



The impacted varus (A2.2) proximal humeral fracture in elderly patients: Is minimal fixation justified? A case control study

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Background: The purpose of this retrospective case control study was to assess the outcome of K-wire osteosynthesis of a varus displaced proximal humeral fracture in patients over 65 years old, compared to a control group treated nonoperatively.

Methods: The patient cohort was taken from our database in the period 2003-2007. After data extraction, the patients were re-examined and scored by the Constant score (CS), modified Constant score (MCS), and the QuickDASH score. The control group was carefully selected and matched to the surgical one for age, type of fracture, and degree of displacement. Minimum follow-up was 12 months, with a mean of 30 months in the surgery group, and 27 months in the nonoperative group.

Results: K-wire osteosynthesis in our series yielded consistently good results in older patients who sustained an A2.2 proximal humeral fracture, with an average MCS of 88 points and a QuickDASH score of 15. The surgery group had a statistically significant higher CS and modified Constant score at follow-up than did the conservatively treated group ($p = .03$).

Conclusion: Operative treatment of varus displaced proximal humerus fractures treated with K-wire osteosynthesis yields good results that are superior to those treated nonoperatively.

Level of evidence: Level 3; Case control study, treatment study.

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Treatment choice for a proximal humeral fracture is still controversial, especially in older patients. A recent epidemiologic analysis has shown that one of the most common humeral fractures is the varus impacted (A2.2) fracture as it accounts for 13% of all the proximal humeral fractures.⁶ The

main characteristic of this fracture is the medial displacement of the greater tuberosity, which may not only weaken the level arm of the shoulder, but also lead to impingement. To the best of our knowledge, to date, no detailed investigation has been made as to the clinical medium-term consequences of the varus malunion. Consequently, there are no clear indications as to "an acceptable degree" of angular displacement before deciding on surgery.

In this well-defined disease, the functional results of nonoperative treatment are suboptimal despite the patients' high subjective impression.⁸ However, there is still concern

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Figure 1 A2.2 proximal humeral fracture: **A**, true anteroposterior view; **B**, trans-thoracic view; **C**, axillary view; **D**, CT scan. The figure shows how the inclination angle was measured by subtracting the post-trauma angle (β) from the normal 50° angle.

as to whether this functional impairment justifies surgery, above all in older patients who are not only usually affected by other medical diseases but are also susceptible to a high rate of operative complications.^{10, 17} Despite the high rate of comorbidity, the older patients affected by a proximal humeral fracture tend to be self-supporting⁷; therefore, an effective treatment that allows for full functional recovery becomes fundamental in order to reduce social impairment and loss of independence.

Of the operative alternatives, a less invasive percutaneous reduction and K-wire fixation would improve range of motion and power, as well as limit pain and mild-severe complications^{3,4,13,18,19,20} However, the major concern facing the surgeon when using this technique is the difficulty in obtaining a secure fixation of the implant to osteoporotic bone with the secondary risk of wire migration and reduction loss.^{11,14,15}

The purpose of our study was to assess the medium-term outcome of a K-wire osteosynthesis in patients over 65 affected by an A2.2 proximal humeral fracture and analyze the implant osteoporotic-related complications. Furthermore, we analyzed the effects of the varus malunion in a matched selected conservative group.

Materials and methods

From January 2003 to March 2006, a total of 640 patients were treated in our hospital with a diagnosis of proximal humeral fracture. A review of the hospital charts identified 45 patients treated surgically using K-wires fixation with the following inclusion criteria: (1) an A2.2 proximal humeral fracture in which the inclination angle (α), on the day of the diagnosis, had been tilted more than, or equal to, 25° (Figure 1); (2) patients over 65 with enough communicative skill to complete a Constant score (CS)⁵; (3) the absence of previous shoulder disease; (4) the ability to perform routine activities independently appropriate for an elderly person (ie, housework, shopping, independent personal toilet, and dressing), and. (5) a minimum follow-up of 12 months post-trauma.

Fractures were assessed by true anteroposterior views (Figure 1, A), scapular Y views, or trans-thoracic views (Figure 1, B), as well as axillary radiographs, when tolerated by the patients (Figure 1, C). The inclination angle was measured by subtracting the post-trauma angle (β) from the normal 50° angle.⁸ The fractures were then classified according to the AO system¹⁶ by an experienced orthopaedic trauma surgeon with special interest in the shoulder. The angle of varus malunion was measured on the true AP x-ray assessed by either reviewing the digital images or by CT scan when available (Figure 1, D).

A control group that had been treated conservatively, but with the same inclusion criteria, were selected from January 2003 to December 2007. The indication for the conservative treatment in the control group were patients who did not consent to the surgery, those referred to us 2 weeks after the original trauma, and patients seen by the consultant on call who were not in agreement with surgical treatment for an A2.2 proximal humeral fracture in older patients (with $\alpha \geq 25^\circ$).

The x-ray and CT scan in both the study and control groups were reviewed carefully to exclude rotational or translational (posterior) displacement. All patients in which the reviewer suspected a major concomitant rotational and/or translational displacement were excluded if a CT (Figure 2) scan was not available to clarify the amount of the posterior displacement. This was done in order to limit confounding factors. A systematic measurement of the posterior displacement in the "Y" view was not, however, performed. Attempts to measure the head-shaft angle in the "Y" or axillary view proved to be inaccurate and not reproducible and were abandoned.

A total of 465 patients with a proximal humeral fracture were treated conservatively from January 2003 to December 2007 and 50 of them fitted our inclusion criteria. The patients in the surgery group were treated with a closed reduction and transitory percutaneous fixation, using partially threaded K wires (Figure 3). Alternatively, an open reduction followed by K-wire fixation inserted through the skin was used, if it was not possible to reduce the fracture percutaneously.

X-rays were taken for the conservative group on the 7th, 14th, and 45th day post-trauma, according to our standard protocol in use as from 2002. For the surgery group, the x-ray protocol was on day 1 post-surgery and at 7, 14, and 45 days post-surgery. If, on the 45th day, the x-ray demonstrated sufficient healing of the

fracture, the K wires were removed in the outpatient's department by unscrewing without the need for anaesthesia.

All patients were asked to wear a shoulder immobilizer sling with the upper limb in the so-called safe position for 3 to 4 weeks in the conservative group and until the removal of the K wires in the surgery group. A home exercise program was started before discharge. This programme involved informing the patients about their injury, teaching them pendulum exercises, and showing them how to flex their arm passively, all within individual pain tolerance. Pendulum exercise and passive assisted range-of-motion exercises, with up to 60° of elevation and abduction and up to 0° of external rotation, were begun at 2-3 weeks post-operatively or after trauma. An active assisted range of motion exercises were commenced once the sling had been removed. A standard physiotherapy program for proximal humeral fracture was prescribed to all the patients, ie, both the conservative and surgery group.

Once selected for review, the patients were invited for a physical and radiological examination in our outpatient's department. The examinations were always done by the same researcher. The outcome was scored by the QuickDASH score,² CS, and modified Constant score (MCS) without correction for handedness.⁹ The number of physiotherapy sessions was also recorded.

Standardized antero-posterior radiographs were used to measure the varus deformity. As the standardized radiographs of the shoulder are very difficult to obtain, and even a minor rotational displacement may interfere with the measurement of the varus angle, the results were grouped as follows: good reduction (an α angle of less than 15°), poor reduction (α between 15° and 24°), displaced (α between 25° and 34°), severely displaced (α > than 35°). The varus displacement was then related to the CS, MCS, single parameters of the MCS, and QuickDASH score.

Surgical technique

The patient is placed on the operating table in the beach-chair position and a fluoroscopic intensifier positioned. The patient's upper extremity is prepared from the shoulder to the fingertips to allow complete mobility of the arm. The fracture is reduced under fluoroscopy by external manipulation. Once the reduction is satisfactory, 3 to 4 2.5-mm partially threaded K wires are inserted in the antero-lateral side of the upper arm, through the distal part of the deltoid muscle insertion, in a distal-to-proximal, lateral-to-medial, and antero-to-posterior direction. The aim is to obtain a crossing of the wires over the fracture just below the subchondral bone, so as to configure a support similar to that of a "4-legged stool" (Figure 3). Alternatively, if a closed manipulation is unable to ensure an accurate reduction, an open reduction by a limited deltopectoral approach is used, followed by K-wire fixation. All patients receive 1 single dose of antibiotic prophylaxis before surgery.

Statistical analysis

The power of the correlation between the variables (degree of varus displacement and outcome) was determined by the Spearman test. The Fisher's exact test and the Student *t* test were used, respectively, for the comparison between proportions and average values. The level of significance was set at $p < .05$ for all the analyses.



Figure 2 3-dimensional CT scan that shows the absence of a major posterior displacement. That view was required in case of suspected concomitant posterior displacement of the humeral head.

Results

A total of 35/45 surgery patients and 38/50 conservative patients initially selected for review were eligible for clinical and radiographic review. Nine members of the surgery group and 8 of the conservative group were lost to follow-up because they had moved to another region, both groups lost 1 patient due to death for unrelated causes, and 3 of the conservative group were untraceable.

After the double control for adherence to inclusion criteria, another 3 patients were excluded from both groups, as, although not evident at first selection, these patients were unable to perform everyday activities independently at the time of surgery. For the data analysis, 32 surgical cases and 35 controls were eligible. The baseline characteristics for each group are shown in Table I. All the injuries were sustained by a pedestrian fall and all but one of the fractures (a contralateral distal radius fracture, in the control group) were isolated injuries. Surgery was performed on an average of 7 ± 5.6 days post-trauma (range, 2-14 days). The average discharge was on the second post-operative day (median value, 2 days; range, 1-5).

The CT scan was available for review in 30 patients: 18 in the surgery group and 12 in the conservative group. At the time of diagnosis, 61 patients were living in their own homes while 6 were in geriatric homes (but were independent for everyday activities), 4 in the conservative group, and 2 in the surgery group.

Clinical results

Follow-up for the surgical group was 30 months (range, 12-42) and 27 months (range, 12-40) for the conservative

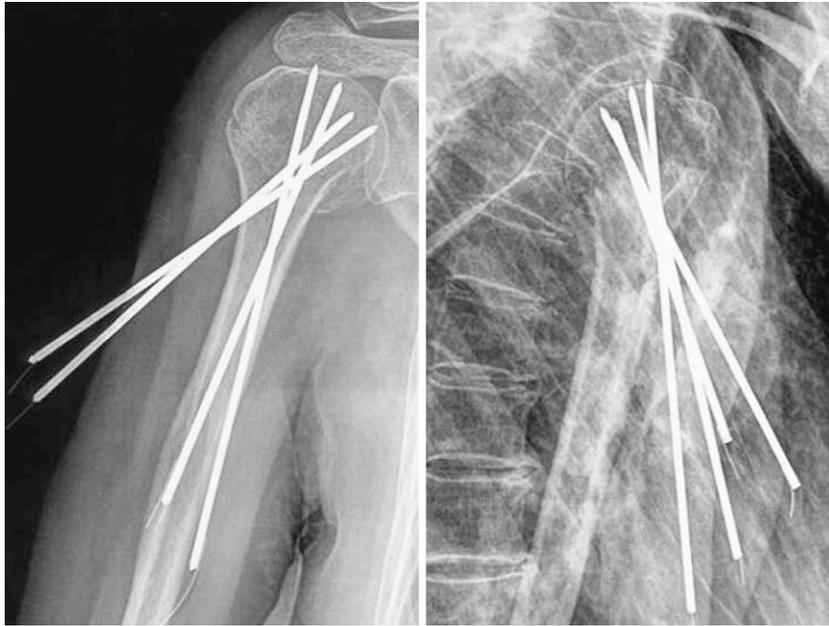


Figure 3 Postoperative x-rays.

Table I Baseline data

Group	Pts	R/L	Age average ± SD (range)	F/M	CS normal side average ± SD (range)	Varus angle average ± SD (range)	Physiotherapy sessions average ± SD (range)
Surgery	32	23/9	73 ± 7.83 (66-85)	20 F 12 M	81.41 ± 6.7 (77-87)	32.53 ± 2.86 (25-40)	23.25 ± 10 (12-36)
Control	35	23/12	75.1 ± 8 (67-84)	26 F 9 M	80 ± 9 (74-86)	30.72 ± 3.6 (25-40)	19.5 ± 9 (12-36)

CS, constant score; SD, standard deviation, M, male; F, female; R/L, right-handed/left-handed; Pts, patients.
Number of sessions $P < .05$.

treatment group. The surgery group had a statistically significantly higher CS and MCS score at follow-up than the conservative group ($p = .03$) (Table II). The MCS showed significantly better results in the surgery group for pain, ability to sleep, abduction, ability to work at specific levels, flexion, and strength (Figure 4). However, there was no significant difference between the 2 groups in the ability to work, to engage in recreational activities, or external/internal rotation. The overall QuickDASH score was 30.5 ± 5.1 in the conservative group and 15.05 ± 3 in the surgery group ($p = .035$). The analysis of the outcome in the conservative group revealed a decrease in the MCS score in patients with a short-term follow-up (less than 18 months) compared to those with medium-term follow-up (over 18 months). Furthermore, an increased pain during daily activities and night pain was observed in the patients with a longer follow-up. In the nonoperative group, the pain score extracted from the CS compared to the score measured on the contralateral unaffected side was 76% in the group, with less than an 18 month follow-up and 66% in the group with a follow-up of over 18 months ($p = .3$).

Table II Results in the conservative and operative treatment

	N	Controls	N	K wires
CS, all the follow-up	35	58.2	32	72
MCS, all the follow-up	35	72.7	32	88.4
CS, follow-up < 18 months	19	60.6	19	71
MCS follow-up < 18 months	19	75.7	19	87.2
CS, follow-up > 18 months	16	55.3	13	73.4
MCS follow-up > 18 months	16	69.1	13	91.4

CS, Constant score; MCS, modified Constant score.

Moreover, in the nonoperative group, with a short-term follow-up, 21% (4/19) of the patients experienced mild to severe night pain whilst it increased to 50% (8/16) in the medium-term follow-up ($p = .3$).

An open reduction was performed in 14 of the surgery patients with no difference in outcome compared to the patients treated with a closed reduction. Six patients in the surgery group and 7 controls were not able to return to the same level of independency they had in the pre-trauma

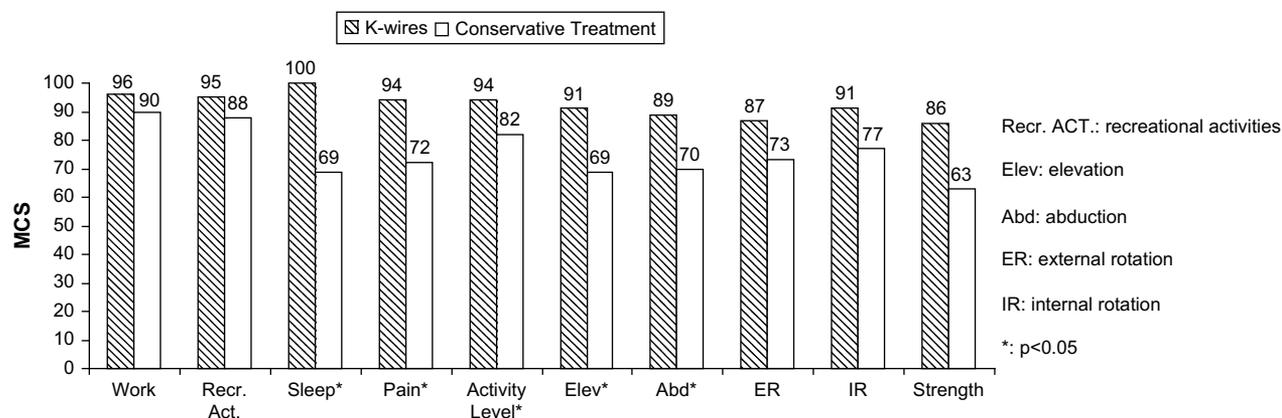


Figure 4 Comparison of the parameters of the modified Constant score between operative and conservative treatment.

state (average age, 84 years). However, only 2 patients in the control group and none in the surgery group were of the opinion that the shoulder was responsible for their difficulty.

Radiographic outcome

A good post-surgical reduction was obtained in all but 4 patients (Figures 5 and 6). Of the 4 patients classified as “poor reduction,” 3 had had a closed reduction and 1 an open reduction. In the conservative group, progressive varus displacement was observed in 6 patients. These patients initially classified in the displaced group (varus displacement 25°-34°) were re-classified as “severely displaced” at the last follow-up (varus displacement >34°). Two fractures in the surgery group were allocated to another group due to an early secondary displacement, while another fracture showed a delayed displacement after 45 days. Two of the 3 cases were due to early mobilization of the K wires.

It was observed during the follow-up that the amount of displacement was significantly related to the MCS ($r = -.624$, $p < .05$) (Figure 7). The strength and abduction were more significantly related to the varus angle ($r = -.798$, $p < .05$). However, the overall analysis of the CS, QuickDASH, and pain extrapolated from the MCS did not show any significant correlation between degree of displacement and clinical outcome.

Complications

Although all the fractures in the 2 groups healed, there were some complications with 1 superficial and 1 deep infection in the surgery group. The deep infection occurred in a patient affected by diabetes after open reduction and was diagnosed at 4 post-surgical weeks resolving after 30 days of antibiotics. The superficial infection was observed at 30 post-surgical days and healed with topic antiseptic after

wire removal. Although the wires slipped out in 3 cases (2 cases after 2 weeks, 1 after 3 weeks), the final clinical results were not compromised. No patients had neurovascular injury.

Discussion

To the best of our knowledge, this is the first study to analyzed the mid-term outcome of the varus impacted (A2.2) proximal humeral fracture. The medial rotation of the greater tuberosity and the consequent decreased level arm of the shoulder is the main feature of the varus displaced proximal humeral fracture. The clinical consequence could be an increased incidence of impingement, due to early and chronic pathological contact between the medial displaced tuberosity and the acromion. Furthermore, it is also possible that the anomalous contact may lead to a reduction in range of motion (ROM) even without impingement. A previous study⁸ has reported that, at 1 year post-trauma, the nonoperative treatment of an A2.2 fracture leads to functional but not clinical impairment, with a flexion of about 70% that of the normal range, an abduction of 53%, and a flexion and abduction power of 70%. However, no direct correlation was found between the varus displacement and outcome. Conversely, we found a good correlation between the degree of varus malunion and MCS. Although this is not in line with the previous study, it may be explained by the fact that the MCS gives a more accurate view of the functional results for shoulder disorders, and that it is less likely to overestimate patient satisfaction in the older patients. Moreover, in the MCS, the strength factor is given a relatively high rating on the final results, parameter that we found significantly related to the varus malunion. This may well justify why, in our study, the MCS, and not the CS, significantly correlated to the degree of malunion. Another factor that differed was the fact that only patients over 65 were included in our study, reducing



Figure 5 AP x-rays during the 12th month follow-up.

the influence of the age on the outcome. Our patients were around 70-75 years of age, making for an easy interpretation of the results.

There was a statistical difference in the total amount of rehabilitation sessions carried out in our study for the 2 groups (Table I), but the consequence of this is unknown. The influence rehabilitation has on the outcome after minimally and 2-part proximal humeral fracture is, in fact, still controversial. Court-Brown and McQueen studied 99 patients affected by an A2.2 proximal humeral fracture and observed that increasing the duration of rehabilitation did not improve the final outcome.⁸ A recent study on 2-part proximal humeral fracture reported that an immediate shorter rehabilitation program confers benefits over a delayed, longer one, but that the differences between the groups were not significant at the 2-year follow-up.¹²

In an effort to clarify which of the parameters in the CS had the most significant effect on the outcome, we compared the single parameters of the MCS between the 2 groups. We found that the main difference was abduction, flexion, power, ability to sleep, and ability to work at specific levels ($p < .05$), while there was no significant difference for work, recreational activities, or internal/external rotation. One explanation for this may be the fact

that older patients have a low functional demand that generally compensates for the poor functional outcomes. Moreover, the CS is not the best method to assess subjective disability, above all in older populations. Therefore, we introduced the QuickDASH score and found a significant reduction in disability in the surgery group, compared to the conservative group. The lack of significant difference in the internal/external rotation of the affected arm compared to the contralateral side may well be due to the lack of associated extensive rotational deformities also in the conservative group.

Although our results are in contrast with the previous study⁸ as to pain, comparisons should be made with caution as the varus angle in all our patients ranged from 25° to 40° (we did not include minor displacement), and different functional assessment methods were used in the analysis of the outcome. Noteworthy is the fact that the day and night pain reported in our study is higher in the group of controls with mid-term follow-up than the controls that had a short term follow-up, despite a slight improvement in the ROM observed in the same period. However, the analysis of the data failed to demonstrate a statistical correlation between the degree of malunion and pain. This may be due, in part, to the difficulty in correctly assessing the varus angle and, in part, to the subjective nature of pain.

Considering the relationship between the varus malunion and MCS (Figure 7), we found that the score was substantially higher (14 points) in the group with 15°-24° compared to the group with 25°-34° of varus angle. This observation may be an indirect indication of the validity that a 25° of varus displacement is a reasonable indication for surgery.

Fixation with K wires is not an easy technique, as it requires knowledge of the muscle forces acting on the individual fracture parts and involves closed reduction of the proximal humerus with manipulation and traction. If performed correctly, it ensures good transitory stability and optimal functional results with an acceptable complication rate, even in the elderly who are often affected by osteoporosis. There was a 9% (3/32) rate of wire mobilization in our study, without major consequences on clinical outcome. However, it must be said that this low complication rate is also due to the intrinsic benign nature of the A2.2 fracture and that the extension of this technique to more unstable and complex fractures requires further investigation.

The present study has clear limitations. First, as we were of the opinion that it would have been unethical to randomize patients who were to receive nonoperative treatment, it is not a randomized study. Therefore, the conservative group may be affected by a selection bias. Second, the measurements of the deformity of the proximal humerus might have been affected by the direction of the x-ray beams and/or by minimal rotational deformities. Due to the retrospective nature of this study, it was not possible to measure in a standard fashion concomitant posterior or

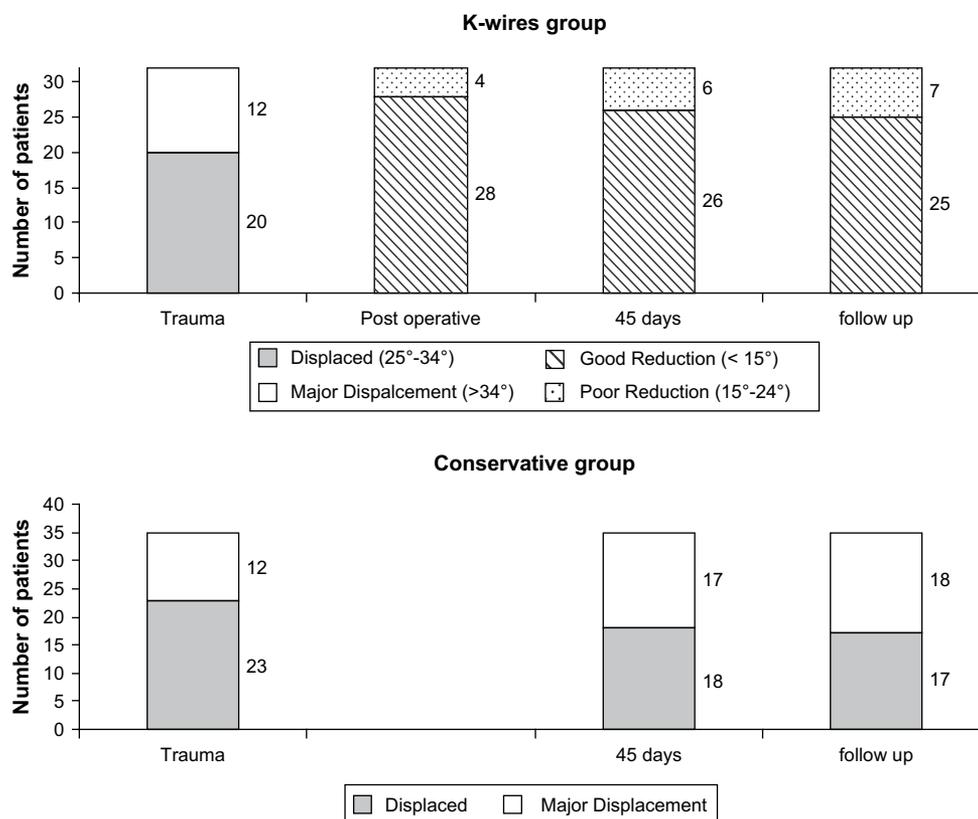


Figure 6 The number of patients that achieved a good reduction, poor reduction, and those that healed with moderate or severe varus displacement.

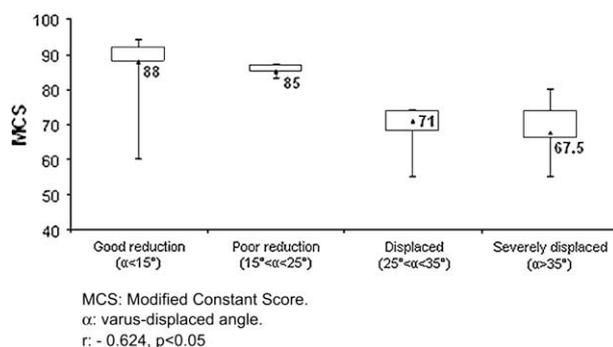


Figure 7 The correlation between MCS and the amount of varus malunion at the follow-up. *MCS*, modified Constant Score. r : - 0.624; $p < .05$; α , varus-displaced angle.

rotational displacement. In order to do that, a standardized and reproducible axillary and “Y” view of the shoulder would have been necessary; however, all the patients included had at least 3 different x-ray projections available for review. One third of the patients had also a CT scan with 3-D reconstruction. The high exclusion rate among the patients treated conservatively is the direct consequence of how strictly we adhered to the exclusion criteria. The absence at the last follow-up of a rotational impairment clinically relevant could also be an indirect proof of the absence or, if any, nonrelevant, concomitant rotational displacement.

Another limitation of this study is that the measurement of the varus displacement was performed with the assumption of a normal inclination angle of 130°. There may be an individual variation of that angle in both the groups that could have slightly modified the amount of the measured displacement. However, in order to reduce but not eliminate, this bias the amount of varus displacement has been classified in 4 more comprehensive groups instead of giving an absolute measure for each patient.

Finally, longer follow-ups and more accurate instrumental evaluation, such as the MRI may be a requisite to fully understand the nature of the shoulder pain.

Nevertheless, our study suggests that conservative treatment is a viable option for patients with severe medical conditions and/or in low functional-demanding patients, even if an impaired functional recovery and an increase in pain might be expected at longer follow-up. The less invasive effective and reproducible K-wire fixation offers optimal functional results in elderly active patients.

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