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TRAUMA SURGERY

Results of open reconstruction of anterior glenoid rim fractures following shoulder dislocation

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Abstract
Introduction The present study evaluates the clinical and radiological outcome following open reconstruction of avulsion fractures of the anterior glenoid rim in traumatic shoulder dislocation.
Material and methods A total of 20 patients (mean age 49.4 years) were treated with open reduction and cannulated screw fixation. Eighteen patients were available for clinical and radiological follow-up after 3.1 (2.0–6.5) years.
Results The average Constant Score was 78 and the average Rowe Score was 90 points. Documented complications were implant failure in one and neurological dysfunction in one patient. Radiographs revealed the bony fragment located in an unimproved displaced position in one patient and a progress in osteoarthritic changes in three patients. No recurrent subluxation or dislocation was observed.
Conclusion Open reconstruction of glenoid rim fractures is a valuable procedure regarding medium-term subjective and objective outcome measures. Recurrent dislocation, glenoid defects and early onset of osteoarthritic degeneration can be avoided.

Keywords Shoulder dislocation · Glenoid rim fracture · Screw fixation

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Introduction

Fractures of the anterior glenoid rim occur as a consequence of traumatic glenohumeral dislocation. Numerous articles are focused on the treatment of anterior glenohumeral instability, but only few reports exist about the management of associated glenoid rim fractures. These avulsion fragments are reported to be an indication for operative refixation [5, 14]. Substantial glenoid bone deficit results in anterior shoulder instability and an increased incidence of recurrent dislocation in patients with concurrent glenoid rim fractures [1, 11]. Itoi et al. denominate a glenoid defect with a width of 21% of the glenoid length as the limit for the stabilizing capsular and ligamentous structures to decompensate, resulting in anterior apprehension and subluxation [8]. Several other studies have either contributed methods to assess the quantity of glenoid bone loss [2, 7, 20] or determined its importance to glenohumeral stability that requires surgical refixation [2, 9, 10, 13, 16, 17]. Conservatively treated glenoid rim fragments of significant size might be either reabsorbed or heal in an unfavourable malposition creating an incongruent articular surface on the glenoid. This, in combination with increased anterior laxity, further promotes the onset of posttraumatic osteoarthritis or accelerates the progression of pre-existing degenerative changes [6]. Scheibel et al. [19] reported excellent and good clinical outcome for patients who underwent either suture anchor repair or cannulated screw refixation of anterior glenoid rim fractures, depending on the fragment size. Tauber et al. [21] performed arthroscopic reduction and screw fixation of large glenoid fractures following shoulder dislocation and recommended the procedure to ensure anatomical fracture healing and glenohumeral joint stability.

The purpose of the present study was to evaluate the clinical and radiological outcome following open reconstruction of these injuries.

Materials and methods

Between 2001 and 2005, 20 of 148 patients (16.5%) treated surgically for acute or recurrent anterior shoulder instability at our hospital, presented with a bony avulsion fracture of the anterior glenoid rim, corresponding to Type Ia in the Ideberg classification [8]. Indication for surgical treatment was present with a solid or comminuted avulsion fragment involving more than 21% of the glenoid length or a step formation of more than 2 mm on the glenoid articular surface. According to Itoi et al. [7, 21], the fragment size is calculated as a percentage of the glenoid length to a line, inclined 45°, drawn through the fracture gap with the equation $(A \times 0.965 - B) \times 100/A$. *A* represents the diameter of the outer fitting circle of the glenoid and *B* the length of the diameter from the outer circle to the fracture line (Fig. 1).

This group included 17 males and 3 females with an average age of 49.9 years (range, 26.4–78.0). Initially all patients sustained an acute traumatic episode with anterior dislocation or subluxation of the shoulder. This was the first incident of instability in 17 cases, whereas three patients had a positive history for recurrent dislocation: 13 right and 7 left, 14 dominant and 6 nondominant shoulders were involved. For diagnostic evaluation, plain radiographs, including standard AP and axillary views, and CT scans with multiplanar and 3D reconstructions were obtained in all cases. Imaging revealed antero-inferior glenoid rim fragments with an average size of 22.9% of the glenoid length (range, 14.2–36.3). All 20 patients were treated operatively immediately after diagnosis was established and underwent open reduction and internal fixation of the bony avulsion fragment with cannulated screws (Fig. 2).

For surgery we use a standard anterior approach. After soft tissue preparation, division of the subscapularis tendon and a vertical capsular incision, the avulsed fragment is reduced and anatomically reattached to the glenoid with one or two self-tapping and cannulated 2.7 mm titanium screws, which are inserted over a guide wire. If an inferior component of instability is present, an antero-inferior capsular shift procedure is performed with the medial capsular reconstruction. The subscapularis tendon is then reattached to its anatomical insertion. Postoperatively the affected limb was immobilized in a shoulder bandage for 6 weeks. Pendulum exercises and passive motion to a limit of 80° abduction and 80° flexion were allowed after the first week. After removal of the shoulder immobilizer, patients were instructed to intensify physical therapy to regain full range of motion and strengthen muscle function.

Eight patients sustained concomitant shoulder injuries. Five presented with an associated fracture of the greater tuberosity, one patient with a fracture dislocation of the

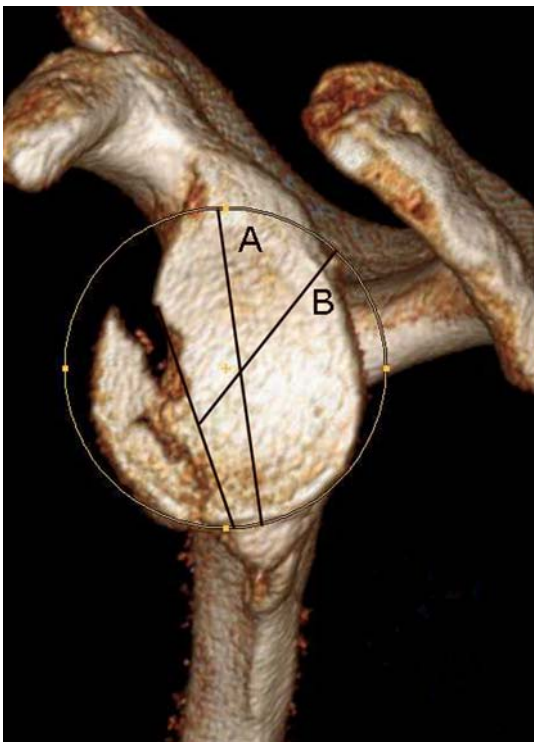

Fig. 1 Orthograd view to an antero-inferior avulsion fracture of the glenoid rim in a 3D-CT. An outer fitting circle that fit the supero-inferior diameter of the glenoid is constructed and a line inclined 45° to the supero-inferior diameter is drawn. *A* diameter of the outer fitting circle. *B* distance to the fracture gap

Fig. 2 Postoperative coronar CT scan demonstrating anatomical fracture reduction and accurate implant position

Fig. 3 Postoperative anteroposterior X-ray after reduction of a comminuted avulsion fragment and stabilisation with two cannulated screws

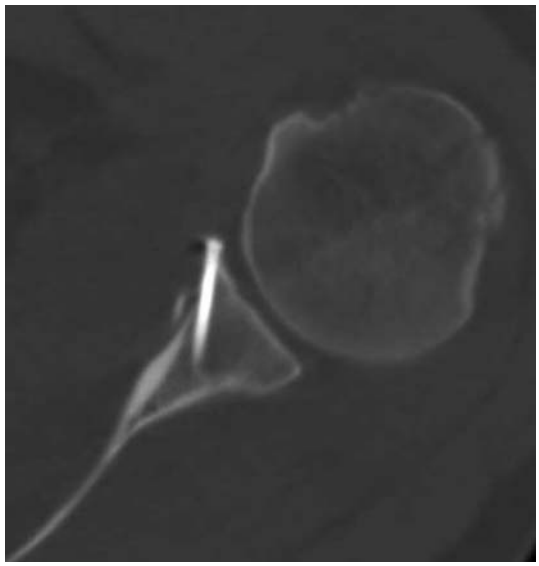

Fig. 4 Postoperative axial CT scan of the same patient with correct implant position and congruent articular surface

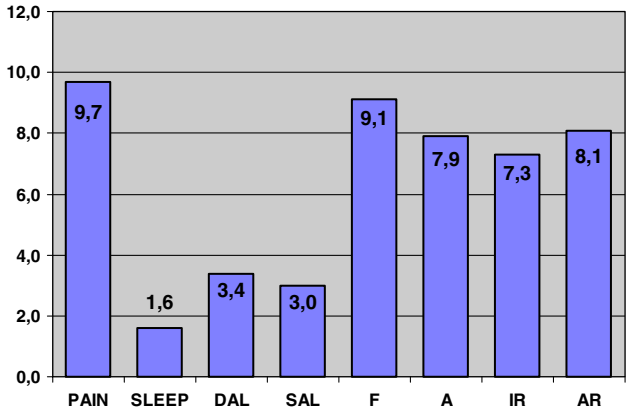

Fig. 5 Average postoperative points for pain, sleep, activities of daily living (*ADL*), sports activity level (*SAL*), flexion (*F*), abduction (*A*), internal rotation (*IR*) and external rotation (ER) based on Constant score

humeral head (3 segments, group 5 according to Neer classification), one with a 3-segment fracture of the proximal humerus (group 3 according to Neer classification) and one with a fracture of the acromion. These additional injuries required internal fixation of the proximal humerus in both cases. The fracture dislocation was stabilized with four K-wires and a suture anchor for refixation of the greater tuberosity after open reduction. The 3-segment fracture was treated with an intramedullary proximal humerus implant after closed reduction. In one of five patients with concomitant fractures of the greater tuberosity, the tuberosity fragment showed significant displacement and required reduction and lag screw refixation.

A total of 18 patients (90%) fulfilled the criterion of a minimum period of 2 years for follow-up (average 3.1 years; range, 2.0–6.5). Clinically, the objective and subjective outcome was assessed using the score of Constant and Murley [4] and the score of Rowe [15]. For radiological evaluation, plain shoulder radiographs and CT scans were obtained (Figs. 3, 4). The onset of posttraumatic osteoarthritis was rated according to the score of Samilson and Prieto [18]. Osseous integration of the fragment and the development of glenoid defects were recorded.

Results

At follow-up the mean Constant score was 78 points (range, 70–96). The Rowe score averaged 90 points (range, 65–100). The results were graded as excellent in nine patients, as good in five, as fair in one and as dissatisfactory in three patients. A total of 78% of patients achieved an excellent and good result according to the Rowe score. The average Constant score ratings for the range of motion is demonstrated in Fig. 5. Average postoperative stability, motion and function rating based on the Rowe score is listed in Fig. 6. No patient complained about subjective sensations of instability. No recurrence of dislocation or subluxation was detected. Six patients were free of pain, six specified mild, five moderate and one patient marked pain. Thirteen patients had no restrictions in their professional work, four were restricted to 75 and to 50%, respectively, and one patient to 25%. Unlimited or only mild limitations in sports activities were documented in 15 cases. Three patients complained a marked limitation in sports. Three patients suffered from a marked disturbance of sleep, the

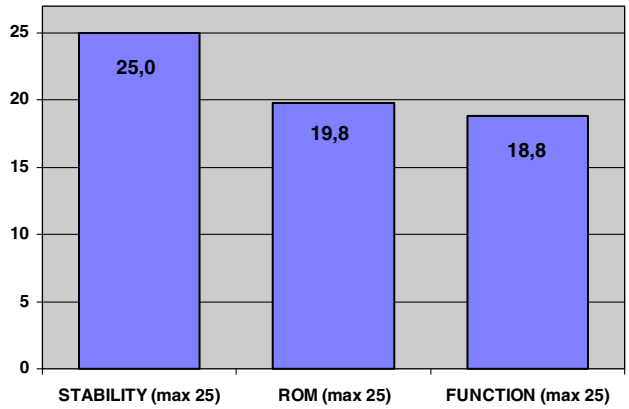

Fig. 6 Average postoperative stability, ROM and function based on Rowe score (maximum score for each category given in *parenthesis*)

rest specified none or only mild affections (Fig. 3). The majority (15 patients) was able to perform at or above head level in their activities of daily life.

The overall complication rate for the procedure was 10%. One transient neurological dysfunction of the axillary nerve and one implant failure were observed. The latter case presented with a loosening of one of the two inserted screws and had to undergo revision surgery with implant removal due to mechanical impingement after consolidation of the fracture. Three patients presented with an unacceptable restriction in range of motion in the postoperative course, which was not improvable by means of physiotherapy. We performed an arthroscopic subacromial decompression with removal of scar tissue formations, a capsular release where appropriate and a passive mobilization of the shoulder under general anaesthesia in these patients. Radiological follow-up demonstrated a complete bony integration of the fragment in all cases. One fragment had healed in an unimproved medially displaced position, which, however, did not adversely affect this patient's outcome. Postoperative CT scans revealed an average articular step formation of 0.8 mm. A satisfactory fragment position was present in 15 patients, with an anatomical reduction in 7 and an articular step formation less than 2 mm in 8 cases. Three patients showed an articular step between 2 and 2.5 mm. No substantial glenoid bone loss was detected. Mild osteoarthritic changes were observed in 3 cases (16.6%) with osteophytes less than 3 mm according to the classification system by Samilson and Prieto (Figs. 3, 4).

Discussion

Several surgical options for approaching avulsion fractures of the anterior glenoid rim have been reported in the literature. Depending on the size of the glenoid defect, recommendations for treatment range from Bankart repair procedure to refixation of the bony fragment, both in open or arthroscopic techniques, utilizing either screws or suture anchors [3, 9, 10, 13, 14, 19, 21]. Even conservative treatment appears to be effective in certain cases [12]. Most authors agree in the necessity to re-establish the glenoid bony circumference to allow for an adaptation to the axial and shear forces in the glenohumeral joint [3]. Large glenoid bone deficiency results in distinctive glenohumeral instability [7]. Arthroscopic Bankart repair does not seem to be appropriate to restore shoulder function and stability in patients with large anterior glenoid rim fractures. Rockwood and Matsen [14] recommended open reduction and internal fixation for those fractures involving 25% of the glenoid surface. All patients in our study presented with anterior glenoid rim fragments of significant size and dislocation resulting in an intrarticular step-off. Open reduction of large fragments facilitates exact anatomical reduction and accurate screw placement. Other studies reported on the appearance of postoperative pain due to mechanical screw impingement and recommended smaller implants and a screw placement underneath the joint line with a minimum distance of 3 mm to the glenoid rim to avoid these early complications [19, 21]. In our series only one patient had to undergo revision surgery due to implant loosening and mechanical impingement, which occurred after complete bony integration of the avulsion fragment. Postoperative CT scans revealed a correct implant position in all cases. Moreover, the refixation of smaller or comminuted fragments seems more feasible with open reduction. Depending on fragment size and comminution an additional or alternative fixation with anchor systems might be necessary in these cases. As reported by Tauber et al., we also experienced that screw fixation provides more stability than pins or wires. The guide-wire system allows for a temporary fixation of the fragment and facilitates the implantation of the self-tapping titanium screws with flattened heads, which are biological inert material and cause no prominence on the glenoid rim [21]. A bony consolidation of the fracture was documented in all patients with no observation of non-union. Only in one case the fragment had healed in an unimproved, medially displaced position, which, however, did not adversely affect this patient's outcome.

In our series, eight patients (40%) sustained concomitant shoulder injuries, which partly required additional surgery and enforced a less aggressive rehabilitation protocol. This might have contributed to a restricted range of motion and the necessity of arthroscopic revision surgery and mobilization under general anaesthesia in three patients (15%). It might also explain the slightly inferior functional result in these patients. The protocol of open reduction and internal screw fixation has nevertheless proven to be an effective treatment option to restore shoulder function and achieve

patient satisfaction. No recurrence of shoulder dislocation has been observed and no glenoid bone deficit had developed. Mild degenerative changes corresponding to the classification of Samilson and Prieto were present in 3 (16.6%) patients at follow-up. However, it is arguable whether to relate these osteoarthritic changes to the procedure itself or to the initial traumatic event.

Open reconstruction of glenoid rim fractures following shoulder dislocation is a valuable procedure regarding medium-term subjective and objective scores. It represents a technically practicable and reliable method to restore both accurate anatomy and pain-free shoulder function and strength. Recurrent dislocation, glenoid defects and early onset of osteoarthritis can effectively be avoided.

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