Luggage Tag Technique of Anatomic Fixation of Displaced Acromioclavicular Joint Separations

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Abstract Acromioclavicular joint dislocations are common injuries in active individuals. Most of these injuries may be treated nonoperatively. However, many techniques have been described when surgical management is warranted. A recent biomechanical study favors anatomic reconstruction of the conoid and trapezoid ligaments and the acromioclavicular joint capsule, as opposed to the traditional technique of excision of the lateral end of clavicle and transfer of the coracoacromial ligament to the intramedullary canal of the distal clavicle. We present a modification of the anatomic fixation technique using a luggage tag method, which places a graft under the base of

the coracoid. This procedure has been associated with few redisplacements of the distal clavicle, reliable pain relief, and minimal postoperative morbidity. We found the luggage tag technique provides anatomic fixation of the distal clavicle and restoration of coronal and sagittal plane stability to the injured acromioclavicular joint. This procedure should reduce the possibility of coracoid fracture and decreases the risk of hardware complications associated with reconstruction techniques that violate the base of the coracoid process.

Level of Evidence: Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

This work was performed at the Hospital of the University of Pennsylvania. Surgical procedures were performed at The University of Pennsylvania and USC Medical Center.

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Introduction

Acromioclavicular (AC) joint injuries are common, occurring in athletes, active patients, and accident victims. Typically, these injuries result from a fall with direct impact to the lateral aspect of the shoulder. Injuries are classified as Grades I to VI [28]. Grade I is a sprain of the AC ligament. Grade II is disruption of the AC joint, with a slight vertical separation of the AC joint when compared with the uninvolved side; the coracoclavicular (CC) ligaments are sprained but intact. Grade III is disruption of the AC and CC ligaments with 25% to 100% displacement of the distal clavicle. In Grade IV injuries, the AC and CC joints are disrupted, and the clavicle is displaced posteriorly through the trapezius muscle. Grade V injuries are characterized by disruption of the AC and CC ligaments, and the distal clavicle is displaced between 100% and 300%. Grade VI injuries are rare and are characterized by inferior displacement in which the clavicle is lodged posterior to the conjoint tendon. Minor injuries (Grades I and

II) typically are treated nonoperatively [3, 6–8]; the treatment of Grade III injuries is controversial [3]; however, Grades IV through VI (with displacement posteriorly, superiorly, and inferiorly, respectively) are treated operatively [3, 16].

The concept of the Weaver-Dunn technique (transfer of the coracoacromial [CA] ligament to the distal clavicle) was first described by Cadenat in 1917 [5]. Weaver and Dunn [34], however, were the first to publish a case series with outcomes using this technique. The original article describes transfer of the CA ligament into the intramedullary canal of the distal clavicle. The transferred ligament is fixed only by the passage of two sutures through superiorly placed drill holes where they are tied over a bony bridge [34]. Since that time, several related techniques have been described [1, 2, 9, 11, 12, 14, 15, 19–23, 25–27, 29, 31, 33, 35]. A recent biomechanical analysis showed anatomic reconstruction in which an autograft or allograft tissue is used to reconstruct the conoid and trapezoid ligaments allows less anterior and posterior translation of the distal clavicle when compared with a modified Weaver-Dunn technique [24]. This analysis concluded an anatomic reconstruction can better control superior displacement under cyclic loading conditions and anteroposterior stability is restored to that of the intact AC joint [24]. This is an important finding given that failures in treatment may result in recurrent instability (15%–29%) [12, 17, 30], pain (11%–42%) [30], and functional deficits [30].

The anatomic reconstruction of the CC ligaments, as originally described, entails drilling a 6- or 7-mm bone tunnel into the base of the coracoid and drilling two 6-mm tunnels into the distal clavicle. The tendon graft then is fixed into these osseous structures using bio-interference screws [24]. Biomechanically, this results in restoration of the trapezoid and conoid ligaments. However, with this technique, one risks coracoid fracture from drilling a relatively large hole in the base of the coracoid process. The technique we present affords rigid fixation of the graft to the base of the coracoid yet reduces the risk of coracoid fracture. The luggage tag is a technique in which a loop of graft is passed under the coracoid and the two remaining limbs are passed through that loop (Fig. 1). Although this particular loop is mentioned in the ophthalmologic literature, it has not been described for treatment of displaced AC dislocations [32]. The free limbs then are secured via bone tunnels in the distal clavicle (Fig. 2). This decreases the risk of coracoid fracture while retaining the strength and biomechanical advantages of an anatomic reconstruction of both CC ligaments.

We introduce the technical aspects of the luggage tag procedure and report the clinical outcomes (pain and function), the frequency of redisplacement, and complications.

Fig. 1 A diagram illustrates the luggage tag technique.

Fig. 2 The graft is sutured to the clavicle.

Materials and Methods

We retrospectively reviewed 21 patients with Grade IV or V AC joint separations treated with the luggage tag procedure from April 2001 through June 2008. All patients who presented to the senior authors' (GRH, JMI) clinics during this period with Grade IV, V, or VI AC joint dislocations were treated with this operative technique regardless of chronicity.

All but one patient presented with an acute or subacute injury. One patient presented with a chronic injury. There were three female patients and 18 male patients. Their average age was 46.3 years (range, 22.7–75.1 years). Minimum followup was 6 months (average, 53 months;

range, 6–90 months). No patients were lost to scheduled followup in the outpatient setting; however, we were able to obtain outcomes measures by telephone in only 13 of 21 patients.

All surgeries were performed by one of the two senior authors (GRH, JMI) between April 2001 and June 2008. For the luggage tag technique, either autograft or allograft semitendinosus tendon may be used. Five patients had autograft semitendinosus grafts; the remaining 16 had allograft semitendinosus grafts. One surgeon (JMI) used only allografts, whereas the other (GRH) allowed the patient to choose between allograft and autograft. The graft was harvested and prepared using either a Number 2-0 FiberWire® (Arthrex, Naples, FL) or an alternate nonabsorbable, braided suture, which was sutured into the ends of the graft with a Krackow running locked whipstitch [18].

Patients were positioned in a beach chair position when allografts were used. However, we found supine positioning with slight elevation of the head and torso was easier when autologous hamstring tendon harvest was performed. One surgeon (JMI) used a horizontal incision and the other (GRH) used a vertical incision to gain access to the AC joint, distal clavicle, and base of the coracoid process. After incision, skin and subcutaneous tissues were sharply dissected down to the fascia of the pectoralis major muscle, the periosteum of the distal clavicle, and the superior AC joint capsule. Wide flaps were raised medially and laterally to expose the underlying dislocated AC joint (Fig. 3). The distal clavicle then was exposed in a subperiosteal fashion using electrocautery or a scalpel and by incising the AC joint capsule. Care was taken to preserve the remaining AC joint capsule for subsequent repair and local augmentation of the reconstruction.

A length of 8 to 10 mm of distal clavicle was excised using a microsagittal saw. Next, the base of the coracoid

was exposed by elevating the pectoralis major from the clavicle using a subperiosteal dissection. The coracohumeral ligament was released from the base of the coracoid to aid in access to the inferior aspect of the coracoid base to allow graft positioning and passage laterally. After exposure was obtained, the base of the coracoid was rasped gently to facilitate biologic integration and healing of the graft. To pass the graft, a Satinsky vascular clamp was passed around the base of the coracoid posterior to the pectoralis minor tendon from medial to lateral to avoid injury to the underlying brachial plexus. A suture loop or relay was passed under the base of the coracoid using the Satinsky clamp. The suture loop then was used to pass a loop of graft under the base of the coracoid (Fig. 4). The two remaining limbs were passed through the loop, which then appeared on the opposite side of the base of the coracoid (the luggage tag) (Fig. 5).

Fig. 4 The luggage tag loop is passed under the base of the coracoid.

Fig. 3 AC dislocation is shown in a skeletal model.

Fig. 5 The two limbs are passed through the loop in the graft.

Fig. 6 Holes are drilled in the clavicle.

Fig. 7 The ends of the graft are passed through the bone tunnels.

Using a 5- to 6-mm cannulated reamer, separate posteromedial and anterolateral bone tunnels were created in the distal clavicle (Fig. 6). The two ends then were passed through the bone tunnels in the clavicle (Fig. 7). The two limbs of the graft were sewn together on top of the distal clavicle with heavy nonabsorbable sutures (Fig. 8), and the remaining graft was imbricated into the AC joint capsule with nonabsorbable sutures. Biotenodesis screws may be used in the clavicle to augment fixation but were not routinely used. The periosteum, AC capsule, and pectoralis fascia were closed. Subcutaneous tissue and skin were closed similarly in a layered fashion.

Postoperatively, patients wore a sling for 6 weeks. Hand, wrist, and elbow motion was allowed immediately. Two weeks postoperatively, patients began passive forward elevation of the shoulder with gravity eliminated (ie, pendulum exercises) and isometrics involving the rhomboid and lower trapezius muscles at home after instruction by

Fig. 8 The graft is tied down on top of the reduced clavicle.

the surgeon. Lifting a glass of water was permitted 4 weeks postoperatively. Formal physical therapy often was not required but typically was not considered until 6 to 8 weeks postoperatively. Full activity was permitted 3 months postoperatively.

Patients reported for office evaluation with radiographs on a monthly basis until 12 weeks postoperatively. Subsequently, radiographs, including anteroposterior, outlet, and Zanca views, were obtained at 6 months and annually after surgery. Baseline, immediate postoperative, and the last available radiographs of the AC joint were reviewed by the senior authors (GRH, JMI) as part of routine clinical care and were reevaluated in a study-specific manner for redisplacement.

Pain was assessed preoperatively and postoperatively as a binary variable (presence or absence of pain) at each followup. Postoperative Simple Shoulder Test [10] (SST) and Disabilities of the Arm Shoulder and Hand [4] (DASH) scores were obtained by phone interview. The DASH instrument is a 30-question self-reported questionnaire that assesses patients with upper extremity dysfunction; the maximum score is 100 and lower scores correspond with higher function [4]. The SST is a 12-question self-reported questionnaire that assesses shoulder function for various everyday tasks; the maximum score is 12 and higher scores indicate better function [10]. In addition, any complications associated with the surgery were recorded. Demographic characteristics and mean outcome scores were calculated with SPSS[®] Version 15.0 (SPSS Inc, Chicago, IL).

Results

For 13 of 21 patients successfully contacted by telephone for administration of the postoperative outcomes questionnaire, the average postoperative DASH score was 11.8

(95% confidence interval [CI]: 2.8, 20.7). The median DASH score was 4.3. The average SST score was 10.6 (95% CI: 9.3, 12.0). The median SST was 12. All patients had pain preoperatively. Only two of 21 had pain at their final followup. One patient had a Rockwood screw that was removed for a concomitant clavicle fracture as part of routine care. Another patient had symptomatic rotator cuff arthropathy, which subsequently required a reverse total shoulder arthroplasty, although the AC joint reconstruction remained stable and this patient remained asymptomatic at this joint. When these two patients were eliminated from analysis ($n = 11$), the mean DASH score was 5.4 (95% CI: 2.1, 8.7), and the mean SST was 11.7 (95% CI: 11.4, 12.0).

One patient (4.8%), with a Type V separation with 300% elevation, had radiographic evidence of elevation of the distal clavicle at the 8-month followup. In this one case, there was less than 100% elevation of the distal clavicle in relation to the acromion at followup. We considered this a redisplacement. This patient continued to complain of pain at the 27-month followup.

No patients had coracoid fractures. One patient had a nondisplaced fracture through the lateral clavicular drill hole. The fracture healed uneventfully without further surgery. At last followup, this patient had no residual pain and no displacement of the AC joint.

Discussion

The rationale for development of the luggage tag technique of anatomic fixation of displaced AC dislocations is that the technique carries the theoretic strength of anatomic restoration of the AC joint [24] while decreasing the hardware-related complications of the modified Weaver-Dunn technique [30] and other forms of nonanatomic reconstruction [30]. Similarly, unlike the original description of anatomic CC ligament reconstruction, the luggage tag technique eliminates a drill hole in the base of the coracoid, thereby minimizing risk of subsequent coracoid fracture.

Limitations of our study include lack of preoperative patient-centered data, direct comparison with other forms of fixation, and long-term followup. However, despite two surgeons with slight differences in operative technique, the use of the luggage tag coracoid fixation with reconstruction of both CC ligaments by these surgeons yielded a median DASH of 4.3, a median SST of 12, and only one (4.8%) AC joint redisplacement. Although two patients had only short-term followup, 19 of 21 had greater than 1 year followup and all but five had greater than 2 years followup.

The modified Weaver-Dunn procedure with isolated CA ligament transfer is associated with 90% good or excellent patient-reported results and few reported complications

related to ligament fixation. However, as much as 17% of patients experience recurrence of the initial deformity with this technique [30]. Several methods of fixation were developed to improve on this. The modified Weaver-Dunn group of techniques involves transferring the CA ligament to the intramedullary canal and then securing the construct with hardware. This method is associated with a 14% to 15% incidence of redisplacement [14, 30]. Another method of fixation involves transferring the CA ligament and then augmenting the fixation with a CC screw or loop of non-absorbable suture. This method is associated with 16% and 29% redisplacement rates, respectively [30, 35]. To combat relatively high rates of redisplacement of these nonanatomic methods of fixation, an anatomic method of fixation using autograft or allograft was developed. Mazzocca et al. [24] reported a biomechanical analysis of an anatomic method of reconstruction of the trapezoid and conoid ligaments with a soft tissue graft. This procedure involves drilling a 7-mm bone tunnel into the base of the coracoid and two 6-mm transosseous tunnels in the distal clavicle. A semitendinosus graft then is doubled over and, at the halfway point, is sutured to itself. That middle portion then is placed in the coracoid base tunnel and secured with a bioabsorbable interference screw. The two ends then are placed in the clavicle tunnels and held in place with interference screws [24]. Using this method in a cadaveric, biomechanical study, Mazzocca et al. [24] reported no difference in displacement under stress in the anteroposterior or superior direction over the intact state. In addition, this anatomic two-bundle approach yielded substantially less anterior and posterior displacement than the Weaver-Dunn approach. There were no differences in superior load to failure [24]. The luggage tag graft configuration avoids violation of the coracoid base and allows secure fixation about the coracoid, while restoring the conoid and trapezoid ligament components in the reconstruction. It is a stable construct at the coracoid base, and the lack of soft tissue screw fixation in the coracoid theoretically reduces failure of fixation with cyclic loading. Because the technique is similar to other anatomic AC joint reconstructions that restore the conoid and trapezoid ligamentous structures, the luggage tag fixation should restore coronal and sagittal plane stability to the distal clavicle similar to the native AC joint. After a mean of 53 months followup, only one patient experienced a recurrence of deformity in our series, and this was a partial redisplacement. This redisplacement rate (4.8%) compares favorably with other procedures reported in the literature (Table 1).

Hardware-related complications are a major concern with many of the nonanatomic methods of fixation. Failure of fixation in the form of broken wires or screws can lead to clavicle redisplacement [30]. When hardware has been used to augment the fixation of historical AC joint reconstructive

Table 1. Comparison of luggage tag method and previous studies

Study	Technique	Average followup (months)	Number of patients	Hardware complications	Redisplacement
Weaver and Dunn [34]	Isolated CA ligament transfer	36	15	0/15 (0%)	4/15 (26.6%)
Karisson et al. [14]	CA ligament transfer with transarticular AC joint stabilization	72	47	7/47 (14.9%)	3/47 (6.4%)
Kumar et al. [19]	CA ligament transfer with CC screw fixation*	33	14	2/14 (14.3%)	2/14 (14.3%)
Weinstein [35]	CA ligament transfer with CC loop stabilization	48	17	0/17 (0%)	5/17 (29.4%)
Current study	Luggage tag anatomic reconstruction	53	21	0/21 (0%)	1/21 (4.8%)

* These patients all had chronic dislocations; however, this was the only study that reported this technique; CA = coracoacromial; AC = acromioclavicular; CC = coracoclavicular.

techniques, it is associated with high rates of hardware-associated complications (Table 1). As hardware is not used routinely in this procedure, there is no risk of hardware-related complications. In addition, by avoiding creation of a bone tunnel in the coracoid, the risk of iatrogenic fracture of the coracoid at the time of surgery theoretically is reduced. A potential complication of restoring conoid and trapezoid ligaments through clavicular bone tunnels is the risk of clavicle fracture. We did identify one such fracture several months after the patient had recovered from his AC joint reconstruction; however, this fracture healed uneventfully without adverse effect on the patient's overall function, satisfaction, or outcome. Our technique is comparable and in some ways superior to other methods of fixation of AC dislocation in terms of hardware-related complications and redisplacement (Table 1).

We believe the luggage tag method of coracoid fixation is an improvement on prior methods for anatomically reconstructing the AC joint in that it provides stable coracoid fixation and allows restoration of both CC ligaments yet minimizes the risk of fracture from violation of the cortical bone of the coracoid. The average postoperative DASH score was 11.7, which is virtually indistinguishable from the average employed adult score of 13 found by Jester et al. [13], particularly in light of the fact that the minimum detectable change for this instrument is 12.7 [4]. Our data suggest this procedure relieves pain, reliably prevents redisplacement of the distal clavicle, and is associated with a low hardware complication rate.

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