A novel arthroscopic transosseous suture-button fixation technique for anterior glenoid fractures

Good to excellent clinical and radiological results with a minimum follow-up of 6 months

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Abstract

Background: This study evaluated the clinical and radiological results of a new transosseous suture-button fixation technique for anterior glenoid fractures.

Methods: From March 2017 to May 2021, 23 patients with anterior glenoid fractures were treated with the new technique. Demographic data, active shoulder function, and several shoulder scores were evaluated after a minimum of 6 months. Fracture reduction and button placement were assessed via computed tomography, while fracture healing and onset or progression of glenohumeral osteoarthritis were evaluated with X-rays.

Results: Overall, 57% of the patients had relevant concomitant intra-articular injury. Clinical follow-up was performed for 22 patients (19 male, 3 female) at 15 months (6.0–34.5) after surgery. The average Constant Score was 83.2 ± 16.7 points (93.4% ± 18.8% vs. the contralateral side), the Rowe Score, 90.7 ± 10.4 points, the Melbourne Instability Shoulder Score (/100), 88.3 ± 14.5 points, the Western Ontario Shoulder Instability Index (%), 82.9 ± 16.7, and the Subjective Shoulder Value (%), 86.9 ± 16.1. Average range of motion was 171.4° ± 22.7° of flexion (contralateral side, 180° ± 0°; p = 0.11) and 170.5° ± 23.6° of abduction (contralateral side, 179.6 ± 2.1; p = 0.07). No complications occurred and no revision surgery was required. The postoperative step-off of the glenoid averaged 1.55 ± 1.05 mm (0–4 mm). Radiological follow-up of 19 patients showed fracture consolidation in all cases, without secondary dislocation of the fracture or of heterotopic ossification. There was no sign hardware impingement or dislocation. There was new-onset osteoarthritis in 3 cases (15.8%). We found no correlation between the step-off and radiological signs of osteoarthritis.

Conclusion: Anterior glenoid fractures were treated safely and reproducibly with the novel arthroscopic double-button-suture technique, but long-term results are still needed.

Keywords
Shoulder fracture · Arthroscopy · Bankart fracture · Instability · Osteoarthritis
Introduction

Anterior glenoid fractures mainly result from anterior shoulder dislocations and can lead to chronic instability and gleno-humeral osteoarthritis. The prevalence of 16% of bony lesions of the anterior glenoid in first-time shoulder dislocation has been reported to be 16% [10]. While conservative treatment can be advocated for undisplaced fractures with centered humeral head, surgery has usually been recommended for dislocated fractures (>4mm) with a decentered joint or for cases with relevant concomitant injuries [8, 13]. Open surgical procedures using screw fixation have long been the standard of care despite the extensive soft tissue trauma of open approaches including detachment of the subscapularis tendon [22]. Thus, therapy has shifted to arthroscopic methods applying screw osteosynthesis or anchor refixation techniques resulting in lower complication and revision rates [4]. However, these methods remain challenging due to several potential intra- and post-operative pitfalls: Screw osteosynthesis requires an anterior approach endangering the neurovascular structures and penetrating through the subscapularis muscle [23, 25]. The other methods applying suture anchors placed along the fracture site are usually not adequate for larger fractures. Also, the linear placement of anchors has been reported to be associated with secondary fractures of the glenoid or irritation of the joint due to non-absorbable sutures [9, 16].

Thus, we have developed an all-arthroscopic transosseous technique that:

- (a.) Uses a glenoid drill guide placed over the posterior portal.
- (b.) Applies a double-button-suture construct placed extra-articularly for refixation.

This recently described procedure avoids the risks of open reconstruction while it still appears to provide adequate stabilization for large fragments [27]. Other similar case reports have confirmed the reproducibility of this method [1, 5]. However, clinical outcome data are lacking to date. The aim of this study was to evaluate the results of this novel arthroscopic technique for anterior glenoid fractures with a minimum follow-up of 6 months.

Patients and methods

Surgical procedure

The system utilized for this procedure (Smith&Nephew Co., London, UK) was developed originally for chronic instabilities by both Ettore Taverna for arthroscopic glenoid augmentation with tricortical iliac crest [26] and by Pascal Bouileau for arthroscopic coracoid transfer [3]. The respective arthroscopic surgery for glenoid fractures has been previously described by our group [27]. In summary, the procedure is performed in the beach-chair position with an en-face view on the glenoid with the arthroscope placed in the anterolateral portal. Several instruments are used through two anterior portals (in the rotator interval) for fracture reduction. Then, the anterior hook-end of the glenoid guide (Fig. 1) is inserted through the posterior portal and placed anteriorly parallel to the glenoid. It then captures the anterior edge of the anterior fragment under the hook. Two bullets are placed on the scapula neck over the glenoid guide through an additional posteromedial skin incision (Fig. 2). A 2.8-mm cannulated drill is placed through each bullet and advanced under power until exiting from the anterior aspect of the anterior fragment. Each drill will be 5 mm below the cortical edge of the glenoid surface. After removal of the glenoid guide, the inner part of the drills is removed posteriorly leaving the cannulated part in place (Fig. 3). Usually, only one pair of endobuttons was placed and therefore the cranial drill was removed in most cases. A flexible looped guide wire is then passed through the remaining cannulated drill from posterior to anterior and retrieved through the anterior portal. The drill can now also be removed, finally leaving only the looped guide wire in the lower drill tunnel.

With the guide wire, all four strands of the endobutton-suture-fixation device (Fig. 4a) are shuttled into the anterior portal, through the glenoid and out of the posteromedial incision. Thus, the anterior
endobutton lies firmly upon the anterior surface of the anterior glenoid fragment (Fig. 4b). The posterior strands are knotted over a posterior endobutton, which is then advanced until it sits firmly against the posterior face of the scapular neck. The construct is locked with a suture tensioner and finally a standard knot pusher. The capsulolabral ring can be reattached additionally on the glenoid rim applying a standard arthroscopic soft-tissue repair technique.

**Patient population**

According to the existing literature, surgery of glenoid fractures was indicated if fragment dislocation of at least 4mm or a decentered humeral head on anteroposterior x-rays was present. Patients were eligible for the novel transosseous technique if a solitary fracture was present or one large main fragment (Type Scheibel 1b or 1c; [21]).

From March 2017 to May 2021, 23 patients received the novel arthroscopic procedure in the two participating centers: Three patients had surgery at the “Klinikam-Ring” Clinic and 20 patients at the Cologne-Merheim Medical Center (CMMC). There were initial plans for two other patients at CMMC to undergo the procedure, but in both cases intraoperative assessment had shown that the anterior fragment was not large enough for the endobutton to engage upon its anterior aspect. Thus, the implant was removed and a conventional arthroscopic suture anchor technique according to Sugaya [24] was performed.

Informed consent was given by all 23 patients. For the results of the clinical outcome, a minimum follow-up of 6 months was required. The study was approved by the local ethics committee of the University Witten/Herdecke (185/2019) and was conducted according to the Declaration of Helsinki.

**Clinical outcome**

Following surgery, patients were screened for complications related to the procedure (neurovascular injury, infection, impaired wound healing, re-operation) or events of instability or re-dislocation. At the final follow-up, all patients were assessed for clinical stability and rotator cuff strength. The range of motion of both shoulders was measured by applying a goniometer. The level of sports activities and return to work were recorded. If patients were already retired, they were asked to estimate the potential to return to their former occupation. Outcome scores were measured including the Constant Score (CS; [2, 6]), Rowe Score (RS; [19]), Melbourne Instability Shoulder Score (MISS; [28]), the Western Ontario Shoulder Instability Index (WOSI; [12]), and the Subjective Shoulder Value (SSV; [7]).

**Radiological assessment**

The size of the glenoid lesion was calculated according to Itoi et al. [11]. The calculation was performed by en-face three-dimensional (3D) computed tomography (CT). The fractures were classified according to the Scheibel classification, where acute lesions of the glenoid are categorized...
as “Type 1” (1a: Osteochondral avulsion lesion, 1b: Solitary glenoid rim fracture, 1c: Multifragmented glenoid rim fracture; [21]). Postoperatively, the patients underwent 3D CT of the scapula to assess fracture reduction and button placement (Fig. 5). These CT scans were examined for fracture reduction and the remained fracture step (in millimeters) by two radiologists. For radiological follow-up, x-rays were obtained in three views (anteroposterior, y view, axial view) to assess fracture healing (Fig. 6) and onset or progression of glenohumeral osteoarthritis according to the Samilson–Prieto classification [20].

**Statistical analysis**

Statistical analysis with calculation of mean values and standard deviations was performed using Microsoft Excel 2019 (Microsoft, Redmond, WA, USA). Further statistical testing was performed applying SPSS (Version 21, IBM Statistics, IBM, Armonk, NY, USA): For clinical follow-up active range of motion of the affected shoulder was compared with the contralateral shoulder using the Wilcoxon test. For comparison of patients with versus without rotator cuff injuries, the Mann–Whitney U test was applied. A value of $p < 0.05$ was considered significant.

**Results**

The study include 23 patients were included in the study. There were three women and 20 men with a mean age of $51.1 \pm 16.1$ years at the time of surgery. An indirect trauma mechanism with a fall on the extended arm or an abduction/external rotation trauma was present in eight patients. In 19 patients (82.6%), the initial trauma was accompanied by a shoulder dislocation. The dominant shoulder was affected in 12 patients. None of the patients reported any history of previous shoulder dislocation.

Calculation of the size of the glenoid lesion according to Itoi showed a mean fragment size of $30.5\% \pm 5.4$ with a minimum $18.7\%$ and a maximum of $40.5\%$. In 21 patients there was a Scheibel type 1b fracture (solitary glenoid rim). Two patients had a Scheibel type 1c fracture (multifragmentary glenoid rim); however, both contained one larger main fragment.

The average time from injury to surgical treatment was $12.4 \pm 11.0$ days. In two cases, a second pair of endobuttons was applied for glenoid fixation, all other 21 cases required one pair, as described above. Mean stay in hospital was $4.3 \pm 1.9$ days.

**Concomitant injuries**

Concomitant injuries were found in 21 cases, mainly Hill–Sachs lesions (16 of 23). Furthermore, concomitant injuries requiring surgical treatment were found in 13 cases (Table 1): Four patients had injuries of the rotator cuff; two of these with a full-thickness tear of the supraspinatus tendon, one with full-thickness tears of the supraspinatus tendon plus partial tear of the infraspinatus tendon, and one patient with traumatic partial tears of both the infraspinatus and the subscapularis tendon plus a chronic retracted tear of the supraspinatus tendon. The supraspinatus tendon tears were all treated arthroscopically in a double-row technique, except for the chronic tear, which received debridement. One patient had a dislocated fracture of the greater tuberosity that was treated with a screw osteosynthesis via a mini-open delta approach. Undislocated greater tuberosity fractures in two patients were treated
Conservatively, since the fluoroscopy at the end of surgery did not show any displacement. Overall, 11 patients had a superior labral anterior–posterior type II lesion that was treated with tenotomy or tenodesis of the long head of the biceps. One of the patients with a full-thickness rotator cuff tear had a nondisplaced coracoid fracture that was treated conservatively. One patient showed a unique injury pattern with concomitant superior labral anterior–posterior type IV lesion, posterosuperior labral tear, acromioclavicular joint injury Rockwood type 5, and a nondisplaced acromion fracture. This patient received long head of the biceps tenodesis, posterior labral refixation, and minimally invasive acromioclavicular joint reconstruction.

**Clinical results**

Complications related to the surgery (neurovascular injury, infection, impaired wound healing) were not observed in any of the 23 cases. No patient required re-operation. After a minimum of 6 months and an average of 15.0 months (range: 6.0–34.5), 22 patients were available for clinical follow-up (three female, 19 male). One patient (with an additional supraspinatus tendon tear) had died from cancer. The average CS was 83.2±16.7 points (93.4%±18.8% compared to the contralateral side), the RS was 90.7±10.4 points, the MISS was 88.3±14.5 points, the WOSI was 82.9%±16.7%, and the SSV was 86.9%±16.1%. The average range of motion was 171.4°±22.7° of flexion (contralateral side, 180°±0°; \( p = 0.11 \)), and 170.5°±23.6° of abduction (contralateral side, 179.6±2.1; \( p = 0.07 \)).

At the time of follow-up, no patient had suffered recurrent shoulder dislocation or a feeling of instability. We could not detect the presence of the apprehension sign in any of these patients. The evaluation of the subscapularis function revealed a negative internal rotation lag sign and belly-off sign in all patients. No patient showed clinically detectable differences in the lift-off test compared with the contralateral side. Of these patients, 21 reported return to work, and one patient had not returned to work 7 months after surgery. Furthermore, 16 patients reported that they had returned to sport at the same level, while six patients were at a slightly reduced level.

Four patients with concomitant rotator cuff tears or displaced greater tuberosity fracture were on average 7 years older than patients without these injuries to the rotator cuff mechanism (57.0 vs. 49.8 years; \( p = 0.37 \)), and they scored significantly lower for the CS (70.5 vs. 98.4; \( p = 0.003 \)), the SSV (65.0 vs. 91.8; \( p = 0.005 \)), and the RS (77.5 vs. 93.6; \( p = 0.019 \)). They also scored lower in the MISS (80.3 vs. 90.1; \( p = 0.34 \)) and the WOSI (65.3% vs. 86.8%; \( p = 0.053 \)); however, without statistical significance.

**Radiological results**

In total, 19 patients were available for radiological follow-up. In all cases, radiological evaluation by two radiologists showed fracture consolidation without secondary dislocation of the fracture and without signs of heterotopic ossification. There were also no signs of hardware impingement or dislocation. The radiological evaluation revealed new onset of osteoarthritis in three cases (15.8%). Of these three patients with posttraumatic osteoarthritis, all showed an inferior humeral osteophyte of 1–3 mm corresponding to a grade I according to the Samilson–Prieto classification. Three other patients had a mild (grade I) pre-existing osteoarthritis already upon injury, which showed no progression at the time of follow-up. Three patients with new osteoarthritis were not older at the time of surgery compared to patients without progressive osteoarthritis at follow-up (51.0±19.5 years vs. 51.2±16.2 years; \( p = 1.00 \)). The postoperative step-off of the glenoid measured by CT averaged 1.55±1.05 mm (0–4 mm). The three patients with signs of osteoarthritis had shown a step-off of 1, 1, and 4 mm, respectively. We found no correlation...
between the step-off and the presence of radiological signs of osteoarthritis.

**Discussion**

Surgical treatment of glenoid fractures remains challenging. Recent evidence has shown that open surgery is associated with higher complication rates and worse clinical outcomes than arthroscopic procedures, probably due to the soft tissue trauma requiring detachment of the subscapularis tendon [4, 14].

Thus, multiple arthroscopic methods have been published, which also involve several potential problems and pitfalls: Anterior screw placement perpendicularly to the fracture line necessitates an arthroscopic trajectory that endangers the brachial plexus and vessels [23]. Also, hardware problems regularly require revision surgery, especially impingement of screw heads [25]. Thus, a myriad of re-fixation procedures have been described using suture anchors at the fracture site, for example, by Porcellini [18], Sugaya [24], or Millett [15]. However, these techniques are usually less applicable for large fragments. Also, Nakawaga et al. found that placing multiple soft suture anchors in a linear arrangement for Bankart repairs might be associated with post-operative recurrence of instability due to new glenoid fractures along the suture anchor insertion sites [16]. In addition, Greenstein et al. demonstrated in a cadaveric model that placement of intra-articular sutures during arthroscopic bony Bankart repair techniques may harm the humeral head cartilage and suggested further investigation of alternative, cartilage-sparing arthroscopic techniques for anterior glenoid fractures [9]. All these arthroscopic methods have in common that the implants are drilled and placed from anteriorly.

Thus, we have described an all-arthroscopic transosseous technique that (a) uses standard portals and a glenoid drill guide placed over the posterior portal thereby sparing the subscapularis tendon and the anterior neurovascular structures, and (b) applies a double-button-suture construct placed extra-articularly for stable refixation that is cartilage-sparing and avoids glenohumeral hardware or suture impingement [27]. In the present study, 23 anterior glenoid fractures were treated safely and reproducibly with this novel method with excellent clinical and radiological short-term results.

Few retrospective studies have previously examined both the clinical and radiological outcomes of glenoid fractures following arthroscopic surgery: Scheibel et al. published the results of a large cohort applying suture anchors and chondral darts [21]. With a minimum follow-up of 24 months, 21 patients showed good to excellent clinical results (CS 84.5 points, RS 90.8 points, MISS 96.2 points, WOSI 89.2%, SSV 92.1%), but there was progression or new-onset osteoarthritis in 28.6%. While the clinical scores are very similar to the results of our present study, we found osteoarthritis in 15.8% of cases. However, we evaluated the patients with a minimum of only 6 months and mean follow-up was just after 15 months, which represents the major limitation of our study. Further follow-up will have to delineate the long-term development of posttraumatic osteoarthritis in these patients. Interestingly, Scheibel et al. also found a high rate of relevant intra-articular concomitant lesions in about 78% of cases. Lin et al. found better pain outcomes of arthroscopic treatment compared to open surgery as it enabled accurate management of associated intra-articular lesions that were found in 50% of cases of the arthroscopic group [14]. In the current study, in 13 of 23 patients (57%) relevant concomitant lesions were found intra-articularly requiring arthroscopic treatment. Especially injury of the rotator cuff was associated with inferior outcome scores, but this might also be due to the short follow-up [17]. However, considering these high rates of concomitant injuries in our and other studies, magnetic resonance imaging should be recommended for patients with glenoid fractures who receive conservative therapy.

In this context, Wieser et al. recently reported that conservative treatment of displaced glenoid fractures with a mean follow-up of 9 years showed good clinical scores and fracture healing in 30 patients [29]. However, 23% had post-fracture onset of osteoarthritis and one patient had to be treated with arthroplasty. Despite conservative therapy, magnetic resonance imaging results were not reported, which could have helped to assess the role of concomitant lesions. Also, six patients had been excluded from follow-up as they had undergone surgery elsewhere. Thus, due to the absence of any prospective evidence, the optimal treatment algorithm for glenoid fractures remains a matter of debate.

**Limitations**

Several limitations of the present study have to be mentioned. We conducted a retrospective analysis, and there was no control group. We only presented a short-term follow-up. Only x-rays with three views were obtained for the follow-up, as we believed that these were sufficiently valid for assessment and that CT scans would expose the patients to too much radiation. Finally, a main limitation of the surgical method presented here is that it is not applicable for smaller fragments or comminuted fractures: As described earlier, if the anterior fragment is too small (from medial to lateral) then the anterior button cannot engage upon the fragment, but will cut out medially. As for the two cases excluded from this study, the implant was just removed through the anterior portal and a standard arthroscopic method (e.g., the Sugaya technique) was applied.

### Practical conclusion

- Anterior glenoid fractures were treated safely and reproducibly with the novel arthroscopic double-button-suture technique with good to excellent short-term results.
- Standard portals can be applied as the glenoid guide is introduced through the posterior portal and the implant through the anterior portal, without the need to establish a portal through the subscapularis and without risk for the neurovascular structures.
- The technique is cartilage-sparing as the endbuttons are placed extra-articularly, i.e., one anterior button on the anterior aspect of the fragment and one button on the posterior aspect of the scapular neck.
- Considering the high rate of concomitant lesions found in our series, magnetic resonance imaging and thorough clinical follow-up are recommended if anterior glenoid fractures are treated conservatively.
Eine neuartige arthroskopische transossäre Endobutton-Faden-Technik zur Versorgung anterierer Glenoidfrakturen. Gute bis exzellente klinische und radiologische Ergebnisse bei einem Mindest-Follow-up von 6 Monaten

Fragstellung: In der vorliegenden Studie wurden die klinischen und radiologischen Ergebnisse nach Versorgung von anterierer Glenoidfrakturen mit einer neuartigen transossären Endobutton-Faden-Technik evaluiert.

Methoden: Von März 2017 bis Mai 2021 wurden 23 Patienten mit anterierer Glenoidfraktur mittels dieser neuartigen Technik versorgt. Demografische Daten, die aktive Schulterfunktion sowie gängige Schulter-Scores wurden nach einem Mindest-Follow-up von 6 Monaten erfasst. Mit einer unmittelbar postoperativ angefertigten Computertomographie wurden die Reposition der Fraktur und die Endobuttonlage bewertet, während die Frakturheilung und der Beginn oder das Fortschreiten einer Oamarthrose anhand von Röntgenbildern beurteilt wurden.

Ergebnisse: Bei 57 % zeigten sich intraoperativ behandlungsbedürftige Begleitverletzungen. Insgesamt standen 22 Patienten dem klinischen Follow-up 15,0 (6,0–34,5) Monate postoperativ zur Verfügung (19 Männer, 3 Frauen). Zum Zeitpunkt des Follow-up betrug der Constant Score 83,2 ± 16,7 Punkte (93,4 % ± 18,8 % im Vergleich zur kontralateralen Seite), der Rowe Score 90,7 ± 10,4 Punkte, der Melbourne Instability Shoulder Score (/100) 88,3 ± 14,5 Punkte, der Western Ontario Shoulder Instability Index (%) 82,9 ± 16,7 und der Subjective Shoulder Value (%) 86,9 ± 16,1. Die aktive Anteverision betrug 171,4° ± 22,7° (kontralateral 180° ± 0°; p = 0,11), die aktive Abduktion 170,5° ± 23,6° (kontralateral 179,6° ± 2,1°; p = 0,07). Es traten keine Komplikationen auf, auch war keine Revisionsoperation erforderlich. Die mittels CT gemessene postoperative Stufe betrug im Mittel 1,55 ± 1,05 mm (0–4 mm). Bei allen 19 Patienten mit radiologischem Follow-up zeigte sich eine Konsolidierung ohne sekundäre Dislokation der Fraktur oder heterotope Ossifikation. Bei 3 Patienten (15,8 %) fanden sich Zeichen einer neu aufgetretenen Oamarthrose. Es bestand keine Korrelation zwischen postoperativ verbliebener Stufe und Oamarthroseentwicklung.

Schlussfolgerung: Anteriore Glenoidfrakturen können in der neu beschriebenen Button-Suture-Technik sicher und reproduzierbar versorgt werden, langfristige Ergebnisse stehen jedoch noch aus.

Schlüsselwörter: Schulterschaden, Arthroskopie, Bankart-Fraktur, Instabilität, Oamarthrose

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Declarations

Conflict of interest. A. Wafaisade is a consultant for Stryker; receives travel costs from Arthrex and DePuy-Synthes; and is a consultant for and receives travel costs from Smith & Nephew, A. Karwatwitz, T.P. Pfeiffer, A. Lages, J. Poggenborg, M. Kallenberg and P. Kappel declare that they have no competing interests.

The study was approved by the local ethics committee of the University Witten/Herdecke (185/2019) and was conducted according to the Declaration of Helsinki.

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