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Does an early mobilization and immediate home-based self-therapy exercise program displace proximal humeral fractures in conservative treatment? Observational study

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Background: Nonoperative management of proximal humeral fractures (PHFs) is the most common treatment, but its functional outcome may improve with early mobilization. In frail osteoporotic patients, quick recovery of prefracture independency is mandatory. This study assessed fracture displacement in PHFs managed with conservative treatment after early mobilization and a home-based self-exercise program.
Methods: We retrospectively analyzed the radiologic displacement of fracture fragments of PHFs treated conservatively with early mobilization and a home-based self-exercise program.
Results: Included were 99 patients with 26 one-part, 32 two-part, 32 three-part, and 9 four-part PHFs managed conservatively, followed by early mobilization and a home-based self-exercise program. In the x-ray examinations, the head displaced from varus into valgus 55° ± 23° to 42° ± 22°, in the normal range of anatomic values. The medial hinge displaced from medial to the diaphysis (+1 ± 6 mm) to lateral to the head (−0.6 ± 6 mm). The greater tuberosity displaced cranially from −1 ± 7 mm to 2 ± 5 mm. The Constant score at the 1-year follow-up was 79.69 ± 16.3.
Discussion and conclusions: The home-based self-exercise program for conservative treatment of PHFs displaces the head-diaphysis angle and the medial hinge toward anatomic reduction, but there is a risk of greater tuberosity cranial displacement. Functional results are fairly good, allowing frail patients to keep on with their independency and life style. Because a large number of patients might need further physiotherapy, the quality of the home-based self-exercises should be supervised.

The "Comité Ético de Investigación Clínica" área de salud Valladolid-Este: CEIC-VA-ESTE-HCUV approved this study (Study No. PI 17-795)

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The choice of treatment for proximal humeral fractures (PHFs) continues to be controversial.[7,16] Nonoperative management is considered the most frequent treatment compared with currently available operative options, including percutaneous Kirschner wiring, open reduction and internal fixation with conventional or locking plates, intramedullary (IM) locking nails, or shoulder prosthesis.[1,2,5,8,9,11,15,18,19,21,22,29-33] Treatment indications are based on fracture fragment displacement and fracture stability. Life expectancy in the elderly population is on the rise and has contributed to the increased incidence of these fractures. Moreover, the expectation of an improved quality of life has increased the activity level and demands from aged osteoporotic patients.[23,24] It is in the interest of these patients to return to their previous independency as fast as possible.

Different surgical treatments have been shown to provide better functional outcomes after 1 and 3 months of follow-up compared with conservative treatment based on 3 weeks of complete immobilization.[4,6,12,16,23,25,27,28] Nonsurgical treatment usually involves a period of immobilization, such as in an arm sling, followed by physiotherapy.[23,25,27] Immobilization of the injured limb provides support and pain relief during healing. There is, however, a risk of the shoulder becoming stiff and painful with substantial reduction of function.[17] This situation implies almost 1 month of dependency, which for an aged patient sometimes means the definitive loss of an independent life, adding a great increase of costs for the health system. Subsequent physiotherapy and exercises aim to restore function and mobility of the injured arm. The waiting time for physiotherapy can be longer in oversaturated rehabilitation systems, which delays independency in frail patients.

Thus, different strategies for early mobilization with the expectation of a faster recovery in conservative treatment have been used.[6,23,25,27] The first author had conducted a prospective randomized control trial (not yet published) comparing minimally invasive plate fixation vs. conservative treatment for PHFs (different number of fracture fragments and patterns of displacement), both with early mobilization. The good results observed in the conservative treatment group stimulated us to start an early mobilization and immediate home-based self-physiotherapy exercise program (EM&IHBSPEP) for PHFs treated nonoperatively. Such a strategy is thought to facilitate prompt recovery and autonomy to this cohort of frail patients.

The main objectives of our study were to evaluate the displacement of the fracture fragments during the healing process while patients exercised at home until osseous bone healing was achieved and to present our home-based self-exercise program for the conservative treatment of 1-, 2-, 3, and 4-fragment PHFs. Secondly, we evaluated the long-term functional results after conservative treatment of PHFs with an immediate home-based exercise program.

Materials and methods

This was a retrospective observational study of a cohort of patients, monitored prospectively, presenting a PHF treated conservatively included in an EM&IHBSPEP, In January 2015 we started in our institution (Hospital Clínico Universitario, Valladolid) an EM&IHBSPEP for PHFs treated conservatively. All patients with the diagnosis of a PHF and indication for conservative treatment were eligible to participate in this program.

Inclusion criteria in the program were (1) diagnosis of a 1-, 2-, 3-, or 4-part PHF, as defined by the Neer criteria of a displaced fracture with the limits of 1.0 cm displacement or 45° angulation,[13,26,28] (2) indication for conservative treatment based on the fracture pattern and the displacement of the fragments, which predict the outcome,[13] (3) independency to perform activities of daily living, (4) patients 18 years or older, (5) ability to exercise and to perform a home-based exercise program, and (6) clinical and radiologic follow-up completed at 1, 3, 6, and 12 months for adequate monitoring of functional progression and complications. All patients included in this program were informed and gave their signed consent.

Exclusion criteria were (1) pathologic fracture, except osteoporosis, (2) open fracture, (3) associated fracture in other locations, (4) PHF with extension to the diaphysis, (5) presence of mental disability limiting collaboration in the program (ie, any condition showing inability to perform the exercises at home without professional supervision), and (6) failure to attend follow-up visits.

We analyzed the radiologic displacement of the fracture fragments during the healing process and the functional outcome after 1 year of follow-up. There were 112 patients involved in the program between January 2015 and June 2016. The program excluded 11 patients who did not attend the 1-year follow-up check or prior visits, and 2 patients died during the follow-up of causes unrelated to the PHF. Finally, 99 patients completed the 1-year follow-up program with all data available for its analysis.

The conservative treatment with early mobilization protocol is based on the following guidelines: (1) all patients are asked to wear an immobilization sling over their clothes from the diagnosis day in a neck-cuff way, for 3 weeks; (2) no fracture reduction maneuvers are done but making the patients understand to keep the shoulder girdle muscles relaxed; (3) patients are allowed and encourage to perform, from the very beginning, their activities of daily living for self-care, such as feeding, dressing, and washing themselves (at diagnosis and in the follow-up visits, the patients are skilled up with the exercises); (4) immobilization can be removed for exercising, activities of daily living, and whenever the patient is resting or feels more comfortable without the sling, depending on pain.

All patients are instructed in home-based self-exercise. At any evaluation point, conventional physiotherapy is applied if clinical

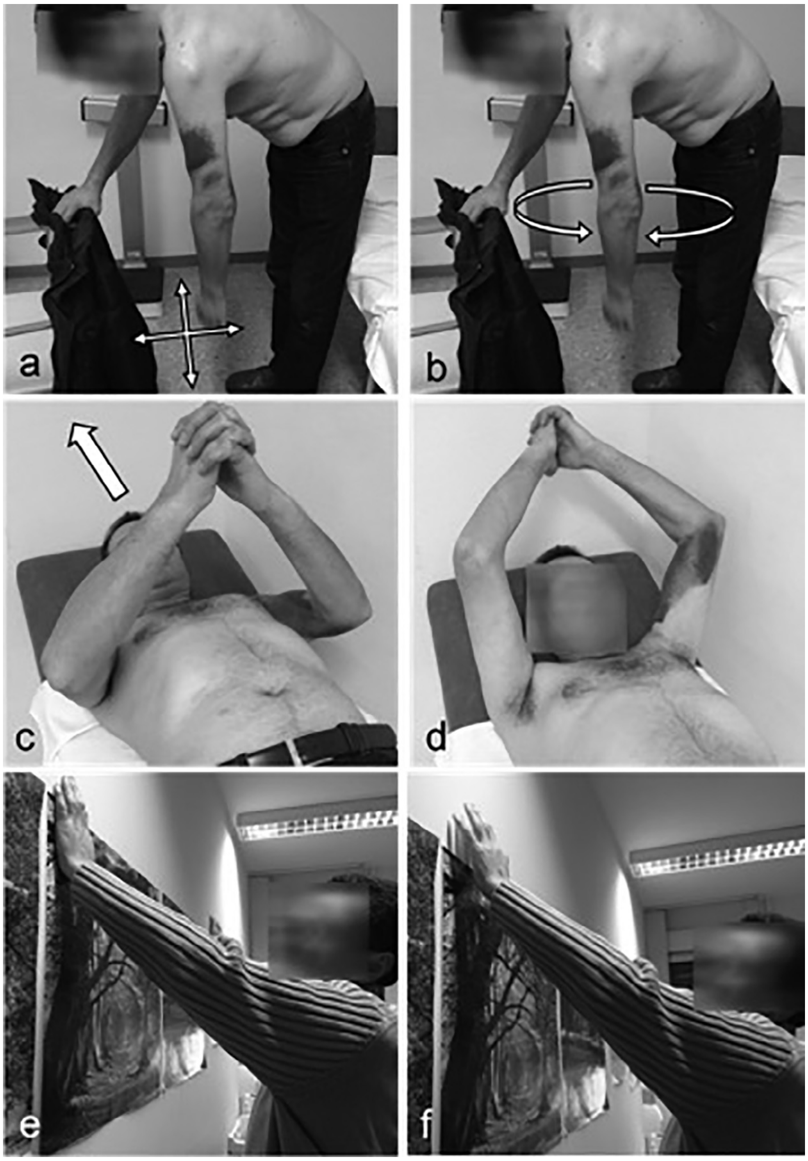

Figure 1 Passive range of motion exercises: (**a, b**) the "pendulum" or "cooking pot," (**c, d**) the "prayer," and the (**e, f**) "ladder."

progression is not observed (no improvement performing the exercises) or pain is not well under control, making impossible to exercise at home or to perform the activities of daily living. Patients are encouraged to perform the exercise program at least 2 times each day for 10 to 15 minutes each time, with 10 to 15 repetitions for each exercise. Although the rehabilitation regimen is the same for all patients, the level of pain experienced by each patient is different; therefore, not all patients cope with the exercises at the same level. To check their exercise skills, patients perform the exercises in the follow-up visits, and corrections on the exercise performance are done if needed. During the follow-up, patients were asked about compliance with the exercise program, but patients did not complete a form stating the time and days performing the exercise program.

The home-based self-exercise program consists of (Table S1):

- Passive range of motion exercises start on the diagnosis day, with the intensity and amplitude of the exercise depending on pain, activity level, and progression. (1) The "pendulum" or "cooking pot": with the trunk flexed and the uninjured hand on a stable element to prevent falls, the injured upper limb hangs perpendicular to the floor due to gravity. Gently, the injured limb is moved loosely in circles, from side to side, and forward-backward (Fig. 1, *a* and *b*). (2) The "prayer": in supine decubitus, with the fingers of both hands interlaced, the uninjured limb is raised above the head, carrying passively the injured limb in a passive forward flexion (Fig. 1, *c* and *d*). (3) The "ladder": facing a wall, the palm of the injured limb is placed on the wall at the abdomen height; the fingers climb upwards until mild pain is felt. The hand rests in that position for 15 seconds and then tries to climb 5 more cm, resting in that upper position another 5 to 15 seconds. If help is needed, the other hand can help pushing up from the wrist (Fig. 1, *e* and *f*). The "ladder" exercise is an active self-assisted exercise and is usually started during the second week. These 3 exercises are performed for the first 3 weeks, followed by active assisted exercises.

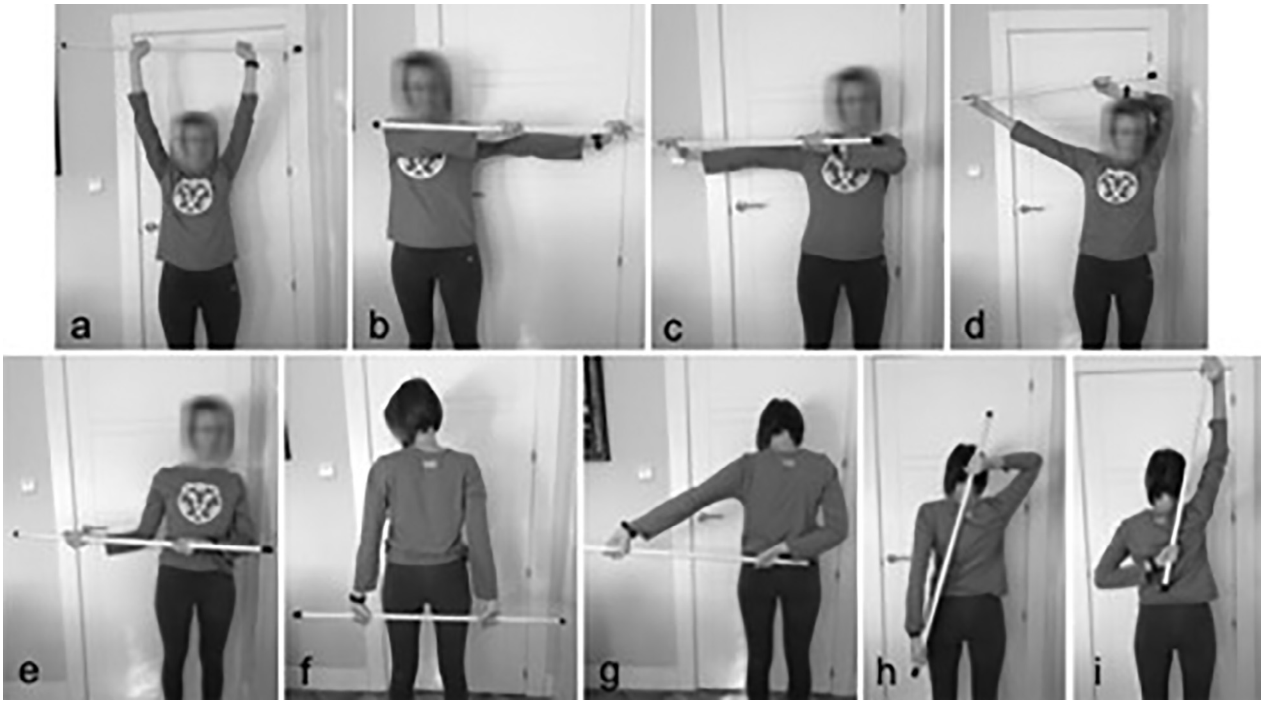

Figure 2 Active assisted exercises: The patient performs movement in all the arcs of motion with the help of a stick held with both hands: (**a**) forward flexion, (**b**) cross adduction, (**c**) abduction, (**d, e**) external rotation (stick over the head and behind the neck or with the elbow flexed 90º and the arm along the trunk), (**f, g**) internal rotation (stick behind the thighs). (**h**) External and (**i**) internal rotation can be increased holding with both hands the stick across the back.

- Active assisted exercises start after 3 weeks. The patient performs movement in all the arcs of motion with the help of a stick held with both hands: forward flexion, cross adduction, abduction, external rotation (stick over the head and behind the neck or with the elbow flexed 90° and the arm along the trunk), and internal rotation (stick behind the thighs; Fig. 2, *a-g*). External and internal rotation can be increased by holding the stick with both hands across the back: for external rotation, the injured hand over the injured shoulder and the uninjured hand in internal rotation over the lumbar region; for internal rotation, the injured hand in internal rotation as close as possible to the lumbar region and the uninjured hand over the uninjured shoulder in external rotation (Fig. 2, *h* and *i*). The stick can be substituted by a piece of cloth or an elastic band. For more comfort, all exercises can also be performed in the water. Pendulum exercises are performed with 1 kg maximum.
- Active nonresisted exercises: After 6 weeks, patients are allowed to perform specific active training in all arcs of motion. Isometric exercises also start: leaning on a wall on the hands and compressing a ball between both hands. Progressive weight lifting is permitted depending on pain. Active exercises involving daily activities are performed progressively from the first day after the trauma.
- Strengthening (active resisted) exercises: After 11 weeks, muscle strengthening starts. With an elastic band (lowest resistance) tied to a doorknob, the patient is asked to do repetitions of different shoulder movements: forward flexion, extension, abduction, adduction; external and internal rotation strength are gained in the plane of the scapula with the arm along the trunk, in neutral adduction (elbow flexed 90°). Once the strength is gain and the patient is more confident, external rotation is also done in 90° of abduction (elbow flexed 90°; Fig. 3).

Radiographic evaluation

Radiographs are taken on the first day for the diagnosis and at 1, 3, 6, and 12 months of follow-up. Radiographs are taken with the hand on the patient's abdomen, which results in approximately 45° of internal rotation. For the diagnosis of PHF, the patient wears a sling (with no abdominal band) and lets the shoulder loose so the shaft does not displace medially (gravity counteracts the pectoralis major traction to medial).

Fracture classification was based on plain radiographs and was determined by 3 experienced surgeons (H.J.A., C.S.P., and M.A.M.-F.). The number of fracture fragments was also taken into account, because these can be displaced during the healing process while the exercises are being done. All measurements were performed by an independent observer (M.M.Z.) using a digital caliper tool from the standard viewer software at our institution (Agfa Study Viewer 5.0.1; Agfa HealthCare, Mortsel, Belgium).

We considered the following parameters from a true anteroposterior (AP) view radiograph with the palm of the hand facing and touching the belly: (1) head-diaphysis angle, (2) medial metaphysis displacement, and (3) greater tuberosity height (Fig. 4).[12] The head-diaphysis angle is the angle defined by the perpendicular line to the humeral shaft axis and the line defined by the most medial and most lateral points of the humeral head articular surface on a shoulder AP view. The anatomic head-diaphysis angle value is between 55° and 30° (the anatomic valgus angle of the head minus 90°).

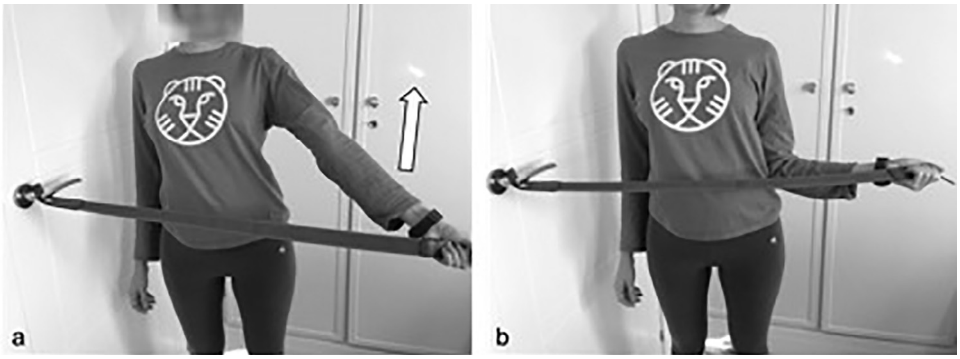

Figure 3 Strengthening (active resisted) exercises: With an elastic band (weakest one) tied to a doorknob, the patient is asked to do repetitions of different shoulder movements: (**a**) forward flexion, extension, (abduction, and adduction; (**b**) external rotation in adduction (elbow flexed 90^{o}), external rotation in 90^{o} abduction (elbow flexed 90^{o}), internal rotation in adduction (elbow flexed 90^{o}), and internal rotation in 90^{o} abduction (elbow flexed 90^{o}).

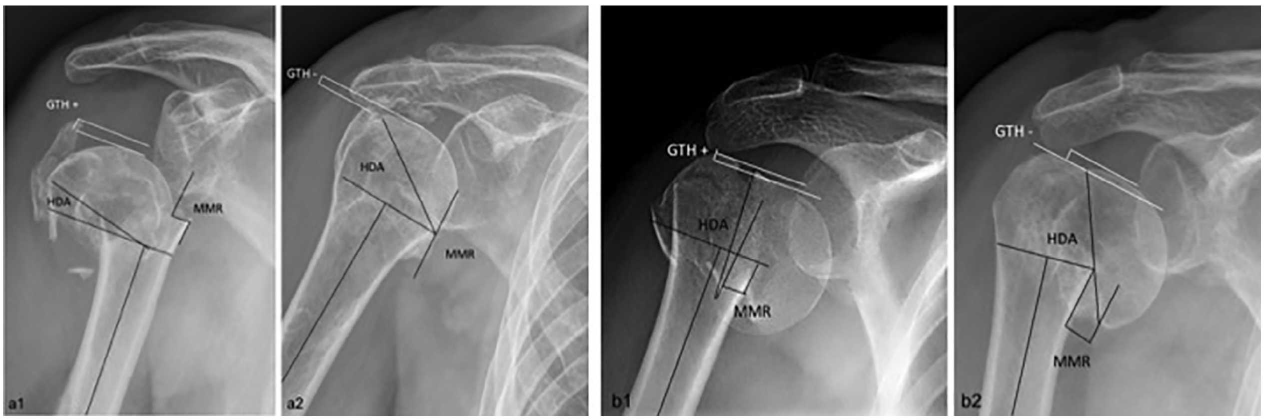

Figure 4 The 3 radiologic measures in true anteroposterior view: head-diaphysis angle (*HDA*), medial metaphysis displacement (*MMD*), and greater tuberosity height (*GTH*). (**a1**) Fracture displaced in valgus and (**a2**) same patient after fracture healing. (**b1**) Fracture displaced in varus and (**b2**) same patient after fracture healing.

The medial metaphysis reduction is measured as the distance between the most distal point of the humeral head articular surface and the most proximal medial point of the humeral shaft on an AP view. Zero value is considered to be no displacement of the medial hinge, negative values in millimeters when the humeral shaft is displaced lateral to the humeral head, and positive values in millimeters when the humeral shaft is displaced medial to the humeral head.

The greater tuberosity height is the distance in millimeters between the proximal tip of the greater tuberosity and the most proximal and lateral point of the humeral head on a true AP view. The greater tuberosity height value is negative when the greater tuberosity is lower (more distal), or is positive when the greater tuberosity is higher than the humeral head. The anatomic greater tuberosity height is −5 mm.

Differences between these measurements in the follow-up visits, if any, were related to fracture displacement while exercising from the diagnosis day until fracture healing. Radiologic union was considered when no fracture line was seen on simple radiographs.

Clinical evaluation

Follow-up was performed at 1, 4, and 6 weeks, and at 3, 6, and 12 months. Clinical evaluation was assessed using the Constant score, including the Constant score of the uninjured contralateral side at the 1-year follow-up.[3] Active range of motion was measured by a goniometer for abduction, forward flexion, and external rotation. Internal rotation was determined as the highest spinal level reached by the thumb. Healing time to clinical union (no pain felt on palpation at fracture site), residual pain on a visual analog scale, subjective results, and complications were also recorded.

Statistical analysis

Data were analyzed using SPSS 23.0 software (IBM, Armonk, NY, USA). Continuous variables are described using means ± standard deviation and the 95% confidence interval (CI). Categoric variables were tabulated with absolute and relative frequencies. Unpaired samples *t* tests were performed to compare subgroups within 1 time point. For all analysis, $P \leq .05$ was considered statistically significant.

Results

A total of 99 patients fulfilled the inclusion criteria. Epidemiologic data from the patients and the fractures as well as for clinical results regarding range of motion and residual pain

Table I Epidemiology and clinical results

Variable	Patients (n = 99)
Age, yr	72.4 ± 11.9
Sex	
Female	79 (79.8)
Male	20 (20.2)
Neer classification:	
1-part	26 (26.3)
2 part	32 (32.3)
3-part	32 (32.3)
4-part	9 (9.1)
Fracture fragments, No.	
2	25 (25.3)
3	58 (58.5)
4	16 (16.2)
Clinical results at 3-mo follow-up	
Constant score	64.03 ± 14.05
Difference in Constant scores between sides	25.88 ± 9.85
Clinical results at 1-yr follow-up	
Constant score	79.69 ± 16.3
Difference in Constant scores between sides	10.23 ± 10.96
Active range of motion	
Forward flexion, °	147 ± 18.3
Abduction,°	137 ± 20.2
Internal rotation	L2 vertebra
External rotation, °	40 ± 8.8
Residual pain (visual analog scale 0-10)	
Absence, 0	21 (21.2)
Low, >0-2	42 (42.4)
Mild, >2-4	28 (28.3)
Severe, >4	8 (8.1)

Data are shown as mean ± standard deviation or as number (%).

Table II Radiologic results

Variable	Postfracture	1-yr follow-up	*P*
Head-diaphysis angle, °	55 ± 23	42± 22	<.001
Medial metaphysis reduction, mm	1 ± 6	−0.6 ± 6	.005
Greater tuberosity height, mm	−1 ± 7	+2 ± 5	<.001

Data are shown as mean ± standard deviation.

are reported in Table I. Fracture healing was achieved in all cases. Mean time to radiologic union was 2.5 ± 0.39 months (95% CI, 1.5-3 months). Mean time to clinical union was 2.23 ± 0.44 months (95% CI, 1.5-3 months). Radiologic results comparing the head-diaphysis angle, the greater tuberosity height, and the medial metaphysis reduction after the trauma and at the 1-year follow-up are reported in Table II. A greater tuberosity fragment was present in 80 fractures (80.8%). At the diagnosis, the greater tuberosity was lower or at least at the same height as the humeral head in 67 patients (67.7%) and was over the head in 32 (32.3%). Once the fracture healed, the greater tuberosity was lower or at least at the same height as the humeral head in 53 patients (53.5%) and was over the head in 46 (46.5%).

External help with physiotherapy was required by 42 patients (42.4%), who were prescribed 28 ± 5.7 physiotherapy sessions starting 46 ± 10.7 days after the fracture occurred. The remaining 57 patients (57.6%) did not need physiotherapy help, recovering exclusively with the home-based self-exercise program.

Complications occurred in 2 patients: 1 patient developed an inflammatory arthritic episode that required immunomodulator therapy, and another patient developed avascular necrosis of the humeral head and in the diagnostic magnetic resonance image also presented a supraspinatus tear. No axillary palsy was recorded. No patient required a secondary operation due to complications or for pain or poor function.

Discussion

Our study yielded several important findings regarding the displacement of PHFs with conservative treatment after EM&IHBSPEP. Although we did not record patient compliance with the exercise program, we know for sure that no patients in the study were immobilized for more than 1 week and that some exercise was done from the moment of the diagnosis. The main finding is that 1-, 2-, 3-, and 4-fragment PHFs heal with no further significant displacement of the head and the medial metaphysis despite immediate mobilization but that cranial displacement of the greater tuberosity may occur.

This study is based on plain radiographs. We use computed tomography scans for the initial diagnosis in a large number of patients, but not in all patients, and never for the follow-up. Therefore, we could only compare x-ray images, and the classification we worked with used the x-ray images at diagnosis time. The radiographic views were intended to be true AP views, orthogonal to the plane of the scapula. Although AP views were not always perfect, measurements were not referred to the glenoid, and only within the proximal humerus. This minimizes the effect of not having a perfect 90° pure AP view.

We chose these radiographic parameters according to the work by Foruria et al[13] on patterns of the fracture and fragment displacement in PHFs. According to Foruria et al,[13] the closer to their anatomic position these 3 parameters are, the better the final functional result. The immediate post-trauma head-diaphysis angle was 55° ± 23° (95% CI, 37°-64°), in the anatomic range, but slightly in varus. This angle changes while the bone heals, displacing into varus 42° ± 22° (95% CI, 33°-64°; $P < .001$) also in the range of normal anatomic values. The head-diaphysis angle displaces with the home-based self-exercise program, but this displacement drives the reduction of the head toward the anatomy (between 55° and 30°).

According to Hertel et al,[20] the integrity of the medial hinge affects the integrity of the head vascular system, but only influencing on the functional outcome if avascular necrosis appears.[14] The diagnosis x-ray image showed medial displacement of the diaphysis (+1 ± 6 mm). After fracture healing and remodeling, the diaphysis displaced lateral to the head (−0.6 ± 6 mm; $P = .005$), meaning impaction of the shaft in the humeral head, which is a more stable configuration, improving bone-to-bone contact. With the passive exercises, muscles relax and gravity force pulls downward from the shaft, facilitating the medial hinge reduction.

The greater tuberosity is meant to be 5 mm below the top part of the humeral head. In this anatomic position, the rotator cuff tendons work correctly, and no further impingement will develop, especially for abduction and external rotation. In our series, we observed displacement of the greater tuberosity from −1 ± 7 mm (−15 mm, +17 mm) at the moment of the diagnosis of the PHF to +2 ± 5 mm (−10 mm, +16 mm) at 1-year follow-up ($P = .000$). These findings suggest that the greater tuberosity becomes at risk of further impingement and insufficiency for abduction.

These 3 radiologic measures prove that the EM&IHBSPEP improves the position of the head and the medial hinge. The reduction of the medial hinge into lateral gives stability to the fracture until fracture consolidation. The repositioning of the head may improve the final functional outcome. However, the displacement of the greater tuberosity may worsen this final functional outcome, specifically in abduction and forward flexion. At the moment of the diagnosis, the greater tuberosity was below the head. During the follow-up, the tuberosity starts displacing cranially, but not in all cases: 14 of 67 patients with the greater tuberosity lower than the head presented a greater tuberosity displacement over the humeral head. Thus, close follow-up is advisable in the presence of a greater tuberosity fracture fragment, because it may displace while exercising. If greater tuberosity displacement is observed and limits abduction or external rotation, surgical treatment should be reconsidered.

Because the fracture fragments settle during fracture healing, a 4-part PHF at the diagnosis may turn into a 1-part PHF at the 1-week follow-up visit. According to our results, a 2-part PHF behaves completely different depending on the displaced fragment: the greater tuberosity or the shaft. This is why we did not perform a subgroup analysis according to the Neer classification of PHFs, and our focus was on displaced fragments.

The EM&IHBSPEP for PHF conservative treatment achieves different objectives step by step. At the beginning, pain relief is obtained by shoulder girdle muscles and rotator cuff tendons relaxation with the Codman "pendulum" exercises. The patient learns how to let the muscles loose while the forearm is resting in the sling, on a cushion, or on a table. This hanging loose position helps the shaft to reduce from medial (usual displacement due to the pectoralis major traction).

The second objective is to recover prefracture full range of motion. The "pendulum" and the "prayer" exercises help to start recovering the range of motion and avoiding the development of fibrous scar tissue. In a progressive way, the "ladder" exercise will increase the range of motion.

The third objective of the PHF treatment is to recover the muscle strength, starting with the "ladder" exercise because it can be done from passive assisted to active assisted.

The independent performance of daily life gives the patient self-confidence and independency, which helps the geriatric frail patients recover their prefracture situation as soon as possible. We could not evaluate the satisfaction of the patients with the treatment method or the time to restore the prefracture state.

The functional results observed at 1-year follow-up (mean Constant score, 79.69 ± 16.3) are at least as good as the results presented in other series of cases with conservative treatment with or without immobilization (Constant score range, 82-71[6,9,16,18,23,25,27]). In other studies, immediate mobilization with physiotherapy was always used.[27] For this reason, our results cannot be compared with other series. We are aware that 1-year follow-up is not long enough to rule out the risk of avascular necrosis. However, the objective of the study was to address fracture displacement before fracture consolidation. Once the fracture has healed, no further displacement is expected. In our patients, all fractures healed with no nonunion after 1 year of follow-up.

The definition of complications varies in the literature, which only partially explains the wide range of reported complication rates.[9,10,16-18,23,25,27,30] The rate of complications in our series was low, with no secondary surgical procedure in any patient, although 12 patients presented a Constant score of less than 65. This includes the patient presenting with avascular necrosis and rotator cuff tear. This same patient was the only one with severe pain after 1 year of follow-up. This patient (58 years old, 3-part fragment PHF) presented a Constant score of 50, depending mainly on the pain experienced (visual analog scale, 8), because range of movement and strength was functional. Although no surgical procedure was performed in our patients, surgical treatment was proposed to the patient presenting avascular necrosis but was declined.

Physiotherapy was needed in almost half of the patients in our series; therefore, the home-based self-exercise program was not enough to achieve a good functional outcome in all patients. Our study did not accurately monitor patient compliance with exercising, the quality of the exercises, or the exercising time. Perhaps patients should be closely supervised by trained physiotherapists after early mobilization and a home-based exercise program in PHF conservative treatment. The physiotherapist would monitor the exercise program compliance, the patients' skills in exercising, and the functional progression. As for the possibility of greater tuberosity displacement, close follow-up by the clinician should be done in those cases with a greater tuberosity fragment.

Hodgson et al[23] compared commencing physiotherapy within 1 week of fracture vs. delayed physiotherapy after 3 weeks of immobilization in a collar and cuff sling in 86 people with minimally displaced fractures. The results showed a tendency for less disability in the group with early mobilization at 1 year.[23] When considering the extent and duration of initial immobilization after a fracture, a balance is needed between the advantages of pain relief and avoidance of fracture displacement vs. the consequences of immobilization: joint stiffness and muscle atrophy. Subsequent physiotherapy and exercises aim to restore function and mobility of the injured arm but might be delayed in our oversaturated rehabilitation centers. Our patients performed their routinely daily activities (feed, dress, and wash themselves) independently between days 7 and 30. In our health system, the time for starting physiotherapy after a PHF is 2 to 3 months. As we see in our results, at 3 months of follow-up, the Constant score was 64.03 ± 14.05 (95% CI, 44-80), and there was a difference of 25.88 points with the contralateral Constant score. These results support the fast recovery of independency and almost a complete return to previous activities and life.[17] Kristiansen et al[25] tested the duration of immobilization in a sling and body bandage (1 week vs. 3 weeks) in 85 people with mainly nondisplaced fractures and reported that 1 week of immobilization resulted in a better total score due to less pain during the first 3 months.

Previous studies with immediate exercising or physiotherapy involved only stable or nondisplaced fractures,[16,23,25,27] whereas our study involved displaced and nondisplaced PHFs. Lefevre-Colau et al[27] compared 74 patients with minimally displaced or "stable" impacted PHFs commencing physiotherapy immediately after 3 days of immobilization vs. delayed physiotherapy after 3 weeks of immobilization. Carbone et al[7] included only impacted fractures in osteoporotic patients. Fractures with medial comminution, unstable, or in nonosteoporotic patients were excluded.[7] They did not measure the medial metaphysis displacement because of the impacted fracture stability.

Our revision included impacted fractures, unstable fractures, and nonosteoporotic patients as well as osteoporotic fractures. Because some of the fractures we present were unstable, there was a reduction of the medial metaphysis while exercising. Better functional results at 6 weeks and 3 months were observed in the immediate physiotherapy group and also less pain at the 3-month follow-up.

Evidence from randomized controlled trials is insufficient to inform the choices between different rehabilitation interventions for PHF.[6] We could not monitor the patients' compliance with the program; thus, we do not know the exact effectiveness of the home-based self-exercise program. We also found compliance differences because of pain, but the intention was to start mobilization immediately, assuming different degrees of exercising. We made sure that all patients did early mobilization, tried to dress, clean, and eat by themselves, and definitively, were not strictly immobilized for 3 weeks. Changes should be introduced in our protocol to identify patients at risk of greater tuberosity displacement. Physiotherapy supervision at a certain point should also be considered to achieve better functional results. The immediate mobilization and home-based self-exercise program offers good functional outcome, which can be improved. A tailor-made program could be implemented offering standard programs. including a home-based self-exercise program that can be modified according to patient-specific requirements. Many patients will do fine only with the home-based self-exercise program, whereas others might need physiotherapy help.

Our study has some limitations. Firstly, it is an observational study trying to identify difficulties with the exercise program, problems experienced by the patients, and needs for improvement; therefore, we have just started a multicenter, randomized controlled trial comparing different protocols and immobilization for a better evaluation of early mobilization and home-based physiotherapy.

Secondly, although the home-based self-exercise program includes the number of repetitions and routine time, no record was taken of the patient's exercise compliance: we do not know exactly how much exercise was done. For a retrospective study, this could be fine because the emphasis was on basic life activities; however, future studies should compare different exercise routines and programs. Our findings need further confirmation from large comparative investigations such as a proper multicenter randomized controlled trial of conservative treatment with early mobilization vs. surgical treatment for PHF. A cost analysis should also be included. The conservative treatment with early mobilization and home-based self-physiotherapy should include physiotherapy supervision.

Conclusions

The home-based self-exercise program for the conservative treatment of PHFs improves the head-diaphysis angle and the reduction of the medial hinge, although there is a risk of greater tuberosity cranial displacement. Because a large number of patients might need further physiotherapy, the quality of the home-based self-exercises should be supervised. Functional outcome of early mobilization for the conservative treatment of PHFs is fairly good. For this reason, elderly frail patients may take advantage of this treatment regimen to regain their independency for self-care duties.

Disclaimer

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Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jse.2018.04.001

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