Nonoperative treatment of humeral shaft fractures revisited

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Purpose: The purpose of this study was to examine the union rate of humeral shaft fractures treated non-operatively and to establish whether a particular fracture type is more likely to go on to nonunion.

Methods: Radiographs and patient records of 207 humeral shaft fractures occurring during 5 years were retrospectively reviewed. All patients were initially managed nonoperatively and placed in a U-slab on diagnosis in the emergency department; this was converted to a functional humeral brace at 7 to 10 days after injury. Fracture location, morphology and comminution were assessed radiologically. Union was defined as the absence of pain and movement at the fracture site in the presence of radiographic callus formation. Nonunion was defined as no evidence of bone union by 1 year after injury or fractures requiring delayed fixation, defined as operative fixation undertaken more than 6 weeks after injury.

Results: The study included 138 humeral shaft fracture patients; 18 patients (11%) were lost to follow-up, and 24 went on to nonunion, giving an overall union rate of 83%. Of the 24 nonunions, 15 underwent delayed operative fixation at an average of 8.3 months after injury. The union rate for proximal-third fractures was 76% compared with 88% for middle-third fractures and 85% for distal-third fractures. Commnuted fractures (defined as 3+ parts) had a 89% union rate regardless of position.

Conclusion: A lower threshold for surgical intervention may be considered in proximal-third, two-part spiral-oblique humeral shaft fractures. Brace therapy can be the optimal treatment regimen, but it is not the only option.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Humerus; fracture; humeral brace; union

Functional humeral bracing is now widely considered the standard nonoperative treatment option for humeral shaft fractures. This technique was initially popularized in 1977 by Sarmiento. He subsequently published the results of a 98% union rate on a series of 920 patients with humeral shaft fractures treated in a functional brace. However, nearly a third of the patients were lost to follow-up. More recent studies by Koch et al and Rutgers and Ring reported union rates of 87% and 90%, respectively. Koch’s study found that predominantly transverse fractures failed
to go on to union. Interestingly, in a subsequent study, Ring suggested that the midproximal-third spiral-oblique type of humeral shaft fracture was more likely to go on to nonunion.7

The aim of this study was to assess the union rate of a consecutive series of patients with a humeral shaft fracture treated by a functional humeral brace protocol and to see whether there was a particular fracture position or configuration that was more likely to go on to nonunion.

Methods

Using our trauma database, we identified every patient between December 2006 and June 2011 with a humeral shaft fracture that had been seen in the accident and emergency department at our institution. The patient records and the serial electronic radiographs were assessed. Patients who underwent operative fixation within 6 weeks of injury, which included all of the open fractures (23 patients) and polytrauma patients (21 patients), were excluded so that only those reaching current criteria for conservative humeral brace management were included. Patients with a pathologic fracture were also excluded. Pediatric patients were analyzed separately (18 patients).

All of the patients were initially placed in a U-slab in the emergency department. They were then reviewed in the orthopedic fracture clinic within 7 to 10 days after injury, and the U-slab was converted to a functional humeral brace (Beagle Orthopaedic, Blackburn, UK; Fig. 1). The brace was fitted by 1 of 2 experienced plaster technicians who educated the patients on brace management and provided a “weekday” drop-in clinic. It was explained to the patients that the use of the brace was an active process with active elbow flexion encouraged but strict advice to avoid leaning on the elbow or to abduct the shoulder until there was evidence of union. We defined union as the absence of pain and movement at the fracture site in the presence of callus formation on radiographs.8 Patients included in this study were followed up at 6 to 8 weeks, 10 to 12 weeks, 6 months, 9 months, and 1 year after injury.

The serial radiographs and clinic notes of each patient were reviewed independently by 2 orthopedic surgeons. Fracture location (proximal, middle, or distal third), morphology, and comminution were recorded. Where the fracture extended over 2 regions, classification was based on the region in which the majority of the fracture lay. The time to radiologic union was determined.

Radiographic nonunion was defined as no evidence of bone union by 1 year after injury. For the purpose of this study, we also considered patients who underwent delayed fixation (fixation occurring beyond 6 weeks) as nonunion, although not all of those included in this nonunion group underwent operative intervention before 3 months of conservative treatment. Whereas the authors agree that functional outcome is an important outcome measure, no attempt was made to assess fracture angulation or functional deficit at union. We believe this is justified in this situation as any functional deficit present in either the union or nonunion group would not necessarily reflect bone disease and risks confusion. For example, if function was adequate in a patient diagnosed with a nonunion, this would not be relevant to our investigation as our study was re-examining the conservative treatment of humeral fractures and its effect on bone union specifically.

Results

There were 200 consecutive adult humeral shaft fractures available for review. Of these, 44 underwent early fixation, which included all of the open fractures, and were excluded. The remaining 156 humeral shaft fractures that were treated in a functional humeral brace were then analyzed.

There were 71 male patients and 85 female patients with a mean age of 54 years at the time of injury (18-92 years). Eighteen patients were lost to follow-up (11%); the majority of these were patients who lived or moved out of the local area. Of the 138 patients left, 24 went on to a nonunion (17%). Fifteen of the nonunions underwent delayed operative fixation at an average of 8.3 months after injury (range, 3-12 months). The mean age of the patients with nonunion was 59 years (21-86 years); there were 12 male patients and 12 female patients.

Of the 138 patients included in this study, 54 sustained proximal-third humeral shaft fractures; 58 and 26 patients presented with mid–humeral shaft and distal-third humeral shaft fractures, respectively. Analysis of the union rates by humeral shaft location found that the proximal third had a union rate of 76% (of which 11 of the 13 were spiral and 1 an oblique fracture); the middle third, 88%; and the distal third, 85%. Comminuted fractures (defined as 3+ parts) had a union rate of 89% irrespective of location along the humeral shaft. Those fractures progressing to union did so before 3 months and were therefore not included in our delayed fixation subgroup.

These results underwent statistical analysis by a logistic regression model (Table I). Two patients from the union group were excluded from the model, one because of incomplete data (missing data on fracture pattern and number of parts) and the other as it was the only segmental fracture. Consequently, the analysis was based on 136 patients with the outcome variable.
being union. Covariates were age, gender, fracture parts, fracture type, and fracture site. Whereas the authors recognize that these data may be better presented as relative risk, this manner of data does permit logistic regression analysis. We believe that both relative risk and odds ratios can be calculated for retrospective cohorts; however, in performing multivariate analysis in which several variables are adjusted for, a logistic regression analysis is implemented and by its nature yields odds ratios.

There were no significant covariates, and there is a trend toward greater odds of fracture union with oblique fracture patterns and middle-third fractures. However, the 95% confidence intervals were wide for all covariates. This may be due to the fact that with a relatively small number of nonunions, there is not enough data to detect significant difference when modeled by 5 covariates (some with more than 2 levels).

An example of a proximal-third humeral shaft fracture that went on to delayed fixation at 9 months is shown in Figure 2.

All 18 pediatric humeral shaft fractures that were separately reviewed went on to solid union (most by 6 weeks).

Discussion

The published work on this topic has been extensive but possibly not conclusive because of poor patient follow-up. We have demonstrated that anatomically varying humeral fracture patterns differ in their ability to go on to union when they are treated conservatively in a humeral brace. The literature supports this method of treatment and is largely based on previously published series as it has proved to be an effective treatment regimen.

The results of this large retrospective review indicate a lower union rate than has been previously described for the treatment of humeral shaft fractures in a functional humeral brace. The follow-up rate for this study is high at 89%, and this may be partly responsible for the lower union rate compared with the major published series. Varying union rates could be explained by differences in methodology and observance to instigated protocols; however, the Sarmiento protocol has been followed strictly, so we do not believe that lack of adherence to the protocol could be responsible for our lower union rate.

Functional humeral bracing is one of the accepted methods of treatment of these fracture types; operative intervention includes fixation with intramedullary nails or plates and screws. Uptake of these methods is dependent on factors such as fracture pattern, patient factors, and surgical preference.

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Log (odds ratio)</th>
<th>P value</th>
<th>Odds ratio</th>
<th>95% CI for odds ratio</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Age</td>
<td>-0.016</td>
<td>.221</td>
<td>0.984</td>
<td>0.960 1.010</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>0.779</td>
<td>.153</td>
<td>2.178</td>
<td>0.749 6.336</td>
</tr>
<tr>
<td>No. of parts</td>
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<td></td>
<td>1.109</td>
<td>0.433 3.031</td>
</tr>
<tr>
<td>3</td>
<td>0.359</td>
<td>.556</td>
<td>1.432</td>
<td>0.433 4.731</td>
</tr>
<tr>
<td>&gt;3</td>
<td>1.109</td>
<td>.901</td>
<td>3.031</td>
<td>0.578 15.900</td>
</tr>
<tr>
<td>Type</td>
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<td></td>
<td>1.107</td>
<td>0.565 16.214</td>
</tr>
<tr>
<td>Oblique</td>
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<td>.196</td>
<td>3.027</td>
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<td>0.496</td>
<td>.748</td>
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<td>0.417 6.465</td>
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<tr>
<td>Mid</td>
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<td>.066</td>
<td>3.600</td>
<td>0.919 14.101</td>
</tr>
<tr>
<td>Distal</td>
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<td>.732</td>
<td>1.280</td>
<td>0.312 5.256</td>
</tr>
<tr>
<td>Constant</td>
<td>0.857</td>
<td>.387</td>
<td>2.357</td>
<td></td>
</tr>
</tbody>
</table>

CI, confidence interval.
Outcome variable was union. Covariates were age (continuous), gender (reference = male), fracture parts (reference = 2), fracture type (reference = transverse), and fracture site (reference = proximal).
General and specific complications are more frequently associated with operative humeral fracture fixation; however, these do also exist with the implementation of a humeral brace. Patients with humeral brace treatment did not develop any complications as a result of this treatment modality.

Bias in the study does exist as it could be argued that those patients who underwent delayed fixation may have subsequently gone on to union. However, mean time to delayed fixation was 8.3 months (3-12 months). A diagnosis of nonunion is ascribed to those fractures that have not gone on to union at 3 months, and hence all those that underwent delayed fixation met the satisfactory criteria to warrant inclusion in this group. The fact that all open fractures and a proportion of polytrauma patients were operated on acutely may also have an effect on union rates. The likelihood is, however, that by excluding these groups, our union rates would be higher than if they were included.

The results also suggest a trend toward lower union rates in proximal-third spiral-oblique fractures, which indicates agreement with the previous work done by Ring but contrasts with the findings of another study that suggested transverse fractures most commonly go on to nonunion. These results were not statistically significant on formal analysis, which we think is a reflection of the generally low nonunion rate, meaning that subgroups were too small to achieve statistical significance. This is despite this being the second largest study on the subject.

Why the union rate in this group is lower is uncertain. It may be due to the fracture’s lying predominantly between the insertion of the deltoid at the deltoid tuberosity and the proximal pectoralis major insertion and the differential pull of these muscles distracting the fracture site. It could also be due to disruption of the predominant vascular supply to the humeral shaft that enters in the proximal third of the humeral shaft on the medial side.

It was interesting that the union rate for comminuted fractures irrespective of location on the shaft was 89%. This may seem counterintuitive because greater comminution is normally associated with greater energy of injury, which may be expected to have a detrimental effect on healing. However, this finding relates well to Perren’s strain theory in that the increased bone surface area provides an ideal fracture strain for good bone healing.

Patients can develop residual deformity of the humerus with brace therapy, which is more marked in patients with short and obese arms, with varus angulation being the most likely deformity. Some authors have stated that a certain degree of shoulder impairment is anticipated; this is deemed acceptable by some and not by others. Some have gone on to assess quality of life, with results after humeral brace treatment being far from favorable. Cases of skin ulceration with protrusion of bone fragments have been described with humeral brace use, but the authors appreciate that the degree of ulceration described in that particular article is uncommon.

Rather surprisingly, once the pediatric fractures were excluded, age appeared to have little effect on union rates. The mean age and age range in the nonunion group closely mirrored those in the group as a whole.

Limitations do exist to the study presented here. Whereas our retrospective review includes a large number of patients, other variables leading to fracture nonunion do exist that we have not examined. These include patient factors and environmental factors, such as the use of nonsteroidal anti-inflammatories, smoking, and infection. The inclusion of these variables would permit a multivariate analysis. Of the patients included here, no cases of infection were identified, and although patients are very much discouraged from use of nonsteroidal anti-inflammatories, this is not departmental policy. All patients who underwent operative intervention for nonunion went on to bone union. Despite this, the authors recognize that inclusion of these additional data would enable production of a more robust conclusion.

Different methods for humeral fracture treatment do exist, with new results for humeral brace therapy less favorable than in previous reports. Often, treatment outcomes with humeral brace use are assessed by clinicians and are deemed successful when union has occurred radiologically. This is the goal of treatment, but the manner in which it is achieved is an important consideration. It is essential to involve patients in the decision-making process and for them to fully appreciate the treatment regimen they are embarking on. Humeral bracing means significantly limited function of the affected arm, with prolonged immobilization and prolonged recovery. We recognize that there are certain situations in which brace therapy is optimal; however, in the current economic and social climate, patients require earlier return to work with short recovery time, which may necessitate early fixation. Whereas we are not suggesting a major modification to accepted practice at present, our study, coupled with the growing data in the literature, suggests that there is an argument for a lower threshold for operative intervention for cases of proximal humeral fractures; however, inclusion of other variables and their effect on nonunion is mandated.

Conclusion

Humeral shaft fractures treated with functional humeral bracing usually go on to union. Our findings add useful information to the knowledge base on the treatment of humeral shaft fractures, and a lower threshold for intervention in proximal-third spiral-oblique humeral shaft fractures may be indicated.

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