**Name of Journal:** *World Journal of Orthopedics*

**Manuscript NO:** 65833

**Manuscript Type:** ORIGINAL ARTICLE

***Prospective Study***

**Plate *vs* reverse shoulder arthroplasty for proximal humeral fractures: The psychological health influence the choice of device?**

Maccagnano G *et al*. Psychological health in proximal humeral fractures

Giuseppe Maccagnano, Giuseppe Solarino, Vito Pesce, Giovanni Vicenti, Michele Coviello, Vittorio Saverio Nappi, Orazio Valerio Giannico, Angela Notarnicola, Biagio Moretti

**Giuseppe Maccagnano, Vito Pesce,** Department of Clinical and Experimental Medicine, Faculty of Medicine and Surgery, University of Foggia, Orthopaedics Unit, General Hospital, Foggia 71122, Italy

**Giuseppe Solarino, Giovanni Vicenti, Michele Coviello, Angela Notarnicola, Biagio Moretti,** Department of Basic Medical Science, Neuroscience and Sensory Organs, Faculty of Medicine and Surgery, University of Bari, Orthopaedics Unit, General Hospital, Bari 70124, Italy

**Vittorio Saverio Nappi,** Orthopaedics Unit, Di Venere General Hospital, Bari 70124, Italy

**Orazio Valerio Giannico,** Department of Biomedical Sciences and Human Oncology, University of Bari Aldo Moro, Bari 70124, Italy

**Author contributions:** Maccagnano G drafted the manuscript, and assisted with data analysis; Solarino G participated in design and oversight of the study; Pesce V drafted the manuscript, and assisted with data analysis; Vicenti G participated in study design and performed statistical analysis; Nappi VS participated in design of the study, and was involved with data collection; Coviello M was involved with data collection, and assisted with data analysis; Giannico OV participated in study design and performed statistical analysis; Notarnicola A participated in design of the study; Moretti B participated in design and oversight of the study.

**Corresponding author: Giuseppe Solarino, MD, PhD, Associate Professor,** Department of Basic Medical Science, Neuroscience and Sensory Organs, Faculty of Medicine and Surgery, University of Bari, Orthopaedics Unit, General Hospital, Piazza Giulio Cesare, 11, Bari 70124, Italy. giuseppe.solarino@uniba.it

**Received:** April 17, 2021

**Revised:** July 6, 2021

**Accepted:** February 19, 2022

**Published online:** March 18, 2022

**Abstract**

BACKGROUND

Proximal humeral fractures represent the third most common observed osteoporotic fracture; the treatment in three and four-part proximal humeral fractures in patients over 65 years is still controversial. Among the treatments described in literature, open reduction and internal fixation (O.R.I.F) and reverse shoulder arthroplasty (RSA) are gaining an increasing popularity.

AIM

To investigate the correct treatment for three and four-part proximal humeral fractures according to psychological aspects.

METHODS

It was conducted a prospective study with a series of 63 patients treated with O.R.I.F. (group A) and with RSA (group B) for three and four-part proximal humeral fractures according to Neer classification system. A conservative treatment group, as control, was finally introduced. One independent observer performed clinical and a psychological evaluation at one (T0), six (T1) and twelve months (T2) postoperatively. The Constant’s score and The Disabilities of the Arm, Shoulder and Hand (DASH score) were used for clinical evaluation, while General Anxiety Disorder-7 (GAD-7) and Caregiver Strain Scale (CSS) were used for psychological evaluation.

RESULTS

At one month follow up in group A the mean values were DASH score 50.8, Constant score 36.1, GAD-7 score 5.4, CSS 5.0. For the group B, the average values at T0 were: DASH score 54.6, Constant score 32.0; GAD-7 score 6.4, CSS 6.2. At six months in group A the average values were DASH score 42.1, Constant score 47.3, GAD-7 score 4.3, CSS 3.9. For the group B, the average values at T1 were: DASH score 39.1, Constant score 43.2, GAD-7 score 5.7, CSS 5.5. At twelve months in the group A, the mean values were DASH score 32.8, Constant score 60.0, GAD-7 score 3.2, CSS 3.1. For the group B shown these mean values: DASH score 33.6, Constant score 52.9, GAD-7 score 4.3, CSS 4.5. We demonstrated a better clinical and psychological outcome at T2 in the group treated with osteosynthesis compared to the group treated with arthroplasty (Constant *P* = 0.049, GAD-7 *P* = 0.012 and CSS *P* = 0.005). A better clinical and psychological outcome emerged in control group at T2 comparing with surgical group (DASH score *P* = 0.014, Constant score *P* < 0.001, GAD-7 *P* = 0.002 and CSS *P* = 0.001).

CONCLUSION

Both open osteosynthesis and reverse shoulder arthroplasty are valid treatments for proximal humeral fractures. According to the best osteosynthesis results the authors suggested to perform a psychological analysis for each patient in order to choose the appropriate treatment.

**Key Words:** Proximal humerus fractures; Open reduction and fixation; Reverse shoulder arthroplasty; Psychological health; General Anxiety Disorder-7 scale; Caregiver Strain scale

**©The** **Author(s) 2022.** Published by Baishideng Publishing Group Inc. All rights reserved.

**Citation:** Maccagnano G, Solarino G, Pesce V, Vicenti G, Coviello M, Nappi VS, Giannico OV, Notarnicola A, Moretti B. Plate *vs* reverse shoulder arthroplasty for proximal humeral fractures: the psychological health influence the choice of device? *World J Orthop* 2022; 13(3): 297-306

**URL:** https://www.wjgnet.com/2218-5836/full/v13/i3/297.htm

**DOI:** https://dx.doi.org/10.5312/wjo.v13.i3.297

**Core Tip:** This was a prospective study with 63 patients seeking to evaluate how psychological factors can influence the choice of device for proximal humeral fractures.

**INTRODUCTION**

Proximal humeral fractures account for 6%-8% of all fractures and around 85% occurs in patients over 50 years old[1]. Most patients sustaining these fractures are women above the age of 60. These fractures represent the third most common observed osteoporotic fracture in elderly patients, after wrist and hip fractures[2-4], with an incidence of 82 per 100000 person-years. It has been suggested that the overall fracture rate is increasing along with the increase in the elderly population[5,6]. Furthermore, a Finnish study estimated the incidence of fall-related proximal humerus fractures has tripled since 1970[7]. The Neer classification, based on the number of bone fragments, is used for the therapeutic decision[8]. This remains the most commonly used classification, but additional systems have been described more recently, giving other useful indications to surgeon for type of surgery to adopt. About 80% of the proximal humeral fractures is nondisplaced or minimally displaced, therefore in these cases the treatment is conservative. In the remaining 20% of cases, the surgical strategy probably is the first option, although conservative treatment is chosen by some surgeons[9]. In relation to different factors, such as age, daily activity, and fracture pattern, operative treatment options include: synthesis and joint replacement[10-13]. Many studies compared the clinical and radiological outcomes of three and four-part proximal humeral fractures in patients over 65 years old treated with open reduction and internal fixation (O.R.I.F.) and joint replacement. Giardella *et al*[14], in their retrospective study enrolling patients over 65 years old, reported better clinical and functional results in patients treated with reverse shoulder arthroplasty (R.S.A.) respect to O.R.I.F, confirming that R.S.A. is the best treatment in proximal humeral fractures in elderly patients, especially in case of a rotator cuff tear or degeneration.

The aim of our study was to compare O.R.I.F. with R.S.A. in terms of clinical and psychological outcomes of three- and four-part proximal humeral fractures in patients older than 65 years evaluating whether post-operative psychological symptoms may influence the clinical results after surgery.

**MATERIALS AND METHODS**

The Authors conducted a prospective observational study with a sequential recruitment of subjects affected by proximal humeral fractures, which was approved by the local Ethics Committee (No. 6809). The study was also registered on ClinicalTrials.gov, Protocol Registration and Result System (NCT04821180).

At the University Hospital of Bari, 63 patients who had undergone shoulder surgery between January 2016 and January 2019 were enrolled.

The inclusion criterion for enrollment was: (1) three and four-part proximal humeral fractures according to Neer classification system; (2) patients seventy years or older; and (3) shoulder surgery within one week after trauma.

The exclusion criteria were: (1) exposed fractures; (2) pathological fractures; (3) proximal humerus fractures with metaphyseal or diaphyseal extension; (4) contraindications to surgery associated with organ dysfunctions or with coagulopathy, allergy or hypersensitivity to the orthopedic implants; (5) patients who were unable to attend the different follow-ups; and (6) patients with psychiatric disorders.

We assumed that all enrolled patients suffered cuff tear arthropathy based on biological and anagraphic age.

All patients were properly informed of the nature of the study and they signed an informed consent document according to the Declaration of Helsinki.

The study group was stratified according to age class (class 1: 70-74 years; class 2: 75-79 years; class 3: 80-85 years) and gender differences (Table 1).

All patients were then divided into two groups according to the choice of surgery treatment: Group A: O.R.I.F. by angle-stable plate PHILOS (PHLPSYNTHES®, Oberdorf, Switzerland) (Figure 1A); and Group B: reverse total shoulder arthroplasty by Modular Shoulder Replacement SMR (LIMA® Corporate, San Benedetto del Friuli, Italy) (Figure 1B).

All patients were treated by the same surgical team with more than five years of experience in upper limb surgery.

The type of treatment was due to rotator cuff status, and shoulder clinical history.

We introduced a control group (Group C), made up of patients with the same characteristics of the study groups, but treated conservatively.

One independent observer performed clinical [Constant score and Disabilities of the Arm, Shoulder and Hand (DASH) score[15,16]] evaluation at one-month (T0), six months (T1) and at one year (T2) post operatively for each groups.

Furthermore the Clinical Psychology Service of our University Hospital performed a psychological evaluation (General Anxiety Disorder-7 scale and Caregiver Strain scale[17,18]) at the same follow-ups for each groups.

The Constant score determines the shoulder functionality and a higher score is indicative of high functional outcomes. The DASH score analyzes individual ability to perform certain activities and a higher score is indicative of worse functional outcomes.

The General Anxiety disorder 7 scale and the Caregiver Strain scale are two screening psychological tools used to define the level of stress. A higher score is indicative of poor outcomes.

In each case we evaluated the antero-posterior, lateral and transthoracic humerus X-rays at the T0, T1 and T2.

***Statistical analysis***

All data were collected electronically and were analyzed using R version 3.5.2 (released on 2018-12-20). In order to account for non-normality (Shapiro-Wilk test), continuous variables were reported as median and interquartile range (IQR) and compared (univariable analysis) through Wilcoxon rank sum test. Categorical variables were reported as absolute and relative frequencies. A multivariable linear regression model was then fitted for each score and time in order to evaluate the effect of PI intervention compared to O.R.I.F. intervention (“beta” coefficients) adjusted for age and sex. Linearity of dependent variable and normality and homoscedasticity of residuals were checked for each model through a test of significance. Statistical significance “alpha” was fixed to 0.05. The primary endpoint examined was psychological outcomes of proximal humeral fractures using General Anxiety disorder 7 scale. The secondary endpoint was clinical and shoulder functionality using Constant score. In addition, the Caregiver Strain scale and DASH score were used to complete psychological and clinical outcomes.

**RESULTS**

The study group was made up of sixty-three patients, 5 males (7.9%) and 58 females (92.1%). The average age was 76.0 (4.0) years, range 70-82. Median (IQR) age was 76.0 (4.0) years.

In 70% of cases the right limb was involved and in 65.1% of cases (41 of 63 cases) were three-part proximal humeral fractures (Table 2).

The analysis showed a prevalence of the four-part proximal humeral fracture in the class 3 age group whilst the three-part proximal humeral fracture in the class 2 (Table 3).

Domestic accident was responsible for 70% of cases whilst road traffic accident was the commonest mechanism in 30% of cases.

The 48.2% (31) of patients were treated by angle stable plate PHILOS (PHLP-SYNTHES®, Oberdorf, Switzerland) with O.R.I.F. (group A) while the 50.8% (32) of patients were treated by reverse total shoulder arthroplasty SMR (LIMA® Corporate, San Benedetto del Friuli, Italy) (group B). The Control group, 32 patients, was treated conservatively.

For the group A, the average values at T0 were: DASH score 50.8 (range 44-62), Constant score 36.1 (range 22-49) (Table 4); as regards the psychological test, the average values at T0 were: General Anxiety Disorder-7 scale 5.4 (range 2-9), Caregiver Strain Scale 5.0 (range 2-9) (Table 4).

For the group B, the average values at T0 were: DASH score 54.6 (range 28-65), Constant score 32.0 (range 23-53) (Table 4); as regards the psychological test, the average values at T0 were: General Anxiety Disorder-7 scale 6.4 (range 3-9), Caregiver Strain Scale 6.2 (range 2-9) (Table 4).

For the group A, the average values at T1 were: DASH score 42.1 (range 32-58), Constant score 47.3 (range 25-63) (Table 5); as regards the psychological test, the average values at T1 were: General Anxiety Disorder-7 scale 4.3 (range 1-8), Caregiver Strain Scale 3.9 (range 1-8) (Table 5).

For the group B, the average values at T1 were: DASH score 39.1 (range 21-60), Constant score 43.2 (range 28-65) (Table 5); as regards the psychological test, the average values at T1 were: General Anxiety Disorder-7 scale 5.7 (range 3-9), Caregiver Strain Scale 5.5 (range 2-9) (Table 5).

At T2 in the group A, the mean values were: DASH score 32.8 (range 16-60), Constant score 60.0 (range 30-80) (Table 6); as regards the psychological test, the average values at T2 were: General Anxiety Disorder-7 scale 3.2 (range 1-7), Caregiver Strain Scale 3.1 (range 1-7) (Table 6).

At T2 the group B shown these mean values: DASH score 33.6 (range 17-55), Constant score 52.9 (range 35-79) (Table 6); as regards the psychological test, the average values at T2 were General Anxiety Disorder-7 scale 4.3 (range 1-7), Caregiver Strain Scale 4.5 (range 1-8) (Table 6).

At T0 median (IQR) DASH score was 53.0 (11.0), Constant score was 34.0 (10.5), General Anxiety Disorder-7 scale was 6.0 (2.0) and Caregiver Strain Scale was 6.0 (3.0).

At T1 median (IQR) DASH score was 38.0 (12.0), Constant score was 44.0 (11.5), General Anxiety Disorder-7 scale was 5.0 (2.5) and Caregiver Strain Scale was 5.0 (3.0).

At T2 median (IQR) DASH score was 32.0 (13.5), Constant score was 55.0 (20.0), General Anxiety Disorder-7 scale was 4.0 (2.5) and Caregiver Strain Scale was 4.0 (3.0).

For the group C, the mean values are reported separately (Table 7).

The univariable analysis (Table 8) showed a significant difference between the two treatment groups for Dash score at T0 (O.R.I.F. *vs* PI, median 50.0 *vs* 57.5, *P* = 0.002), Constant at T0 (O.R.I.F. *vs* PI, median 38.0 *vs* 31.5, *P* = 0.008), GAD-7 at T0 (O.R.I.F. *vs* PI, median 5.0 *vs* 6.0, *P* = 0.015), CSS at T0 (O.R.I.F. *vs* PI, median 5.0 *vs* 6.5, *P* = 0.008), GAD-7 at T1 (O.R.I.F. *vs* PI, median 4.0 *vs* 6.0, *P* = 0.002), CSS at T1 (O.R.I.F. *vs* PI, median 4.0 *vs* 6.0, *P* = 0.001), Constant at T2 (O.R.I.F. *vs* PI, median 60.0 *vs* 51.0, *P* = 0.049), GAD-7 at T2 (O.R.I.F. *vs* PI, median 3.0 *vs* 4.0, *P* = 0.012) and CSS at T2 (O.R.I.F. *vs* PI, median 3.0 *vs* 4.0, *P* = 0.005).

A second univariable analysis (Table 9) between conservative and surgical treatment (using values of the two treatments) was made to enhance the relevance of the study. We reported no statistical difference at T0 regarding clinical and psychological outcomes. On the contrary, conservative treatment has shown to have better clinical and psychological outcomes, although not statistically significant at T1 and statistically significant at T2.

We did not observe complications in the study and control group.

**DISCUSSION**

Three- and four-part fractures account for 21% to 23% of proximal humerus fractures[19,20], are usually treated surgically by O.R.I.F. in younger patients and by arthroplasty in the elderly[21,22].

Many risk factors patient-related such as osteoporosis, degenerative joint disease of the shoulder, rotator cuff dysfunctions, comorbidities and non-modified risk factors such as gender and age class may influence the choice of treatment[23,24].

In accordance with the literature, we reported a gender differences and age class stratification in favor of female and first class which was most represented (Table 1, Table 3)[25,26].

Due to the poor outcomes associated with conventional anatomic replacement of the humeral head, an extended use of the reverse shoulder arthroplasty has emerged in the literature, linked to good results as both a primary procedure and as a secondary procedure for failed open reductions[27-29].

Until now all the studies described in the literature comparing open reduction and osteosynthesis with reverse shoulder arthroplasty as surgical options of treatment for three and four-part proximal humeral fractures in patients over 65 years old, used clinical and radiological methods of evaluation[30-33].

Our study is the first in literature that compares the psychological and functional results in order to underline the importance of each one or both for the pre-operative planning.

In our study, the Authors reported a tendency to the improvement of functional outcomes for the two groups. As regards the DASH and the Constant score, the Authors reported good results in both groups from T0 to T2 by analyzing the average value of Table 4, Table 5, and Table 6.

The univariable analysis (Table 8) showed a significant difference between the two treatment groups in favor of Group A as regards DASH score at T0 (O.R.I.F. *vs* PI, median 50.0 *vs* 57.5, *P* = 0.002) and Constant at T0 (O.R.I.F. *vs* PI, median 38.0 *vs* 31.5, *P* = 0.008).

The Authors linked these results to reach more confidence with the plate respect to the prosthesis. Furthermore, we did not report any statistically significance difference between the two groups at T1 (*P* = 0.256; *P* = 0.110).

The univariable analysis (Table 8) did not show a statistically significant difference between the two treatment groups for DASH score at T2 (O.R.I.F. *vs* PI, median 30.0 *vs* 32.0, *P* = 0.587); as regard the Constant score at T2 (O.R.I.F. *vs* PI, median 60.0 *vs* 51.0, *P* = 0.049), there emerged a statistically significant difference in favor of group A who obtained better results but these were very near to the significance limit.

According to the literature, the functional results of the two surgical options (O.R.I.F. *vs* reverse prosthesis) overlapped at 1 year post operatively[34].

As regards the psychological evaluation, the Authors observed a tendency to the improvement for both groups from T0 to T2 according to Table 4, Table 5, and Table 6.

By better analysis, the Authors highlighted an improvement of psychological evaluation for the group A at T0.

Analyzing GAD-7 at T0 (O.R.I.F. *vs* PI, median 5.0 *vs* 6.0, *P* = 0.015) and CSS at T0 (O.R.I.F. *vs* PI, median 5.0 *vs* 6.5, *P* = 0.008), the Authors reported the superiority in terms of results for the group A respect to the group B according to Table 8.

The statistical evaluation was significant for both tests in the group A and also at T1 and at T2 as reported in the Table 8 analyzing GAD-7 at T1 (O.R.I.F. *vs* PI, median 4.0 *vs* 6.0, *P* = 0.002), CSS at T1 (O.R.I.F. *vs* PI, median 4.0 *vs* 6.0,*P* = 0.001), GAD-7 at T2 (O.R.I.F. *vs* PI, median 3.0 *vs* 4.0, *P* = 0.012) and CSS at T2 (O.R.I.F. *vs* PI, median 3.0 *vs* 4.0, *P* = 0.005).

Patients underwent primary reverse shoulder arthroplasty (group B) showed in each postoperative follow-ups a generalized anxiety disorder and a greater irritability then patients underwent osteosynthesis (group A).

We revealed a residual fear during shoulder movement in patients underwent primary reverse shoulder arthroplasty, unlike the group of patients which have done osteosynthesis, who seemed more confident and secure in shoulder movements.

The authors linked these results for group B to the anxiety about loosening of humeral head. In fact, the patients underwent osteosynthesis, showed better results in terms of anxiety due to the idea to preserve their humeral head. The perception of own humeral head could play a role in the genesis of anxiety.

Moreover, the comparison between the surgical (group A and B) and the conservative group (group C) revealed better clinical and functional results at 12 mo for the group C. In fact, with mean values of 3.1 and 3.0 for the GAD-7 and CSS scales respectively, the group C showed less anxiety and fear at T2 notwithstanding at 12 mo no statistically differences were found. These results are consistent with a previous study that underlined the importance of conservative treatment which remains a valid option mainly in the three-part proximal humeral fractures in selected cases with good functional results and low complications[9].

This study has some limitations: the number of participants is limited to 63; the maximum follow-up achieved was 12 mo; the device for open reduction and internal fixation used was a single type of angle stable plate with specific surgical technique.

**CONCLUSION**

The aim of our study was to compare open osteosynthesis and reverse shoulder arthroplasty in the three and four-part proximal humeral fractures, in terms of functional and psychological scores at one, six months and at one year follow-ups in order to underline the importance of each one or both of them for the pre-operative planning.

Based on the results obtained, we highlighted the best results for group A in terms of psychological results respect to group B.

For this reason, we suggest to evaluate before surgical choice not only anatomical parameters but also patient psychological profile, always evaluating the possibility of a hypothetical conservative treatment.

The strong point of our study is the type of the study in fact it is a prospective observational comparative study.

Instead, the weak point is the lack of psychological evaluation for each patient enrolled before the surgery.

Due to the pain after the trauma, the Authors did not administer the psychological evaluation because it may be influenced negatively.

According to recent data of bibliography, we confirm the efficacy at 1 year of the osteosynthesis and shoulder arthroplasty in terms of functional evaluation.

As pointed out by the Authors, it is very important to perform a psychological analysis of each patient, in order to identify correctly the patient and to reserve the shoulder arthroplasty for a very limit case in which the bone stock is very poor.

**ARTICLE HIGHLIGHTS**

***Research background***

Patient affected by fractures is evaluated only from a surgical point of view. Psychological aspect is very often underestimated.

***Research motivation***

More studies are needed in literature, to evaluate before surgical choice not only anatomical parameters but also patient psychological profile.

***Research objectives***

The aim of our study was to compare open reduction and internal fixation with joint replacement in terms of clinical and psychological outcomes of three- and four- part proximal humeral fractures in patients older than 65 years evaluating whether post-operative psychological symptoms may influence the clinical results after surgery.

***Research methods***

An observational prospective single-center study with 12 mo follow-up was performed with a sequential recruitment of subjects affected by proximal humeral fractures treated with open reduction and internal fixation and joint replacement. A conservative treatment group, as control, was introduced.

***Research results***

Patients underwent primary reverse shoulder arthroplasty showed in each postoperative follow-ups a generalized anxiety disorder and a greater irritability then patients underwent osteosynthesis.

***Research conclusions***

Patient psychological profile should be evaluated by the surgeon before surgery for the choice of surgical devices.

***Research perspectives***

Future investigations are needed to confirm the role of the psychological profile in the field of orthopedic surgical treatment. In addition, long- term analysis needs to clarify if differences in outcomes are really related to the patient’s mental state.

**REFERENCES**

1 **Court-Brown CM**, Caesar B. Epidemiology of adult fractures: A review. *Injury* 2006; **37**: 691-697 [PMID: 16814787 DOI: 10.1016/j.injury.2006.04.130]

2 **Lauritzen JB**, Schwarz P, Lund B, McNair P, Transbøl I. Changing incidence and residual lifetime risk of common osteoporosis-related fractures. *Osteoporos Int* 1993; **3**: 127-132 [PMID: 8481588 DOI: 10.1007/BF01623273]

3 **Seeley DG**, Browner WS, Nevitt MC, Genant HK, Scott JC, Cummings SR. Which fractures are associated with low appendicular bone mass in elderly women? The Study of Osteoporotic Fractures Research Group. *Ann Intern Med* 1991; **115**: 837-842 [PMID: 1952469 DOI: 10.7326/0003-4819-115-11-837]

4 **Launonen AP**, Lepola V, Saranko A, Flinkkilä T, Laitinen M, Mattila VM. Epidemiology of proximal humerus fractures. *Arch Osteoporos* 2015; **10**: 209 [PMID: 25675881 DOI: 10.1007/s11657-015-0209-4]

5 **van Staa TP**, Dennison EM, Leufkens HG, Cooper C. Epidemiology of fractures in England and Wales. *Bone* 2001; **29**: 517-522 [PMID: 11728921 DOI: 10.1016/s8756-3282(01)00614-7]

6 **Hagino H**, Yamamoto K, Ohshiro H, Nakamura T, Kishimoto H, Nose T. Changing incidence of hip, distal radius, and proximal humerus fractures in Tottori Prefecture, Japan. *Bone* 1999; **24**: 265-270 [PMID: 10071921 DOI: 10.1016/s8756-3282(98)00175-6]

7 **Palvanen M**, Kannus P, Niemi S, Parkkari J. Update in the epidemiology of proximal humeral fractures. *Clin Orthop Relat Res* 2006; **442**: 87-92 [PMID: 16394745 DOI: 10.1097/01.blo.0000194672.79634.78]

8 **Neer CS 2nd**. Displaced proximal humeral fractures. I. Classification and evaluation. *J Bone Joint Surg Am* 1970; **52**: 1077-1089 [PMID: 5455339]

9 **Soler-Peiro M**, García-Martínez L, Aguilella L, Perez-Bermejo M. Conservative treatment of 3-part and 4-part proximal humeral fractures: a systematic review. *J Orthop Surg Res* 2020; **15**: 347 [PMID: 32831119 DOI: 10.1186/s13018-020-01880-7]

10 **Beks RB**, Ochen Y, Frima H, Smeeing DPJ, van der Meijden O, Timmers TK, van der Velde D, van Heijl M, Leenen LPH, Groenwold RHH, Houwert RM. Operative versus nonoperative treatment of proximal humeral fractures: a systematic review, meta-analysis, and comparison of observational studies and randomized controlled trials. *J Shoulder Elbow Surg* 2018; **27**: 1526-1534 [PMID: 29735376 DOI: 10.1016/j.jse.2018.03.009]

11 **Robinson CM**, Page RS, Hill RM, Sanders DL, Court-Brown CM, Wakefield AE. Primary hemiarthroplasty for treatment of proximal humeral fractures. *J Bone Joint Surg Am* 2003; **85**: 1215-1223 [PMID: 12851345 DOI: 10.2106/00004623-200307000-00006]

12 **Solberg BD**, Moon CN, Franco DP, Paiement GD. Surgical treatment of three and four-part proximal humeral fractures. *J Bone Joint Surg Am* 2009; **91**: 1689-1697 [PMID: 19571092 DOI: 10.2106/JBJS.H.00133]

13 **de Kruijf M**, Vroemen JP, de Leur K, van der Voort EA, Vos DI, Van der Laan L. Proximal fractures of the humerus in patients older than 75 years of age: should we consider operative treatment? *J Orthop Traumatol* 2014; **15**: 111-115 [PMID: 24233865 DOI: 10.1007/s10195-013-0273-8]

14 **Giardella A**, Ascione F, Mocchi M, Berlusconi M, Romano AM, Oliva F, Maradei L. Reverse total shoulder versus angular stable plate treatment for proximal humeral fractures in over 65 years old patients. *Muscles Ligaments Tendons J* 2017; **7**: 271-278 [PMID: 29264338 DOI: 10.11138/mltj/2017.7.2.271]

15 **Constant RC**. Age related recovery of shoulder function after injury. Thesis, Univ Coll. 1986.

16 **Hudak PL**, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *Am J Ind Med* 1996; **29**: 602-608 [PMID: 8773720 DOI: 10.1002/(SICI)1097-0274(199606)29:6<602::AID-AJIM4>3.0.CO;2-L]

17 **Sadak T**, Korpak A, Wright JD, Lee MK, Noel M, Buckwalter K, Borson S. Psychometric Evaluation of Kingston Caregiver Stress Scale. *Clin Gerontol* 2017; **40**: 268-280 [PMID: 28459351 DOI: 10.1080/07317115.2017.1313349]

18 **Spitzer RL**, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med* 2006; **166**: 1092-1097 [PMID: 16717171 DOI: 10.1001/archinte.166.10.1092]

19 **Tamai K**, Ishige N, Kuroda S, Ohno W, Itoh H, Hashiguchi H, Iizawa N, Mikasa M. Four-segment classification of proximal humeral fractures revisited: a multicenter study on 509 cases. *J Shoulder Elbow Surg* 2009; **18**: 845-850 [PMID: 19297201 DOI: 10.1016/j.jse.2009.01.018]

20 **Schumaier A**, Grawe B. Proximal Humerus Fractures: Evaluation and Management in the Elderly Patient. *Geriatr Orthop Surg Rehabil* 2018; **9**: 2151458517750516 [PMID: 29399372 DOI: 10.1177/2151458517750516]

21 **Boileau P**, Pennington SD, Alami G. Proximal humeral fractures in younger patients: fixation techniques and arthroplasty. *J Shoulder Elbow Surg* 2011; **20**: S47-S60 [PMID: 21281922 DOI: 10.1016/j.jse.2010.12.006]

22 **Gregory TM**, Vandenbussche E, Augereau B. Surgical treatment of three and four-part proximal humeral fractures. *Orthop Traumatol Surg Res* 2013; **99**: S197-S207 [PMID: 23333125 DOI: 10.1016/j.otsr.2012.12.006]

23 **Murray IR**, Amin AK, White TO, Robinson CM. Proximal humeral fractures: current concepts in classification, treatment and outcomes. *J Bone Joint Surg Br* 2011; **93**: 1-11 [PMID: 21196536 DOI: 10.1302/0301-620X.93B1.25702]

24 **Murena L**, Canton G, Ratti C, Hoxhaj B, Giraldi G, Surace MF, Grassi FA. Indications and results of osteosynthesis for proximal humerus fragility fractures in elderly patients. *Orthop Rev (Pavia)* 2020; **12**: 8559 [PMID: 32391138 DOI: 10.4081/or.2020.8559]

25 **de Oliveira AP**, Mestieri MC, Pontin JC. Epidemiological Profile of Patients with Proximal Humerus Fracture Treated at Hospital São Paulo, Brazil. *Acta Ortop Bras* 2015; **23**: 271-274 [PMID: 26981037 DOI: 10.1590/1413-785220152305143730]

26 **Iglesias-Rodríguez S**, Domínguez-Prado DM, García-Reza A, Fernández-Fernández D, Pérez-Alfonso E, García-Piñeiro J, Castro-Menéndez M. Epidemiology of proximal humerus fractures. *J Orthop Surg Res* 2021; **16**: 402 [PMID: 34158100 DOI: 10.1186/s13018-021-02551-x]

27 **Grassi FA**, Murena L, Valli F, Alberio R. Six-year experience with the Delta III reverse shoulder prosthesis. *J Orthop Surg (Hong Kong)* 2009; **17**: 151-156 [PMID: 19721141 DOI: 10.1177/230949900901700205]

28 **Klein M**, Juschka M, Hinkenjann B, Scherger B, Ostermann PA. Treatment of comminuted fractures of the proximal humerus in elderly patients with the Delta III reverse shoulder prosthesis. *J Orthop Trauma* 2008; **22**: 698-704 [PMID: 18978545 DOI: 10.1097/BOT.0b013e31818afe40]

29 **Grassi FA**, Zorzolo I. Reverse shoulder arthroplasty without subscapularis repair for the treatment of proximal humeral fractures in the elderly. *Musculoskelet Surg* 2014; **98 Suppl 1**: 5-13 [PMID: 24659198 DOI: 10.1007/s12306-014-0321-4]

30 **Ross M**, Hope B, Stokes A, Peters SE, McLeod I, Duke PF. Reverse shoulder arthroplasty for the treatment of three-part and four-part proximal humeral fractures in the elderly. *J Shoulder Elbow Surg* 2015; **24**: 215-222 [PMID: 25168347 DOI: 10.1016/j.jse.2014.05.022]

31 **Mata-Fink A**, Meinke M, Jones C, Kim B, Bell JE. Reverse shoulder arthroplasty for treatment of proximal humeral fractures in older adults: a systematic review. *J Shoulder Elbow Surg* 2013; **22**: 1737-1748 [PMID: 24246529 DOI: 10.1016/j.jse.2013.08.021]

32 **Rosas S**, Law TY, Kurowicki J, Formaini N, Kalandiak SP, Levy JC. Trends in surgical management of proximal humeral fractures in the Medicare population: a nationwide study of records from 2009 to 2012. *J Shoulder Elbow Surg* 2016; **25**: 608-613 [PMID: 26475637 DOI: 10.1016/j.jse.2015.08.011]

33 **Fjalestad T**, Iversen P, Hole MØ, Smedsrud M, Madsen JE. Clinical investigation for displaced proximal humeral fractures in the elderly: a randomized study of two surgical treatments: reverse total prosthetic replacement versus angular stable plate Philos (The DELPHI-trial). *BMC Musculoskelet Disord* 2014; **15**: 323 [PMID: 25261913 DOI: 10.1186/1471-2474-15-323]

34 **Ockert B**, Biermann N, Haasters F, Mutschler W, Braunstein V. [Reverse shoulder arthroplasty for primary fracture treatment. Displaced three and four part fractures of the proximal humerus in the elderly patient]. *Unfallchirurg* 2013; **116**: 684-690 [PMID: 23934531 DOI: 10.1007/s00113-013-2410-5]

**Footnotes**

**Institutional review board statement:** The authors conducted a prospective observational study with a sequential recruitment of subjects affected by proximal humeral fractures, which was approved by the local Ethics Committee (No. 6809).

**Clinical trial registration statement:** The study was also registered on ClinicalTrials.gov, Protocol Registration and Result System (PRS) (NCT04821180).

**Informed consent statement:** All patients were properly informed of the nature of the study and they signed an informed consent document according to the Declaration of Helsinki.

**Conflict-of-interest statement:** The authors declare that there are no conflicts of interest regarding the publication of this paper.

**Data sharing statement:** No additional data are available.

**CONSORT 2010 statement:** The authors have read the CONSORT 2010 statement, and the manuscript was prepared and revised according to the CONSORT 2010 statement.

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: https://creativecommons.org/Licenses/by-nc/4.0/

**Provenance and peer review:** Invited article; Externally peer reviewed.

**Peer-review model:** Single blind

**Peer-review started:** April 17, 2021

**First decision:** June 23, 2021

**Article in press:** February 19, 2022

**Specialty type:** Orthopedics

**Country/Territory of origin:** Italy

**Peer-review report’s scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): 0

Grade C (Good): C

Grade D (Fair): 0

Grade E (Poor): 0

**P-Reviewer:** Kdolsky R **S-Editor:** Wang JL **L-Editor:** A **P-Editor:** Wang JL

**Figure Legends**



**Figure 1 X-rays images of a patient.** A: Post-operative X-rays of a patient treated with open reduction and internal fixation for three-parts proximal humeral fractures; B: Post-operative X-rays of a patient treated with reverse shoulder arthroplasty for three-parts proximal humeral fractures.

**Table 1 The range value of variables analyzed for the study group**

|  |  |  |
| --- | --- | --- |
| **Age (yr)** | **Female** | **Men** |
| CLASS 1 (70-74) | 30 | 1 |
| CLASS 2 (75-80) | 15 | 3 |
| CLASS 3 (80-85) | 13 | 1 |
| Total  | 58 | 5 |

CLASS: Age class.

**Table 2 Analysis of the fracture pattern**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Total** | **Three-part fractures** | **Four-part fractures** |
| Number | 63 | 41 | 22 |

**Table 3 Analysis of distribution considering age class and fracture personality**

|  |  |
| --- | --- |
|  | **Age class (yr)** |
| Neer classification | 70-75 | 75-80 | 80-90 |
| Three-part fractures | 10 | 27 | 4 |
| Four-part fractures | 5 | 7 | 10 |

**Table 4 Postoperative clinical and psychological mean values at T0 follow-up**

|  |  |  |
| --- | --- | --- |
|  | **Group A** | **Group B** |
| DASH | 50.8 | 54.6 |
| CONSTANT | 36.1 | 32.0 |
| GAD-7 | 5.4 | 6.4 |
| CSS | 5.0 | 6.2 |

DASH: The Disabilities of the Arm, Shoulder and Hand score; CONSTANT: The Constant score; GAD-7: General Anxiety Disorder-7; CSS: Caregiver Strain Scale.

**Table 5 Description of clinical and psychological scores at T1 follow-up**

|  |  |  |
| --- | --- | --- |
|  | **Group A** | **Group B** |
| DASH | 42.1 | 39.1 |
| CONSTANT | 47.3 | 43.2 |
| GAD-7 | 4.3 | 5.7 |
| CSS | 3.9 | 5.5 |

DASH: The Disabilities of the Arm, Shoulder and Hand score; CONSTANT: The Constant score; GAD-7: General Anxiety Disorder-7; CSS: Caregiver Strain Scale.

**Table 6 Analysis of clinical and psychological scores at T2 follow-up**

|  |  |  |
| --- | --- | --- |
|  | **Group A** | **Group B** |
| DASH | 32.8 | 33.6 |
| CONSTANT | 60.0 | 52.9 |
| GAD-7 | 3.2 | 4.3 |
| CSS | 3.1 | 4.5 |

DASH: The Disabilities of the Arm, Shoulder and Hand score; CONSTANT: The Constant score; GAD-7: General Anxiety Disorder-7; CSS: Caregiver Strain Scale.

**Table 7 Group C clinical and psychological mean values at three different follow-ups**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **DASH** | **CONSTANT** | **GAD-7**  | **CSS** |
| T0 | 51.1 | 33.2 | 5.9 | 5.7 |
| T1 | 38.8 | 46.9 | 4.9 | 4.5 |
| T2 | 29.9 | 65.5 | 3.1 | 3.0 |

DASH: The Disabilities of the Arm, Shoulder and Hand score; CONSTANT: The Constant score, GAD-7: General Anxiety Disorder-7; CSS: Caregiver Strain Scale.

**Table 8 Score distribution between treatment open reduction and internal fixation and PI**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **TO** | **T1** | **T2** |
| **O.R.I.F. (*n* = 31)** | **RSA (*n* = 32)** | ***P* value** | **O.R.I.F. (*n* = 31)** | **RSA (*n* = 32)** | ***P* value** | **O.R.I.F. (*n* = 31)** | **RSA (*n* = 32)** | ***P* value** |
| DASH | 50.0 (7.5) | 57.5 (7.0) | **0.002** | 45.0 (12.5) | 36.5 (12.3) | 0.256 | 30.0 (24.0) | 32.0 (5.5) | 0.587 |
| CONSTANT | 38.0 (7.5) | 31.5 (6.0) | **0.008** | 48.0 (19.0) | 42.0 (7.3) | 0.110 | 60.0 (31.0) | 51.0 (5.8) | **0.049** |
| GAD-7 | 5.0 (2.5) | 6.0 (2.3) | **0.015** | 4.0 (2.5) | 6.0 (2.0) | **0.002** | 3.0 (3.0) | 4.0 (1.3) | **0.012** |
| CSS | 5.0 (2.0) | 6.5 (2.3) | **0.008** | 4.0 (2.5) | 6.0 (1.3) | **0.001** | 3.0 (2.5) | 4.0 (2.3) | **0.005** |

Data are median (Interquartile range). *P* values are from Wilcoxon rank sum test. O.R.I.F: Open reduction and internal fixation; RSA: Reverse shoulder arthroplasty; DASH: The Disabilities of the Arm, Shoulder and Hand score; CONSTANT: The Constant score, GAD-7: General Anxiety Disorder-7; CSS: Caregiver Strain Scale.

**Table 9 Comparison between surgical and conservative treatment**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***n* = 32** | **T0** | ***P* value** | **T1** | ***P* value** | **T2** | ***P* value** |
| DASH | 53 (44.5) | 0.344 | 39 (35) | 0.421 | 30 (26) | 0.014 |
| CONSTANT | 32 (30) | 0.223 | 48.5 (42) | 0.063 | 65.5 (60) | < 0.001 |
| GAD-7 | 6 (5) | 0.827 | 5 (3.3) | 0.548 | 3 (2) | 0.002 |
| CSS | 6 (5) | 0.481 | 5 (3) | 0.090 | 3 (2) | 0.001 |

Data are median (Interquartile range) of conservative group. *P* values are from Wilcoxon rank sum test. DASH: The Disabilities of the Arm, Shoulder and Hand score; CONSTANT: The Constant score, GAD-7: General Anxiety Disorder-7; CSS: Caregiver Strain Scale.



Published by **Baishideng Publishing Group Inc**

7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA

**Telephone:** +1-925-3991568

**E-mail:** bpgoffice@wjgnet.com

**Help Desk:** https://www.f6publishing.com/helpdesk

https://www.wjgnet.com



**© 2022 Baishideng Publishing Group Inc. All rights reserved.**