ABSTRACT

Background and Hypothesis: Non-operative management of proximal humeral fractures (PHF) is the most common treatment, but its functional outcome may improve with early mobilization. In frail osteoporotic patients quick recover of pre-fracture independency is mandatory. The objective of the present study is to assess fracture displacement in PHF conservative treatment following early mobilization and a home-based self-exercise program.

Methods: We retrospectively analyzed the radiological displacement of fracture fragments of PHF treated conservatively with early mobilization and a home-based self-exercise program.

Results: 99 patients presenting 26 1-part, 32 2-part, 32 3-part and nine 4-part PHF managed conservatively, followed early mobilization and a home-based self-exercise program. In the X-ray exams, the head displaced from varus into valgus: 55°±23 to 42°±22, in the normal range of anatomic values. The medial hinge displaces from medial to the diaphysis (+1 mm±6) to lateral to the head (-0.6 mm ±6). And the greater tuberosity displaces cranially from -1 mm ±7 to 2 mm ±5. Constant score at one-year follow-up was 79.69±16.3.

Discussion and Conclusion: The home-based self-exercise program for conservative treatment of PHF displaces the "head-diaphysis angle" and the medial hinge towards anatomical 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. As a big number of patients might need further physiotherapy, the quality of the home-based self-exercises should be supervised.

Level of evidence: IV

KEY WORDS

26 Proximal humeral fracture, conservative treatment, early mobilization, osteoporotic,
27 physiotherapy, displaced, home-based exercise.

TITLE

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

INTRODUCTION

The choice of treatment for proximal humeral fractures (PHF) continues to be controversial[7,16]. Non-operative management is considered the most frequent treatment when compared with currently available operative options including percutaneous K-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. The rise of life expectancy in the elderly population 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]. It is on the interest of these patients to return to their previous independency as fast as possible. Different surgical treatment modalities have shown to provide better functional outcomes after one and three-months follow-up when compared with conservative treatment based on 3 weeks of complete immobilization[4,6,12,16,23,25,27,28]. Non-surgical 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. But, there is a risk of the shoulder becoming stiff and painful with substantial reduction of function[17]. This situation implies almost one 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.

Time for physiotherapy can be longer in the case of over saturated rehabilitation systems, which delays independency in frail patients.

Thus, different strategies for early mobilization expecting a faster recovery in conservative treatment had been used[6,23,25,27]. The first author had carried out a prospective randomized control trial (not yet published) comparing minimally invasive plate fixation vs conservative treatment for PHF (different fracture number of 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&IHBSTP) for PHF treated non-operatively. Such a strategy is thought to facilitate prompt recovery and autonomy to this cohort of frail patients.

The main objectives of our study are to evaluate the displacement of the fracture fragments during the healing process while doing exercises at home until osseous bone healing has been achieved and to present our home-based self-exercise program for the conservative treatment of PHF (1-2-3-4 fragment fractures). Secondly, we evaluate the long term functional results after conservative treatment of PHF with an immediate home-based exercise program.

PATIENTS AND METHODS

This is a retrospective observational study of a cohort of patients, followed prospectively, presenting a PHF treated conservatively included in an EM&IHBSTP. In January 2015 we started in our institution ([redacted]) an EM&IHBSTP for PHF 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 1-2-3-4 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 one, three, six and 12 months for adequate monitoring of functional progression and complications. 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 (i.e. any condition showing inability to perform the exercises at home without professional supervision), and (6) not attendance to follow-up visits. All patients included in this program were informed and gave their signed consent.

We analyzed the radiological displacement of the fracture fragments during the healing process and the functional outcome after one-year follow-up. A total of 112 patients were involved in the program between January 2015 and June 2016. Eleven patients didn´t attend to the one-year follow-up check or prior visits, thus were excluded from the program; and two patients died during the follow-up for causes unrelated to the

PHF. Finally, 99 patients completed the one-year follow-up program with all data available for its analysis. This study has been approved by our institution´s ethics committee.

The conservative treatment with early mobilization protocol is based on the following guidelines: (1) all patients are asked to wear a sling immobilization over their clothes from the diagnosis day in a neck-cuff way, for three 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: feed, dress and wash 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 for home-based self-exercise. At any evaluation point conventional physiotherapy is applied, if clinical 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 per day for 10-15 minutes each time, with 10-15 repetitions for each exercise. Although the rehabilitation regime 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; 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 fill out any paper form stating the time and days performing the exercise program.

The home-based self-exercise program consists on: (table I)

- Passive range of motion exercises start on the diagnosis day. The intensity and amplitude of the exercise depends on pain, activity level, and progression. Passive exercises are: (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 (Figure 1.a-b). (2) The "prayer": in *decubitus supinus*, with both hands interlacing fingers, the uninjured limb is driven above the head, carrying passively the injured limb in a passive forward flexion (Figure 1.c-d). And (3) the "ladder": facing a wall, the palm of the injured limb is placed 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 5-15 seconds. If help is needed, the other hand can help pushing up from the wrist (Figure 1.e-f). The "ladder" exercise is an active self-assisted exercise, and is usually started during the second week. These three exercises are carried out for the first three weeks, followed by active assisted exercises.

- Active assisted exercises start after three 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 90º and the arm along the trunk), internal rotation (stick behind the thighs) (Figure 2.a-g). External and internal rotation can be increased holding the stick with both hands across the back of the patient: 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 (Figure 2.h-i). The stick can be substituted by a piece of clothe 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 non-resisted exercises: After six weeks, patients are allowed to perform specific active training in all arcs of motion. Also isometric exercises start: leaning on a wall on the hands, and compressing a ball between both hands. Progressive weight lifting is permitted depending on pain. Although active exercises involving daily activities are performed progressively from the first day after trauma.

- Strengthening (active resisted) exercises: after 11 weeks muscle strengthening starts. With an elastic band (softest one) 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 90º). Once the strength is gain and the patient is more confident, external rotation is also done in 90º of abduction (elbow flexed 90º) (Figure 3.a-b).

Radiographic evaluation

Radiographs are taken on the first day for the diagnosis, at one month, three months, six months and at 12-months follow-up. Radiographs are taken with the hand on the patient's abdomen: that means 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 three experienced surgeons ([redacted]). The number of fracture fragments was also taken into account, as these can be displaced during the healing process while doing the exercises. All measurements were performed by an independent observer ([redacted]) 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 AP view X-ray with the palm of the hand facing and touching the belly: (1) head-diaphysis angle, (2) medial metaphysis displacement, and (3) greater tuberosity height (Figure 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 anatomical head-diaphysis angle value is between 55° and 30° (the anatomical valgus angle of the head minus 90°). 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 positive when the greater tuberosity is higher than the humeral head. The anatomical "greater tuberosity height" is −5 mm. Differences between these measurements in the follow-up visits, if any, should be related to fracture displacement while exercising from the diagnosis day until fracture healing. Radiological union was considered when no fracture line was seen on simple radiographs.

Clinical evaluation

Follow-up was performed at one, four, six weeks, three, six and 12 months. Clinical evaluation was assessed using the Constant score (including Constant test of the

uninjured contralateral side at one-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 (VAS: visual analogue scale), subjective results and complications were also recorded.

Statistical analysis

Data were analyzed using SPSS 23.0 (SPSS, Chicago, IL). Continuous variables were described using means ± standard deviation (sd) (confidence interval 95%). Categorical variables were tabulated with absolute and relative frequencies. T tests for unpaired samples were performed to compare subgroups within one-time point. For all analysis, $p \leq 0.05$ was considered statistically significant.

206 RESULTS

207 A total of 99 patients fulfilled the inclusion criteria. Epidemiologic data from the
208 patients and the fractures, as well as for clinical results regarding range of motion and
209 residual pain are shown in Table II. Fracture healing was achieved in all cases. Mean
210 time to radiological union was 2.5±0.39 months (range 1.5–3 months). Mean time to
211 clinical union was 2.23±0.44 months (range 1.5–3 months). Radiological results
212 comparing the "head-diaphysis angle", the "greater tuberosity height" and the "medial
213 metaphysis reduction" post-trauma and at one-year follow-up are shown in Table III. 80
214 fractures (80.8%) presented with a greater tuberosity fragment. At diagnosis time the
215 greater tuberosity was lower or at least at the same height as the humeral head in 67
216 patients (67.7%), being over the head in 32 patients (32.3%). Once the fracture healed,
217 the greater tuberosity was lower or at least at the same height as the humeral head in 53
218 patients (53.5%), being over the head in 46 patients (46.5%).
219 Regarding the need of external help with physiotherapy: 42 patients (42.4%) were
220 prescribed 28±5.7 physiotherapy sessions starting 46±10.7 days after the fracture
221 occurred. 57 patients (57.6%) didn´t need any physiotherapy help at all, recovering
222 exclusively with the home-based self-exercise program. Two patients presented
223 complications: one patient developed an inflammatory arthritic episode which required
224 immunomodulator therapy; another patient developed avascular necrosis of the humeral
225 head and in the diagnostic MRI also presented a supraspinatus tear. No case of axillary
226 palsy was recorded. There was no patient undergoing secondary surgery due to
227 complications neither for pain or poor function.

DISCUSSION

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

This study is based on plain radiographs: we use CT scans for the initial diagnosis in a large number of patients, but not in all of them, and never for the follow-up. Therefore, we could only compare X-rays and the classification we worked with was using the X-rays at diagnosis time. X-ray views are intended to be true AP views, orthogonal to the plane of the scapula. Although AP views were not always perfect, measurements are not refer to the glena, and only within the proximal humerus. This minimizes the effect of not having a perfect 90º pure AP view. We chose these radiographic parameters according to Foruria et al. work on patterns of the fracture and fragment displacement in PHF[13]. According to Foruria, the closer to their anatomical position these three parameters are, the better final functional result. The immediate post-trauma "head-diaphysis angle" was 55°±23 (37°-64°), in the anatomical range, but slightly in varus. This angle changes while bone healing, displacing into varus 42°±22 (33°-64°), (p=0.000) also in the range of normal anatomical values. The "head-diaphysis angle" displaces with the home-based self-exercise program, but this displacement drives the reduction of the head towards the anatomy (between 55° and 30°).

According to Hertel et al., the integrity of the medial hinge affects the integrity of the head vascular system, but only influencing on the functional outcome if avascular

253 necrosis appears[14,20]. The diagnosis X-ray showed medial displacement of the diaphysis
254 (+1±6 mm); after fracture healing and remodeling, the diaphysis displaced lateral to the
255 head (-0.6±6 mm) (p=0.005), meaning impaction of the shaft in the humeral head,
256 which is a more stable configuration, improving bone to bone contact. With the passive
257 exercises, muscles relax and gravity force pulls downwards from the shaft facilitating
258 the medial hinge reduction.
259 The greater tuberosity is meant to be 5 mm below the top part of the humeral head. In
260 this anatomical position, the rotator cuff tendons work correctly, and no further
261 impingement will be developed, especially for abduction and external rotation. In our
262 series, we observed displacement of the greater tuberosity: from -1 mm ±7 (-
263 15mm,+17mm) at the moment of the diagnosis of PHF to +2 mm ±5 (-10mm,+16mm)
264 at one-year follow-up (p=0.000). These findings suggest that the greater tuberosity
265 becomes at risk of further impingement and insufficiency for abduction.
266 These three radiological measures prove that the EM&IHBSTP improves the position of
267 the head and the medial hinge. The reduction of the medial hinge into lateral gives
268 stability to the fracture until fracture consolidation. The repositioning of the head may
269 improve the final functional outcome. On the other hand, the displacement of the greater
270 tuberosity may worsen this final functional outcome, specifically in terms of abduction
271 and forward flexion. At the moment of the diagnosis, the greater tuberosity was below
272 the head. During the follow-up the tuberosity starts displacing cranially, but not in all
273 cases: 14 patients out of 67 patients with the greater tuberosity lower than the head
274 presented a greater tuberosity displacement over the humeral head. Thus, in the
275 presence of greater tuberosity fracture fragment, close follow-up is advisable, as it may
276 displace while exercising. If greater tuberosity displacement is observed, surgical
277 treatment should be reconsidered if it limits abduction or external rotation. Because the

fracture fragments settle during fracture healing, a 4 part PHF at the diagnosis may turn into a one part PHF at the one-week follow-up visit. According to our results, a two 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 PHF and our focus was on displaced fragments.

The EM&IHBSTP for PHF conservative treatment achieves different objectives step by step. At the beginning pain relieve is obtained by shoulder girdle muscles and rotator cuff tendons relaxation with the Codman´s "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 pre-fracture full range of motion. The "pendulum" and the "prayer" exercises helps to start recovering the range of motion avoiding the development of fibrous scare 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 as it can be done from passive assisted to active assisted. On the other hand, the independent performance of daily life gives the patient self-confidence and independency which helps the geriatric frail patients to recover their pre-fracture situation as soon as possible. We could not evaluate the satisfaction of the patients with the treatment method, neither the time to restore the pre-fracture state.

The functional results observed at one-year follow-up (mean Constant score 79.69 ±16.3) are at least as good as the ones 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 can not be compared with other series. We

303 are aware that one-year follow-up is not long enough to rule out the risk of avascular
304 necrosis. But the objective of the study was to address fracture displacement before
305 fracture consolidation. Once the fracture has healed, no further displacement is
306 expected. In our patients, all fractures healed with no cases of nonunion after one year
307 follow-up. The definition of complications varies in the literature, which only partially
308 explains the wide range of reported complication rates [9,10,16-18,23,25,27,30]. The rate of
309 complications in our series was low, with no secondary surgical procedure in any
310 patient, although 12 patients presented a Constant score of less than 65. This includes
311 the patient presenting with avascular necrosis and rotator cuff tear. This same patient
312 was the only one with severe pain after one-year follow-up. This patient (58 yo, 3
313 fragment PHF) presented a Constant score of 50, depending mainly on the pain
314 experienced (VAS=8), because range of movement and strength was functional.
315 Although no surgical procedure was performed in our patients, the patient presenting
316 avascular necrosis was proposed surgical treatment but declined.
317 In our series of cases, physiotherapy was needed in almost half of the patients;
318 therefore, the home-based self-exercise program wasn´t enough to achieve a good
319 functional outcome in all patients. In our study, we did not accurately monitor the
320 compliance of the exercising: nor the quality of the exercises, neither the exercising
321 time. Maybe patients following early mobilization and a home-based exercise program
322 in PHF conservative treatment should be closely supervised by trained physiotherapists.
323 The physiotherapist would monitor the exercise program compliance, the patients' skills
324 exercising and the functional progression. As for the possibility of greater tuberosity
325 displacement, close follow-up by the clinician should be done in those cases with a
326 greater tuberosity fragment.

Hodgson compared commencing physiotherapy within one week of fracture versus delayed physiotherapy after three 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 early mobilization group at one 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, versus the consequences of immobilization: joint stiffness and muscle atrophy. Subsequent physiotherapy and exercises aim to restore function and mobility of the injured arm but it might be delayed in our over saturated rehabilitation centers. Our patients performed their routinely daily activities (feed, dress and wash themselves) independently between day seven and 30. In our health system, the time for starting physiotherapy after a PHF is two to three months. As we see in our results, at three-months follow-up the Constant score was 64.03 ±14.05 (44-80), and 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 tested the duration of immobilization in a sling and body bandage (one week versus three weeks) in 85 people with mainly non-displaced fractures, reported that one week of immobilization resulted in a better total score due to less pain during the first 3 months[25].

Previous studies with immediate exercising or physiotherapy involved only stable or non displaced fractures[16,23,25,27], while our study involves both, displaced and non-displaced PHF. Lefevre-Colau et al. compared 74 patients with minimally displaced or "stable" impacted PHF commencing physiotherapy immediately after three days of immobilization versus delayed physiotherapy after three weeks of immobilization[27]. Carbone et al. included only impacted fractures in osteoporotic patients. Fractures with medial comminution, unstable, or in non-osteoporotic patients were excluded[7]. They do

not measure the medial metaphysis displacement because of the impacted fracture stability. Our revision includes impacted fractures, unstable fractures, and non-osteoporotic patients as well as osteoporotic fractures. Because some of the fractures we present are unstable, there is a reduction of the medial metaphysis while exercising. Better functional results at six weeks and three months were observed in the immediate physiotherapy group; and also less pain at three-months follow-up. There is insufficient evidence from randomized controlled trials 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 is 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, weren´t strictly immobilized for 3 weeks. Changes should be introduced in our protocol in order to identify patients at risk of greater tuberosity displacement. Physiotherapy supervision at 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 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, while 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 control 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 don´t know exactly how much exercise was done. For a retrospective study, this could be fine, as emphasis was given on basic life activities; but future studies should compare different exercise routines and programs. Our findings need further confirmation from large comparative investigations, like a proper multicenter randomized control trial between conservative treatment with early mobilization versus surgical treatment for PHF. 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 PHF improves the "head-diaphysis angle" and the reduction of the medial hinge; although, there is a risk of greater tuberosity cranial displacement. As a big 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 PHF is fairly good. For this reason, elderly frail patients may take advantage of this treatment regime regaining their independency for self-care duties.

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502 TABLE LEGENDS

503 Table I: home-based self-physiotherapy exercise program for PHF in conservative
504 treatment

505

506 Table II: Epidemiology and clinical results, n=99. Expressed by mean and standard
507 deviation (sd), confidence interval 95%.

508

509 Table III: Radiological results. Expressed by mean and standard deviation (sd).

510 FIGURE LEGENDS

511 Figure 1. Passive range of motion exercises: the “pendulum” or “cooking pot” (a,b), the
512 “prayer” (c-d), and the “ladder” (e,f).

513

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

521

522 Figure 3. Strengthening (active resisted) exercises: With an elastic band (softest one)
523 tied to a doorknob, the patient is asked to do do repetitions of different shoulder
524 movements: forward flexion, extension, abduction (a), adduction, external rotation in
525 adduction (elbow flexed 90º), external rotation in 90º abduction (elbow flexed 90º) (b),
526 internal rotation in adduction (elbow flexed 90º), and internal rotation in 90º abduction
527 (elbow flexed 90º).

528

529 Figure 4. The three radiologic measures in true AP view: head-diaphysis angle (HDA),
530 medial metaphysis displacement (MMD), and greater tuberosity height (GTH). Figures
531 a1 fracture displaced in valgus and a2 same case after fracture healing. Figures b1
532 fracture displaced in varus and b2 same case after fracture healing.