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# Evaluation of shoulder and elbow functions after treatment of humeral shaft fractures: a 20-132-month follow-up study

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**Objective:** The aim of this study was to evaluate the long-term results of shoulder and elbow functions in humeral shaft fractures treated with functional brace, plate and screw osteosynthesis or intramedullary nailing.

**Methods:** The study included 128 patients treated for humeral shaft fracture. The patients were divided into three groups according to treatment method: Group 1 (n=62) received functional brace, Group 2 (n=36) plate and screw osteosynthesis and Group 3 (n=30) intramedullary nailing. Coronal and sagittal humeral angulations were measured radiologically during the final follow-up. Shoulder and elbow functions were evaluated using the Constant shoulder score, the Mayo Elbow Performance Scoring and range of movement measurements.

**Results:** The mean follow-up time was 74 (range: 20 to 132) months. Mean Constant shoulder scores were 92.4 in Group 1, 85.6 in Group 2 and 74 in Group 3. A statistically significant difference was detected between the Constant shoulder scores of Groups 2 and 3 ($p<0.05$). In the last follow-up, the mean Mayo Elbow Performance Score of Group 1 was 96.9, Group 2 was 95.7 and Group 3 was 89.2. Statistically significant differences were not detected between the Group 2 and 3 ($p>0.05$). In the statistical evaluation of the Constant shoulder scores, a statistically significant difference was detected between the Constant scores of patients with a varus angulation greater than 20° and those with neutral alignment.

**Conclusion:** Functional results of humeral shaft fractures treated with functional brace appear to be satisfactory. Varus and antecurvatum may affect shoulder and elbow function. In the presence of surgical indications, plate and screw fixation technique is the most effective method in terms of shoulder and elbow functions.

**Key words:** Elbow function; functional brace; humerus fracture; shoulder function; surgical treatment.

Humerus fractures constitute 1 to 7% of all fractures and can be treated successfully using conservative treatment methods.[1-3] Surgical treatment is required in cases with extensive soft tissue damage, multiple trauma, loss of reduction, nonunion and pathological fractures.[3] Moreover, surgical treatment should be preferred in patients with vessel injury, post-reduction radial nerve damage, segmental fractures or 'floating elbow'.[4-6]

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**Table 1.** Patient demographics.

| | | Group 1 | Group 2 | Group 3 | Total |
|---|---|---|---|---|---|
| Number of patients | | 62 | 36 | 30 | 128 |
| Gender | Male | 38 | 20 | 23 | 81 |
| | Female | 24 | 16 | 7 | 47 |
| Side | Right | 40 | 22 | 18 | 80 |
| | Left | 22 | 14 | 12 | 48 |
| Fracture mechanism | Fall | 42 | 25 | 18 | 85 |
| | Traffic accident | 12 | 5 | 4 | 21 |
| | Work accident | 5 | 4 | 4 | 13 |
| | Sports injury | 3 | 2 | 4 | 9 |
| Gustilo classification | Grade 1 | 1 | 2 | 2 | 5 |
| | Grade 2 | 0 | 1 | 2 | 3 |
| Fracture localization | Proximal | 17 | 7 | 2 | 26 |
| | Middle | 37 | 24 | 20 | 81 |
| | Distal | 8 | 5 | 8 | 21 |
| AO/ASIF classification | 12-A1 | 34 | 4 | 3 | 41 |
| | 12-A2 | 16 | 16 | 2 | 34 |
| | 12-A3 | 3 | 8 | 21 | 32 |
| | 12-B1 | 2 | 4 | 2 | 8 |
| | 12-B2 | 3 | 2 | 2 | 7 |
| | 12-B3 | 2 | 1 | | 3 |
| | 12-C1 | 1 | 1 | | 2 |
| | 12-C2 | 1 | | | 1 |

Surgical treatment options include plate and screw osteosynthesis, intramedullary (IM) nailing and external fixation.

Various problems related with shoulder and elbow functions can develop during treatment and after healing. Our hypothesis is that factors such as the treatment choice, humeral angulation and radial nerve damage affect the long-term shoulder-elbow functions. The purpose of our study was to evaluate the long-term shoulder and elbow function results of humerus shaft fractures treated with functional brace, plate and screw osteosynthesis or IM nailing.

## Patients and methods

One hundred and fifty-two patients who were treated for humerus shaft fractures between 1998 and 2007 were retrospectively evaluated. Patients over 18 years of age with humerus shaft fracture that completely healed following treatment with functional brace, plate and screw osteosynthesis or IM nailing and who did not have a new trauma concerning the shoulder and elbow after fracture union met the inclusion criteria. Exclusion criteria included patients under the age of 18, those with fractures of the proximal or distal humerus, fractures treated by external fixator, fractures that did not heal, patients who experienced a new trauma concerning the shoulder and the elbow after healing of the fracture or underwent a second surgical operation due to pseudarthrosis, or those with Gustilo Grade 3 open fractures. One hundred and twenty-eight patients (81 males, 47 females; mean age: 38.5 years, range: 18 to 69 years) with adequate information in their files were included in the study. Accompanying injuries and demographic information are shown in Table 1.

Information on patients with humerus fractures has been recorded in our clinic since 1998. Patient files were examined and demographic information, fracture mechanisms, locations of fractures, union time, indications of surgery, complications developing during the treatment and the presence or absence of radial nerve damage were recorded. Fractures were classified according to the AO/ASIF method (Tables 1 and 2).[7]

Patients were divided into 3 groups according to the method of treatment. Group 1 patients (n=62) were treated using functional brace, Group 2 (n=36) plate

**Table 2.** Indications of surgery.

| Indications of surgery | Group 2 | Group 3 | Total |
|---|---|---|---|
| Loss of reduction | 25 | 21 | 46 (69.7%) |
| Delayed union | 6 | 4 | 10 (15.2%) |
| Multi-trauma | 1 | 4 | 5 (7.6%) |
| Inadaptability to brace using | 3 | 0 | 3 (4.5%) |
| Floating elbow | 0 | 1 | 1 |
| Segmental humerus fracture | 1 | 0 | 1 |

and screw osteosynthesis, and Group 3 (n=30) with IM nailing.

Group 1 patients were treated using a U-splint or hanging cast for initial external fixation. A functional brace was then applied at an average of 10.4 (range: 7 to 18) days after the injury (Fig. 1). Passive elbow and pendular shoulder exercises were performed with the patient in the brace for the initial 3-week period. During follow-up, active elbow and shoulder exercises were implemented according to tolerance and the status of fracture union. The brace was removed when union was detected clinically and radiologically (Fig. 2).

For plate and screw osteosynthesis, the anterolateral approach was used in fractures of the upper two-third and in patients requiring radial nerve exploration, and the posterior approach was used in fractures of the lower one-third. Broad DCP and cortical screws of 4.5 mm were used in all patients. Following anatomical reduction of the major fragment, a minimum of six cortexes were fixed at each side of the fracture. The radial nerve was preserved during the operation. Passive hand, wrist, elbow and pendular shoulder exercises were started at the 3rd postoperative day. Patients were encouraged to perform active elbow and shoulder exercises as tolerated (Fig. 3).

For the antegrade IM nailing, proximal fibers of the deltoid were separated and an entry hole was drilled through the rotator cuff insertion. The fracture was reduced using fluoroscopy. The nail was advanced distally from the proximal and distal and proximal lockings were made. On the postoperative 3rd day, passive hand, wrist, elbow, and pendular shoulder exercises were begun according to pain and edema control. Active elbow and shoulder exercises as tolerated were encouraged.

**Fig. 1.** Functional brace. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Coronary and sagittal humeral angulations were measured radiologically at the final follow-up. The Constant score and shoulder range of motion (ROM) were evaluated for shoulder functions and the Mayo Elbow Performance Score and elbow ROM for elbow functions. Shoulder and elbow ROM were measured with a goniometer. Patients were asked about their ability to return to pre-injury occupations and activities. The results of conservative treatment were evalu-


**Fig. 2.** **(a)** Radiograph of a 43-year-old male patient with a transverse humeral shaft fracture. **(b, c)** Views of the same patient after treatment with functional brace.

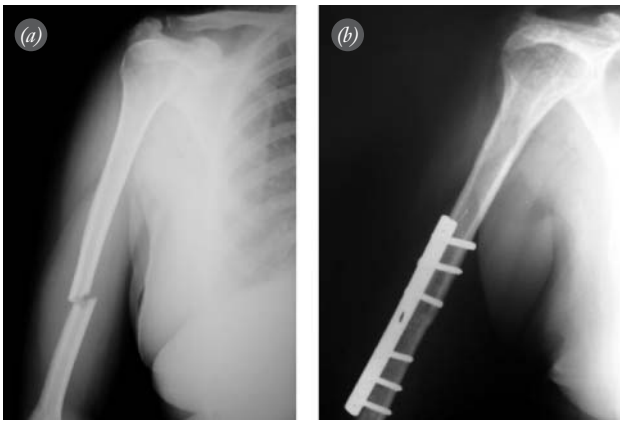

**Fig. 3.** **(a)** Fracture in a 53-year-old female patient due to multitrauma. **(b)** Union is achieved after plate and screw fixation.

ated by comparing the injured side of the Group 1 patients with their intact, opposite side. The results of operative treatment were evaluated by comparing the results of the patients of Groups 2 and 3.

Statistical analyses were performed with the ANOVA and chi-square tests using the SPSS 13.0 program (SPSS Inc., Chicago, IL, USA). P values less than 0.05 were considered significant.

## Results

Average follow-up time was 74 (range: 20 to 132) months. Average time to union was 12.6 weeks in Group 1, 14.5 weeks in Group 2, and 14.2 weeks in Group 3. No statistically significant difference was found between Groups 2 and 3 ($p>0.05$). Time to union in the dominant arm was statistically shorter in Group 1 than the other groups ($p<0.05$).

The mean Constant shoulder score was 92.4 in Group 1 at the final follow-up. When compared with the patients' contralateral shoulder, no statistically significant difference was found ($p>0.05$). The mean Constant shoulder scores were 85.6 and 74 in Group 2 and Group 3, respectively. A statistically significant difference was found between the groups ($p<0.05$). Accordingly, shoulder functions were evaluated to be better in the plate and screw osteosynthesis. A statistically significant difference was found in average shoulder abduction between Groups 2 and 3 ($p<0.05$) (Table 3).

Mayo elbow score in the final follow-up was 96.9 in Group 1. There was no statistically significant difference in comparison to the patients' contralateral elbows ($p>0.05$). Mayo elbow score was 95.7 in Group 2 and 89.2 in Group 3. No statistically significant difference was found between the two surgically treated groups ($p>0.05$). Mean elbow flexion and extension loss is shown in Table 3.

Average Mayo elbow performance score was 90.3 for the 5 patients in which plate and screw osteosynthesis was applied through the posterior approach. In 8 (26.7%) of the patients treated with IM nailing, shoulder impingement syndrome developed due to proximal migration of the nail. Conservative treatment was attempted and early implant removal was performed at an average of 10 months. The Constant score was poor in three of these cases and medium in five (medium=70-79 points, poor=<70 points).

As most of the fractures were class AO/ASIF 12-A in all groups, no statistical analysis was performed between fracture type, location and shoulder and elbow functions. The mean Constant scores of patients with proximally located fractures were 88.6 (17 patients) in Group 1, 84.2 (7 patients) in Group 2, and 60 (2 patients) in Group 3. Fifty-five patients in Group 1 (88.7%), 28 patients in Group 2 (77.8%) and 24 patients in Group 3 (80%) returned to their previous occupation and activity level.

No significant difference was determined between Groups 2 and 3 in terms of shoulder-elbow functions ($p>0.05$). Comparison between all indications was not performed due to insufficient patient numbers.

At the final follow-up, an average varus angulation of 12.4°, recurvatum of 9.3° in 16 patients, and antecurvatum of 15.2° in 24 patients was determined by radiological evaluation in Group 1. No angular deformities were determined in Group 2 and 3 patients, with

**Table 3.** Shoulder and elbow functional results.

| | | Group 1 | Group 2 | Group 3 |
|---|---|---|---|---|
| Shoulder | Constant score | 92.4 | 85.6 | 74 |
| | Abduction | 142° | 135° | 118° |
| | Flexion | 155° | 145° | 136° |
| Elbow | Mayo score | 96.9 | 95.7 | 89.2 |
| | Flexion | 138° | 140° | 131° |
| | Extension loss | 6° | 8° | 10° |

the exception of one patient with a 10° varus. Refracture developed as a result of material insufficiency and treatment was maintained conservatively for this patient.

Group 1 was divided into different groups according to their coronal and sagittal humerus angulation (Table 4). Mean Constant and Mayo scores of each group were compared. Patients with varus angulation greater than 20° had significantly poorer shoulder function than those who were neutral on the coronal plane ($p<0.05$). In addition, Mayo elbow scores of the 24 patients with an average of 15.2° antecurvatum angle were statistically poorer than those of patients who were neutral on the sagittal plane ($p<0.05$).

Complications during treatment were; brace-related dermatitis in 5 patients in Group 1, delayed union necessitating application of autogenous graft in 3 patients in Group 2, implant failure in one patient who was treated conservatively due to high risk, superficial infection treated by antibiotics in 3 patients, exchange IM nailing and autogenous grafting because of delayed union in 1 patient in Group 3, and persistent shoulder pain resulting in premature nail removal in 8 patients.

Radial nerve palsy was determined in 11 patients (8.6%). Partial motor deficits were present in 10 patients and radial nerve disruption in one. In these patients, early radial explorations and plate and screw osteosynthesis was performed. Ten patients underwent radial nerve exploration intraoperatively. In the patient with nerve disruption, the nerve was explored and stitched end-to-end through the epineurium. Extension splint was used for patients with radial nerve palsy. Nerve function returned in all patients after an average of 5.2 months. At the final follow-up, the mean Constant and Mayo scores of the 11 patients treated surgically and those with radial nerve damage were 90.5 and 94.6, respectively. Ten of these patients stated that they returned with their original occupation and activity levels.

## Discussion

Poorer results in terms of shoulder pain and functions have been reported with the use of IM nailing than plate fixation.[8-16] In their prospective randomized study, McCormack et al. found no difference between IM nailing and plate fixation in terms of the American Shoulder and Elbow Surgeons score, shoulder pain and joint range of motion.[17] Lin obtained similar results in their retrospective comparative study.[18] On the contrary, Chapman et al. noted that ROM limitations and shoulder pain were worse in patients with IM nailing.[19] Crates and Whittle presented the results of 73 patients with humerus shaft fractures treated with antegrade Russell-Taylor IM nailing and reported full shoulder movements in 90% of the patients, full elbow movements in 96% and shoulder impingement syndrome related to proximal locking screw in 2 patients and to nail migration in one patient (4%).[20] In our study, we determined shoulder functions to be poorer in the IM nailing group. In 8 (26.7%) patients, shoulder impingement syndrome developed. In all these patients, follow-up X-rays showed proximal nail migration. We think that this migration affects the long-term shoulder functions by generating permanent defective damage at the rotator cuff.

Rotator cuff damage at the nail entry is believed to be one of the causes of subacromial impingement, which can also cause pain and stiffness.[14] Some articles state that humerus shaft fractures did not recover totally when treated with non-operative or plate and screw osteosynthesis.[18,19,21-23]

The protrusion of the proximal locking screws into the deltoid muscle is another possible complication of IM nailing.[24] In antegrade nailing, the incisions made on the region of the hypovascular critical zone of the supraspinatus tendon can cause problems in healing.[21] However, recent articles state that as this is a hypervascular area, even degenerative rotator cuff ruptures in this area can be healed with surgical treatment.[25,26]

**Table 4.** Humeral angulation in Group 1.

| | | Group 1 | Constant score | Mayo score |
|---|---|---|---|---|
| Humeral angulation *(Coronal and sagittal)* | Mean varus angulation | 12.4° | 92.4 | 96.9 |
| | Antecurvatum | 15.2° (24 patients) | 92.8 | 84.6 |
| | Recurvatum | 9.3° (16 patients) | 91.4 | 94.6 |
| | Sagittal neutral | 22 patients | 92.6 | 94.8 |
| | Coronal neutral | 18 patients | 94.8 | 92.2 |
| | Sagittal-coronal neutral | 15 patients | 94.6 | 96.4 |
| | Coronal only varus | 19.6° (42 patients) | 88.6 | 88.2 |
| | Varus >20° | 19 patients | 82.2 | 90.7 |

It is obvious that surgical trauma can negatively affect shoulder and elbow functions. Therefore, minimal invasive surgery has recently become widespread.[27] Moreover, operations performed for implant removal or nonunion can lead to loss of joint function. While some studies found no difference in functional results between plate and screw and IM nailing methods,[27-29] other studies reported fewer shoulder problems with plate and screw fixation.[30] We found shoulder and elbow functions to be better with plate and screw fixation than IM nailing. Furthermore, shoulder abduction was significantly lower in the IM nailing group. We could not find a significant difference in terms of fixation materials and healing times ($p>0.05$).

The common theory is that in humerus body fractures treated with functional brace, shoulder muscles are not injured and early shoulder movements are allowed.[31] Hence, a good shoulder function is expected following fracture healing.[32-34] Rosenberg and Soudry[35] compared the shoulder functions of patients treated with functional brace to the opposite extremity and found that in 9 of 15 patients shoulder functions did not return entirely, and 13 patients complained of pain. Additionally, they found the Constant score of the affected shoulder to be significantly poorer compared to that of the healthy shoulder. In our study, when we compared the shoulder scores of the patients treated using the functional brace to the healthy side, we could not find a significant difference. Our opinion is that long-term shoulder-elbow results are satisfactory in treatment with functional brace.

In the comprehensive series of Sarmiento et al.,[3] 620 patients with humerus shaft fractures were treated using brace. They found the average healing time was 11.5 weeks and the rate of nonunion was 3%. For 465 patients with closed fractures, the rate of nonunion was about 2%. Nevertheless, they stated that as the cost of functional brace treatment was less than operative treatment and did not require hospitalization, it should be preferred because of the low nonunion ratio. The early rehabilitation practiced in the conservative treatment accelerates healing by allowing micro motion at the fracture line. Average healing times of the patients in Group 1 was 12.6 weeks.

The mean Constant score of 19 patients with varus angles greater than 20° was 82.2. When these patients were compared to the group neutral on the coronal plane (18 patients, mean Constant score: 94.8), significantly poorer shoulder functions were determined ($p<0.05$). Our opinion is that varus angulation may unfavorably affect shoulder functions by reducing shoulder deltoid strain and abduction power. In addition, in this group, the mean Mayo elbow score of the 24 patients who had an average of 15.2° antecurvatum was 84.6. When this result was compared to the group neutral on the sagittal plane (22 patients, mean Mayo score: 94.8), significantly poorer elbow functions were determined ($p<0.05$). We think that the antecurvatum angulation can cause unfavorable results by adversely affecting elbow biomechanics.

Chapman et al.[19] found that elbow flexion and extension loss was markedly high and elbow pain and stiffness were higher in the plate fixation group than the IM nailing. We found the Mayo elbow scores of the 5 patients to whom we applied the posterior approach were poorer compared to the other patients. In addition, elbow pain located around the distal locking screw was present in six of eight patients with distally located fracture in the IM nailing group.

The most common indication for surgical treatment was the failure of reduction at 3 weeks. These patients were those initially treated conservatively but required repeated reduction and splint and consequently were unable to begin an appropriate rehabilitation program. Because it is believed that shoulder-elbow functions could worsen during the period before surgical treatment treated, we compared them with those of others indications. Consequently, we did not find any significant difference. Comparison among the other indications could not be performed due to insufficient numbers. Shoulder elbow functions may be affected in severe injuries such as segmental fractures and multi-trauma patients. Therefore, large patient series are needed.

The mean Constant and Mayo scores of the 11 patients with radial nerve damage treated surgically were 90.5 and 94.6, respectively. In the literature, several approaches for fractures accompanied with radial nerve damage, including conservative treatment or acute exploration have been reported.[36-38] In our study, we applied acute exploration and plate and screw osteosynthesis. Early exploration of the radial nerve is required for full-thickness cut of the nerve, interposing between fracture fragments.[39] Although these problems are difficult to determine, USG may be helpful. It is well-known that early end-to-end nerve repair has better results when compared with repair with grafting. Furthermore, many studies show no significant differences between early exploration and conservative follow-up. Recovery rates with conservative follow-up of 70-90% has been reported in the literature.[37,40] Our opinion is that radial nerve damage will not adversely affect shoulder and elbow rehabilitation and that suc-

cessful results can be obtained with the appropriate programs until the return of nerve functions.

In conclusion, the treatment of humeral shaft fractures with functional brace yields satisfactory shoulder and elbow functions. Humeral angulations such as varus and antecurvatum can affect shoulder functions. Therefore, patients should be closely followed up. Plate and screw osteosynthesis should be the preferred treatment method in fractures with an indication of surgery considering the shoulder and elbow functions.

**Conflicts of Interest:** No conflicts declared.

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