



Outcome and Complications of Proximal Humeral Fractures after ORIF with Angular Stable Plating: A Single Center Study

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Abstract Background: The incidence of proximal humeral fractures has increased in the last decades. There is still a debate regarding conservative and operative indication and type of fixation or replacement. Therefore, long-term post-therapeutic follow up is essential to identify the posttherapeutic outcome of different interventions. In this context, fracture registries were recently introduced and facilitated outcome improvement. The goal of this research is to review the post-therapeutic outcome and complication of proximal humeral fractures after management with ORIF with angular stable plating. **Methods:** All patients who had a proximal humeral fracture and were managed with angular stable plating over 10 years period (2012-2022) in King Fahad Hospital Hofuf were identified. AO/OTA and Neer classification systems were used. Long-term functional outcome was assessed primarily through a validated patient-reported questionnaire, the Munich Shoulder Questionnaire (MSQ), from which Constant score equivalents were derived. We analyzed the demographic data like age, follow up interval, fracture type and functional parameters of the MSQ and Constant score. Exclusion criteria were patients with: polytrauma, open fractures, neurovascular associated injuries, neurological disorders, follow up under 12 months, patients younger than 16 and older than 95 years old and patients unable to consent. **Results:** All Patients with proximal humeral fractures who were treated with angular stable plating (n = 595) were identified in our center between 2012-2022 with female predominance (n = 378; 63,6%). About 268 questionnaires were successfully completed (45% response rate). 268 patients were managed with angular stable plating with 3- and 4-part fractures was 160 and 108 respectively. Mean MSQ score after angular stable plating of 3- and 4-part fractures was 86,3 and 72,8 respectively. Postoperative complications after angular stable plating were: 2,5% secondary varus malalignment, 2,23% AVN, 2,61% shoulder stiffness, 0,37% shoulder impingement, 2,61% cut out, 0,74% non-union. **Conclusion:** In this single-center retrospective cohort, ORIF with angular stable plating was associated with generally acceptable patient-reported functional outcomes and a relatively low recorded complication frequency among respondents. The most commonly recorded complications were screw cutout and shoulder stiffness. These findings should be interpreted cautiously because of the retrospective design and the 45% questionnaire response rate.

Key Words Fracture Register, Shoulder, Proximal Humerus, Outcome, Function, Patient-Rated Outcome Measure, PROM

INTRODUCTION

The incidence of proximal humeral fractures has increased in the last decades [1]. Conservative management of undisplaced proximal humeral fractures has satisfactory outcomes. Otherwise, displaced multifragmentary fractures should be surgically treated [1-6]. Different surgical modalities were described from minimal invasive percutaneous techniques to total shoulder arthroplasty. There is still a debate regarding conservative and surgical indication and type of fixation or replacement [6]. This is particularly relevant for angular stable plating, which

remains one of the most frequently used fixation strategies for displaced proximal humeral fractures, especially in 3-part and selected 4-part patterns. However, outcomes are influenced by patient age, bone quality, fracture complexity, surgical technique and local rehabilitation conditions. For this reason, single-center data from Hofuf are valuable because they provide center-specific information on treatment patterns, patient-reported function and recorded complications within the local Saudi clinical context [7]. This is particularly relevant for angular stable plating, which remains one of the most frequently used fixation strategies

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Double-blinded, Randomized Controlled Trials (RCTs) are considered the gold standard method to study results of therapeutic interventions. In this context, fracture registers were recently introduced. These fracture registers helped trauma surgeons understand fracture types, compare different management modalities and identify the posttherapeutic outcome and function.

METHODS

We retrospectively identified all patients treated with ORIF using angular stable plating for proximal humeral fractures at King Fahad Hospital, Hofuf, during the period 2012–2022. Eligible cases were identified from hospital operative records and fracture registry documentation and fracture patterns were classified using AO/OTA and Neer systems based on recorded clinical and radiographic documentation. AO/OTA and Neer classification systems were used. We sent a validated standardized questionnaire to test the post-therapeutic functional outcome of the shoulder (MSQ; Munich Shoulder Questionnaire). Questionnaire follow-up was performed through direct patient contact using the available hospital contact information. The MSQ was administered in the language routinely used for patient communication in our center and completed responses were used to derive the corresponding Constant score values. Because this was a retrospective long-term follow-up study, not all originally treated patients could be successfully contacted or included in the final questionnaire analysis. We analyzed the demographic data like age, follow up interval, fracture type and functional parameters of the MSQ and Constant score. Exclusion criteria were patients with: polytrauma, open fractures, neurovascular associated injuries, neurological

disorders, follow up under 12 months, patients younger than 16 and older than 95 years old and patients unable to consent. Because of the retrospective design, detailed screening for all pre-existing shoulder disorders, severe glenohumeral arthritis, cognitive impairment, or rehabilitation non-compliance was not uniformly available for every case and should be considered a limitation of cohort characterization.

Statistical Analysis

The present study was analyzed primarily using descriptive statistics. Categorical variables were summarized as frequencies and percentages, while continuous variables were summarized as means and ranges or follow-up intervals where available. Functional outcomes across fracture groups were presented descriptively. Because of the retrospective design, incomplete follow-up and non-response in a substantial proportion of the original cohort, no formal regression modeling or inferential subgroup testing was performed in the present analysis. Therefore, differences between fracture groups should be interpreted as descriptive rather than statistically confirmed.

RESULTS

A total of 595 patients with proximal humeral fractures treated with angular stable plating were identified in our fracture register between 2012 and 2022. The overall identified cohort showed female predominance ($n = 378$; 63.6%). Of the total identified cases, 268 patients completed the long-term questionnaire and formed the respondent cohort for functional-outcome analysis, corresponding to a response rate of 45%. These respondent data form the basis of the patient-reported outcome findings presented below. 268 patients were managed with angular stable plating with 3- and 4-part fractures was 160 and 108 respectively. Mean MSQ score after angular stable plating of 3- and 4-part fractures was 86,3 and 72,8 respectively. Postoperative complications after angular stable plating were: 2,5% secondary varus malalignment, 2,23% AVN, 2,61% shoulder stiffness, 0,37% shoulder impingement, 2,61% cut out, 0,74% non-union (Figure 1).

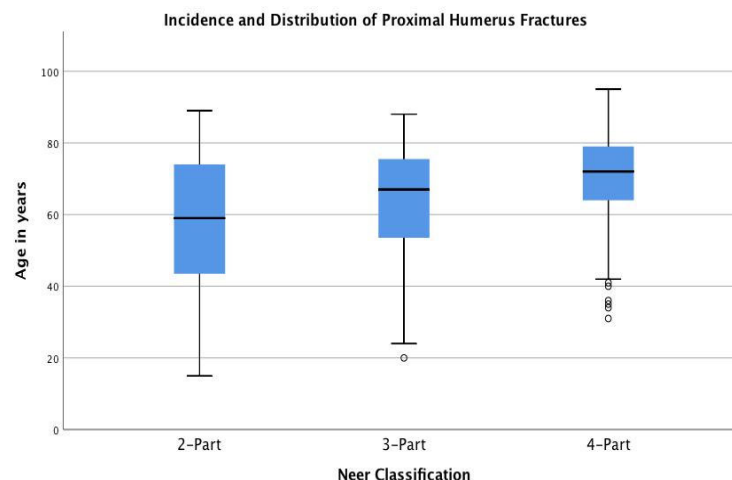


Figure 1: Vertical Boxplot Showing the Incidence of Proximal Humeral Fractures among Age and Neer's Classification

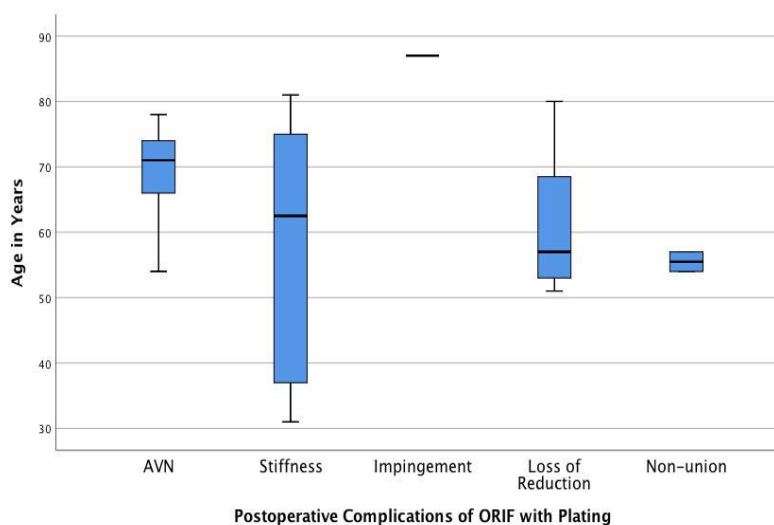


Figure 2: Vertical Boxplot Showing the Distribution of Postoperative Complications of ORIF with Plating among Age

Function

Function was evaluated using the MSQ and Constant scores.

Function after Angular Stable Plating

About 37 patients with 2-part fractures managed with stable angular plating had mean MSQ score of 83,2 and Constant score of 72. 103 patients with 3-part fractures had mean MSQ score of 86,3 and Constant score of 75,7. 128 patients with 4-part fractures had mean MSQ score of 72,8 and Constant score of 62,8. These differences suggest poorer patient-reported function in 4-part fractures than in 2-part and 3-part fractures; however, because formal inferential testing was not performed, these observations should be interpreted descriptively.

Postoperative Complications

Recorded postoperative complications after angular stable plating included secondary varus malalignment in 2.5% of cases, avascular necrosis in 2.23%, shoulder stiffness in 2.61%, shoulder impingement in 0.37%, screw cutout in 2.61% and non-union in 0.74%. Where possible, the corresponding raw case counts have now been added to the results table to improve interpretability (Figure 2).

DISCUSSION

There is a need for establishing nationwide fracture registers as they contribute to a better recognition of resource allocation and improvement of management quality especially in the areas where double-blinded controlled trials are difficult to implement. Within our own center, the main findings were that patient-reported function after angular stable plating was generally better in 2-part and 3-part fractures than in 4-part fractures and that screw cutout and shoulder stiffness were the most commonly recorded complications. These observations are clinically plausible and align with the greater technical and biological challenge of more complex fracture configurations.

Existing Fracture registers like NHFR, DFDB and FDR have proved the importance of establishing population-based fracture registers and have contributed to an improved therapeutic outcome. To our knowledge, the Swedish Fracture Register (SFR) is the only existing fracture register that collect data of all types of fractures and treatment modalities using PROMs.

As to 2017 in the SFR, a total of 98,770 proximal humeral fractures were identified between 2001 and 2012. The overall incidence of proximal humeral fractures increased 31% in the examined period of time (2001-2012). A total of 17,013 surgical procedures were conducted between 2001 and 2012. There were 810 fractures that were treated operatively in 2001 and 1552 fractures in 2012. The number of fractures treated operatively was 4892 (29%) in men and 12,121 (71%) in women with a male to female ratio of 3:7. Open reduction and internal fixation with a plate was the most common procedure ($n = 5050$, 30%), followed by endoprosthesis implantation ($n = 3962$, 23%) and intramedullary nailing ($n = 3376$, 20%). No functional outcomes were yet published.

Among our patients, there was 83% increase of the incidence of proximal humeral fractures over 10 years period (2012-2022). The incidence increases significantly as a result of an aging population with an increased risk of osteoporosis-associated low energy trauma fractures. Nevertheless, treatment of osteoporotic bone fractures has been challenging despite the presence of modern implants and techniques.

Good functional outcomes of angular stable plating were recorded, though with risk of cut out (2,61%), shoulder stiffness (2,61%), secondary varus malalignment (2,5%), AVN (2,23%), non-union (0,74%), shoulder impingement (0,37%). Functional outcome of reversed shoulder arthroplasty was satisfactory with a risk of aseptic loosening (2,17%). There is a limitation assessing the postoperative function of other performed procedures as they were rarely indicated. It is therefore necessary to widen single-center fracture studies to be nationwide with patient-rated outcome measures to be able to assess all treatment modalities and to identify their advantages and disadvantages.

Review of Current Treatment Methods

Conservative as well as different types of surgical management modalities of proximal humeral fracture are still controversially discussed. Fixation with angular stable plates, intramedullary nails, K-wires, tension band wiring and humeral head replacement whether with hemi- or total arthroplasty were in the literature discussed? Therefore, careful evaluation of proximal humeral fractures is crucial for the right indication to gain a better function and avoid postoperative complications.

Although angular stable plating is considered the most widely used type of fixation of proximal humeral fractures, it has a relatively high rate of complications including varus malalignment, cut out, avascular necrosis and shoulder stiffness, particularly with elderly patients [8]. Angular stable plates are considered biomechanically the most stable implants. Compared with intramedullary nailing, interlocking plates have a better stability particularly in torsion and bending moments [9].

Age, bone quality, type of fracture, head split, functional demand and other factors must always be considered. In this context, indication of primary humeral head replacement should always be considered with osteoporotic unreconstructable 3- and 4-part fractures.

Percutaneous Pinning and Tension Band Wiring

Many authors described the fixation of proximal humeral fractures with percutaneous pinning and tension band wiring with satisfactory results [4,5,10,11]. Otherwise, it has a higher risk of proximal wire migration and loss of fixation [5,6,10,11]. Thus, limiting its indication to displaced 2-part fractures with good bone quality. On the other hand, surgical technique and type of implant play a major role. Herscovici *et al.* [10] demonstrated 100% failure rate using K-wires, 20% failure rate using DHS pins, though, no failure using Schantz pins.

Intramedullary Nailing

Intramedullary nailing provides minimal invasive fixation with more biomechanical stability compared to percutaneous pinning. It provides a good option for elderly patients with displaced 2- and 3-part fractures. It preserves the periosteal and soft tissue envelope [6,12-15].

Surgical technique tends to play a major role as poor insertion point and closed reduction have great effect on the postoperative results. As the nails's insertion is very close to the rotator cuff, it often leads to rotator cuff tendinopathy and unsatisfactory results with younger patients [6]. Nevertheless, metaphyseal comminution has an adverse effect on this type of fixation. Several authors stated satisfactory results after interlocking intramedullary nailing for elderly patients with displaced 2- and 3-part fractures enabling an earlier range of motion with satisfactory function. Poor function was noted with displaced 4-part fractures [12-15].

ORIF with Angular Stable Plating

Angular stable plating is considered the most widely used type of fixation of 3- and 4-part proximal humeral fractures as it is the most biomechanically stable implant with

satisfactory postoperative outcome [9]. On the other hand, poor surgical technique with extensive manipulation and soft tissue damage lead to humeral head ischemia and screw perforation which are challenging complications requiring revision and subsequently humeral head replacement [6]. In addition, some authors reported open reduction and internal fixation is inferior to closed reduction and internal fixation with elderly patients because of high rate of shoulder stiffness, avascular necrosis and loss of fixation [8,11].

New Modalities

Screw perforation after ORIF has been a challenging complication. Predisposing factors are: 3- and 4-part fractures, advanced age, inadequate medial hinge and osteoporotic bone. Recent studies have shown that ORIF with fixed angular stable plates with fracture site augmentation with calcium phosphate reduces the risk of screw perforation and loss of fixation [16,17]. Thus, maintaining normal anatomy and a better function with reconstructable 3- and 4-part fractures and elderly highly active patients.

Humeral Head Replacement

The indication of humeral head replacement should be considered with elderly patients with osteoporotic bone, fractures with increased risk of humeral head ischemia as well as fractures with signs of irreparability (tuberosity comminution, indiscernible fracture fragments, soft bone that depresses under digital pressure, egg-shell like cortical bone, humeral head devoid of soft-tissue attachment and significant fracture displacement and/or calcar comminution) [2,3,18,19].

Although Hemiarthroplasty preserves the normal glenohumeral articulation, its indication in the acute management of multifragmentary proximal humeral fractures is limited. It requires intact tuberosities and rotator cuff, which are usually damaged and difficult to reconstruct in displaced 3- and 4-part fractures and thus resulting in poor function with non-functioning rotator cuff [20-23].

In such cases, reverse shoulder arthroplasty should be considered as it medializes the glenohumeral center of rotation recruiting the deltoid muscle to compensate for the deficient rotator cuff [22-25].

Cuff *et al.* [23] compared the functional outcome of primary hemiarthroplasty and reverse shoulder arthroplasty for the treatment of proximal humeral fractures in elderly patients. A better functional outcome with less revision rate was noticed with the primary treatment with reverse shoulder arthroplasty.

Limitations

This retrospective single-center study is subject to selection bias and incomplete data. The 45% response rate introduces potential follow-up bias. Outcomes were mainly patient-reported and descriptively analyzed without standardized clinical, radiographic, or statistical evaluation, limiting causal and comparative conclusions.

CONCLUSION

In this single-center retrospective cohort, ORIF with angular stable plating was associated with generally acceptable patient-reported functional outcomes and a relatively low frequency of recorded complications among respondents. Functional outcomes appeared less favorable in more complex fracture patterns, particularly 4-part fractures and screw cutout and shoulder stiffness were the most commonly recorded complications. Because of the retrospective design, incomplete follow-up and absence of formal comparative analysis, these findings should be interpreted cautiously. Further multicenter and prospective studies are needed to strengthen evidence for surgical decision-making in proximal humeral fractures.

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