	85	96	ACJ excision at 10 mo
5	37	R/D	Fall from bike	3	No	18	Cleaner industrial	Minor S/L	50	95	96	No
6	42	L/ND	Fall	3	Weaver—Dunn	20	Joiner	Minor S/L	48	85	94	SAD at 8 months
7	20	R/D	Fall	3	Sling (scapular#)	3	Engineer	Minor S/L	48	100	98	No
8	24	R/D	Fall from bike	3	Sling	24	Engineer	Minor S/L	50	95	92	No
9	31	L/D	Football	3	Sling	18	Builder	Minor S/L	78	100	94	No
10	36	R/D	Fall from bike	4	No	19	Mechanic	Minor S/L	50	100	100	No
11	61	R/D	RTA	3	Weaver—Dunn	36	Security officer	Minor S/L	40	85	87	No
Ave.	39					18			55	90.5	92.3	

D: dominant, ND: non-dominant, Interval: interval between injury and operation, S/L: subluxation, #: fracture, SAD: subacromial decompression.

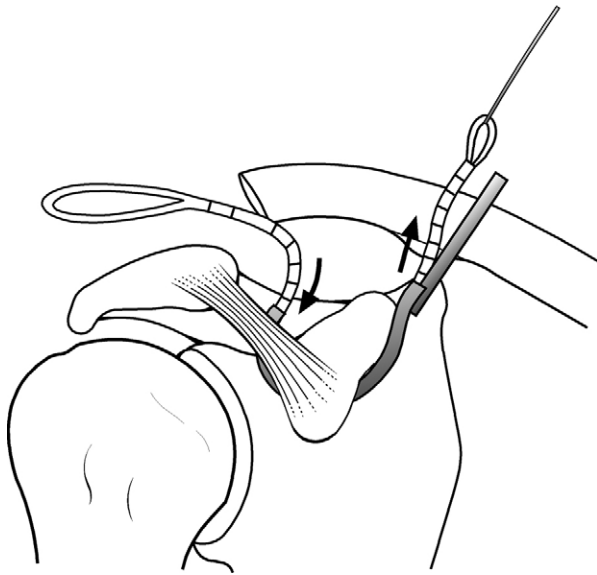


Figure 2 Curved guide passed around the coracoid process from medial to lateral in order to avoid the brachial plexus. The ligament was passed around the coracoid process and then the ligament was threaded through one of its loops to afford secure attachment at the base of the coracoid process.

in order to avoid the brachial plexus and allow the passing of the ligament to be close to the coracoid process [Fig. 2]. After reduction of the clavicle, the appropriate length of the prosthetic ligament was determined by the use of a measuring length gauge [Fig. 1]. The ligament was passed around the coracoid process [Fig. 2] and threaded through one of its loops to afford secure attachment at the base of the coracoid process [Fig. 3]. The free end was then passed from inferiorly round the posterior aspect of the clavicle and finally tensioned, before it was fixed onto the superior or anterior surface of the clavicle with a 3.5 mm bi-cortical screw through the second loop [Fig. 4A and B]. The clavicle was this way held in its manually reduced position.

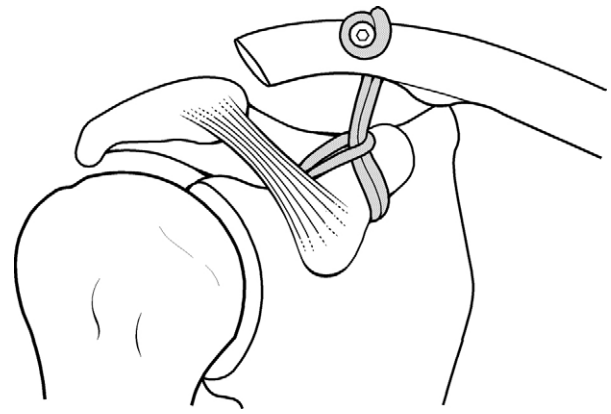


Figure 3 The free end was then passed inferiorly round the posterior aspect of the clavicle and tensioned prior to fixation through the second loop onto the clavicle. The AP (anterior–posterior) view after fixation onto the clavicle.

Postoperatively, the affected arm was placed in a sling for comfort for 10–14 days, after that time, the patients were permitted to mobilise as freely as they were able, but told to abstain from demanding use.

Follow-up evaluation

All eleven patients were reviewed clinically and radiographically by two doctors who were not primarily involved in the treatment. The functional outcome was assessed using the Constant¹ and Ima-tani scoring system.⁷

The subjective results were also assessed in terms of patients' satisfaction and the patients were asked whether they would undergo the same procedure again for a similar problem.

Preoperatively and at follow-up, AP, axial radiographs were taken with 10° cephalic tilt view of ACJ. Radiographic analysis of subluxation was graded as mild, moderate and severe (Table 1).⁷

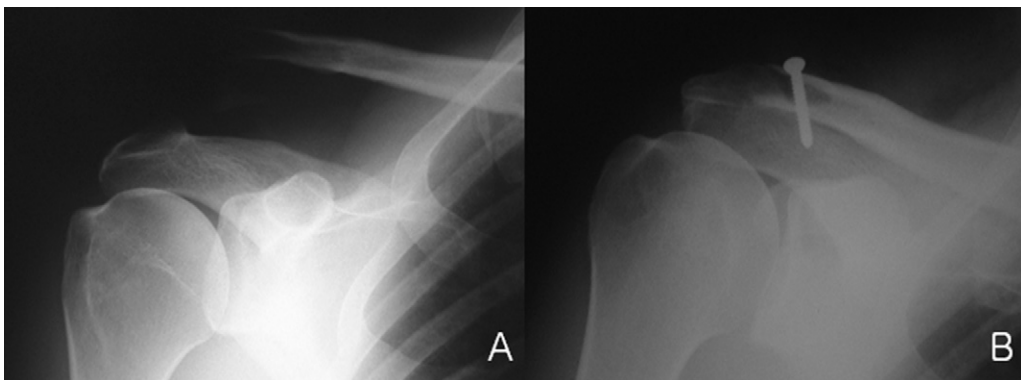


Figure 4 The preoperative (A) and postoperative (B) radiographs of the patient (case number 1).

Results

The mean follow-up period was 55 months (range, 40–80 months). The mean Constant score for the whole group was 92.3 (range, 64–100). Applying the Imatani evaluation system, seven patients were graded as excellent, three as good and one as poor. Table 1 summarises the results.

Pain

Mild occasional pain was present in six patients. However, only the patient who had had a coracoid fracture (case 2) reported constant pain with normal activity. Another patient (case 3) complained of pain when lying on the affected side at night.

Range of motion

In all patients except two, the operation restored a normal range of motion. One patient (case 2) developed a coracoid fracture, which was subsequently treated with a Dewar–Barrington procedure.² This patient had restricted elevation to 90° and external rotation of 30° at final follow-up. The other patient (case 4) had preoperative limitation of 140° of flexion related to rotator cuff pathology, which improved to full range after a subsequent subacromial decompression.

Patient satisfaction

Nine of the patients stated that they were satisfied with the procedure, and would undergo the same operation again if a similar problem occurred. One patient was unsure regarding the procedure and another stated that he would not have the surgery again. They were, however, both satisfied with the improvement in strength and power. Nine patients were judged as having a normally appearing acromioclavicular joint without deformity on inspection. Two patients had minimal elevation of the clavicle.

Function

All patients were able to return to their previous level of activity and employment, except one (case 2). Nine of the patients were in manual occupations (Table 1). The mean time to return to work was 5 weeks (range, 2–10 weeks). Two patients returned to work in 2 weeks.

Complications

In one patient, the coracoid process had been eroded by the ligament and a subsequent fracture

developed. The patient had received one previous Weaver–Dunn operations, which failed after recurrent trauma. After the implantation of the Nottingham Surgilig, the patient injured the shoulder lifting heavy items in his work place in the early recovery phase, against advice. There was no accompanying erosion of the distal clavicle.

Two patients required further surgery for persistent problems. One patient (case 6) required a subacromial decompression for impingement symptoms at 6 months, and later removal of the screw from the clavicle due to tenderness around the fixation site. The other patient (case 4) underwent trimming of the lateral end of the clavicle at 10 months after stabilisation.

Radiological review

Postoperative radiographs showed minor subluxation in 10 (difference in the distance between the inferior border of the acromion and the clavicle of 2–4 mm when comparing the operated side with the healthy side), and moderate subluxation in one (4–8 mm difference). The mean superior migration on weight bearing views was 7 mm (range, 2–8 mm). Calcification and ossification in the remainder of the coracoclavicular ligaments were noted in one patient (case 3) but the patient was asymptomatic.

Discussion

Most complete acromioclavicular dislocations treated conservatively do not become symptomatic.^{5,6,15–17} However, there are some patients who have persistent symptoms after conservative treatment. Some surgeons advocate early operation for ACJ dislocation particularly in manual workers and sportsmen and it has been suggested that the results of early repair are superior to late repair.⁶ The weight of evidence, however, is in favour of initial non-operative management. In this series, three patients were treated surgically in the early stage after injury. Our preferred approach is to treat disruption of the ACJ conservatively in the first instance, with operative management being largely reserved for those who remain symptomatic after conservative treatment.

Polyester has been used previously to reconstruct the ligament in the knee. The literature demonstrates that polyester provides a scaffold for tissue ingrowth with minimal synovial reaction^{4,12} and sufficient mechanical strength.³ In this series, we used a braided polyester ligament with loops on both ends.

Many different operative techniques for ACJ injury have been proposed.^{5,6,8,13,17} Transfer of

the coracoacromial ligament is widely used, with good results being reported in the literature.¹⁷ Guy et al. reported the positioning of the distal clavicle was well maintained with a coracoacromial ligament transfer and a coracoclavicular lag screw.⁶ However, using this technique, resisted strengthening exercises should be avoided until after screw removal at 12–24 weeks. Using the artificial ligament we have developed, we were able to allow our patients to return to daily living earlier without long-term immobilisation. The functional outcome of this procedure was very similar to other reports;^{5,6,13,15} Constant score of 92 point and 10 patients showed excellent or good results.

One advantage of this technique is that it does not rely on the presence of the coracoacromial ligament, which may be a particular advantage when carrying out revision surgery or when the coracoacromial ligament is deficient such as in patients who had a previous Weaver–Dunn operation or a subacromial decompression. Because the ligament is passed around the clavicle and fixed with a cortical screw through the second loop, the clavicle is free to rotate along the long axis during elevation of the arm without the bone being eroded by the ligament sliding over it. The construct is more physiological because the loop does not interfere with the clavicular motion.

The ligament used has been shown to be able to tolerate enough mechanical strain to allow early postoperative mobilisation. Independent biomechanical testing of this ligament demonstrated that 1 million cycles at 300 N load in a bath of normal saline at 37 °C caused no more than 1 mm elongation.

Two patients were able to return to their manual jobs at 2 weeks after surgery. In addition to the ligament having high initial strength, we identified good tissue ingrowth into the polyester ligament when we removed the screw in the distal clavicle (case 6) where the new ligament remained in situ securely attached on the periosteum of the clavicle. This finding is also reported in previous studies.^{8–11}

Examples of the potential complications of this technique are described in this series. The complication of cutting through the coracoid process can happen with any simple coracoclavicular circlage, and we had one such complication leading to a fracture. However, the patient applied a significant load onto the shoulder within the first 3 weeks after the operation against advice. As long as the patient follows the postoperative instruction properly, this complication can probably be avoided.

Two patients required further surgery for persistent problems. One patient (case 6) already had a Weaver–Dunn procedure for stabilisation, but the

joint had completely re-displaced such that it was akin to a type III dislocation. The patient had persistent symptoms warranting further surgery. Following his successful operation using this technique, he required a subacromial decompression for impingement symptoms 8 months later, and subsequently removal of the screw from his clavicle due to tenderness around the fixation site. The second patient (case 4) requiring re-operation was a 61-year-old car park attendant who underwent trimming of the lateral end of the clavicle at 10 months after stabilisation as it was impinging on the acromion as its posterolateral corner. In both cases, subjective improvements after the additional surgery were reflected by an improvement in the Constant scores from 42 to 88 and from 68 to 78, respectively.

The limitations of this study are the relative small sample size with retrospective nature of study and no preoperative functional score, thus it is not possible to assess and compare the definite achievement through this procedure. The sample size did not permit an accurate assessment of the time to functional recovery. There was a potential observer bias as the observer could not be blinded. However, we recommend this technique for chronic symptomatic cases of ACJ disruption, especially where the coracoacromial ligament is deficient or absent. Also, this method preserves the coracoacromial ligament whose role is important as a restraint to anterosuperior migration of the humeral head in rotator cuff deficiencies. The implant allows very early mobilisation when comparing to other methods, resulting in financial savings and reduction in patient inconvenience, absence from work, etc. At a relatively long follow-up, we have not seen the complications reported in relation to other coracoclavicular ligament implants, and we believe that the Nottingham Surgilig, because of its design and the way it is implanted has advantages which has lead to results that should alleviate the fear of complications commonly associated with the use of artificial ligaments for this indication.

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Conflict of interest

All authors declare that no financial and personal relationships with other people, or organisations, that could inappropriately influence (bias) our work, all within 3 years of beginning the work submitted.

References

1. Constant CR, Murley AG. A clinical method of functional assessment of the shoulder. *Clin Orthop* 1987;214:160–4.
2. Dewar FP, Barrington TW. The treatment of chronic acromioclavicular dislocation. *J Bone Joint Surg Br* 1965;47B:32–3.
3. Field JR, Hearn TC, Costi JJ, et al. Ultimate tensile strength of a Leeds-Keio/autograft ACL reconstruction utilising PLLA tibial staple fixation. *Injury* 2003;34:334–42.
4. Fujikawa K, Iseki F, Seedhom BB. Arthroscopy after anterior cruciate reconstruction with the Leeds-Keio ligament. *J Bone Joint Surg Br* 1989;71B:566–70.
5. Goldberg JA, Viglione W, Cumming WJ, et al. Review of coracoclavicular ligament reconstruction using Dacron graft material. *Aust N Z J Surg* 1987;57:441–5.
6. Guy DK, Wirth MA, Griffin JL, Rockwood Jr CA. Reconstruction of chronic and complete dislocations of the acromioclavicular joint. *Clin Orthop* 1998;347:138–49.
7. Imatani RJ, Hanlon JJ, Cady GW. Acute, complete acromioclavicular separation. *J Bone Joint Surg Am* 1975;57A:328–32.
8. Kappakas GS, McMaster JH. Repair of acromioclavicular separation using a dacron prosthesis graft. *Clin Orthop* 1978;131:247–51.
9. Keen CE, Amis AA. Polyester fibre prosthetic anterior cruciate ligament implant rupture: necrosis of ingrown connective tissue. *Histopathology* 1999;35:74–81.
10. Macnicol MF, Penny ID, Sheppard L. Early results of the Leeds-Keio anterior cruciate ligament replacement. *J Bone Joint Surg Br* 1991;73B:377–80.
11. Mantas JP, Bloebaum RD, Hofmann AA. Histologic analysis of a retrieved expanded polytetrafluoroethylene posterior cruciate ligament. *J Appl Biomater* 1992;3:183–90.
12. Marcacci M, Gubellini P, Buda R, et al. Histologic and ultrastructural findings of tissue ingrowth. The Leeds-Keio prosthetic anterior cruciate ligament. *Clin Orthop* 1991;267:115–21.
13. Morrison DS, Lemos MJ. Acromioclavicular separation. Reconstruction using synthetic loop augmentation. *Am J Sports Med* 1995;23:105–10.
14. Nakayama Y, Shirai Y, Narita T, Mori A. Remodeling of patellar tendon grafts augmented with woven polyester after anterior cruciate ligament reconstruction in humans. *J Orthop Sci* 1999;4:163–70.
15. Rockwood Jr CA, Young DC. Disorders of the acromioclavicular joint. In: Rockwood Jr CA, Matsen III FA, editors. *The shoulder*. Philadelphia: WB Saunders; 1990. p. 413–68.
16. Rockwood Jr CA. Injuries to the acromioclavicular joint. In: Rockwood Jr CA, Green DP, editors. *Fractures in adults*. 2nd ed., Philadelphia: Lippincott; 1984. p. 860–910.
17. Weaver JK, Dunn HK. Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. *J Bone Joint Surg Am* 1972;54A:1187–94.