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The relationship between the trauma-to-surgery interval and results in c-type distal humeral fractures

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Abstract

Background: Delayed surgery will lengthen the immobilization time and lead to soft tissue contracture in AO C-Type distal humeral fractures. We aimed to investigate the relationship between the trauma-surgery interval (TSI) and the functional and radiological parameters. Our hypothesis is delay in surgery separately affects functional and radiological outcomes and results worsen as surgical delay increases. In addition, we investigated if there is a breaking time for surgical delay in deterioration of results.

Methods: A total of 39 surgically treated C-Type distal humeral fractures between January 2003 and May 2013 were investigated retrospectively. Cases with additional problems to prolong TSI were excluded. Only patients with long TSI due to lack of operating room or lack of implant were included in the study. Two groups were made according to TSI as group I: 0-2 days and group II: 2-5 days. Groups were evaluated according to MEPI (Mayo Elbow Performance Index), elbow joint ROM (Range of Motion), and stability. Also, estimated radiological parameters were arthrosis, heterotopic ossification, avascular necrosis, joint stepping, malunion, and nonunion.

Results: There was no correlation between TSI and MEPI score, but there was a moderate positive correlation between the TSI and extension loss, a moderate negative correlation between the TSI and flexion range. We found that three days is a breaking time for surgical delay in deterioration of results.

Conclusions: Delay in surgery independently affected the functional and radiological outcomes and results worsen as surgical delay increased. TSI is even ahead of the fracture type in determining the functional results when TSI is three days and above. Delayed surgery more than three days of C2 fractures may result in more inferior functional results than a C3 fracture treated within three days.

Keywords: Humerus, distal, fracture, delay, surgery

1. Introduction

Delayed surgery will lengthen the immobilization time and lead to soft tissue contracture in AO C-Type distal humeral fractures ^[1]. Thus, immediate treatment determines the functional outcomes. However, urgent surgery in cases with severe soft tissue injury can lead to wound problems. Time for antibiotic prophylaxis in open fractures, concomitant injuries, and need for pre-operative intensive care may delay the surgery deliberately or unintentionally. It is not known whether the poor results are due to delay in surgery or accompanying problems. Therefore, we excluded the patients who had severe soft tissue injury, open fracture, concomitant injury and need for pre-operative intensive care. To our knowledge, there is no study focused on delayed treatment of C-Type distal humeral fractures in English literature. We looked for the answers to the following questions: ^[1] Whether this worsening of functional and radiological parameters is due to the causes of delay or delay in surgery? (2) Do functional and radiological outcomes deteriorate as the delay increases? ^[3] Is there any breaking time if functional and radiological outcomes are getting worse?

Our hypotheses are as follows: ^[1] Delay in surgery independently affects functional and radiological outcomes ^[2]. Results worsen as surgical delay increases ^[3]. There is a cut off time for surgical delay in deterioration of results.

2. Materials and methods

After IRB (Institutional Review Board) approval is obtained; a total of 46 surgically treated AO C-Type distal humeral fractures, between January 2003 and May 2013 were investigated retrospectively. Inclusion criteria were; closed fractures, AO Type C fractures, patients >16

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years old, olecranon osteotomy and double plate fixation, at least two years follow-up. Exclusion criteria were; severe soft tissue injury, accompanying injuries, need for preoperative intensive care unit, refractures, open fractures, previous fractures of the same elbow, and related previous surgical operations. Cases with additional problems to prolong TSI were excluded. Only patients with long TSI due to lack of operating room or lack of implant were included in the study. Seven patients were lost to follow-up (4 were deceased unrelated to the fracture). Remaining 39 fractures of 39 cases were included. Functional parameters were MEPI (Mayo Elbow Performance Index) [2], elbow joint ROM, and stability. Radiological parameters were arthrosis, heterotopic ossification, avascular necrosis, joint stepping, malunion, and nonunion. Arthrosis was evaluated according to Broberg-Morrey classification, and HO (Heterotopic ossification) was evaluated according to Brooker classification [3, 4]. Cases were divided into two groups according to the TSI as group I was 0-2 days and group II was 2-5 days. These two groups were compared according to age, gender, fracture type, complications, functional, and radiological parameters. The cases were classified as < 50 and ≥ 50 years old, and according to gender and fracture subtypes; complications were compared regarding functional and radiological parameters. Pre and post-operative elbow anteroposterior, and lateral x-rays and CT (computerized tomography) were taken. For prophylaxis, cefazolin sodium (1 g) was applied intravenously. Tourniquet was not used, not to narrow the surgical field (Figure 1). For heterotopic ossification prophylaxis, oral indomethacin treatment (75 mg per day) for three weeks was advised. A posterior splint was applied in full extension to encourage the patient after surgery. The splint was removed after 24 h and drains were removed after 48 h. Following the removal of the splint, active elbow ROM exercises were started immediately. Cases experiencing rehabilitation problems were followed-up weekly for the first two months. The range of motion of the elbow measured with a goniometer, and the rating system of Cassebaum's method was used to quantify the final results [5].

Descriptive statistics were used to describe continuous variables (mean, standard deviation, minimum, median, and maximum). Comparisons of independent variables with normal distribution were performed using the Student's t-test, and comparisons of two independent and non-normal distributions were performed using the Mann-Whitney U-test. One-way analysis of variance (ANOVA) was used to compare two independent variables that were independent of the normal distribution, and the Kruskal Wallis test was used to compare two independent variables with the independent normal distribution. The Chi-Square or Fisher Exact tests were used to examine the relationship between categorical variables. We used Pearson correlation for correlation analyses for normally distributed variables, and Spearman's rho correlation analysis for continuous variables with a non-normal distribution. Analyzes were performed using the MedCalc Statistical Software (version 12.7.7) (MedCalc Software BVBA, Ostend, Belgium; <http://www.medcalc.org>).

3. Results

There were 24 (%62) males and 15 (%38) females with a mean age of 46 years (range, 17–84) and mean follow-up period was 70 months (range, 24–132; median, 84).

According to AO/ASIF classification there were 11 C1 (28%), 16 C2 (41%), and 12 C3 (31%) fractures. Eighteen (46%) were right-sided and 21 (54%) were left-sided. Etiology was falling on the flat ground in 19 (49%), motor vehicle accidents in 12 (31%), fall from high in 5 (13%), and direct impact in 3 (7%) cases. The mean TSI was 2.9 ± 1 days (range, 1–5 days; median, 3.2 days). Group I was consisted of 22 (56%) members and group II was consisted of 17 (44%) members. The mean elbow ROM was 111 ± 13.5 degrees (median, 113; range 85–130) and the mean MEPI Score was 92.7 ± 6.3 (median, 90; range 80–100) according to the last visits. MEPI scores were 'perfect' for 37 (94%) and 'good' for 2 (5%). ROM and flexion degree was decreased and extension loss was increased as TSI increased. Thus, a moderate positive correlation between extension loss and TSI and a moderate negative correlation between TSI and elbow ROM (Spearman's rho test: p = 0.004, 0.003 respectively) was found (Table 1). Further analysis was made between TSI and MEPI score, gender and complications and no correlation were found (Spearman's rho test; p = 0.995, Mann-Whitney U test: p = 0.578, Kruskal Wallis test: p = 0.055, respectively). There were differences between groups according to extension loss and elbow ROM (Kruskal Wallis test: p = 0.020) (Table 2).

TSI was longer in C2 fractures than C1 and C3 fractures (Kruskal Wallis test: p = 0.006). Consequently, there was a higher proportion of C2 fractures in Group II, compared to the other group (Fisher's Exact test: p = 0.008) (Table 3). There were also differences between fracture types according to extension loss and flexion as well as elbow ROM. Extension loss was higher, and flexion degree was lower in C2 fractures (Kruskal Wallis test: p = 0.024 and 0.003, respectively) Radiological complications were given in Table 4. All superficial infection and wound problems improved without requiring any additional intervention. No deep infection, nonunion, or instability was encountered in these series. In Table 5, all complications and mean TSI, MEPI, and ROM values were given.

Table 1: MEPI, extension loss, flexion range and ROM according to TSI

	MEPI Score	Extension Loss	Flexion Degree	ROM
TSI overall (n=39) (r)	-0,268	0,455	-0,459	-0,590
(p)	0,099	0,004	0,003	<0,001

Table 1: MEPI, extension loss, flexion range and ROM according to TSI independent from groups.

Table 2: MEPI, extension loss, flexion range and ROM according to groups

	MEPI Score	Extension Loss	Flexion	ROM
Group I (n=22)	93±6	13±5	123±8	116±12
Group II (n=17)	91±7	23±8	116±7	93±11
(p)	0,404	0,020	0,057	0,003

Table 3: Distrubution of fracture type according to groups.

		Group I	Group II	P
AO Type	C1	8	3	0,008
	C2	4	12	
	C3	10	2	

Table 4: Distribution of radiologic complications and their features.

Radiologic Complications n=27 (%69)	N	Grade 1	Grade 2	Grade 3	Grade 4
Arthrosis (Broberg-Morrey classification)	22 (%56)	15(%38)	5 (%13)	1 (%3)	1 (%3)
Heterotopic Ossification (Brooker classification)	17 (%44)	5(%13)	10 (%26)	1 (%3)	1 (%3)
Avascular Necrosis	3 (%8)	none	2 (%5)	1 (%3)	none

Table 5: Complications and mean TSI, MEPI and ROM values.

Complication	N	TSI (mean days)	MEPI (mean)	ROM(mean)
Arthrosis	22 (%56)	3.2	92	99
Heterotopic Ossification	17 (%44)	4.1	92	95
Infection and Wound Problems	9 (%23)	2.4	95	91
Ulnar Neuropathy	6 (%15)	3.7	98	102
Joint Stepping	5 (%13)	3.9	99	93
Avascular Necrosis	3 (%8)	4.1	92	93
Malunion and Valgus Deformity	3 (%8)	4.3	97	93



Fig 1: a) Preoperative anterior-posterior XR of a 77 years old female patient shows a multi-fragmented fracture, b) Axial CT diagram shows a Type C2 fracture, c) 3D reconstruction CT of same patient, d) Per-operative diagram shows fixation, the ulnar nerve is dissected, e) Post-operative anterior-posterior x-ray of patient, f) Lateral x-ray of patient.

4. Discussion

Surgical treatment delays are common in LMICs (low and middle-income countries) [6]. Because of the limitation of the authors' hospital's operation rooms, few patients had undergone surgery within 48 h of injury. Sekimpi *et al.* evaluated the femoral fracture fixation in developing countries and found that patients waited an average of 13 days for surgery [7]. Surgical treatment of humeral distal end fractures within the first two days leads to better functional results, an earlier return to work and higher elbow joint ROM [2, 8, 9]. Elmadag *et al.* concluded that early surgical treatment might be the critical factor affecting the functional outcomes because delayed surgical treatment will lengthen the immobilization time and lead to soft tissue contracture [1]. In one of the rare studies reporting the time between trauma and surgery there are only two cases with TSI > 48 h. [10]. Unfortunately, no further information has been given about the results of these two patients. In another study, Huang *et al.* investigated 19 elderly patients with surgically treated distal humeral fractures. In that study, 5/19 were undergone surgery between 2-7 days while 6/19 were undergone surgery in 8-12 days. Unfortunately, no statistical analysis was made according to TSI in that study [11]. We performed a statistical analysis of their results. Although not significant, in patients with longer TSI (8-12 days) mean flexion degree was 6

degrees lower than overall flexion degree. At the same time, in patients with shorter TSI (0-2 days) mean extension loss was 7 degrees lower than overall extension loss. Consequently, to our knowledge, our series with 17 patients who underwent surgery with TSI >48 h. is the first and most significant series in the literature.

Our first question was; whether this worsening of functional and radiological parameters is due to the causes of delay or delay in surgery? Delay in surgery independently affected our functional and radiological outcomes. Also, results worsen as surgical delay increased. Thus, our second question was also answered.

We found no association between TSI and age and complication rates, but there were correlations between TSI and extension loss, flexion degree, and elbow joint ROM. Another impressive result was extension loss, and flexion degree were worse in C2 fractures than C3 fractures. Whereas, in literature, when the fracture type becomes more complex, functional outcomes worsen [12-14]. The decreased elbow ROM in C3 fractures might be related to advanced age, delay of surgery, accompanying fracture, intensive care unit admission, and soft tissue problems [15]. Also, post-operative pain is typically more severe in C3 fractures than C1 and C2 fractures, which makes rehabilitation more difficult. What is the reason for worse extension loss and flexion degree in C2 fractures than C3 fractures in our series? This may be due to the longer TSI of C2 fractures than C3 fractures in our series. In group II, there were more C2 fracture than C3 fracture. This gap may belong to the neglect of C2 fractures for early surgical treatment, compared to more alarming C3 fractures. From this point of view, TSI is even ahead of the fracture type in determining the functional results when TSI is longer than three days. Delayed surgery of C2 fractures more than three days may result in more inferior functional results than a C3 fracture treated within three days.

Our third question was: Is there any breaking time if functional and radiological outcomes are getting worse? Results worsen as surgical delay increased, but we found a breaking time as three days in this study. Above three days, the delay becomes more effective than the fracture type.

Also, we found that ROM decreases as the TSI increases. However, the reduction rate of ROM is accelerated after three days. This means; stable anatomical fixation and active ROM exercises may provide good functional and radiological outcomes up to three days of delay.

Holdsworth and Ilahi reported that delay in treatment of greater than 48 hours increases the rate of HO from 0% to 33% [16, 17]. Crawford *et al.* reported that in patients who persisted with a passive and active-assisted range of motion, especially beyond the range of pain-free movements, the

ossification progressed to complete ankylosis and required surgical intervention to remove the heterotopic bone. We encountered 17(44%) HO cases, but only 2 (5%) were grade 3 and 4. Despite the delay of treatment, active exercise program instead of passive may improve the results and reduce the grade of HO.

The study design was retrospective with relatively a few numbers of cases. A prospective study would give more information about the effects of TSI. However, it would not be ethical to obtain favorable case series and a prospective study about delayed surgery results.

5. Conclusions

Delay in surgery independently affects functional results. ROM decreases as the TSI increases. Three days is a breaking time for surgical delay in deterioration of functional results. Above three days, the delay becomes more effective than the fracture type. Delayed surgery of C2 fractures more than three days may result in more inferior functional results than a C3 fracture treated within three days. We suggest warning the patients with TSI > 3 days, about the possible decrease of final elbow ROM. If surgery is delayed, anatomic reduction, stable fixation, and immediately started active assisted ROM exercises may provide good functional and radiological outcomes.

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