

## Clinical and radiographic outcome after acromioclavicular reconstruction: a single-center comparison of three different techniques

Karolien VLEUGELS<sup>3</sup>, Joren MERTENS<sup>1,3</sup>, Nick JANSEN<sup>2</sup>, Geert DECLERCK<sup>2</sup>, Olivier VERBORGT<sup>1,2,3,4</sup>

<sup>1</sup>University Hospital of Antwerp, Antwerp, Belgium; <sup>2</sup>Orthopaedic Centre Antwerp (Orthoca), AZ Monica, Antwerp, Belgium; <sup>3</sup>Faculty of Medicine and Health Sciences, University of Antwerp, Antwerp, Belgium; <sup>4</sup>Research Group MOVANT, Department of Rehabilitation Sciences and Physiotherapy (REVAKI), University of Antwerp, Antwerp, Belgium.

Correspondence at: Karolien Vleugels, MD, University Hospital Antwerp, Orthopaedic Surgery, Drie Eikenstraat 655, 2610 Wilrijk, Belgium. E-mail: karolien\_vleugels@hotmail.com - Telephone number: +32 4 76245331

**This prospective, observational cohort study compares the clinical and radiographic outcomes of the modified Weaver and Dunn (WD) technique with the newer, anatomical double-button plus tendon allograft technique (DB), and the suture anchor repair plus tendon allograft (SA).**

**The study cohort includes 53 patients, who underwent surgery for acromioclavicular joint (ACJ) dislocation Rockwood type 3, 4 and 5. Patient-reported outcome scores and clinical results, including Disabilities of the Arm, Shoulder and Hand (DASH), the Subjective Shoulder Value (SSV), the Visual Analogue Scale (VAS) and the Constant score (CS) results as well as loss of reduction rates on plain radiographs were compared.**

**Nineteen patients in the DB group, 19 patients in the SA group and 15 patients in the WD group were included. Average time of follow up was 5 years. The mean VAS scores (SD) were 0.3 (0.6), 0.5 (0.8) and 1.2 (1.4) in the WD, DB and SA groups ( $p=0.06$ ). There were no significant differences in DASH, SSV and Constant scores between groups.**

**Loss of reduction on plain radiographs occurred in 4 patients in total (1 WD, 1 DB, 2 SA). The SSV score, the DASH score, the Constant score and the VAS-score revealed no statistically significant differences between the group with good alignment compared to groups with partial reduction or loss of reduction.**

**In conclusion we can state that the use of anatomical reconstruction techniques with tendon allograft and additional button or suture anchors fixation does not affect the clinical and radiographical outcomes compared to the classic Weaver and Dunn procedure. Loss of reduction was not correlated to worse clinical outcome scores.**

**Keywords:** AC joint reconstruction; acromioclavicular joint; instability; suture anchor; augmentation; double button.

### INTRODUCTION

The acromioclavicular joint (ACJ) links the clavicle to the scapula. It ensures synchronous motion of the shoulder girdle and stability to the scapula during mobilisation<sup>1</sup>.

ACJ separations are one of the most common injuries seen in orthopaedic and sports medicine practices, accounting for 9% of all injuries to the shoulder girdle and even up to 40% in contact sports. The injury is often caused by a direct force to the shoulder or by falling on the shoulder with the arm in adduction<sup>2</sup>.

The most commonly used classification is the Rockwood classification. Bilateral anteroposterior or Zanca views to assess the vertical stability and clinical examination to assess the horizontal instability are sufficient to diagnose and classify this injury<sup>3</sup>. Low-grade injuries (Rockwood grade 1 and 2) are usually

treated conservatively whereas symptomatic high-grade injuries (types IV–VI) are routinely managed surgically. There is no consensus regarding the treatment of a grade 3 injury, and for that reason the ISAKOS members divided this group in grade 3a and grade 3b. Because of the horizontal instability in grade 3b, they suggested surgical repair in symptomatic high demand patients<sup>3</sup>.

The ACJ lesions are divided in acute and chronic injuries. An acute injury is less than 3 weeks old and an injury of more than 3 months old is diagnosed as a chronic injury. Between 3 weeks and 3 months there is a grey zone of subacute injuries. The use of graft augmentation is advised for injuries older than 3 weeks as it is accepted that after 3 weeks the acromioclavicular and coracoclavicular ligaments have lost their property to heal<sup>4</sup>.

More than 160 techniques have been described in literature to stabilise the ACJ, ranging from anatomic

versus non-anatomic repair, open versus arthroscopic repair, acromioclavicular and/or coracoclavicular repair, and with or without augmentation of allografts, autografts or synthetic ligaments. In literature complication rates go up as high as 30% and loss of reduction (LOR) rates on radiographic follow-up up to 20%<sup>5,6</sup>.

In our study, we compare three surgical techniques for coracoclavicular reconstruction used for Rockwood grade 3, 4 and 5 ACJ separations. The 3 techniques compared are the modified Weaver and Dunn technique, the double button with tendon allograft technique and the suture anchor with tendon allograft technique, all performed with an ACJ capsule repair.

## METHOD

### *Participants*

This is a single-centre prospective follow-up study. The study sample consists of patients who underwent an ACJ stabilisation procedure for ACJ instability Rockwood grade III, IV or V. Patients who underwent surgery in AZ Monica hospital in Antwerp in between 2010 and 2021 were included. Patients with rheumatoid arthritis, other significant medical conditions (psychological or neurological diseases, drug or alcohol abuse) were excluded.

Patients were randomly allocated to either one of the surgeons, depending on availability.

The diagnosis was made on radiographs and clinical assessment in clinic.

### *Surgical technique*

Three surgical techniques, performed by three different surgeons in the same hospital, were compared. Each technique was surgeon specific. All three techniques were performed in beach chair position and used a single longitudinal incision (strap) made over the ACJ extending down over the coracoid.

#### *1. Modified Weaver And Dunn technique (WD)*

The coracoacromial (CA) ligament was released from the acromion and transferred to the distal end of the clavicle. A small distal clavicle excision of 5 mm was performed.

Additionally, 2 drill holes were made in the clavicle and a thick PDS cordell was passed around the coracoid and through the 2 holes in the clavicle. The PDS cord was tied up, whilst the clavicle was held down and the scapula pushed up, thereby reducing the dislocation. The CA ligament was then transferred to the lateral end of clavicle with two interposing

resorbable sutures transosseous. The posterosuperior capsule and delto-trapezial fascia were tightened with resorbable sutures.

#### *2. Double button repair with tendon allograft (DB)*

The lateral end of the clavicle was exposed and a small distal clavicle excision of 5 mm was performed. Two tunnels of approximately 2 and 4 cm from the distal end of the clavicle (after resection) towards the base of the coracoid were performed to restore the anatomical insertion of the conoid and trapezoid ligaments. A drill of 4 mm was used for both tunnels. The surgeon didn't search for any remnants of the CC ligaments or tubercle because the surgeon aimed to keep the deltoid muscle attached to the clavicle and a deltoid split was made to reach the coracoid. A tightrope (Arthrex) was positioned from the base of the coracoid through the lateral tunnel and fixed with two buttons. Additionally a tendon allograft, extensor hallucis longus graft, was passed around the base of the coracoid and pulled through the medial tunnel of the clavicle and sutured onto itself with Fiberwire (Arthrex). When closing in layers the posterosuperior ACJ capsule and delto-trapezial fascia were tightened with resorbable sutures.

#### *3. Suture anchor repair with tendon allograft (SA)*

This technique is comparable to the anatomical DB technique. A small clavicle resection was performed. Two anatomical clavicle tunnels were drilled. For males the surgeon drilled the clavicle tunnels at 25 mm from the distal clavicle and central to restore the insertion of the trapezoid ligament, for females this was 20 mm. To restore the anatomical insertion of the conoid ligament he drilled 45 mm medial from the distal clavicle for males and 40 mm for females in the posterior third of the clavicle width. The surgeon aimed to keep the deltoid muscle attached to the clavicle and a deltoid split was made to reach the coracoid. A Y-knot suture anchor with Ribbon tape (Conmed) was placed in the base of the coracoid. The tape was pulled through the medial tunnel of the clavicle and fixed with a knot that was tightened with a knot pusher onto the anchor. Additionally a tendon allograft, extensor hallucis longus graft, was passed around the base of the coracoid and pulled through the lateral tunnel of the clavicle and sutured not only onto itself but also onto the conjoined tendon with Ethibond or Ti-Cron. The posterosuperior ACJ capsule together with the delto-trapezial fascia was re-attached to the posterosuperior distal part of the clavicle with two suture anchors (y-knot, Conmed).

*Study design*

All patients followed the same postoperative protocol, including immobilization in a sling and gentle passive pendulum arm motion and assisted elevation up to shoulder height for 4 weeks; then, the sling was discontinued and active mobilization was started. Any types of activities involving heavy lifting or contact sports were prohibited for 3 months.

The patients were contacted by telephone to participate in this study. The study was explained and if the patients agreed to participate they were invited for a clinical appointment to perform a standardized clinical assessment and plain radiographs, to complete the questionnaires, and to sign the consent form. This study was approved by the ethics committee of AZ Monica.

Functional evaluation was performed using the Constant score (CS), along with patient self-evaluation through the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire and the Subjective Shoulder Value (SSV) questionnaire. Pain was rated on a 1–10 visual analogue scale (VAS). All questionnaires have been validated in Dutch.

General data such as date of birth and gender, time from injury to surgery as well as overhead sport activities were documented. Complications and adverse events such as graft failure, revision surgery and clavicle or coracoid fracture were noted.

Plain radiographs included anteroposterior and Zanca-view of the ACJ. As per routine post-operative assessment, all patients had a plain radiograph six weeks post-operatively and this was repeated at least one year after surgery. To evaluate maintenance of reduction, the position of the distal clavicle to the acromion was evaluated and compared between the postoperative radiograph and the last control by the same radiographic viewer system. The radiographic measurements were classified as follows: (1) ‘no loss of reduction’ (NLR) when the ACJ position was maintained or when subluxation of less than 50% of the height of the clavicle

compared to the superior border of the acromion was noted on early postoperative radiographs; (2) ‘loss of reduction’ (LOR) when secondary displacement of the ACJ compared to the direct postoperative radiographs was seen or a displacement of more than 90% of the height of the clavicle compared to the superior border of the acromion was seen direct post operatively; or (3) ‘partial loss of reduction’ (PLR) when subluxation of 50% to 90% of the height of the clavicle compared to the superior border of the acromion was noted on early postoperative radiographs.

*Statistical analysis*

All statistics were analysed using JMP software version 16 (SAS institute, Cary, NC, USA). Between-group comparisons were performed using the Kruskal-Wallis test. The percentages in loss of reduction were compared in all groups. The level of significance was defined as  $P < 0.05$ .

**RESULTS**

In total 53 patients with an ACJ dislocation Rockwood grade III to V were identified for our study. Nineteen patients in the DB group, 19 patients in the SA group and 15 patients in the WD group met the inclusion criteria. We did not find any statistically significant differences between the 3 groups (Table I). Most patients had surgery in acute or subacute stage. The WD group was slightly younger compared to the DB and SA group, although this was not statistically significant (median age [Q1-Q3], WD 34[26-44] years, DB 50[29-59] years, SA 52[30-59] years,  $p=0.06$ ).

*Clinical outcome*

Functional outcome scores, using the Constant score, at least one year after surgery did show excellent results and did not show a statistically significant difference between the three groups ( $p=0.38$ ).

This was the same for the patient self-evaluation scores using the DASH and SSV questionnaire, which

**Table I.** — Demographic characteristics.

|                                       | WD         | DB         | SA         | P-value |
|---------------------------------------|------------|------------|------------|---------|
| Median age, years (Q1-Q3)             | 34 (26–44) | 50 (29–59) | 52 (30–59) | 0.08    |
| Male gender, No. (%)                  | 12 (80)    | 18 (94)    | 18 (95)    | 0.4     |
| Overhead sports, No. (%)              | 5 (33)     | 5 (26)     | 4 (21)     | 0.9     |
| Median time to surgery, weeks (Q1-Q3) | 2 (1-6)    | 2 (2-7)    | 2 (2-7)    | 0.49    |
| Rockwood, No. (%)                     |            |            |            |         |
| III                                   | 6 (40)     | 8 (42)     | 6 (37)     | 0.6     |
| IV                                    | 7 (47)     | 5 (26)     | 7 (44)     |         |
| V                                     | 0 (0)      | 2 (11)     | 3 (19)     |         |

did not show a statistically significant difference either (p=0.16) (Table II).

Pain was evaluated using the VAS score. There was almost a statistically significant difference with a P-value of 0.06 in favour of the DB and WB group.

*Radiographic outcome*

Radiographic follow-up showed LOR in 4 patients (1 WD, 1 DB and 2 SA). With a p-value of 0.16 there was no significant difference between the three groups. One of them suffered a new fall with LOR, while the other 3 patients did not mention a new trauma. Early postoperative radiographs showed PLR in 15 patients (28 %) (Table III).

*Clinical-radiographic correlation*

Subjective satisfaction was not related to the degree of ACJ reduction. The median SSV score of the patients with NLR was 95 [90-100], compared to the patients with PLR (90 [90-100]) or LOR (95 [60-100]; p=0.91).

Also the DASH score, the Constant score and the VAS-score revealed no statistically significant

differences between the group with NLR compared to groups with PLR or LOR (Table IV, Fig I).

*Complications*

Only minor harm was reported in two patients, both in the DB group. One had a superficial wound infection and another patient had some sensitivity over the suture knots. None of them needed surgical intervention and had excellent clinical outcome scores.

One patient in the SA anchor group suffered a distal clavicle fracture after a new fall during snowboarding. The fracture was related to the medial tunnel but no loss of reduction in CC distance or highriding of the medial clavicle was seen. Conservative treatment was appropriate with good healing of the fracture and excellent clinical outcome.

**DISCUSSION**

Various techniques have been proposed for stabilizing the ACJ. Biomechanical studies have shown that anatomic reconstruction with a double tunnel technique

**Table II.** — Clinical and patient reported outcome scores for each surgical technique.

|                | WD         | DB          | SA          | P-value |
|----------------|------------|-------------|-------------|---------|
| Constant score | 96.3 (6.1) | 97 (3.9)    | 94.4 (6.0)  | 0.38    |
| DASH           | 4.9 (7.9)  | 2.5 (2.7)   | 7.8 (10.4)  | 0.22    |
| SSV            | 93.3 (7.2) | 90.6 (22.4) | 89.5 (10.4) | 0.16    |
| VAS            | 0.3 (0.6)  | 0.5 (0.8)   | 1.2 (1.4)   | 0.06    |

Measures reported as mean (SD). CS=Constant score ; DASH= Disabilities of the Arm, Shoulder and Hand; SSV=Subjective Shoulder value; VAS=Visual analogue scale.

**Table III.** — Radiographic outcome

|     | WD   | DB   | SA   |
|-----|------|------|------|
| LOR | 1/15 | 1/19 | 2/19 |
| PLR | 1/15 | 5/19 | 9/19 |

PLR= partial loss of AC joint alignment, LOR=loss of reduction.

**Table IV.** — Clinical and patient reported outcome scores for each type of loss of reduction.

|          | NLR           | PLR          | LOR            | P-value |
|----------|---------------|--------------|----------------|---------|
| SSV      | 95 [90-100]   | 90 [90-100]  | 97.5 [68-100]  | 0.91    |
| DASH     | 2.5 [0.8-5.7] | 1.7 [0-10.2] | 1.6 [0.3-33.5] | 0.96    |
| Constant | 98.5 [90-100] | 98 [93-100]  | 100 [89-100]   | 0.79    |
| VAS      | 0 [0-1]       | 1 [0-2]      | 0 [0-3]        | 0.37    |

Measures reported as median [Q1-Q3]. NLR=no loss of reduction, PLR= partial loss of AC joint alignment, LOR=loss of reduction, CS=Constant score, DASH= Disabilities of the Arm, Shoulder and Hand, SSV=Subjective Shoulder value, VAS=Visual analogue scale.

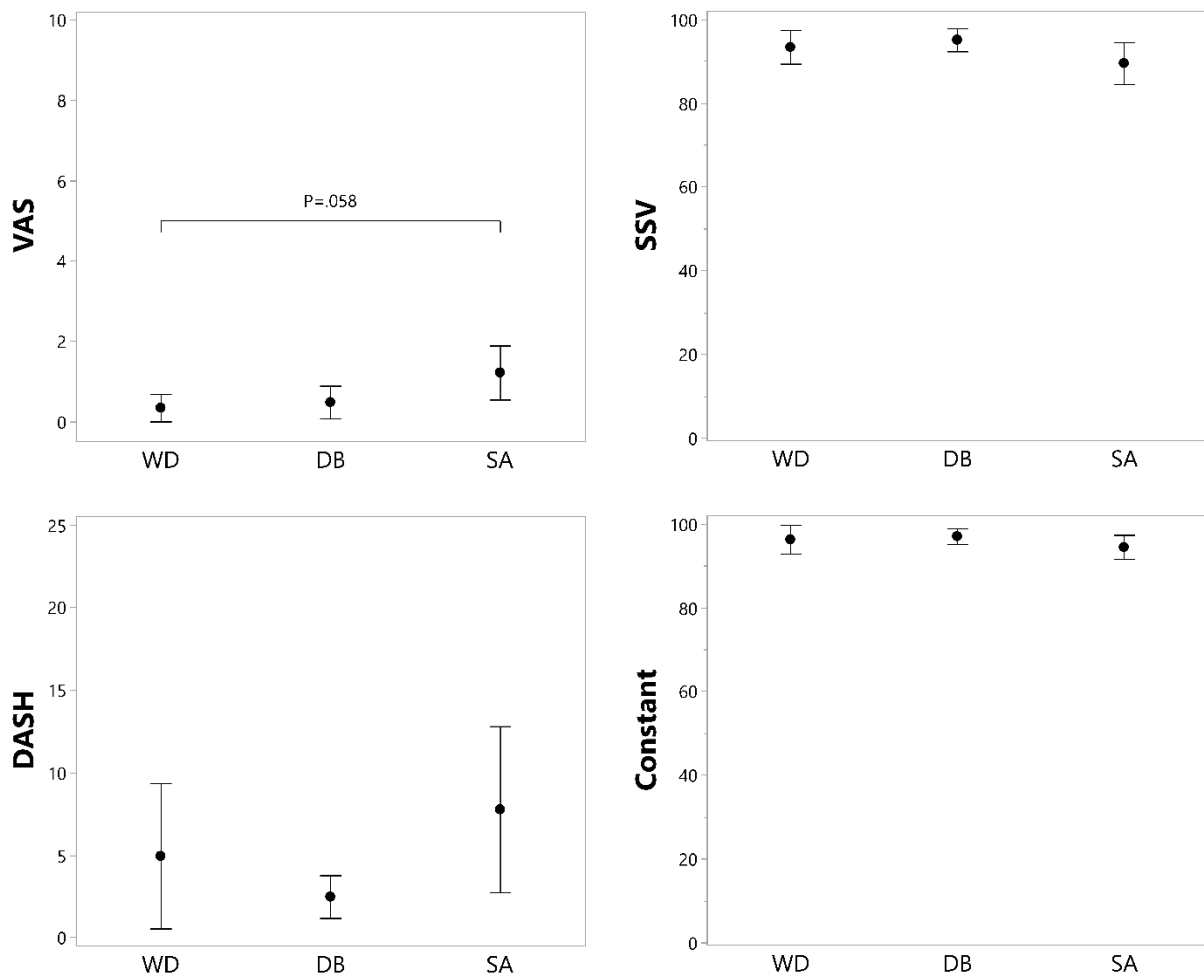


Fig. 1 — Patient reported outcome measures for each surgical group. Data points and error bars represent mean values and 95% confidence interval, respectively.

can improve the native kinematics of the shoulder joint<sup>6</sup>. Nevertheless, our study does not demonstrate a clinical advantage of an anatomically-based repair in comparison to the modified Weaver and Dunn surgical approach. All three groups, including those undergoing anatomical repair, exhibited excellent clinical outcomes as assessed by various scoring systems, including the CS, DASH, SSV and VAS. The VAS score exhibited a nearly statistically significant trend favouring the WD and DB group. It is important to note, however, that a discrepancy of less than one point on the VAS score is considered to lack clinical significance<sup>7</sup>.

In our study, one of the three groups utilized suture anchors for the reconstruction of coracoclavicular ligaments. This technique offers the advantage of smaller tunnel diameters compared to double-button techniques, potentially mitigating the risk of complications such as fractures. Rokito et al. demonstrated in a biomechanical study that similar stability can be achieved for coracoclavicular fixation with suture anchors or with sutures placed around the base of the coracoid for the treatment of ACJ

separations<sup>8</sup>. Multiple studies have shown us excellent results with a suture anchor technique alone<sup>8-12</sup>.

Our study revealed that the DB group does not exhibit a higher risk of fractures compared to the other two groups. The suture anchor group was the only one with a distal clavicle fracture noted postoperatively following new trauma. This group also displayed a higher incidence of partial loss of reduction, although statistical significance was not reached.

Nevertheless, the relationship between maintaining reduction and clinical outcomes remains poorly understood. Our investigation shows that there is no significant difference in clinical outcome scores with respect to the incidence of loss of reduction. All three groups had excellent clinical outcome scores. This has also been documented by multiple studies which showed a lack of correlation between radiographic failure and poor clinical outcome scores<sup>13,14</sup>. Scapular dyskinesia (SD) is suspected as a contributing factor to poor clinical outcomes, although, to date, there exists no preoperative test or classification to predict who will benefit from surgery regarding type of SD.



Natera et al. suggest that there are no significant differences between acute and chronic repair of ACJ dislocations, supporting the use of tendon allograft plus a primary mechanical stabiliser 3 weeks after injury<sup>15</sup>. Freedman et al. demonstrated that acutely performed ACJ reconstruction with or without allograft had both similar functional outcomes, complications, and revision rates<sup>16</sup>.

Our study substantiates these findings, with two of the three groups employing tendon allograft augmentation in all cases, resulting in favourable clinical outcomes and no elevated complication rates.

### Limitations

Several limitations must be acknowledged. The absence of a control group diminishes the interpretability of this study's findings. Additionally, the relatively small sample size, while larger compared to previously published series, still represents a limitation.

Another limitation is the classification of ACJ injury severity with Rockwood classification, of which the reliability and reproducibility have been challenged<sup>17</sup>.

The fact that a single surgeon performed each technique introduces the potential for confounding factors.

New clinical outcome scores such as the Specific AC Score (SACS) and Nottingham Clavicle Score (NCS), tailored specifically for ACJ evaluation, might be more suitable for follow-up of ACJ pathology.

## CONCLUSION

The use of newer techniques with tendon allograft and additional button or suture anchors fixation, with or without repair of the posterior ACJ capsule, does not affect the clinical and radiographical outcomes compared to the classic Weaver and Dunn procedure for ACJ stabilisation. The overall surgical effect of all three techniques showed excellent clinical results. In our study loss of reduction was not correlated to worse clinical outcome scores.

*Competing interests:* The authors have no competing interests to declare that are relevant to the content of this article.

*Ethics approval:* This study was approved by the ethics committee of AZ Monica Antwerp, Belgium.

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