Grafting and fixation of proximal humeral aseptic non union: a prospective case series

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Summary

Background. Fractures of the proximal part of the humerus represent almost 4-5% of all fractures. The rate of non union is estimated to be 1.1 to 10%. Non union, displacement, and fixation failure can be hazardous complications for these injuries. The purpose of our study was to evaluate the outcomes of plate and bone strut allograft with bone chips grafting augmentation in the management of proximal humeral aseptic non union.

Methods. We treated 16 aseptic non union proximal humeral fractures by the medial humeral shaft bone strut allograft and lateral plate and screws with bone chips grafting. The patients’ ages were between 55 and 70 years. The chosen criteria to evaluate the group during the clinical and radiological follow-up were the quality of life measured by The Short Form (12) Health Survey (SF-12), shoulder function and related quality of life measured by the Constant Shoulder Score (CSS) compared with healthy side, bone healing measured by X-rays, and postoperative complications. The follow-up was performed with clinical and radiographic controls at 1, 3, 6 and 12 months. Surgical time and international units of red blood cells transfused were also calculated. The evaluation endpoint was set at 12 months.

Results. The X-rays bone healing occurred in our group on average of 126.4 days after surgery. The surgical time and blood loss were consistent with standard surgical procedures. The quality of life and functional recovery were excellent after plate and bone strut allograft.

Conclusions. Surgical techniques that increase mechanical stability, while incorporating bone biology, are effective aids for treating problematic fractural patterns.

KEY WORDS: aseptic non union; proximal humeral fracture outcome; bone strut allograft; plate; osteosynthesis; complications.

Introduction

Proximal humeral fractures represent about 4-5% of all fractures (1, 2), and are the third most common fracture type in patients with osteoporosis. Currently, the incidence is increasing in patients over 50 years of age. In patients older than 65, the mortality rate in the first year after surgery ranges from 1 to 10%. The displacement fracture patterns require surgical treatment; however this treatment is contraindicated in frail patients because they are unstable and have a high risk of displacement. According to AO principles, reduction with plate fixation is the current recommended approach (2). A recent clinical study has demonstrated that the intramedullary nail may be used in the treatment of 3 and 4 part fractures (Neer’s classification) (3).

For these injuries (2), malunion, secondary fracture displacement, and fixation failure can be dangerous complications (Figure 1). There are also various predisposing factors for the onset of these complications, which are linked to the patient and to the site of fracture. The treatment of aseptic non union, with or without necrosis of the humeral head, is challenging for orthopedic surgeons. The outcomes are often unsatisfactory, as they are associated with long-term morbidity. The purpose of our study was to evaluate the outcomes of the plate opposed to a strut allograft with morcellised bone graft in the management of aseptic non union of the proximal humerus.

Material and methods

From January 2008 to September 2016, we treated 16 aseptic non union proximal humeral fractures by the medial humeral shaft bone strut allograft and lateral plate with screws and bone grafts, at our center of Orthopedics and Traumatology, “Vito Fazzi” Hospital, Lecce, Italy.

The average age of the study population was 62.3 years (range 55-70), and the sex ratio was 0.75 in favor of females (Table 1). All previous fractures were classified according to the Neer’s Classification (4) (Table 1). The proximal humeral fractures were stabilized by plate and screws or short intramedullary nail with screws (Table 1). The side previously operated on was mostly the left in 10 patients (62.5%), while the dominant side previously fractured was to the right in 3 patients (18.75%) and to the left in 2 patients (12.5%) (Table 1). The non union risk factors were smoking in 50% (n=8) of the patients and alcohol abuse in only 12.5% (n=2).
All cases had atrophic non union according to the Weber-Chech classification (5) (Table 1).

All patients had a shoulder and humeral CT scan before surgery.

To understand and study the type of nonunion, we used the Non-Union Scoring System (NUSS) (6). The score averaged 61.7 (range 35-74) (Table 1).

We used the NUSS also to choose the type of surgery to be performed (6).

All patients were informed in a clear and comprehensive way of the type of treatment and other possible surgical and conservative alternatives. Patients were treated according to the ethical standards of the Helsinki Declaration, and were invited to read, understand, and sign the informed consent form.

The chosen criteria to evaluate the group during the clinical and radiological follow-up were the quality of life measured by The Short Form (12) Health Survey (SF-12) (7), the shoulder function and quality of life related to it, measured by the Constant Shoulder Score (CSS) (7) compared with the healthy side, bone healing measured by X-rays, and postoperative complications. The follow-up was performed with clinical and radiographic controls at 1 month, 3 months, 6 months, and 12 months and annually thereafter. We also counted the surgical time and the international units (IU) of red blood cells (RBC) transfused after surgery.

The evaluation endpoint was set at 12 months.

We did not include 21 patients with the chosen exclusion criteria of refractures caused by hematological or oncological pathologies, Grade III and IV shoulder joint osteoarthritis (8), Stage IV or V avascular necrosis of the humeral head according Cruess classification (9, 10), and patients who did not adhere to a minimum follow-up of 24 months.

Surgical technique

In all cases, surgery was performed in beach chair position using the deltopectoral approach (Figure 2). After having exposed the non union focus, we removed the previous implant and surgically reduced the focus of fracture. The humeral shaft strut allograft was prepared on a separate table and the Philos1 plate (Synthes, Oberdorf, Switzerland) was temporarily fixed with a K-wire. Cortical screws were to stabilize the strut bone allograft, which was placed to support the medial humeral neck. Afterwards, we drilled the humeral head only subchondrally to implant cephalic screws of the correct length (Figure 3). Bone grafts were placed as an augmentation inside the humeral head and neck. In addition, the tuberosities were sutured with non-absorbable wire. At the end of the surgery, the reduction result was inspected by fluoroscopy in three different views (AP, external rotation, and axial).

Rehabilitation

All patients adhered to the standardized postoperative rehabilitation protocol. Patients wore a shoulder brace for three weeks following surgery. Pendulum exercises were implemented after 2 weeks from surgery. Free range of motion (ROM) with elevation of >90° was started 8 weeks after surgery.

Results

The mean of follow-up was 32 months (range 12-96).

The surgery lasted an average of 105.2 minutes (range 65-145). The RBC IU of preoperative transfusions in our patients was on average of 0.8 IU (range 0-3).

All 16 patients demonstrated wound healing within 21 days. In 16 patients, we intraoperatively confirmed the previous 10 cases of avascular necrosis of humeral head. According Cruess Classification (9, 10), we found 1 patient in Stage I, 5 patients in Stage II (Osteopenia and Sclerosis, wedge and mottled), and 4 patients in Stage III (Crescent sign indicating a subchondral fracture).

The quality of life of our study population before the trauma, measured by SF-12, was about 94.8 (range 88-100) points. Preoperatively, the SF-12 was 34.7 (range 22.8-54.3). Twelve months after surgery, the SF-12 score was 88.3 (range 64.3-
For a more detailed description see Figure 4. The functionality of the affected shoulder and quality of life before the trauma, measured by CSS, was about 92.6 points (range 88-100). Preoperatively, the CSS was 26.4 (range 18-40) in the affected shoulder and 88.6 (range 74-92) in the non-affected shoulder. The non-affected shoulder score decreased because patients had to increase its functionality and loading to perform normal daily activities, which led increased fatigue and soreness (Figure 5). At the 6 month follow-up, the CSS score was 76.3 (range 68-88) points and the difference between the affected and non-affected shoulder decreased by 11 points, indicating excellent results. For a more detailed description see Figure 5.

There were no cases of infection, implant failure, or humeral head necrosis during the 24 months of follow-up from the revision surgery.

The X-rays bone healing occurred in about 126.4 (range 90-210) days after surgery (Figure 6). The median range of motion in the affected shoulder was 138° of flexion (range 84°-167°), extension 39° (range 30°- 54°), internal rotation 42° (range 25°-65°), external rotation 55° (range 25°- 90°), and abduction 115° (range 75°-180°).

### Discussion

Early complications represent a significant problem in shoulder surgery, but late clinical complications are an even greater problem. The three major clinical complications are avascular necrosis of the humeral head, sepsis, and non union. The frequency of avascular necrosis of the humeral head is 4-5%, which varies considerably depending on if treatment surgical or non-surgical (1, 10). The incidence of infection is very variable in the literature, ranging from 0 to 10%. The incidence of non union in proximal humeral fractures is about 1.1%, although it may increase to 8% in cases with metaphyseal comminution, and to 10% if the surgical neck is involved (1, 11).

Many clinical studies based on the reduction of 3 and 4 part proximal humeral fractures using plate and nails show cases of non union, even though they are numerically lower than infections (12-14). Non union is a mechanical problem affected by internal fixation, and is also influenced biological factors and comorbidity (1). Based on these factors, our study population may be divided in Group 2 and Group 3 according to NUSS (1).

Some studies show that non union is a variable outcome, highly influenced by the perforation of the articular surface with screws or varus collapse, especially in comminuted osteoporotic bone fractures of the medial plateau (15). Adequate mechanical medial column support may be obtained by an anatomical reduction of the fracture and a medial cortical contact in the case of comminution, by placing an oblique locking screw from the inferomedial region of the proximal fragment (15, 16).

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**Table 1 - Description of population. Demographic data, risk factors, and complications.**

<table>
<thead>
<tr>
<th>Number of patients</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age (years)</td>
<td>62.3</td>
</tr>
<tr>
<td>Range of age (years)</td>
<td>55-70</td>
</tr>
<tr>
<td>Gender (M:F)</td>
<td>6:8</td>
</tr>
<tr>
<td>Male/Female ratio</td>
<td>0.75</td>
</tr>
<tr>
<td>Type of fracture according Neer's Classification (%)</td>
<td></td>
</tr>
<tr>
<td>I fragment:</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>II fragments:</td>
<td>3 (18.75%)</td>
</tr>
<tr>
<td>III fragments:</td>
<td>8 (50%)</td>
</tr>
<tr>
<td>IV fragments:</td>
<td>5 (31.25%)</td>
</tr>
<tr>
<td>Orthopedic device used in the surgery for the osteosynthesis of the first proximal humeral fracture</td>
<td>Plate: 12 (75%)</td>
</tr>
<tr>
<td></td>
<td>Short Nail: 4 (25%)</td>
</tr>
<tr>
<td>Type of Non Union according Weber-Cech classification</td>
<td>Atrophic or Avascular: 16 (100%)</td>
</tr>
<tr>
<td>Side of Non Union; N and (%)</td>
<td></td>
</tr>
<tr>
<td>Right:</td>
<td>6 (37.5%)</td>
</tr>
<tr>
<td>Left:</td>
<td>10 (62.5%)</td>
</tr>
<tr>
<td>Number and % of dominant side</td>
<td></td>
</tr>
<tr>
<td>Right:</td>
<td>3 (18.75%)</td>
</tr>
<tr>
<td>Left:</td>
<td>2 (12.5%)</td>
</tr>
<tr>
<td>Average Point of Non Union Scoring System</td>
<td>61.7</td>
</tr>
<tr>
<td>Range of Non Union Scoring System</td>
<td>35-74</td>
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<tr>
<td>Smoking</td>
<td>Yes: 8 (50%)</td>
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<tr>
<td>&gt;20 cig/d:</td>
<td>6 (37.5%)</td>
</tr>
<tr>
<td>No:</td>
<td>8 (50%)</td>
</tr>
<tr>
<td>Alcohol</td>
<td>Occasional: 10 (62.5%)</td>
</tr>
<tr>
<td>Frequent:</td>
<td>4 (25%)</td>
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<tr>
<td>Abuse:</td>
<td>2 (12.5%)</td>
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<tr>
<td>Complications</td>
<td>Avascular Necrosis of the humeral head: 1 (62.5%)</td>
</tr>
<tr>
<td>Non-union:</td>
<td>16 (100%)</td>
</tr>
<tr>
<td>Screw cut out:</td>
<td>8 (50%)</td>
</tr>
</tbody>
</table>
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Figure 2 - After two days the patients went under surgery, by deltopectoral approach: we removed firstly the old hardware (A-B); we founded an aseptic non union (C); we drilled the intramedullary humeral shaft (D) and the hole of bone cervical screws (E); we implanted a medial bone strut allograft with a lateral plate and screws and an augmentation of bone chips (F).

Figure 3 - The schematic illustration showing the transition from improper reduction of the proximal wall (on the left: scum lines and balls), the vision of the intra operative correct fracture reduction and treatment of osteoporosis, the XR postoperative control showing the correct reduction medial wall (on the right: squares line) grafting of bone plate and bone chip augmentation.
Figure 4 - Trend of the follow-up of quality of life measured by The Short Form (12) Health Survey (SF-12). At the twelfth month of follow-up already there was a good recovery before the first trauma.

Figure 5 - Trend of the follow-up of the affected shoulder joint measured by Constant Shoulder Score (CSS) compared with non affected shoulder joint. At the twelfth month of follow-up already there was an excellent recovery.

Figure 6 - XR control at 9 months after surgery in our structure: the two projections AP (A) and Oblique (B) show the correct consolidation of the fracture. The images C, D, E and F show that despite the good consolidation functional recovery is sufficient for the activities of normal daily life.
Matassi et al. (15) reported the evaluation of clinical and radiographic outcomes of the plate and locking screws with intramedullary graft of allogeneic fibula in unstable humeral fractures in 17 patients (13). The outcomes revealed positive results in that no patients were lost during follow-up and there were no major complications. Collapse of the humeral head was no more than 2 mm, and no osteonecrosis or screw perforation of the articular surface occurred. All fractures healed clinically and radiographically. After an average follow-up of 13 months, the mean Constant score was 79 points. The mean active flexion was 149°, extension was 47°, internal rotation was 40°, external rotation was 65°, and abduction was 135°. The median VAS pain level was 1 point. The median DASH score was 33 points, and the median SF36 was 83 points.

Lescheid JH et al. (18) in their biomechanical study reported an experience with forty synthetic humeri divided into three subgroups. They were osteotomized and fixed at 0 degrees, 10 degrees, and 20 degrees of varus mal-reduction, with a locking proximal humerus plate to simulate mechanical medial support with cortical contact retained. For isolated mal-reduction with cortical contact, the construct at 0 degrees showed statistically equivalent or higher axial, torsional, and shear stiffness than other subgroups examined (18). However, constructs with cortical contact is 0 degrees and 10 degrees yielded mean shear failure forces of 12965.4 N and 9341.1 N, respectively, being statistically higher (p <0.05) compared with most other subgroups tested. Specimens failed primarily by plate bending as the humeral head was pushed down medially and distally (18). Analysis of the histomorphometry and microstructural architecture of the humeral head bone stock demonstrated that trabecular thickness and density are greater in the medial region compared to the lateral side, flexion was impaired by 13%, abduction by 14%, and external rotation by 15%. On average, the initial varus displacement was 38° (51° preoperatively to 13° postoperatively). The disadvantage of this technique proposed by (15) Euler et al. and Carulli et al. (13) was the prolonged surgical time and possible increased risk of nonunion. However, these disadvantages are considered normal in a revision or salvage surgery.

Thompson et al. (27) proposed to treat proximal humeral nonunions with compressive plating. They reported only three cases with positive results in pain relief and functional outcomes. However, this surgical technique has numerous known complications (28).

Despite significant advances in surgical technique and a constantly expanding armamentarium of reconstructive options, adequate fixation of metalwork in bone loss remains a problem (29). Joint replacement options for proximal humeral fractures include shoulder hemiarthroplasty, stemmed total shoulder, and reverse polarity total shoulder replacements. These options may be used in elderly patients with displaced four-part fractures, fracture dislocations, and head-splitting fractures with a high risk of avascular necrosis. Additionally, they can be used as salvage procedures following failed reconstruction. Primary replacement surgery is less attractive in young active patients, given the limited longevity of the prosthesis and potential need for several revision operations (29). Hemiarthroplasty is the most commonly used replacement option, 29 indicated for the revision of failed reconstructions, provided the tuberosities remain intact. However, tuberosity reabsorption is one of the most feared events of correct or incorrect osteosynthesis of the proximal humeral fracture (1, 14). A high rate of complications with reverse polarity total shoulder arthroplasty has been reported by Bronson et al. (30) in a recent systematic review of the literature. These included dislocation, infection, hematoma, instability, neurological injury, intraoperative and periprosthetic fracture, baseplate failure, and scapular notching (30), which in the long-term has been associated with component loosening and glenoid bone loss (29). The prosthetic solution should be reserved only in elderly patients (29, 30).

The perception of an improved physical and mental quality of life was greater in our group than the first surgery or bloodless treatment as reported in a meta-analysis (14). In the scientific literature, there is evidence that early mobilization (within one week) resulted in less pain and faster recovery in patients with stable fractures compared with a delayed mobilization (after three weeks) (16). Although aseptic nonunions are not stable fractures (16), very limited evidence suggests similar outcomes for early versus delayed mobilization after surgical fixation (16). Locking plate with bone splint allograft and bone grafts is a reliable and promising technique to support the humeral head and...
maintain reduction in the treatment of proximal humeral aseptic non unions with medial comminution. We suggest the use of this technique in proximal humeral aseptic non union with medial comminution to restore the integrity of the medial wall, support the humeral head, and to maintain reduction until complete healing. This technique may minimize the risk of reverse shoulder arthroplasty or hemiarthroplasty in selected patients.

Acknowledgments

Conflict of interest statement

All Authors do not have any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential conflicts of interest include employment, consultations, stock ownership, fees, paid expert testimony, patent applications/registrations, and grants or other funds.

Human and animal right

This type of study does not require any statement relating to studies on humans and animals. All patients gave the informed consent prior to being included into the study. All procedures involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments.

References


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