

## Subjective outcome measures of open reduction and internal fixation of both-bones forearm fractures

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### Abstract

Anatomical reduction and stable internal fixation continues to be the standard methods of treatment for fractures of both bones of the forearm. But there have been no investigations using validated subjective functional outcome instruments. We have therefore evaluated the outcome of patients treated by ORIF for such injuries by comparing subjective, validated outcome measures i.e. musculoskeletal function assessment (MFA) and the disabilities of the arm, shoulder and hand (DASH) scores. Out of 23 participating patients, (24 fractures), 14 were males and 9 were females. Mean follow-up was 30 months. The mean total MFA score was  $19 \pm 17$  (0 to 51). The two domains with the highest scores (suggesting poorest function) were mobility and coping. The mean DASH score was  $12 \pm 10$  (0 to 42). A strongly positive correlation was noted between the total MFA score and the DASH score.

**Keywords:** Bone forearm, fractures, ORIF.

### 1. Introduction

In treating diaphyseal fractures of radius and ulna, it is essential to regain length, apposition, axial alignment and normal rotational alignment to gain good range of pronation and supination.[1] The chances for the occurrence of malunion and non-union are greater because of the difficulties in reducing and maintaining the reduction of two parallel bones in the presence of the pronating and supinating muscles, which have angulatory as well as rotatory influences.[2] The management of these fractures and their associated injuries deserve special attention as their treatment is not the same as the treatment of other diaphyseal fractures. Imperfect treatment of fractures of radius and ulna diaphyses leads to a loss of motion as well as muscle imbalance and poor hand function. Treatment by closed reduction and cast immobilization results in a poor functional outcome with unsatisfactory results reported in upto 92% of cases, usually caused by malunion, nonunion, or synostosis.[3]

Validated functional outcome instruments are used to evaluate a patient's perceptions of their recovery from musculoskeletal injuries, but there have been no investigations using these instruments to assess the outcome in patients after treatment for fractures of both bones of the forearm.[4] We have therefore evaluated the outcome of

patients treated by open reduction and internal fixation (ORIF) for such injuries by comparing subjective, validated outcome measures with the more commonly used objective measures.

### 2. Material and Methods

We identified all patients treated surgically for fracture of both bones of the forearm between May 2013 and July 2016. The objective of the study was to evaluate the functional outcome after open reduction and internal fixation in patients of fractures of both bones of the forearm. Those who had been treated by ORIF within one week of injury were eligible for inclusion. Grade 2 and 3 Open fractures and pathological fracture were excluded from this study. Twenty-eight patients were identified and 23 (24 fractures) were willing to return for follow-up studies. Of the five patients who did not return for follow-up, three could not be located, one refused participation and one had died. Our institutional ethic committee approved this investigation and informed consent was obtained from all patients before participation in the study.

There were 14 men and 9 women with a mean age of 40 years (19 to 74). The mean time to follow-up was 12 months (11 to 24). There were 9 fractures of the dominant

and 15 of the non-dominant limb. Out of 24, 18 were closed and 6 were grade 1 open fractures. There were neither concomitant injuries nor a history of previous fractures nor abnormalities of the affected limb. Seven patients had associated musculoskeletal injuries. Two had fractures of the contralateral upper limb, three had a fracture of the tibia, two had a fracture of the pelvis and two had abdominal injuries. The mechanism of injury was a road traffic accident in 13 patients, a fall from a height in five, a work-related injury in five. At the time of injury, 14 patients were employed outside of the home, four were unemployed, three were full-time students, and two were housewives. All patients were initially treated in the emergency department by application of a long arm splint. Six with open injuries received urgent irrigation and debridement, immediate ORIF and primary wound closure. The other 18 fractures were treated operatively at a mean of two days (0 to 7) after injury. In each case, the ulna was approached along its subcutaneous border and the radius was exposed through a volar Henry approach with preservation of the insertion of pronator teres. All fractures were stabilized by 3.5 mm dynamic compression plates.

Post-operatively, long-arm splints were applied with the elbow flexed to 90° and the forearm in neutral rotation for a mean of eight days (6 to 14). After removal of the splint the patients were instructed in active, and active-assisted, range of movement of the upper limb. Formal physiotherapy, with therapist-assisted range-of-movement and muscle-strengthening exercises, began six weeks after operation. Follow-up was done with clinical and radiological examination at immediate post-op, two, six and 12 weeks and then, usually, at intervals of two to three months until healing was confirmed. There were no complications and no cases of delayed union or nonunion. No additional surgery was required.

## 2.1 Subjective evaluation

We used two validated, self-administered questionnaires for the assessment of musculoskeletal function; the musculoskeletal function assessment (MFA)[5] and the disabilities of the arm, shoulder and hand (DASH)[6] scores. The MFA is a 100-item, self-administered

questionnaire on health status intended to assess self-perceptions of physical status, psychological status and the social well-being of patients who have disorders of the upper or lower limbs. Studies have shown that this instrument has good reliability, good criterion and good construct validity. Specific functional domains assessed by the MFA include self-care, sleep and rest, hand and fine motor skills, mobility, housework, employment and work activities, leisure and recreational activities, family relationships, cognition and thinking, and emotional adjustment. A low score indicates that the patient perceives minimal problems with function, while a high score indicates a greater perception of a problem. The questionnaire provides a summary score as well as a separate score for each domain. The outcome measures used in our study included the total score and the score for the hand and fine motor skills domain.

The DASH is a 30-item questionnaire intended to assess the function and symptoms of persons with disorders of the upper limb. Patients rate their ability to perform 21 physical activities such as opening jars, turning doorknobs and similar activities. The remaining nine items relate to symptoms (six items) and self-image and social life (three items). Each is scored on a five-point Likert scale. A score of 0 indicates 'no disability', and 100 indicate 'severe disability'.

## 2.2 Objective evaluation

Rotation of the forearm was assessed with the elbow flexed to 90° and the arm adducted. Extension and flexion of the wrist were measured by a goniometer placed along the ulnar border of the forearm and hand. The contralateral, unaffected forearm and wrist were used as controls for each measurement. In the patient with bilateral fractures of the radius and ulna, the mean range of movement of the unaffected limbs of the other patients was used as the control value.

## 2.3 Imaging evaluation

Standard AP and lateral radiographs of the forearm were taken at the time of injury and were used to classify each fracture according to the comprehensive classification of fractures (Figure 1).[7]

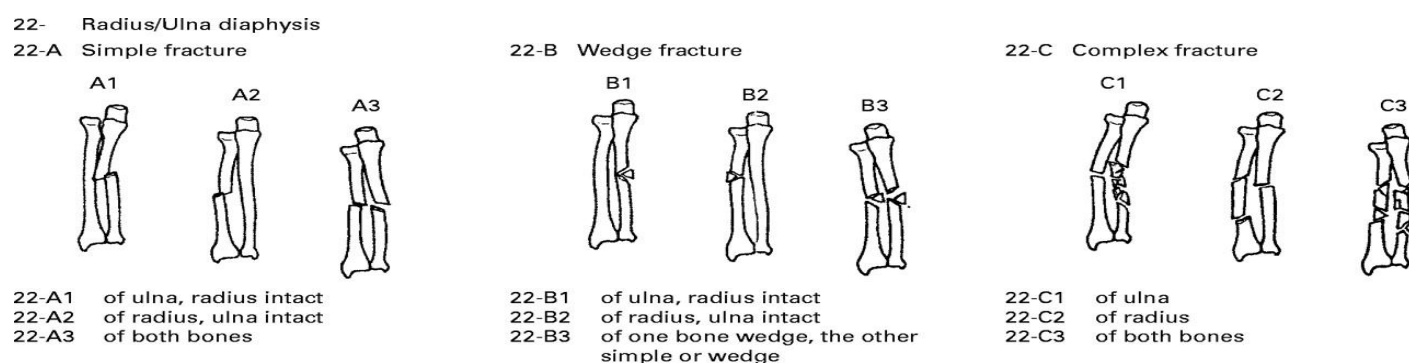


Fig 1 - AO/OTA classification of diaphyseal fractures of the radius and ulna

There were 18 22-A, three 22-B and three 22-C fractures (Figure 2) Standard radiographs taken at the time of final follow-up were evaluated in a blinded fashion by an independent observer (Figure 3).



**Figure 2: Pre-op x ray**



**Figure 3: Post-op x ray**

## 2.4 Statistical analysis

The data were analysed by the open Epi Info 7.0 software. Testing for significance was performed by the t-test for paired continuous variables. The level of significance was  $p \leq 0.05$  and the Wilcoxon signed-rank probability test was used.

## 3. Observation and Results

The mean total MFA score was  $19 \pm 17$  (0 to 51). The two domains with the highest scores (suggesting poorest function) were mobility ( $5 \pm 4$ ) and coping ( $5 \pm 4$ ). The hand and fine motor domain scores ( $1 \pm 1$ ) and cognition score ( $1 \pm 1$ ) had the lowest domain scores (best function). The mean scores for the other six domains were between 1 and 2. The mean DASH score was  $12 \pm 10$  (0 to 42). A strongly positive correlation was noted between the total MFA score and the

DASH score ( $r = 0.82$ ,  $p \leq 0.01$ ). There were eight patients with an MFA score above 20. There were nine patients with a DASH score above 12.

The mean ( $\pm$ SD) pronation for the involved and uninvolved sides was  $75 \pm 25^\circ$  and  $85 \pm 25^\circ$  respectively and the mean supination  $85 \pm 30^\circ$  and  $95 \pm 15^\circ$ , respectively. The difference in pronation between the injured and uninjured sides was statistically significant ( $p = 0.005$ ), while the difference in supination was not ( $p = 0.11$ ). Six patients lost more than 20% of their arc of rotation and six between 10% and 20% of rotation. Two patients did not maintain a functional arc of pronation and supination ( $50^\circ$  pronation/ $50^\circ$  supination) while two others failed to maintain a functional arc of pronation or supination. Worsening DASH scores correlated with worsening subjective function in those patients with decreased pronation of the forearm ( $p < 0.05$ ).

The mean extension of the wrist for the involved and uninvolved sides was  $65 \pm 10^\circ$  and  $70 \pm 15^\circ$ , respectively and the mean flexion  $65 \pm 15^\circ$  and  $70 \pm 10^\circ$ , respectively. The difference in extension and flexion of the wrist between the injured and uninjured sides was not statistically significant ( $p > 0.05$  and  $p = 0.06$ , respectively). Five patients lost more than 20% of their arc of either flexion or extension; no patient lost more than 10% of both. All patients maintained a functional arc of movement of the wrist ( $10^\circ$  extension and  $30^\circ$  flexion). Both the DASH and the MFA showed worse outcomes in patients with a decreased range of movement of the forearm and wrist. Inverse correlations were observed between the MFA and flexion and extension of the wrist. The total MFA score was inversely correlated with flexion of the wrist ( $r = -0.51$ ,  $p \leq 0.05$ ), but was not correlated with extension ( $r = -0.41$ ,  $p \leq 0.10$ ). Additionally, worsening DASH scores correlated with decreased supination ( $r = -0.47$ ,  $p \leq 0.05$ ), pronation ( $r = -0.66$ ,  $p \leq 0.01$ ) and flexion ( $r = -0.64$ ,  $p \leq 0.01$ ) and extension of the wrist ( $r = -0.46$ ,  $p \leq 0.05$ ). The mean grip strength for the involved and uninvolved sides was  $34 \pm 15$  kg and  $40 \pm 15$  kg, respectively. The difference between the injured and uninjured sides was statistically significant ( $p = 0.0004$ ). The mean lateral key pinch strength, for the involved and uninjured sides was  $21 \pm 5$  kg and  $23 \pm 10$  kg, respectively. The difference between the injured and uninjured sides was also statistically significant ( $p = 0.02$ ). Surprisingly, neither pinch nor grip strength correlated with the DASH or MFA scores. As would be expected, however, pinch strength was strongly correlated with grip strength ( $r = 0.58$ ,  $p \leq 0.001$ ).

The mean maximal radial bow in our patients after fixation of the fracture was  $16 \pm 3$  mm (10 to 20) and its mean location  $62 \pm 8\%$  (42 to 70). A thorough evaluation of the relationship between movement of the forearm and the radiological parameters showed that patients with a loss of the arc of rotation of less than 10% had a mean difference of 1.9 mm (12%) from the normal maximal radial bow and of 6.7% from the normal location of the maximal radial bow. Those patients with a loss of rotation of 10% to 20% had a

mean difference of 2.0 mm (13%) from the normal maximal radial bow, and of 6% from the normal location of the maximal radial bow, while those with a loss of rotation of more than 20% had a mean difference of 2.3 mm (15%) from the normal maximal radial bow and of 6.5% from the normal location of the maximal radial bow. We were unable to demonstrate a significant difference between the groups concerning rotation and either maximal radial bow or location of the maximal radial bow ( $p = 0.40$  and  $0.19$ , respectively). Statistical analysis showed that as the difference from the normal maximal radial bow increased, regardless of whether it was greater or less than normal, supination of the injured limb also increased ( $r = 0.53$ ,  $p = 0.01$ ).

#### 4. Discussion

Compression plate fixation has become the treatment of choice for fractures of both bones of the forearm.<sup>[8]</sup> Compression plate fixation gives a high rate of union, a low rate of complications, and a satisfactory return of rotation of the forearm. However, while the objective and radiological data support the use of compression plating for such fractures, validated subjective data have been lacking. We sought to address this deficit by the use of two validated outcome instruments, the DASH and the MFA.

The results of our study are consistent with the clinical and radiological results of previous studies of ORIF of fracture of both the radius and ulna.[8-10] Compression plating with an attempt to restore the pre-injury anatomy of the forearm, led to satisfactory movement of the forearm and muscle strength. While subjective patient outcomes were also generally good, an assessment of the objective data with reference to the outcome scores has provided additional information. While the range of movement was decreased in most patients at the final follow-up, only pronation showed a statistically significant reduction compared with the contralateral limb. However, the outcomes questionnaires found a subjective decrease in function when the range of movement of the wrist and forearm was less than that of the uninjured side. This suggests that any decrease in movement of the forearm or wrist must be carefully noted since it may affect the patients' perception of their functional outcome. By contrast, decreasing grip and pinch strength were not found to correlate with outcome scores suggesting that while these decreases may be statistically significant they are not clinically significant. The MFA and the DASH were strongly correlated suggesting that function of the upper limb may be sufficiently assessed by a general health questionnaire such as the MFA. However, differences in the two measurements were noted which confirms a role for each questionnaire. For example, the MFA score showed a significant correlation with range of movement of the wrist, while the DASH score correlated with range of movement of both the forearm and wrist. The higher sensitivity of the DASH to decreasing movement of the forearm suggests that this instrument may

be more useful than the MFA when evaluating function of the upper limb.

Pronation and supination of the forearm and flexion and extension of the wrist were specifically assessed for their relationship to the maximal radial bow and its location. While pronation and the arc of movement of the wrist were both significantly reduced ( $p < 0.05$ ) in our patients, neither correlated with the maximal radial bow or its location. The arc of supination, which was not significantly reduced ( $p > 0.05$ ) at the final follow-up, did correlate with the maximal radial bow. Our data do not minimise the importance of an anatomical reduction during fixation by a compression plate, but they do suggest that other factors may also be important for the restoration of the arc of movement of the forearm. We currently emphasise the use of early active and passive movement of the forearm and wrist in an attempt to maximise post-operative function. The DASH score for our patients was considerably better than that of patients with long-standing problems of the shoulder or wrist. In the study by Beaton *et al*[11] to validate use of the DASH score, patients with shoulder problems had a mean score of  $48.4 \pm 21.2$ , while those with isolated problems of the wrist had a mean score of  $34.2 \pm 23.69$  before treatment. Although the MFA scores of our patients (mean of  $20 \pm 17$ ) were considerably higher than previously published norms for non-patient groups (mean of  $9.26 \pm 8.9$ ) they were approximately equal to the 75<sup>th</sup> percentile (17.33) in the previously published study on the AO/OTA group with elbow, forearm and hand injury at 12 months after injury.

The primary limitation of our study is the small number of patients. However, we feel that this was mitigated by two factors. First, we presented a homogeneous group of patients treated by a single surgeon in a standard fashion and secondly, there was a high percentage of eligible patient participation with a follow-up for more than one year. A second weakness of our investigation was our technique of assessment of forearm rotation. The method used included the assessment of rotation of the wrist and forearm. However, we were consistent and we measured the contralateral, uninjured limb in a similar fashion. Therefore, this limits our data only in the fact that our measurements of forearm rotation may not be comparable with those of other investigations. Anatomical reduction and stable internal fixation should continue to be the standard methods of treatment for fractures of both bones of the forearm in adults.

#### 5. Conclusion

In order to maximise the patients' perception of outcome, attention should be paid to the return of normal movement of the forearm and wrist. The patient's view of function as determined by the DASH questionnaire was dependent on the return of rotation of the forearm and range of movement of the wrist whereas outcome based upon the MFA correlated only with movement of the wrist. The DASH



outcome measure is more sensitive than the MFA when assessing outcome after ORIF of such fractures.

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