Fractures of the Humeral Proximal Extremity in Three and Four Fragments in the Elderly Patient: Conservative Treatment or Reverse Arthroplasty?

Fracturas de la extremidad proximal de húmero en tres y cuatro fragmentos en el anciano: ¿Tratamiento conservador o artroplastia reversa?

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Abstract

Objective   This study compared functional results in two cohorts of older adults with three- and four-part proximal humeral fractures (PHFs) per Neer's classification treated with reverse shoulder arthroplasty (RSA) or nonoperative management.

Materials and Methods   Ambispective, non-randomized study with two cohorts of patients aged 75 or older treated with RSA (n = 15) or nonoperative management (n = 16) with a minimum follow-up period of 12 months. We analyzed the American Shoulder and Elbow Surgeons (ASES), Constant-Murley, and Disabilities of the Arm, Shoulder, and Hand (DASH) scores and the visual analog scale (VAS) for pain at 3, 6, and 12 months. In addition, we recorded radiological findings and surgical complications.

Results   The mean Constant-Murley score at 12 months was significantly higher for the RSA group (75.1 +/- 10.3 vs. 51.9 +/- 12.4, p = 0.001). There were no differences in ASES, DASH, and VAS scores. Statistically significant differences for flexion and external rotation in abduction favored the RSA group (128.9 +/- 17.0 versus 99.3 +/- 20.1, p = 0.001, and 35.7 +/- 13.9 vs. 23.4 +/- 15.5, p = 0.032, respectively). For the RSA group, tuberosity positioning was correct in 43% of subjects. These patients presented better scores than those with malpositioned or absent tuberosities but with no statistical significance. Complications in the surgical group were not higher.

Conclusions   Nonoperative treatment is a valid option regarding pain and functionality in elderly patients with three- and four-part PHFs. Characteristics of patients with high demands who may be candidates for the initial surgical treatment remain to be defined.

Level of Evidence   Level III

Keywords
► proximal humeral fracture
► elderly
► nonoperative treatment
► reverse shoulder arthroplasty

Resumen

Objetivo Comparar los resultados funcionales obtenidos en dos cohortes de pacientes ancianos tratados de forma quirúrgica (artroplastia reversa de hombro) versus tratamiento conservador.

Material y Métodos Estudio ambispectivo, no aleatorizado. Se incluyeron pacientes de 75 años o más, 15 tratados de forma quirúrgica y 16 siguieron tratamiento conservador. Seguimiento mínimo de 12 meses. A los 3, 6 y 12 meses de la fractura evaluamos las escalas ASES, Constant-Murley and Disabilities of the Arm, Shoulder and Hand score (DASH) y EVA. Además evaluamos los resultados radiológicos y las complicaciones.

Resultados No encontramos diferencias significativas para las escalas ASES, DASH, ni EVA .El grupo tratado de forma quirúrgica obtuvo a los 12 meses una puntuación media en la escala Constant mayor, diferencia estadísticamente significativa(75.1 +/-10.3 vs. 51.9 +/-12.4 p = 0.001). Además presentaban mayor rango de movilidad para flexión y rotación externa (128.9 +/-17 versus 99.3 +/-20.1 p = 0.001, and 35.7 +/-13.9 vs. 23.4 +/-15.5 p = 0.032). El 43% de los pacientes tratados mediante artroplastia reversa presentaban tuberosidades normoposicionadas y mejores resultados en las escalas versus pacientes con tuberosidades ausentes o malposicionadas. El grupo sometido a cirugía no presentó mayor tasa de complicaciones.

Conclusiones El tratamiento conservador en las fracturas de EPH en tres y cuatro fragmentos en pacientes ancianos ofrece buenos resultados en cuanto a dolor y funcionalidad en la mayoría de pacientes. Falta por definir qué pacientes por tener alta demanda funcional serían candidatos a tratamiento quirúrgico de entrada.

Palabras Clave
► fractura extremidad proximal húmero
► anciano
► tratamiento conservador
► artroplastia reversa de hombro

Nivel de Evidencia Nivel III

Introduction

Proximal humeral fractures (PHFs) are common, accounting for 10% of all skeletal fractures. Their incidence increases exponentially after age 40.[1–4] We expect the PHF number to rise three-fold in the next decade.[5]

Although most of these fractures do not present displacement and their conservative management is successful, several surgical techniques treat higher-complexity fractures.[6] The most appropriate treatment must consider the age of the patient, bone quality, fragment number, and displacement.[7,8]

Three- and four-part fractures in elderly patients remain controversial. Reverse arthroplasty is the most proper surgical option for these patients. Since there are reports of specific surgical complications in significant percentages 9, conservative management may be a feasible alternative in older patients with lower functional demand and potentially compromised bone quality.[10–12]

This study compared the functional outcomes from two cohorts of elderly patients with PHFs with three or four fragments per the Neer classification. Subjects underwent a shoulder arthroplasty or conservative management. The minimum follow-up period was 12 months.

Material and Methods

We have designed an ambispective (with a historical cohort), single-center, non-randomized study with two cohorts of elderly patients with PHFs treated at our center from October 2013 to June 2019.

The inclusion criteria were the following:

- Age over 75.
- PHF with three or four fragments according to the Neer classification.

The exclusion criteria were the following:
- Neurological or vascular injury.
- Open fracture.
- Fractures with glenohumeral dislocation.
- Previous conditions compromising functional recovery and collaboration in a rehabilitation protocol (neurological disease, cognitive impairment).

Sample Size Calculation and Recruitment

We have calculated a sample size of 15 patients for each cohort and an alpha error of 5%, estimating an analytic power of 96% to detect mean differences of 14 points or more on the ASES score with a standard deviation of 10.[13]

Patients undergoing reverse shoulder arthroplasty represented a historical cohort of 15 patients recruited from October 2013 to April 2016. All of them were over 75 years old and had a PHF with three or four fragments and a minimum follow-up period of 12 months. These patients' recruitment occurred for a prospective study to compare the outcomes of the reverse arthroplasty of PHFs to another prospective cohort undergoing shoulder hemiarthroplasty. The previously mentioned study is registered in Clinical

Trials under the name FRALUX34, NCT 03339570, with a currently pending publication.

From November 2017 to June 2019, we prospectively included 19 patients in the conservative treatment cohort. Three subjects were excluded from the study due to death or lack of adherence to the rehabilitation treatment. Therefore, the conservative treatment cohort consisted of 16 patients with a minimum follow-up period of 12 months.

We informed all patients about the study, and they gave their written informed consent for inclusion. The Ethics and Clinical Research Committee from our hospital approved this study, which was subsequently registered in Clinical Trials under the name SCIARPA 3/4 NCT03339570.

Surgical Treatment

All patients undergoing reverse arthroplasty were operated on in the first week after trauma (days 2-7) by two senior surgeons (FLM and JCAG). The surgical approach was the standard deltopectoral approach, with tenodesis of the long head of the biceps to the pectoralis major and coracoacromial ligament section. The implant was the Delta Xtend reverse shoulder prosthesis (DePuy, Warsaw, IN, USA) with a cemented stem. We re-anchored the greater and lesser tuberosities to the prosthetic stem using horizontal cerclage alone with a high-strength suture (Etibond #5). We did not perform vertical cerclage in any subject. The metaglene fixation used two polyaxial screws in a superior and inferior position. The retroversion of the humeral stem was calculated between 10 and 20°. We did not perform any tendon transfer or lateralization techniques of the rotation center (BIO-RSA).

Rehabilitative Treatment

All patients in both cohorts similarly received specific rehabilitation treatment. Immobilization with a sling occurred during the first three weeks (►Table 1). Elbow, wrist, and shoulder pendulum exercises were allowed from the first day as tolerated. After 15 days, the patients began passive/assisted mobility exercises in flexion and abduction. In the fourth week, active mobilization exercises started, including rotations and progressive sling removal.

Clinical and Radiological Evaluation

Follow-up visits for all patients from both cohorts occur 1 week, 3 weeks, 3 months, 6 months, and 12 months after the fracture.

The 12-month follow-up visit assessed mobility. The same specialist evaluated all subjects, recording flexion with the arm close to the body and external rotation in both abduction and adduction in degrees. Internal rotation assessed the thumb' position to anatomical references (trochanter, gluteus, sacroiliac joint, T12 vertebra, or interscapular level).

The patients answered functional assessment questionnaires at 3, 6, and 12 months. These questionnaires included ASES,[14] Constant-Murley,[15] and DASH.[16] We also used the VAS scale for a single pain assessment in the final 12-month follow-up.[17]

The radiological study consisted of plain anteroposterior and axial shoulder radiographs at each follow-up. In the conservative management cohort, we evaluated the time to fracture consolidation, tuberosity positioning, and the presence of cephalic necrosis or nonunion. In the reverse arthroplasty cohort, we assessed tuberosity positioning, complications (including neurovascular injury, postsurgical infection, and implant instability or loosening), peri-implant osteolysis, and scapular notching.[18]

We also recorded complications such as neurovascular injury, surgical wound infection, implant instability, or the need for reintervention for any reason.

Statistical Analysis

The statistical analysis used the SPSS 22.0 program for Mac (SPSS Inc., Chicago, Illinois, USA). To study quantitative variables with dichotomous qualitative features, we used the Student's t-test if the distribution was normal or the Mann-Whitney U test if it was non-normal. The determination of relationships between qualitative variables employed the Chi-square test. Differences with a p-value less than 0.05 were statistically significant.

Results

Demographics

There were no statistically significant differences regarding gender, fracture type (three or four fragments), American Society of Anesthesiologists (ASA) classification, or dominant side. However, the mean age was slightly higher for the conservative treatment group (82.7 years) than for the surgical treatment (79.4 years) ($p = 0.0029$) (►Table 1).

Functional Outcomes

►Table 2 shows the results on the functional assessment scales.

The Constant-Murley score at the 12-month follow-up was significantly higher in the reverse arthroplasty cohort ($p = 0.001$). At 12 months, the mean score in the surgical cohort was 75.1 +/- 10.3 compared to a mean score of 51.9 +/-12.4 in the conservative management cohort (►Fig. 1)

We did not find statistically significant differences in mean ASES, DASH, and VAS scores between the two cohorts at 12 months of follow-up. The final mean ASES score was 74.1 +/- 11.9 in the surgical cohort versus 72.4 +/-11.4 in the conservative management cohort ($p = 0.552$). The DASH score was 29.4 +/- 7.3 in the surgical group and 23.8 +/- 14.8 in the conservative management group ($p = 0.208$). The final VAS score was 1.3 +/- 1.5 in the surgical group and 1.2 +/-2 in the non-surgical group ($p = 0.423$).

The range of mobility at 12 months presented statistically significant differences for flexion and external rotation in abduction in favor of the surgical cohort. The final mean flexion in the surgical group was 128.9 +/- 17 degrees versus 99.3 +/- 20.1 in the conservative management group ($p = 0.001$). External rotation in abduction was 35.7 +/-13.9 in the surgical group and 23.4 +/- 15.5 in the conservative management group ($p = 0.032$). The mean values at

Table 1 Demographics

Variable	Conservative management (n = 16)	Reversed arthroplasty (n = 15)	p-value
Mean age, years (range)	82.7 (77-91)	79.4 (75-86)	0.0029
Gender, n (%)			0.55
Female	13 (81%)	11 (73%)	
Male	3 (19%)	4 (27%)	
Dominant hand, n (%)			0.64
Dominant	10 (63%)	11 (73%)	
Non-dominant	6 (37%)	4 (27%)	
Fracture type, n (%)			0.174
Three fragments	13 (81%)	10 (67%)	
Four fragments	3 (19%)	5 (33%)	
American Society of Anesthesiologists (ASA), n (%)			0.362
ASA II	7 (44%)	8 (53%)	
ASA III	7 (44%)	6 (40%)	
ASA IV	2 (12%)	1 (7%)	
Last follow-up, n (%)	16 (100%)	15 (100%)	

Table 2 Functional and mobility outcomes at 12 months

Variable	Conservative management (n = 16)	Reversed arthroplasty (n = 15)	p-value
Constant-Murley score, mean +/- SD	51.9 +/- 12.4	75.1 +/- 10.3	0.001
ASES score, mean +/- SD	72.4 +/- 11.4	74.1 +/- 11.9	0.552
DASH score, mean +/- SD	23.8 +/- 14.8	29.4 +/- 7.3	0.208
VAS, mean +/- SD	1.2 +/- 2	1.3 +/- 1.5	0.423
Flexion, mean (°) **External rotation in abduction (°)** **External rotation in adduction (°)**	99.3 +/- 20.1 23.4 +/- 15.5 21.6 +/- 13.8	128.9 +/- 17 35.7 +/- 13.9 29.3 +/- 7.6	0.001 0.032 0.066
Internal rotation			0.189
Trochanter	2 (12%)	1 (7%)	
Gluteus	6 (38%)	5 (33%)	
Sacroiliac joint	6 (38%)	6 (40%)	
T12 vertebra	1 (6%)	2 (13%)	
Interscapular	1 (6%)	1 (7%)	

Abbreviation: SD, Standard deviation.

12 months for external rotation in adduction and internal rotation were better in the surgical group but with no statistical significance.

Both cohorts showed a significantly progressive improvement in the average Constant-Murley, ASES, and DASH scores at 3, 6, and 12 months (►**Figs. 1**, **2** and **3**).

Radiological Outcomes and Complications at 12 Months

All patients managed conservatively present fracture radiological consolidation in the 12-month radiographs. However, most images were consistent with malunion or tuberosity malpositioning (►**Table 3**). Moreover, there were three cases of avascular necrosis.

Fifty- three percent of the patients undergoing reverse arthroplasty presented correct tuberosity positioning. In the remaining cases, the tuberosities were absent or malpositioned. Patients with normal positioned tuberosities had better results on the functional scales at 12 months, although with no statistical significance (►**Table 4**). In the evaluation 12 months after the fracture, there were five cases of scapular notching (33%), including four type 1 and one type 2
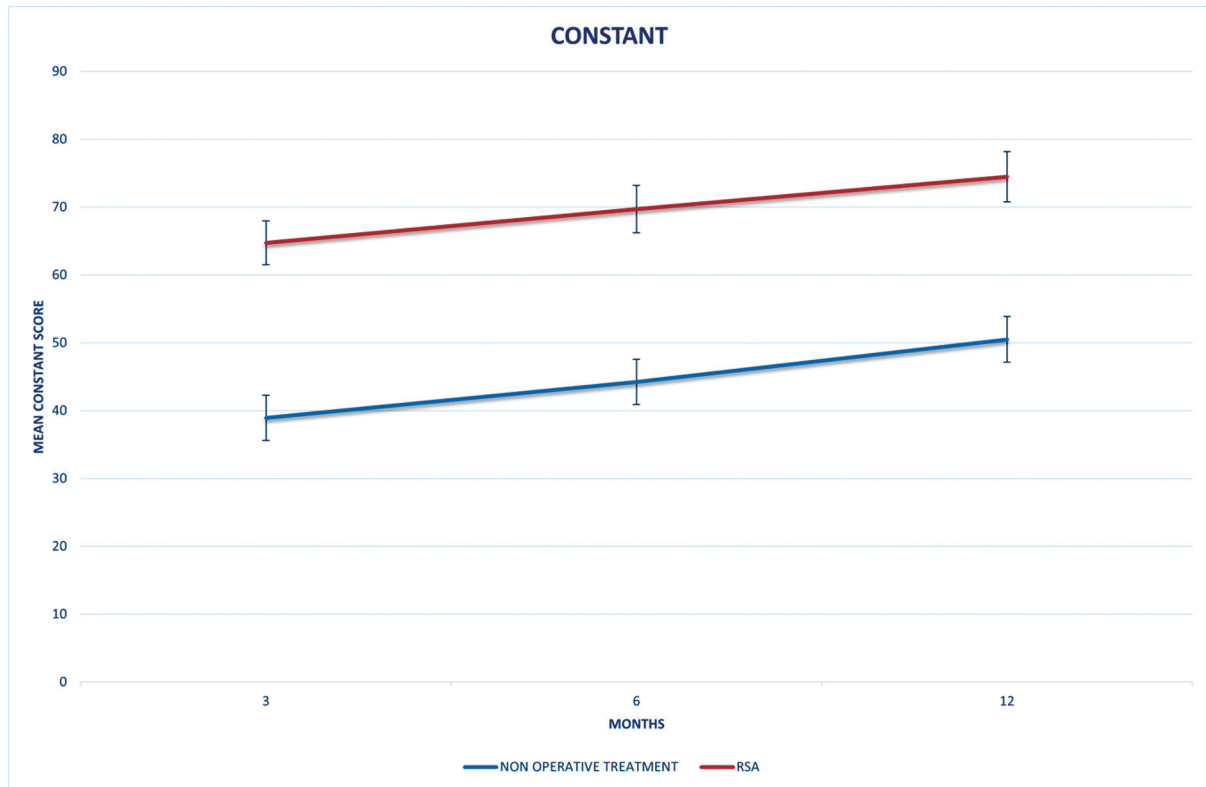
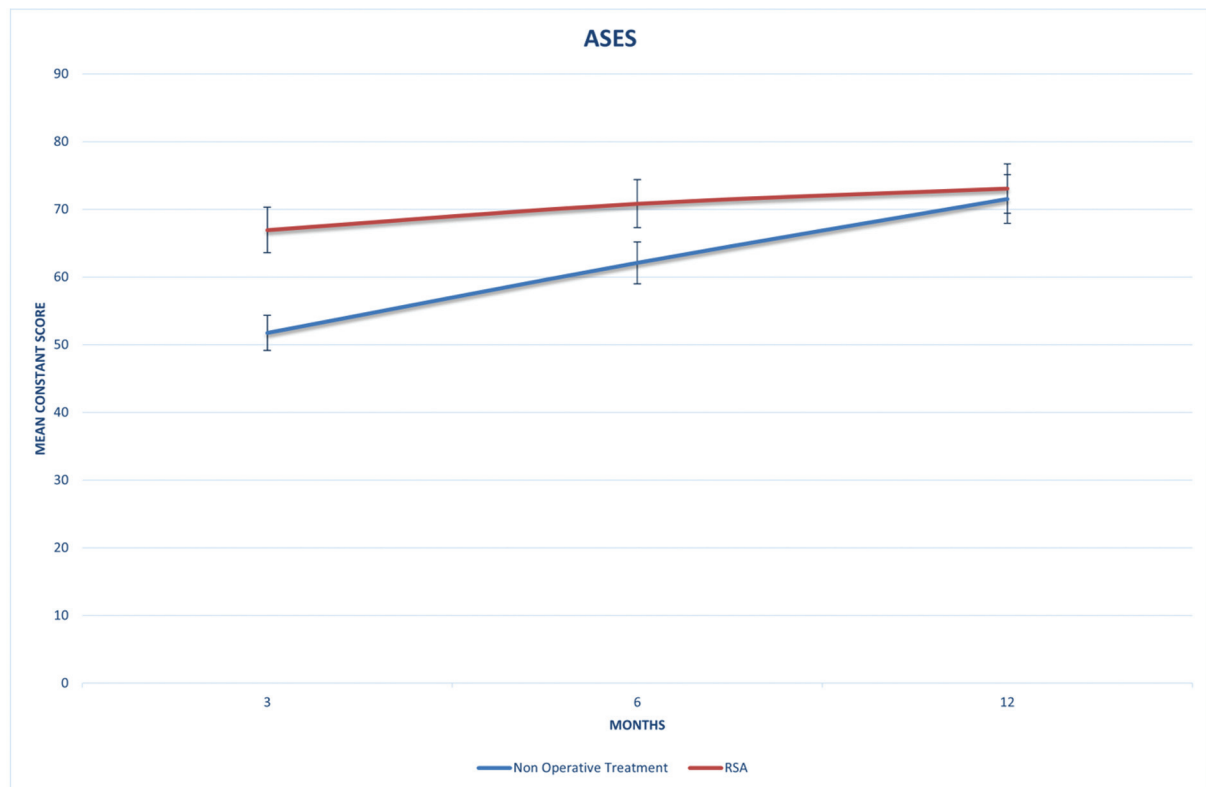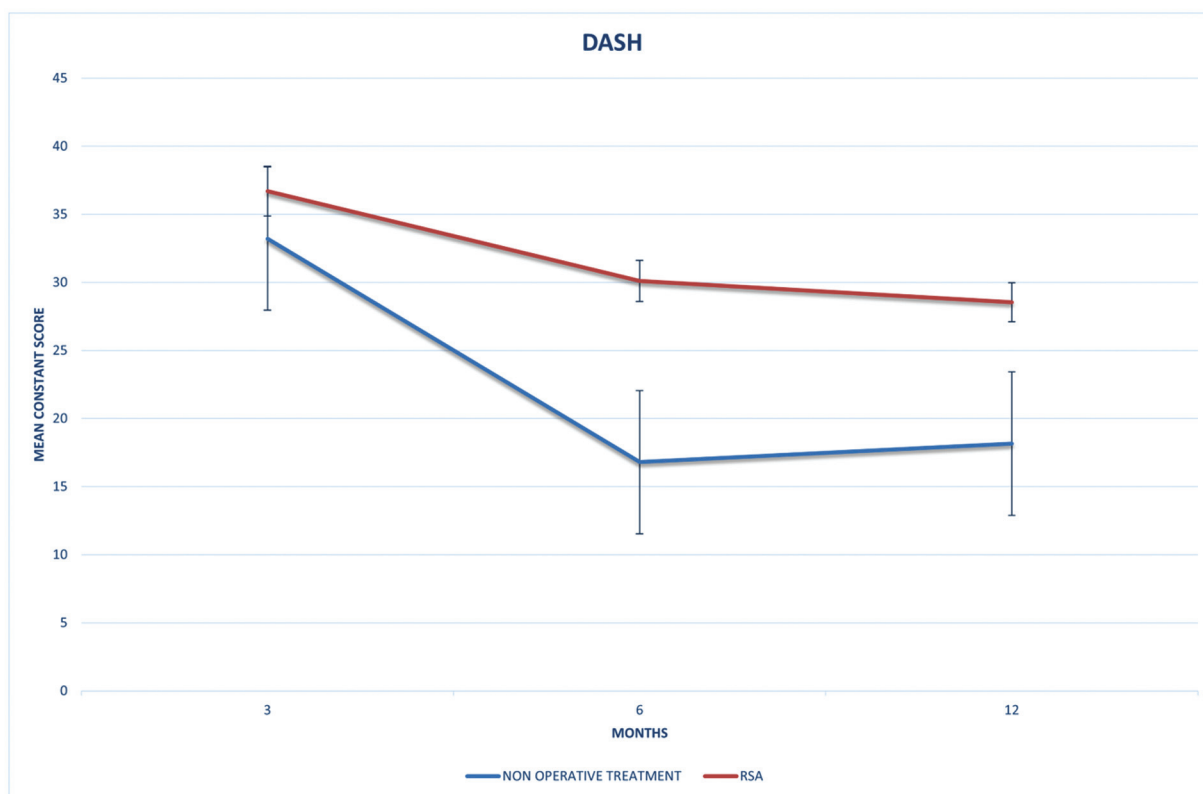**Fig. 1** Constant-Murley score.

Fig. 2 American Shoulder and Elbow Surgeons (ASES) score.

Fig. 3 Disabilities of the Arm, Shoulder and Hand score (DASH) score.

notching,[18] but causing no higher pain or functional repercussion.

The surgical group had no complications (infection, instability, prosthetic loosening, or surgical revision required for any reason). One patient presented lower brachial plexus involvement in the immediate postoperative period, resolving without specific treatment in the first 3 months.

Discussion

The literature comparing outcomes from reverse arthroplasty and conservative management of PHFs 3 or 4 per the Neer classification in elderly patients remains scarce.

Roberson et al.[19] conducted a retrospective, non-randomized study with a 2-year follow-up in two cohorts of 19 and

Table 3 Radiological outcomes and complications at 12 months

Variable	Conservative management (n = 16)	Reversed arthroplasty (n = 15)
Pseudoarthrosis, n (%)	0 (0%)	–
Malunion, n (%)	10 (62%)	–
Avascular necrosis, n (%)	3 (19%)	–
Normal positioned tuberosities, n (%) Scapular notching, n (%) Loosening, n (%)	- - -	7 (43%) 5 (33%) 0 (0%)

Table 4 Functional outcomes in the reversed arthroplasty cohort at 12 months per tuberosity positioning

Variable	Correct positioning (n = 8)	Incorrect positioning (n = 7)	p-value
Constant-Murley score, mean	73.8	74.4	0.0897
ASES score, mean	74.6	71.5	0.625
DASH score, mean	30.8	27.2	0.359

20 patients undergoing conservative treatment or reverse arthroplasty. These authors find no differences in mobility or functional scores. Although their study population was significantly younger compared to ours (average age, 71), their results were consistent with our study regarding degrees of mobility (mean flexion, 120 degrees) and mean ASES score (72 points). Fifteen percent of their surgical patients required a reintervention, with no differences between early and delayed surgery. These authors propose to offer non-surgical treatment for this group of patients.

Similarly, Chivot et al.[20] conducted a retrospective, multicenter study with two cohorts of 28 and 32 patients with an average age closer to our population (77 and 79 years) and a minimum follow-up period of 2 years. Like us, they found statistically significant differences favoring the reverse arthroplasty group for the Constant-Murley score. However, the improvement was small and perhaps of little clinical relevance (56.5 points for the surgical group vs. 50.5 for the non-surgical group). As in our study, there were no differences in the DASH or VAS scores, concluding that only patients with high functional demands should undergo reverse arthroplasty.

As far as we know, the most complete study on this subject is the recently published work by Lópiz et al.[21] This prospective, randomized trial compared 30 patients treated non-surgically with 29 patients undergoing reverse arthroplasty. All patients were at least 80 years old. The only statistically significant difference occurred in the VAS scale for pain, favoring the surgical group at the end of the 12-month follow-up (1.6 vs. 0.9). They found no differences on the Constant-Murley score even though the surgical group had a favorable score of six points, potentially representing a clinically relevant improvement. In addition, they found no differences in the DASH score. The study concluded that the high comorbidity rate in both cohorts could mask the potential benefits of reverse arthroplasty for patients with higher functional demands and better health status.

The most striking finding from our study was the 20-point difference in the Constant-Murley score favoring the surgical cohort, well above the minimum limit for a clinically relevant outcome.[22] This difference is largely explained by the better outcomes in terms of mobility in the surgical group. Moreover, the ASES and DASH functional scores, which do not evaluate the range of mobility, had no statistically significant differences. Pain perception also had no differences between the cohorts, consistent with other publications. We also agree with other studies in not obtaining significant results when comparing mobility in surgical patients with or without correct tuberosity positioning.[23–25]

Since our study is non-randomized and has a historical cohort, a selection bias could occur and explain the differences in the range of mobility between groups, assigning patients with lower functional demand to the non-surgical cohort.

It remains to be defined which patient is "elderly" since different studies use this designation for subjects at least 75 years old.[26,27] Elderly patients often form a heterogeneous group of subjects with critical differences regarding comorbidities, functional demand, and life expectancy. Again, this definition may lead to selection bias and wrong conclusions. A recent study[28] comparing mortality in the geriatric population (over 75) with PHF in three or four fragments undergoing reverse arthroplasty or conservative treatment found no differences in the mortality rate 1 year after the fracture (8.1% for the surgical group and 10.8% for the conservative treatment group). Likewise, a report claimed that the mortality associated with these fractures does not depend so much on age but on previous functional capacity and social factors.[29]

Our study has several limitations, including its non-randomized design, the use of a retrospective cohort, its small sample size, and sufficient but limited 12-month follow-up period. Its qualities include homogeneity in monitoring and data collection and the standardization of the surgical procedure.

Conclusions

The surgical treatment of the elderly patient with PHF in three and four fragments resulted in better outcomes in some movements (anterior flexion and external rotation in abduction) and the Constant-Murley score. However, we did not find significant differences in pain (VAS) or functional requirements for daily living activities, reflected in ASES and DASH scores.

Delayed surgery also seems a valid option; some studies do not find significant differences in functional outcomes or complications between patients who undergo an initial reverse arthroplasty compared to those operating after attempting conservative treatment.[19,30]

For this reason, we propose offering an initial conservative treatment to most elderly patients with EPH fractures in three or four fragments. The characteristics of patients with high demands and good functional reserve who may undergo an initial surgical treatment remain to be defined.

Conflict of Interest
None.

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