Original Article

Clinical and Patient-Reported Outcomes for Acute Acromioclavicular Joint Fixation are Similar With or Without Allograft Augmentation

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Purpose: To compare functional outcomes, complications, and revision rates between allograft reconstruction and graftless fixation techniques for the treatment of Rockwood grades III-V acute acromioclavicular (AC) joint separation. **Methods:** Patients who underwent graftless or allograft surgery acutely (≤6 weeks from injury) for Rockwood type III-V AC joint separations from 2012 to 2018 were retrospectively reviewed. Clinic notes and operative reports were identified to confirm the surgical technique and presence of complications including revision, infection, and fracture. In addition, postoperative radiographs were assessed to determine any instances of loss of adequate reduction, and several patient-reported outcomes were collected. **Results:** In total, 115 patients (52 allograft, 63 graftless) were included in this study with a mean follow-up of 3.8 ± 2.5 years. There were no differences between allograft and graftless patients regarding rates of loss of reduction >5 mm (11.1% graftless vs 21.2% allograft), revision (3.2% vs 1.9%), infection (1.6% vs 3.9%), fracture (3.2% vs 7.7%), or total complication (7.9% vs 9.6%) rates (all $P > .05$). Patient-reported outcome measures also did not significantly differ between groups. Multivariate analysis found that increased time from injury to repair and increased Rockwood injury grade (grades IV and V) were associated with increased CC distance at postoperative follow-up ($P = .008$, .050, and .047, respectively). **Conclusion:** Multivariate analysis found that patients who underwent acute AC joint fixation without allograft augmentation had similar functional outcomes, complications, and revision rates compared with patients who underwent AC joint reconstruction with allograft. **Level of Evidence:** Level III, retrospective comparative study.

Acromioclavicular (AC) joint injuries most commonly present in young athletic patients participating in collision sports[1] and are often due to direct trauma to the lateral aspect of the shoulder with the arm in an adducted position. While low-grade sprains of the AC joint account for approximately 90% of these injuries and are typically treated conservatively, Rockwood type IV-VI separations as well as acute, horizontally unstable type III separations are commonly indicated for surgical intervention.[2-11] However, for high-grade, acute AC joint injuries that require operative treatment, significant heterogeneity among reported surgical strategies including technique, graft choice, and fixation constructs remains.[5,6,12-17]

Numerous biomechanical and anatomical studies evaluating the native coracoclavicular (CC) and AC ligaments have led to a multitude of novel surgical techniques that aim to best reproduce the native kinematics of the AC joint.[5,18-21] Of these treatment options, anatomic fixation with suture and cortical button constructs,[22-24] free tendon graft

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reconstruction,[25,26] and tendon graft augmentation have been of particular interest.[5,6,10] Recent critical analysis for the operative management of AC separations demonstrated no difference in loss of reduction between suture–button constructs and tendon graft techniques, although techniques using tendon grafts demonstrated a higher risk of fracture.[6] Furthermore, reconstruction with tendon grafts have been associated with donor-site morbidity and are more costly and invasive than arthroscopic fixation techniques using synthetic devices.[6,27]

In contrast to chronic AC joint injuries, which typically require reconstruction,[2,5] acute, high-grade AC joint separations have been reported to achieve adequate stabilization with both anatomic fixation and reconstruction methods.[5] However, minimal research exists directly comparing anatomic fixation with allograft reconstruction (allograft) and without (graftless) for acute AC joint injuries. Thus, direct comparison of patient groups treated with graftless versus allograft techniques will help guide clinical decision-making for the surgical management of acute, high-grade AC joint injuries. The purpose of this study was to compare functional outcomes, complications, and revision rates between allograft reconstruction and graftless fixation techniques for the treatment of Rockwood grades III-V acute AC joint separation. The authors hypothesized that there would be no differences in functional outcomes, complications, or revision rates between allograft and graftless techniques.

Methods

Inclusion/Exclusion Criteria

This retrospective cohort study was approved by our institutional review Board (Thomas Jefferson University, study #20D.930). A list of all patients diagnosed with the Current Procedural Terminology codes 23550 (treatment of AC joint dislocation, acute or chronic) or 23552 (open treatment of AC joint dislocation, acute or chronic, with fascial graft) who underwent surgical intervention at our institution from 2012 to 2018 was obtained from the medical records. Patients were included if they sustained a Rockwood grade III-V AC joint separation and underwent surgery acutely, which was defined as within 6 weeks of initial injury. Patients were excluded if they underwent AC joint surgery greater than 6 weeks after their initial injury, had a concomitant distal clavicle fracture or resection, had scapular fractures, or had an intra-articular glenohumeral joint injury. Patients with severe glenohumeral joint osteoarthritis or previous AC joint surgery also were excluded.

Standard of Care

Treatment method was at the surgeon discretion. Several surgeons preferred to use allograft augmentation for treatment of all AC joint injuries, whereas others used graftless anatomic fixation for more acute injuries with allograft augmentation reserved for less-acute cases. Allograft was used instead of autograft by surgeons in this retrospective study due to the increased availability of allograft, the lack of donor-site morbidity, and the similarity in postoperative outcomes between allograft and autograft.[28] Patients with grade III AC joint separations were typically indicated for surgery if horizontal instability with cross-body adduction was observed. Postoperatively all patients received the same standardized rehabilitation regiment regardless of graft use, fixation type, and sport participation. Patients were immobilized in a sling for 4 weeks, followed by several months of physical therapy involving progressive range of motion and strengthening, with full return to activity expected 3 to 4 months after surgery. Radiographs were performed preoperatively, as well as at 2 weeks and 3 months postoperatively. Once full functional ability was achieved, patients were allowed full return to physical and sporting activity regardless of surgical technique. Partial or complete loss of reduction was not used to determine return to sport unless the loss of reduction caused significant symptoms.

Data Collection

The physician chart notes and operative reports were then reviewed to confirm technique of fixation (allograft vs graftless), injury date, surgery date, and injury severity, as well as intraoperative and postoperative complications. Postoperative American Shoulder and Elbow Surgeons (ASES) and Single Assessment Numeric Evaluation (SANE) scores were reviewed with a minimum 2-year follow-up (range 2-8 years). Patients were contacted via RedCap (Vanderbilt University, Nashville, TN) to obtain long-term follow-up. Patient anterior-posterior radiographs were also evaluated by 2 independent reviewers (B.K. and J.D.) preoperatively, immediately postoperative, and at subsequent postoperative visits to measure the CC distance and determine whether loss of reduction has occurred. CC distance was quantified between the superior aspect of the coracoid process and the nearest point of the distal clavicle, and the values were averaged between the 2 reviewers.[29] Loss of reduction was defined as a change of >5 mm between the immediate postoperative radiograph CC measurement and any follow-up radiograph measurements.[25,29]

Statistical Analysis

Demographic and postoperative outcomes were compared between allograft and graftless AC joint fixation patients. Postoperative outcomes were also compared between groups after isolating patients with Rockwood grade III injuries and patients with

Table 1. Patient Demographics for Graftless and Allograft Patients

Group	Age, y	Male Sex	BMI	Laterality (Right/Left)	Time From Injury to Surgery, wk
Graftless (n = 63)	31.9 ± 12.5	53 (84.1%)	25.7 ± 3.5	39/24	1.7 ± 1.0
Allograft (n = 52)	37.7 ± 14.2	45 (86.5%)	26.1 ± 3.0	29/23	2.5 ± 1.4
P value	**.025**	.921	.186	.634	**.001**

NOTE. Continuous data are presented as mean ± standard deviation, and categorical data presented as n (%). Statistically significant differences are shown in bold.

BMI, body mass index.

Rockwood grade V injuries. Mann–Whitney *U* tests were used to calculate *P* values for nonparametric data. χ^2 tests or Fisher Exact were used to calculate *P* values for categorical data. *P* values less than .05 were deemed significant. Multivariate regression was performed to determine whether independent risk factors exist for worse ASES scores, SANE scores, or increased postoperative CC distance. Postoperative CC distance (millimeters) was included in the multivariate analysis rather than frequency of loss of reduction >5 mm (%) to increase statistical power, as continuous variables are better suited for regression analyses than categorical variables. All statistical analyses were completed using R Studio (Version 3.6.3; R Foundation for Statistical Computing, Vienna, Austria).

Results

Overall, 391 patients underwent AC joint surgery during the study period, and 276 of these patients were excluded for the following reasons: 5 of these patients were undergoing revision AC joint surgery, 40 patients had a concomitant distal clavicle or scapular fracture, 80 patients had no available follow-up information, and 151 patients underwent AC joint surgery more than 6 weeks after initial injury. Thus, 115 patients that were included in this study, 52 had allograft reconstruction, and 63 received graftless fixation with a mean follow-up of 3.8 ± 2.5 years. Intraoperative reduction was achieved in all 115 included patients.

Patient age was statistically different between groups (37.7 years allograft vs 31.9 years graftless, $P = .025$), and graftless patients also underwent surgery 0.85 weeks earlier from the date of injury (Table 1). The majority of graftless patients underwent reduction with suture or tape only (42.9%), the Dog Bone (Arthrex, Naples, FL) button fixation technique (27.0%), or the TightRope (Arthrex) device (11.1%). The majority of allograft patients received a semitendinosus (73.1%) or tibialis anterior (19.2%) allograft.

In total, 25 patients (39.7%) who underwent graftless fixation had a Rockwood grade V injury, whereas 41 patients (78.8%) who underwent allograft reconstruction had a Rockwood grade V injury ($P < .001$). Conversely, graftless patients had a greater proportion of Rockwood grade III injures (n = 29 [46.0%] vs n = 9 [17.3%], $P = .002$) compared with allograft patients.

Graftless and allograft patients both had low rates of postoperative infection, fracture, and revision (Table 2). There were no differences between groups regarding infection, fracture, revision, and total complications rates. Both groups had a statistically similar proportion of patients with loss of reduction >5 mm (21.2% allograft vs 11.1% graftless, $P = .223$).

In total, 70% of patients completed ASES and SANE surveys at a mean of 5.0 ± 1.9 years after surgery. There were no significant differences between groups for postoperative ASES and SANE scores (Table 3).

No differences in postoperative outcomes were observed when comparing allograft and graftless patients with Rockwood grade III injuries only (Table 4). All postoperative outcomes were also similar between allograft and graftless patients with Rockwood grade V injuries. Rockwood grade IV injuries were excluded from this comparison due to limited sample size (n = 2 allograft vs n = 9 graftless).

Multivariate analysis found that allograft versus graftless fixation did not affect postoperative ASES scores, SANE scores, or postoperative CC distance (Table 5). Patient age, sex, and body mass index also did not affect postoperative ASES scores, SANE scores, or postoperative CC distance. However,

Table 2. Postoperative Complication Rates Between Graftless and Allograft Patients

Group	Infection	Fracture	Total Complications	Revision	Immediate Postoperative CC Distance, mm	Loss of Reduction >5 mm
Graftless (n = 63)	1 (1.6%)	2 (3.2%)	5 (7.9%)	2 (3.2%)	8.6 ± 4.0	7 (11.1%)
Allograft (n = 52)	2 (3.9%)	4 (7.7%)	5 (9.6%)	1 (1.9%)	9.3 ± 4.1	11 (21.2%)
P value	.589	.407	.753	1.000	.345	.223

NOTE. Continuous data are presented as mean ± standard deviation, and categorical data are presented as n (%).

CC, coracoclavicular.

Table 3. Postoperative Patient-Reported Outcomes

Group	Postoperative ASES Score	Postoperative SANE Score
Graftless (n = 46)	89.1 ± 14.2	81.9 ± 26.9
Allograft (n = 35)	89.8 ± 15.8	87.1 ± 17.5
p-value	0.574	0.439

NOTE. Continuous data are presented as mean ± standard deviation.

ASES, American Shoulder and Elbow Surgeons; SANE, Single Assessment Numeric Evaluation.

increased time from injury to repair, and increased Rockwood injury grade (grades IV and V), were associated with an increased postoperative CC distance ($P = .008$, .050, and .047, respectively). Finally, time from injury to repair and increased Rockwood injury grade were not related to ASES scores and SANE scores.

Discussion

The most important finding from this study was that there were no statistically significant differences in functional outcomes, complications, or revision rates between patients who underwent allograft reconstruction versus graftless fixation, which supported the initial hypothesis. After controlling for demographic variables with multivariate analysis, allograft versus graftless fixation did not affect postoperative ASES scores, SANE scores, or postoperative CC distance.

Previous clinical and biomechanical studies have identified advantages and disadvantages for both allograft reconstruction and graftless fixation. For example, reconstructing the completely torn CC ligament allows for closer replication of the CC ligament stiffness than other surgical techniques.[18,19] Also, allograft reconstruction has the advantages of biological fixation, leading to secondary vascularization and increased durability.[18,19,30] However, graftless fixation allows for smaller bone tunnels to be created since a tendon graft does not have to be passed, potentially reducing the risk of complications and fracture.[9,25] Because of the significant advantages and disadvantages for both surgical options, the current clinical comparative study was warranted to evaluate postoperative complication and revision rates in patients after AC joint surgery, as it found no significant differences between allograft and graftless techniques.

There was a difference observed in preoperative Rockwood grading; 40% of graftless operations were performed on patients with Rockwood grade V injury compared with 79% of allograft reconstructions. Several factors may contribute to the difference in Rockwood grading between groups, such as the condition of the ligaments and surgeon preferences.[18,31] Many surgeons may see a significantly elevated CC distance and be inclined to treat the patient with allograft reconstruction, whereas less drastic CC distances may trigger an inherent bias to treat with graftless methods alone. This selection bias would cause the allograft cohort to have more significant pre-operative injuries than the graftless patients. Since multivariate analysis showed that time from injury to surgery and Rockwood injury grade were associated with postoperative CC distance, it is possible that these demographic variables confounded our comparison of loss of reduction between allograft reconstruction and graftless fixation.

Graftless patients underwent surgery about 5 days sooner than allograft patients. While undergoing surgery sooner after initial injury is considered advantageous after an AC joint dislocation,[32] a difference of 0.8 weeks likely has minimal effects on complications, revisions, and patient-reported outcomes. Previous research has compared 29 patients who underwent AC joint reconstruction 10 days postinjury to 20 patients who underwent AC joint reconstruction 7 months postinjury due to a period of failed conservative treatment and found that the patients who underwent immediate surgery had better clinical results and fewer complications than the patients who had significantly delayed AC joint reconstruction.[32] Earlier AC joint

Table 4. Postoperative Complication Rates Between Graftless and Allograft Patients for Patients With Rockwood Grade III and for Patients With Rockwood Grade V

Group	Infection	Fracture	All Complications	Revision	Immediate Postoperative CC Distance, mm	Loss of Reduction >5 mm
Rockwood Grade III Injuries						
Graftless (n = 29)	0 (0.0%)	0 (0.0%)	2 (6.9%)	1 (3.5%)	8.7 ± 4.7	2 (6.9%)
Allograft (n = 9)	0 (0.0%)	1 (11.1%)	1 (11.1%)	0 (0.0%)	10.2 ± 4.5	0 (0.0%)
P value	1.000	.237	1.000	1.000	.751	1.000
Rockwood Grade V Injuries						
Graftless (n = 25)	1 (4.0%)	2 (8.0%)	3 (12.0%)	1 (4.0%)	9.0 ± 3.3	4 (16.0%)
Allograft (n = 41)	2 (4.9%)	3 (7.3%)	4 (9.8%)	1 (2.4%)	9.3 ± 4.1	10 (24.4%)
P value	1.000	1.000	1.000	1.000	.751	.618

NOTE. Continuous data are presented as mean ± standard deviation, categorical data presented as n (%).

CC, coracoclavicular.

Table 5. Multivariate Analysis Assessing the Effect of Various Demographic Variables on Postoperative ASES Score, SANE Score, and Postoperative CC Distance

	ASES Score			SANE Score			Postoperative CC Distance, mm		
Predictors	Estimates	95% CI	*P* Value	Estimates	95% CI	*P* Value	Estimates	95% CI	*P* Value
Allograft augmentation*	1.00	−7.5 to 9.5	.819	12.49	−2.1 to 27.1	.100	−1.56	−3.3 to 0.17	.081
Patient age	0.11	−0.2 to 0.4	.402	0.19	−0.2 to 0.6	.389	0.02	0.0 to 0.1	.404
Female sex†	9.67	−0.3 to 19.7	.063	1.28	−15.5 to 18.0	.882	−1.06	−3.3 to 1.2	.352
Body mass index	−0.58	−1.7 to 0.6	.323	0.87	−1.0 to 2.8	.371	−0.15	−0.4 to 0.1	.173
Time from injury to repair	−0.08	−3.1 to 3.0	.958	0.89	−4.4 to 6.1	.740	0.88	0.25 to 1.5	**.008**
Grade IV injury‡	−0.03	−13.2 to 13.1	.996	8.29	−13.0 to 29.6	.449	−2.57	−5.1 to −0.1	**.050**
Grade V injury‡	0.83	−7.7 to 9.3	.849	−13.05	−27.8 to 1.7	.089	−1.85	−3.6 to −0.1	**.047**

NOTE. Statistically significant differences are shown in bold.
ASES, American Shoulder and Elbow Surgeons; CC, coracoclavicular; SANE, Single Assessment Numeric Evaluation.
*Comparison group = no allograft augmentation.
†Comparison group = male sex.
‡Comparison group = grade III injury.

reconstruction may be better for patients since scar tissue has less time to build up, allowing easier reduction and possibly improving healing capacity. However, this difference in surgical timing is much more drastic than that observed in the current study, and thus is likely not generalizable to the findings of this study.

The current study found no differences in complication rate, revision rate, and patient-reported outcomes between allograft and graftless techniques for acute AC joint surgery patients. Lee et al.[29] did perform a similar retrospective study in 2019 by retrospectively comparing 35 AC joint surgery patients who received fixation without a tendon graft with 12 AC joint patients with tendon graft reconstruction. Acute AC joint injuries were isolated by only including patients who received surgery within 3 weeks of their initial injury.[29] Overall, there were no observed differences in complication rates and patient-reported outcomes (ASES and SANE scores), and no patients in either group required a revision.[29] However, the current study benefits from a larger cohort of patients and ultimately reinforces these findings. More than 150 different techniques for surgical management of AC joint dislocation have been described, and although some have fallen in and out of fashion, it is still not well borne out in the literature if the addition of tendon graft reconstruction in the acute setting results in improved outcomes. Furthermore, a recent meta-analysis by Gowd et al.[6] analyzed the clinical outcomes and complication rates of several different surgical techniques and found an overall complication rate of 14.2%, which is slightly higher than both cohorts investigated in the current study. Although future randomized controlled trials will provide clearer clinical recommendations, the current literature supports that clinicians may perform AC joint fixation with an allograft or graftless approach with no differences in complication rates, reoperation rates, and patient-reported outcomes between groups.

The current study also had statistically similar differences in loss of reduction, which was supported by multivariate analysis. In total, 21% of the allograft patients had a loss of reduction >5 mm whereas only 11% of the graftless patients experienced a loss of reduction >5 mm relative to the immediate postoperative radiograph. Although this difference in loss of reduction rates was not statistically significant, it is at risk for Type II error, given the sample size available. Similar to the current study, Lee et al.[29] also found no statistical difference in loss of reduction rates (23% graftless vs 42% with graft, $P = .22$). However, the 42% loss of reduction rate in the group who received a tendon graft represented 5 of 12 patients; thus, a larger comparative study such as the current study was necessary before drawing further conclusions about differences in loss of reduction rates between patients who undergo AC joint surgery with versus without a tendon graft.

Limitations

This study is not without limitations. First, multiple different fixation devices and allografts were used surgically, so any differences in outcomes based on instrument or graft could not be determined. Also, the study was likely underpowered for evaluation of several postoperative outcomes, especially revision (n = 3), infection (n = 3), and fractures (n = 6). An increased sample size would strengthen the conclusions drawn regarding revision, infection, and fracture rates between these 2 groups. Plus, the clinical outcomes of this study may have been affected by 29 (25%) patients being lost to 2-year follow-up and 34 (30%) patients not completing the patient-reported outcome measures. In addition, the current study defined acute treatment as within 6 weeks from injury, whereas previous studies used 3weeks as the cut-off for acute treatment. Further, return to sport rate and time were not assessed, which would provide valuable

information regarding the outcomes for athletes. Finally, statistically significant differences in preoperative factors such as time from injury to surgery and percentage of patients with Rockwood grade V injuries may have affected the comparisons between groups and were likely affected by selection bias. However, we provided subanalyses isolating patients with Rockwood grade III and grade V injuries, as well as multivariate analysis, to account for some of this selection bias.

Conclusions

Multivariate analysis found that patients who underwent acute AC joint fixation without allograft augmentation had similar functional outcomes, complications, and revision rates compared with patients who underwent AC joint reconstruction with allograft.

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