Nonoperative Treatment for Displaced Proximal Humeral Fractures in Elderly Patients: Correlation Between Deviations and Clinical Outcomes[*]

Tratamento não operatório de fraturas desviadas da extremidade proximal do úmero em idosos: Correlação entre os desvios e os resultados clínicos

Mauro Emilio Conforto Gracitelli[1]   Gustavo Jum Yamamoto[1]   Eduardo Angeli Malavolta[1]
Fernando Brandão Andrade-Silva[1]   Kodi Edson Kojima[1]   Arnaldo Amado Ferreira Neto[1]

[1] Shoulder and Elbow Group, Instituto de Ortopedia e Traumatologia, Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil

Address for correspondence Mauro E. C. Gracitelli, Ph.D, Rua Dr. Ovídio Pires de Campos, 333, 3° andar, Cerqueira Cesar, São Paulo, SP, 05403-010, Brazil (e-mail: mgracitelli@gmail.com).

Abstract

Objectives To describe the functional result of the conservative treatment of displaced proximal humerus fractures (PHF) using the American Shoulder and Elbow Surgeons (ASES) score after 12 months and assess whether the different initial classifications and radiographic measurements are related to clinical results.

Methods Forty patients > 60 years old, with displaced PHUs submitted to conservative treatment were evaluated at standardized times (3, 6, and 12 months). The American Society of Shoulder and Elbow Surgeons (ASES), Constant-Murley and Single Assessment Numeric Evaluation (SANE) scales were used as clinical outcomes. Radiographic variables included the Neer and Resch classifications, the presence and displacement of tuberosity fracture, metaphyseal comminution, medial periosteal lesion, and angular and translational deviations of the head in the coronal and sagittal plane.

Results The result of the ASES score was 77.7 ± 23.2 for the whole sample, the mean absolute values of the Constant-Murley score were 68.7 ± 16 and 82.6% for the scale relative to the contralateral side. The SANE scale at 12 months was 84.8 ± 19. We

Keywords
► shoulder fractures
► complications
► conservative treatment
► diagnostic imaging

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[*] *Study developed at the Instituto de Ortopedia e Traumatologia, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.*

observed that the severity of the Neer classification and the coronal plane angular deviation (measured by the head-shaft angle) and the presence of fractures in both tuberosities negatively influenced the ASES score after 12 months of treatment.

Conclusion Nonoperative treatment of displaced proximal humerus fractures in elderly patients results in good clinical results. Clinical results are negatively influenced by the angular deviation of the humeral head and the presence of fractures of the greater and lesser tubercles, as well as by the Neer classification.

Resumo

Objetivos Descrever o resultado funcional do tratamento não operatório de fraturas desviadas da extremidade proximal do úmero (FEPU) pela escala da American Shoulder and Elbow Surgeons (ASES, na sigla em inglês) após 12 meses e avaliar se as diferentes classificações e medidas radiográficas iniciais têm correlação com os resultados clínicos.

Métodos Foram avaliados em tempos padronizados (3, 6 e 12 meses), 40 pacientes > 60 anos com FEPU submetidos ao tratamento não operatório. Foram utilizadas as escalas da ASES, Constant-Murley e Single Assessment Numeric Evaluation (SANE, na sigla em inglês). As variáveis radiográficas incluíram as classificações de Neer e Resch, a presença de fratura e desvio dos tubérculos, cominuição metafisária, lesão periosteal medial, desvios angulares e translacionais da cabeça no plano coronal e sagital e desvio dos tubérculos.

Resultados Observamos resultados pela escala de ASES de 77,7 ± 23,2 para toda a amostra, pela de Constant-Murley de 68,7 ± 16 e de 82,6% para a escala em relação ao lado contralateral. A escala de SANE aos 12 meses foi de 84,8 ± 19. Os critérios radiográficos que apresentaram influência negativa no resultado clínico pela escala de ASES aos 12 meses foram a gravidade pela classificação de Neer e pelo desvio angular no plano coronal (mensurado pelo ângulo cabeça-diáfise) e a presença de fratura dos tubérculos.

Conclusão O tratamento não operatório de fraturas desviadas da extremidade proximal do úmero em pacientes idosos resulta em bons resultados clínicos. Os resultados clínicos são influenciados negativamente pelo desvio angular da cabeça do úmero e pela presença de fratura dos tubérculos maior e menor, assim como pela classificação de Neer.

Palavras-chave
► fraturas do ombro
► complicações
► tratamento conservador
► diagnóstico por imagem

Introduction

Osteoporosis-related fractures affect ~ 2 million people per year in the United States, and proximal humeral fractures (PHFs) account for 10% of these injuries.[1] Recent studies revealed that nonoperative treatment outcomes are similar to those obtained with surgery, regardless of the age and fracture pattern of the patient.[2,3]

However, there are still controversies about the main fracture patterns benefiting from surgical treatment and little evidence regarding prognostic radiographic parameters for nonoperative treatment.

The Neer, Arbeitsgemeinschaft für Osteosynthesefragen (AO) and binary classification systems have low reliability and add little to the therapeutic decision-making process.[4–6] Previous studies demonstrate that functional outcomes are influenced by several fracture-related features that are not evaluated by these classification systems, such as medial metaphyseal comminution,[7] deviation type and degree in coronal and sagittal views, and bone loss due to impaction.[8] Other prognostic factors are related to the patient and the injury, such as age, osteoporosis and time from fracture to treatment.[9,10]

Few studies evaluate different radiographic criteria to predict functional outcomes from the nonoperative treatment of deviated PHF.[8,11–15] In addition, no previous study evaluates the Resch criteria and other radiographic variables in PHF prognosis.

The primary objective of the present study is to describe functional outcomes from the nonoperative treatment of deviated PHFs using the American Shoulder and Elbow Surgeons (ASES) score at a 12-month follow-up. The secondary objective is to evaluate whether different classification systems and initial radiographic measurements are related to worse outcomes according to the ASES score.

Methods

Study design

We conducted a prospective study involving 40 patients with deviated PHFs submitted to nonoperative treatment. The patients belong to a randomized study and were treated from February 2016 to October 2018 at a single center. The protocol was approved by the Ethics Committee of our service under the opinion number 1.266.876.

Subjects

The inclusion criteria were age ≥ 60 years, trauma within the last 30 days and PHF with surgical neck involvement and at least one of the following parameters: head-diaphysis angle with $\geq 20°$ deviation (in varus or valgus); head-to-shaft translation > 1 cm (in frontal or sagittal view) and greater and/or lesser tubercle fracture with > 0.5 cm deviation. Two physicians specialized in shoulder and elbow surgery evaluated these criteria before the patient was included in the study.

Dislocation-fractures, fractures with no contact between the humeral head and the diaphysis, and bilateral fractures were not included. Patients with ipsilateral or contralateral upper limb fractures, neurological injuries diagnosed at physical examination, other fractures in the affected limb, pathological fractures, bilateral fractures, previous surgery on the affected shoulder or previous full-thickness tear of one of the rotator cuff tendons were not included in the present study.

Intervention

The nonoperative treatment consisted of velpeau sling use and early rehabilitation. No patient underwent closed reduction. Analgesia was standardized with dipyrone (500 mg; one tablet every 8 hours for 10 days), codeine (30 mg; one tablet every 6 hours for 7 days and then as required, according to pain) and paracetamol (500 mg; one tablet each 8 hours for 10 days).

Guidance to sling use was standardized and each patient received a printed leaflet containing the rehabilitation guidelines described below after inclusion in the study. Home exercises were personally guided by a physical therapist on the 1st day of inclusion in the study.

Elbow, wrist, and hand movements started on the 1st day of inclusion in the study. Sleeping position, personal hygiene, and feeding modes were advised. Home cervical, scapular, elbow, wrist, and hand exercises were oriented on the 1st day of inclusion in the study; pendulum exercises were added on the 7th day. In 15 days, passive shoulder exercises for lifting, abduction and rotation were started. After 30 days, active-resisted elbow exercises, active-assisted and active-free shoulder exercises, as well as isometric exercises for the rotator cuff, the deltoid and the scapular girdle were started as tolerated by the patients. Active-resisted exercises for the rotator cuff, the deltoid and the scapular girdle began at the 45th day. The maximum time indicated for sling use was 30 days after the fracture.

Outcomes

The primary outcome consisted in clinical evaluation using the ASES score 12 months after the fracture. Secondary outcomes were the following: Constant-Murley score, both in absolute values and relative values for the contralateral limb (CRI) and the Single Assessment Numeric Evaluation (SANE) score. Scores were assessed at 3, 6 and 12 months after the fracture. Clinical scores were applied by an evaluator who did not participate in the physical rehabilitation or clinical follow-up of the patients.

Radiographs were obtained in four views, including the AP (anteroposterior) view, Y lateral view, axillary view and Velpeau views, whenever tolerated by the patient. Images were evaluated using the institutional image storage system (iSite enterprise 4.1, Phillips, Amsterdam, Netherlands). All patients underwent a computed tomography (CT) scan before study inclusion. The CT results complemented the definition of radiographic fracture variables, such as classifications and deviation features. Two orthopedists, members of the Brazilian Shoulder and Elbow Society, with 11 and 12 years of experience, evaluated all images and consensually determined ratings. The measurements used in the study were taken by one of these evaluators.

An ultrasound examination was performed 6 months after the fracture to assess rotator cuff integrity. Ultrasounds were obtained at the radiology department of the institution by the musculoskeletal radiologist team using a Logiq E9 device (GE Healthcare, Waukesha, WI, USA) with an ML6-15 linear transducer (6- to 15-MHz linear, ML-6-15, GE Healthcare, Waukesha, USA). Findings related to rotator cuff tendons were classified according to the full-thickness tear of one or more tendons.

Complications were noted according to their occurrence, and their total number was recorded separately for each individual patient. Vicious consolidation was not deemed a complication. The need for surgical approach and the type of surgery performed were also recorded. The following complications were analyzed as binary variables (present or absent) and were considered present if identified at any time during treatment: recurrent pain with functional limitations requiring additional treatment (clinical or surgical therapy) after 1 year of treatment; fracture-related clinical complication or treatment requiring hospitalization; death related to the fracture or treatment; re-fractures: shoulder stiffness, defined by decreased shoulder range of motion with sustained functional limitation 6 months after the fracture; complex regional pain syndrome; heterotopic ossification; glenohumeral osteoarthritis; and osteonecrosis of the humeral head and pseudoarthrosis, defined by the lack of consolidation 1 year after the fracture. Ancillary tests (CT, magnetic resonance imaging [MRI] or electroneuromyography) were requested per clinical suspicion.

Analyzed variables

The analyzed clinical variables were the following: gender, side, dominance, smoking status, diabetes, time until the beginning of rehabilitation, rehabilitation duration and number of sessions.

Radiographic variables included Neer and Resch classification systems and presence of tuberosity fracture (regardless of deviation), metaphyseal comminution, and medial periosteal lesion. Several radiographic parameters of fracture deviation were evaluated. The head-shaft angle was assessed as previously published.[16] Greater tuberosity deviation was evaluated according to the distance from the apex of the humeral head at a AP (anteroposterior) view radiograph. The lesser tuberosity was evaluated on axillary or velpeau views if the fragment was deviated. Other measures were taken in relation to fragment deviation. All measures were categorized into three levels according to previously

Table 1 Description of the radiographic deviation criteria analyzed

Metaphyseal comminution
No
Yes
Medial periosteal lesion
No
Yes
Tuberosity fracture
No tuberosity fracture
Greater tuberosity fracture
Lesser and greater tuberosities fracture
Greater tuberosity deviation
Up to 2 mm inferior to the top of the humeral head
Up to 2 mm superior to the top of the humeral head
Over 2 mm from the top of the humeral head
Lesser tuberosity deviation
Up to 2 mm
2 to 5 mm
> 5 mm
Diaphyseal head angle, front view
125° to 150°
110° to 124° or 151° to 165°
< 110° or >166°
Diaphyseal head angle, lateral view
No deviation
Moderate (0-20°)
Severe (> 45°)
Diaphyseal deviation, front view
Up to 5 mm
5 to 10 mm
> 10 mm
Diaphyseal deviation, lateral view
Up to 5 mm
5 to 10 mm
> 10 mm

established criteria. ►**Table 1** describes all analyzed radiographic variables.

Statistical analysis

Due to the sample size, nonparametric tests were used regardless of data normality. Continuous variables were presented as mean and standard deviation (SD), median and interquartile range values. Categorical values were shown as absolute and percentage values. The sample was calculated for convenience and cases were included sequentially.

Functional scores before and after treatment were compared using Wilcoxon tests. Kruskal-Wallis tests were performed for univariate analyzes of radiographic variables, and the Friedman test was used for post-hoc analysis.

Data was analyzed in IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA) adopting a 5% significance level.

Results

Forty-five patients were included for nonoperative treatment. Five patients did not show up for the first assessment at 3 months, with complete loss to follow-up. Forty patients with a complete 12-month follow-up were included at the final evaluation. ►**Table 2** shows general sample data. Most patients were female, with a mean age of 69 ± 6 years old. ►**Figures 1**, **2** and **3** show radiographic and clinical outcomes from one patient. The mean time until the beginning of physical therapy was 21 ± 12 days; the mean duration of rehabilitation was 111 ± 51 days, with 18 ± 10 sessions. The mean ASES score in patients who

Table 2 Clinical features of patients undergoing nonsurgical treatment for deviated proximal humeral fractures

	n	%
Gender		
Male	7	17.5
Female	33	82.5
Side		
Right	13	32.5
Left	27	67.5
Dominant side affected?		
Yes	15	37.5
No	25	62.5
Smoking		
No	31	77.5
Smoker	7	17.5
Former smoker	2	5.0
Diabetes		
No	30	75.0
Yes, non-insulin-dependent	8	20.0
Yes, insulin-dependent	2	5.0
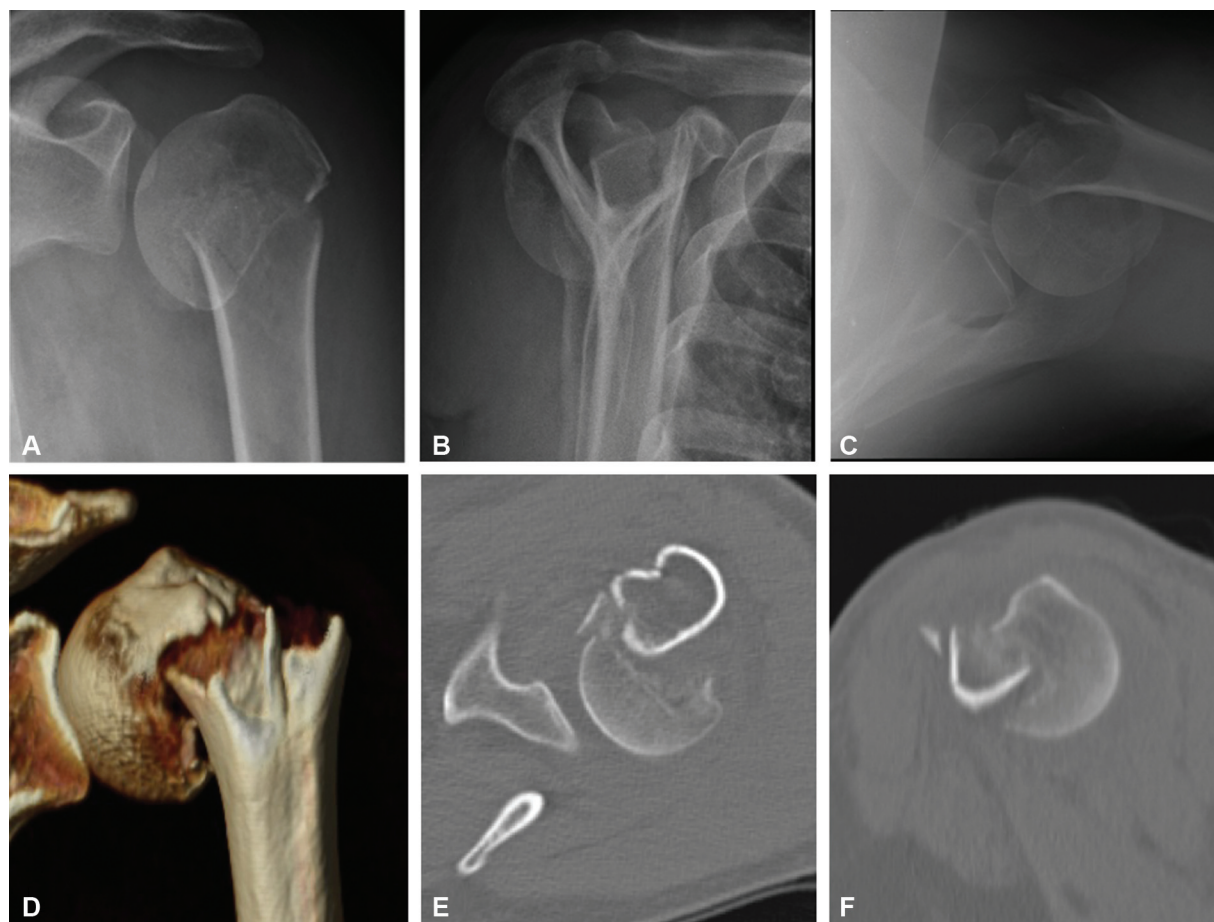
Fig. 1 Initial radiographs in AP (anteroposterior) view (A), lateral (B) and axillary (C) views. Computed tomography showing the fracture with three-dimensional reconstruction (D), in axial (E) and sagittal (F) sections.

started physical therapy more than 15 days after the fracture was 72 ± 25 points, whereas patients who started rehabilitation within 15 days presented a mean ASES score of 79.9 ± 23.4 points.

The ASES score at 12 months was 77.7 ± 23.2 points for the entire sample, improving over time. At 12 months, the mean absolute Constant-Murley score was 68.7 ± 16 points, with 82.6% for the contralateral side. The SANE score at 12 months was 84.8 ± 19 points. ►**Table 3** shows clinical outcomes.

Ultrasonography was performed in 37 patients (92.5%). Full-thickness tears of the rotator cuff were observed in eight subjects. The mean ASES score in patients presenting cuff tear was 76.9 ± 24.0 points at 12 months, with no statistically significant difference compared with patients with no cuff injuries (p = 0.188).

Eight patients (20%) had complications, including 4 cases of osteonecrosis (10%), 2 cases of pseudarthrosis (5%) and 2 cases of persistent stiffness (5%). No patient chose for a surgical approach to treat complications. ►**Figure 3** shows an osteonecrosis case and ►**Figure 4** demonstrates a pseudoarthrosis case. The mean ASES score in patients with complications was 53.8 ± 23.0 points.

The analysis of radiographic variables revealed the negative influence of the following parameters on the clinical outcome according to the ASES score at 12 months: severity according to the Neer classification and angular deviation at the coronal plane (measured by the head-diaphysis angle) and tuberosity fracture. The remaining radiographic variables did not influence functional outcomes according to the ASES score. ►**Table 4** shows a subgroup analysis for the main variables of the present study.

Discussion

Our results demonstrate that even fractures with significant tuberosity or humeral head deviation can be treated nonoperatively. The Constant-Murley score for the contralateral side was 82.6%, consistent with other studies on nonoperative treatment,[8,11–14] as well as with the surgical treatment using arthroplasty or locked plate fixation.[17–20] Subjective scores (i.e., ASES and SANE) were similar to those reported in systematic reviews.[2] Our results reinforce findings from the Proximal Fracture of the Humerus Evaluation by Randomization (PROFHER) study and a Cochrane systematic review demonstrating that nonoperative treatment can provide good functional outcomes even in deviated fractures.[2,3]

In a systematic review, Sabharwal et al.[21] obtained similar clinical outcomes with both treatments. However, these
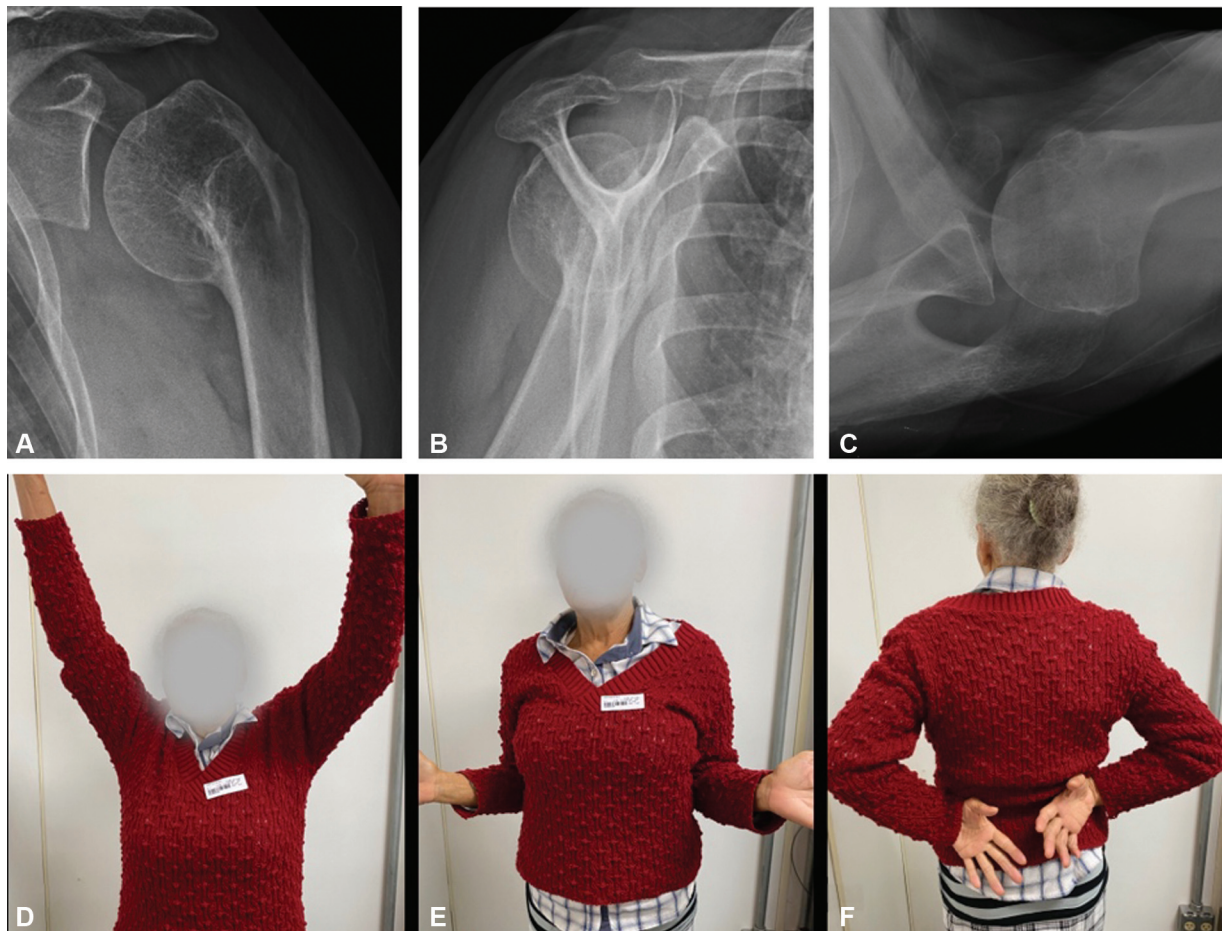
Fig. 2 At the 12-month follow-up, images show fracture consolidation and varus deviation in AP (anteroposterior) view (A), profile (B) and axillary (C) views. Clinical outcome showing active elevation (D), active lateral rotation (E) and active medial rotation (F).
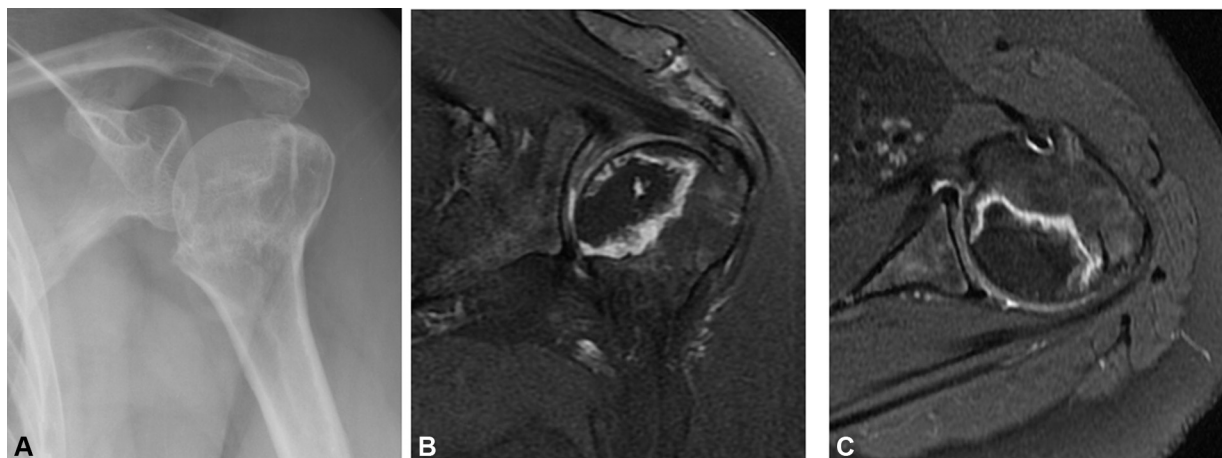
Fig. 3 Radiography (a) and magnetic resonance imaging (b) demonstrating a case of osteonecrosis at the humeral head.

authors demonstrated that, in more complex, four-part fractures, the surgical treatment resulted in better clinical outcomes and a lower rate of complications. They highlighted the need for future studies with specific fracture subtypes.

Few investigations evaluated the influence of the classification and deviation criteria defined by Neer on the nonoperative treatment of PHF.[8,14] Although routinely used as

criteria to indicate surgical treatment, a 45° angular deviation, 1 cm translational deviation and 0.5 cm tuberosity deviation were arbitrarily defined, as explained by Neer himself in 2002.[22]

Our secondary objective was to evaluate not only the deviation criteria described by Neer, but also several other radiographic parameters. The classification recently described

Table 3 Functional scores at 3-, 6- and 12-month follow-up visits after nonsurgical treatment for deviated proximal humeral fractures

	n	Mean	Standard deviation	Median	IQR
ASES					
3 months	39	57.7	24.5	56.3	42.8
6 months	39	71.6	24.3	80.7	36.0
12 months	40	77.7	23.2	85.2	40.1
SANE					
3 months	39	66.2	22.6	70.0	40.0
6 months	39	82.2	19.4	85.0	22.5
12 months	40	84.8	19.0	90.0	20.0
Constant-Murley					
3 months	39	55.6	16.7	60.0	31.0
6 months	40	64.8	15.9	68.5	28.5
12 months	40	68.7	16.0	72.0	24.0
Relative Constant score for the contralateral limb					
6 months	39	80.1%	18.7%	87.2%	37.8%
12 months	39	82.6%	23.6%	89.5%	31.3%

Abbreviations: ASES, American Shoulder and Elbow Surgeons score; IQR, Interquartile range; SANE, Single Assessment Numeric Evaluation.

by Resch et al.[23] has better inter- and intraobserver reliability when compared with the Neer system, but its potential in determining prognosis has not been evaluated yet.[6]

Univariate analyses revealed statistically significant, clinically relevant differences for some radiographic variables, mainly angular deviation, assessed by the head-diaphysis angle, and greater and lesser tuberosity fracture, regardless of its deviation. The mean ASES score in patients with greater and lesser tuberosity fractures was 23 points, a clinically significant relevant finding. Patients with deviated, four-part fractures according to Neer presented worse outcomes,

consistent with Yüksel et al.;[14] however, there was no statistically significant difference in two- or three-part fractures.

The head-diaphysis angle may be difficult to be evaluated on radiographs of acute fractures and presents variable interobserver correlation.[16,24] Nevertheless, with an adequate radiographic standardization and the potential use of CT scans, the head-diaphysis angle is an important parameter to aid the decision-making process, as it directly influences clinical outcomes. Patients with $< 110°$ or $> 166°$ had 29 points less on the ASES score when compared with subjects with minimal angular deviation (125° to 150°). Yüksel et al.[14] did not observe such influence on the Constant-Murley score, with similar results between valgus or varus impacted fractures $< 110°$.

Comparing only the mean head-diaphysis angles can lead to incorrect interpretations when fractures with varus and valgus deviation are included, as it approximates figures from opposite ends. The categorized analysis, such as the one performed in our study, or separated by valgus or varus deviations, avoids evaluation bias. In contrast to Court-Brown et al.,[12] in our sample, subjects with deviated fractures in severe valgus ($> 166°$) had lower ASES scores compared to those with severe varus ($< 110°$), but there was no statistically significant difference. Consistent with our findings, Foruria et al.[8] demonstrated that valgus impacted fractures had a three-fold higher risk of worsening 10 points on the Disability of Arm, Shoulder, and Hand (DASH) score when compared with varus impacted injuries.

Other factors did not show a statistically significant difference. The most prominent factor was the presence or absence of metaphyseal comminution, medial periosteal lesion, and deviations at the sagittal plane. Some studies[25,26] observed worse outcomes regarding stability after plate fixation in patients with posteromedial metaphyseal comminution, but no study has evaluated the importance of this finding in the nonoperative treatment.

We were unable to detect a statistically significant difference in functional scores for the classification described by
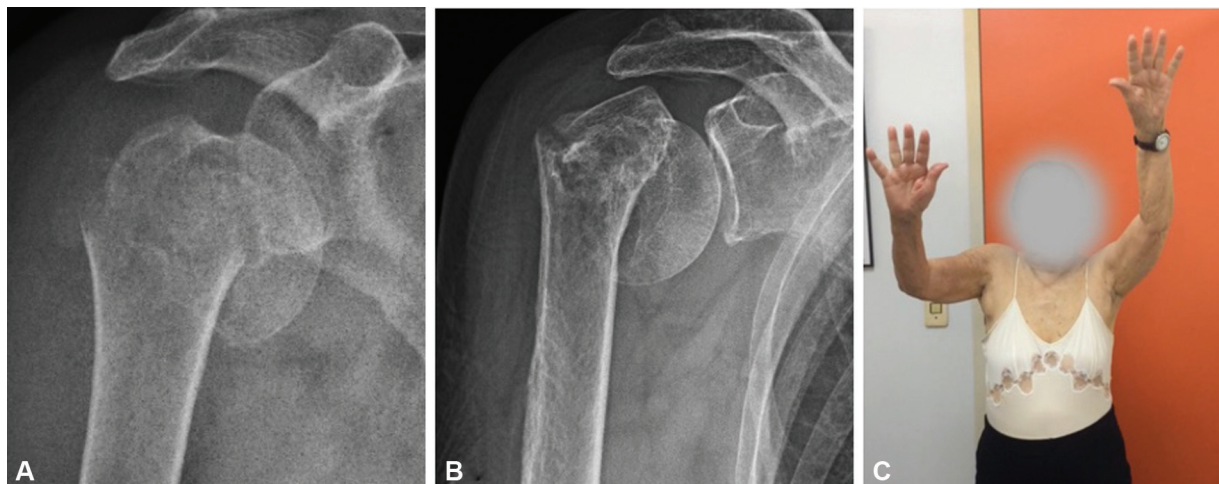
Fig. 4 Initial radiograph (A) and at the 12-month follow-up (B) from a patient with humeral neck pseudoarthrosis. Clinical examination (C) showing maximum active elevation.

Table 4 Subgroup analysis results for the main radiographic variables and classification systems

	ASES score at 12 months				
	Mean	Standard deviation	Median	IQR	p-value
Neer classification					
2 parts	88.4	15.4	94.2	19.9	
3 parts	79.0	21.5	85.2	32.3	
4 parts	61.0	28.3	47.5	56.0	0.031
Diaphyseal head angle, coronal view					
125° to 150°	93.4	7.8	96.3	11.9	
110° to 124° or 151° a 165°	74.5	25.2	78.4	45.4	
< 110° or >166°	64.3	25.0	56.5	48.2	0.004
Angular deviation, coronal view					
Minimal deviation	84.7	20.4	93.8	26.1	
Severe valgus (>166°)	60.0	22.3	58.1	41.9	
Severe varus (<110°)	66.2	27.1	56.5	54.9	0.034
Tuberosity fracture					
No tuberosity fracture	84.7	19.7	94.2	38.4	
Greater tuberosity fracture	82.8	20.3	88.1	27.5	
Lesser and greater tuberosities fracture	61.5	26.9	50.4	54.6	0.031
Resch classification					
1	94.2	6.4	95.9	12.6	
2	88.1	16.8	88.1	NA	
3	64.4	27.1	61.5	53.0	
4	76.2	23.7	84.9	44.8	0.052
Metaphyseal comminution					
No	75.8	23.7	85.4	49.7	
Yes	77.7	25.2	85.0	36.7	0.570
Medial periosteal lesion					
No	82.9	22.3	93.2	27.3	
Yes	71.6	24.7	78.5	51.7	0.168

Abbreviation: IQR: Interquartile range.

Resch et al.[23] Nevertheless, mean values for subtypes in valgus (type 3) and varus (type 4) were lower than types 1 and 2.

Rehabilitation-related variables showed no difference in subgroup analyzes either for time until the start of rehabilitation and its total duration and number of sessions.

As for rotator cuff injuries, there was no relationship between injury and worse clinical outcomes. Although we did not include patients with previous rotator cuff injury, it is possible that some cases were asymptomatic lesions, explaining the high rate observed in our sample. In addition, ultrasound scans in patients with fracture sequelae may be less accurate due to mobility limitations or deformities.

Rotator cuff tears did not influence the clinical outcome according to the ASES score in our sample.

Our study has some limitations. Since the sample size is relatively small for multivariate analysis, these radiographic factors were submitted to a univariate analysis, which can increase the risk of confounding factors. However, this is a homogeneous sample consisting of patients with similar features.

As positive points, this is a prospective clinical and radiographic evaluation, in standardized times, with an evaluator who did not participate in the study and did not follow-up the patients. All fractures included had significant deviations, which could be considered an indication for surgical treatment; there were no fractures with no or minimal deviation in this investigation. Our results can assist the decision-making process between non-operative and surgical treatment for some specific patterns of PHFs.

Conclusion

Nonoperative treatment of deviated PHFs in elderly patients had good clinical outcomes. These outcomes were negatively influenced by the Neer classification, the angular deviation of the humeral head and the presence of greater and lesser tuberosities fractures.

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