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Functional treatment of closed humeral shaft fractures

Received: 30 September 2004 / Accepted: 18 October 2004 / Published online: 21 December 2004
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Abstract We treated 93 consecutive patients, average age 53 (16–90) years, with closed humeral shaft fractures applying a functional brace immediately after injury. Seventy-two (77%) fractures healed without problems. There were significantly more consolidation problems in fractures in the proximal third (46% consolidated) compared to those at the middle (81% consolidated) and distal third (86% consolidated) of the shaft. Logistic regression analysis revealed the only predictive factor in respect to successful brace treatment was fracture location. No significant difference was found in respect to healing between different AO-type fractures.

Résumé Nous avons traité 93 malades consécutifs, d'âge moyen 53 ans (16–90), avec une fracture diaphysaire humérale fermée en utilisant une attelle fonctionnelle immédiatement après le traumatisme. Soixante-douze (77%) fractures ont guéri sans problème. Il y avait plus de difficultés de consolidation dans les fractures du tiers proximal (46% ont consolidé) comparé à celles du tiers moyen (81% ont consolidé) et du tiers distal (86% ont consolidé) de la diaphyse. L'analyse statistique a révélé que le seul

facteur prédictif de la réussite du traitement est la localisation de la fracture. Aucune différence significative n'a été trouvée selon les types de la classification AO.

Introduction

It is the general view that humeral shaft fractures can be treated non-operatively [4, 5, 9, 12]. However, not all humeral shaft fractures are eligible for conservative treatment. Absolute and relative indications for surgical treatment have been described [1, 11] (Table 1). Plaster splint, hanging cast and sugar tong splint were formerly used in conservative treatment. In the 1970s, Sarmiento et al. [16] introduced the functional treatment, which has gained numerous advocates [2]. Initially, a sugar tong plaster cast was applied for the first couple of weeks prior to the functional brace [2]. However, later, it was suggested that functional bracing should start immediately after injury [21]. The aim of this study was to evaluate functional bracing in a consecutive series of patients with closed humeral shaft fractures.

Material and methods

Between January 1997 and December 2000, 93 consecutive adult patients with closed humeral shaft fractures were admitted to Tampere University Hospital. Patients with open or pathological fractures as well as patients with fractures of more than 1 week's duration were excluded from the study. All fractures were treated with a functional brace. There were 38 male and 55 female patients with mean age 53.4 (16–90) years. According to the AO classification, there were 27 fractures of type A1, 26 type A2, 30 type A3, eight type B1 and two type B2. Thirteen fractures were located in the proximal third, 59 in the middle third and 21 in the distal third of the shaft. Fifty-seven patients sustained the fracture in falling at ground level and nine by falling from a height of less than 3 m.

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Table 1 Indications for surgical treatment of humeral shaft fractures

Absolute indications
Open fracture
Fractures with secondary radial nerve palsy
Fractures with vascular injury
Patients with multiple injuries
Bilateral humeral shaft fractures
Serial fractures in the same arm
Pathological fractures
Non-unions
Relative indications
Unstable transverse or short oblique fracture
General illness such as Parkinson's disease

Five sustained the fracture following traffic accidents and in 13 patients, the fracture was caused by torsional forces.

The functional brace was applied in the emergency unit and we generally used a prefabricated brace (Ortamerica). The patient was informed of the treatment and referred to a physiotherapist who met the patient within 5 days to ensure that the patient was familiar with the treatment. The first follow-up in the orthopaedic outpatient clinic was 6 weeks after injury at which time the fracture was evaluated clinically and radiographically. If there were no radiological or clinical signs of consolidation at this stage, the patient was admitted for surgery. If the fracture was stabilised and bony callus visible, bracing continued and a new follow-up repeated after another couple of weeks. The patient was followed until fracture union. The treatment was considered successful if clinical and radiographically bony union was found.

An experienced physiotherapist carefully monitored the rehabilitation. The patient was encouraged to carry out

active exercises of the shoulder and elbow immediately after brace application. Outward rotation was, however, not permitted until after 6 weeks. An uninterrupted use of the brace was emphasised and the brace was not removed until there were clinically and radiographically signs of consolidation.

Statistical analysis

To describe the data, both means and standard deviations were used. For categorised variables, percentiles were used. In statistical analysis, differences between the groups were tested using the Mann–Whitney *U* test for continuous variables and Fisher's exact test for categorised variables. If the differences in fracture consolidation between groups could be explained by factors other than fracture location, logistic regression analysis was applied. The predictors were age, fracture location, gender and fracture configuration. Statistical analysis was carried out on a computer using the SPSS for Windows program (Version 10.0; SPSS Inc.). Throughout the study, a *p* value of <0.05 was considered statistically significant.

Results

Of all fractures in the present cohort, 72 consolidated without problems using functional brace treatment. Residual malalignment did not exceed 20° in any plane in any of the fractures. Six patients experienced a transient radial nerve palsy diagnosed before fracture manipulation and brace application. In 21 fractures, brace treatment failed and fractures were surgically treated using plating

Table 2 Details of 21 humeral shaft fractures with failed brace treatment. *LCDCP* low contact dynamic compression plate, *ABG* autogenous bone graft, *AIMLN* antegrade intramedullary locking nail, *RIMNL* retrograde intramedullary locking nail, *OR* open reduction, *W* wire fixation

Case	Age	Gender	AO type	Fracture location	Interval from injury to fixation	Fixation mode
1	35	F	A2	Middle	93	LCDCP+ABG
2	65	F	A1	Middle	90	AIMLN
3	76	M	B1	Middle	114	LCDCP+ABG
4	59	F	A1	Middle	93	AIMLN
5	45	F	A3	Middle	81	LCDCP+ABG
6	23	M	A3	Proximal	92	LCDCP+ABG
7	67	F	A2	Distal	62	LCDCP+ABG
8	45	F	A1	Distal	42	RIMLN
9	57	M	B1	Middle	46	AIMLN
10	85	F	A2	Middle	77	AIMLN+ABG
11	50	F	A1	Proximal	150	OR-AIMLN+W
12	73	M	A2	Middle	60	OR-AIMLN+W
13	51	M	A1	Proximal	43	OR-AIMLN+W
14	63	F	A1	Proximal	52	LCDCP+ABG
15	48	M	A2	Proximal	58	OR-AIMLN+W
16	71	F	A1	Distal	48	LCDCP+ABG
17	62	F	A1	Proximal	115	LCDCP+ABG
18	50	F	A3	Middle	42	LCDCP+ABG
19	56	M	A3	Middle	90	LCDCP+ABG
20	72	F	A1	Proximal	48	AIMLN
21	82	F	A2	Middle	50	RIMLN

(11 patients), intramedullary nailing (six patients) or intramedullary nailing in combination with wires (four patients). The average duration from injury to surgical treatment was 74 (42–150) days (Table 2). All surgically treated fractures healed properly.

Six fractures out of 13 in the proximal third, 48 out of 59 in the middle third and 18 out of 21 in the distal third united using a functional brace. There was a significant difference with respect to consolidation between the proximal and middle third ($p < 0.01$) and between the proximal and distal third ($p < 0.05$) of the humeral shaft whereas there was no significant difference between fractures of the middle and distal third ($p > 0.75$). Of AO-type A1, 18 fractures united with brace treatment, as did 20 type A2, 26 type A3 and eight type B1 or B2.

In 31 men and 41 women, fractures united with brace treatment and the difference between genders was not statistically significant. The mean age of patients whose fractures united with brace treatment was 51.4 (SD 21.1) years and of patients treated surgically was 60.5 (SD 15.4) years, which was a statistically significant difference ($p > 0.04$). Using logistic regression analysis, the only factor predicting a successful brace treatment was the fracture location in the humeral shaft.

Discussion

There is nowadays general agreement that total immobilisation of an injured extremity is harmful for fracture healing [17] and for the whole limb [8]. Latta and co-workers [11] and Sarmiento and co-workers [17] noted that controlled movement at the fracture site is conducive for osteogenesis. In recent years, important studies have been published comparing plating and intramedullary nailing of the humeral shaft [3, 6] but the role and justification of conservative treatment has not been called into question [10, 19].

According to our results, functional treatment of a humeral shaft fracture with brace offers an appropriate environment for fracture healing in the middle and distal third of the shaft. If only fractures in the middle and distal third had been included in the study, the consolidation rate would have been 83%. Moreover, the fractures that did not unite in a brace could later be treated surgically with success. However, probably for anatomical reasons, more than half of the fractures in the proximal third failed to achieve consolidation using a functional brace. The insertions of the deltoid and pectoralis major muscles at the proximal humeral diaphysis caused distraction between fracture fragments, preventing consolidation. In recent studies, Wallny and co-workers [20] found that 94%, and Koch and co-workers [10] that 87%, of humeral shaft fractures consolidated using a functional brace. These figures are in line with our results.

It is noteworthy that, formerly, transverse fractures of the humeral shaft were considered relatively unsuitable for conservative treatment [1, 12]. In contrast, the present results indicate that closed functional treatment also may

be appropriate; as many as 87% of the transverse AO-type A3 fractures united successfully.

In general, patient co-operation is a cornerstone in fracture treatment. Functional brace treatment is particularly demanding and non-compliant patients are at marked risk of failure. Although logistic regression analysis in this series showed the only predictive factor in respect of fracture consolidation to be the anatomical location of the fracture, it seemed that the ideal patient for functional brace treatment is an otherwise healthy and co-operative person aged less than 60 years. Pehlivan [14] drew a similar conclusion in his series. The functional treatment of humeral shaft fractures is also demanding for the health care personnel. Doctors and staff in emergency and outpatient clinics must be familiar with the principles of functional treatment. The importance of appropriate physiotherapy must be emphasised.

When compared to treatment with a plaster cast, functional brace treatment carries many advantages. Firstly, the patient can remove the brace for personal hygiene. Secondly, elbow movements are not restricted and joint stiffness therefore unlikely to develop. It is reasonable to assume that stiffness of the elbow joint may cause excessive movements between the fracture fragments and thus hinder the consolidation process. Thirdly, the brace is of limited weight and causes no distraction over the fracture site.

In functional brace treatment patients are not exposed to severe surgical risks. Surprisingly, high complication rates have been reported when intramedullary nails are used [7, 15, 18]. In a series comparing functional brace treatment and interlocking intramedullary nailing for the treatment of humeral shaft fractures, the complication rates were low and both treatments were regarded as useful in treatment of humeral shaft fractures. Nonetheless, the authors advocated functional bracing as the method of choice if no contraindications existed [19]. The complication rates in plating are reported to be lower than in intramedullary nailing [6, 13]. Open reduction and plating causes a scar, which might be troublesome, especially for young women. Furthermore, functional bracing does not require hospitalisation and the direct costs of medical care are thus significantly lower. The disadvantage of functional bracing in comparison with surgical treatment is the possible residual deformity of the arm. From 10% to 15% of humeral fractures treated with functional bracing unite with a residual angulation of more than 10° [20]. However, there is general agreement that malalignment up to $20\text{--}25^\circ$ is acceptable and functionally harmless [20, 21].

In summary, functional brace treatment commenced immediately after injury is a viable alternative in the treatment of middle and lower third diaphyseal fractures of the humerus regardless of fracture configuration.

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