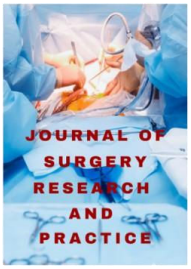

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Research Article

The Effect of Coronoid Nonunion on the Terrible Triad of the Elbow

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Abstract

Elbow dislocation associated with radial head and coronoid fractures is known as terrible triad of the elbow. Despite the improvement in the results of its surgical treatment, complications such as stiffness, osteosynthesis problems, ulnar nerve neuropathy, heterotopic ossification and late arthrosis still occurs. No study so far has showed the clinical repercussion of these complications. This study aims to compare the clinical, functional and radiographic results of patients treated for terrible triad of the elbow in whose there was union of the coronoid process with others in whom the union did not occur.

Twenty-five patients who were surgically treated for a terrible triad from March 2007 to December 2012 were retrospectively analyzed. The patients were divided into two groups: C group, comprised of 18 patients with coronoid union and NC group, comprised of 7 patients with nonunion. The groups were compared regarding gender, affected side, coronoid fracture type, coronoid osteosynthesis method, radial head management, follow-up time, time elapsed between fracture and surgery, range of motion, Disabilities of the Arm, Shoulder and Hand Disabilities of the Arm, Shoulder and Hand (DASH) and Mayo Elbow Performance Index (MEPI) functional scores and number of complications.

In total, 19 men and 12 women with mean age of 43 years were enrolled. The mean final flexion and extension arc was 111°. The mean pronation and supination were 68° and 630, respectively. The mean DASH was 12 and the mean MEPI was 86. According to MEPI, 20 patients (80%) had good and excellent results. There was no statistically significant difference in any of the variables in the comparison between C and NC groups.

Therefore, it was concluded that the coronoid nonunion does not affect the outcome of patients treated for terrible triad of the elbow.

Keywords: Elbow; Fracture-Dislocation; Terrible Triad; Coronoid

Introduction

Elbow dislocation associated with fracture of the radial head and coronoid fractures is known as terrible triad of the elbow once surgeons used to face difficulties in it approaches, obtaining unsatisfactory results [1-3]. A better understanding of elbow biomechanics and stability contributed to better surgical outcomes in its treatment by following a protocol that includes osteosynthesis or replacement of the radial head, osteosynthesis of the coronoid and repair of the Lateral Ligamentous Complex (LCL) [4-9].

Despite the improvement in the results of its surgical treatment, complications such as stiffness, osteosynthesis failures, ulnar nerve neuropathy, heterotopic ossification and late arthrosis still occurs. However, no study so far has showed the clinical repercussion of these complications [10].

This study aims to compare the clinical, functional and radiographic results of patients surgically treated for terrible triad of the elbow in which there was union of the coronoid process with others in which the union did not occur.

Methodology

This study was approved by the Hospital Ethical Committee (Study Number: 33891220.0.0000.5127). Between March 2007 and December 2012, 48 patients were treated for terrible triad of the elbow. Table 1 presents the approaches to the coronoid process, the radial head and the medial and lateral collateral ligaments. After surgery, the elbow was immobilized in flexion of 90° and the forearm pronated for one week. Then, home rehabilitation was initiated. Patients returned for follow-up at one, two, six, twelve, twenty-four and forty-eight weeks.

Twenty-three patients were excluded from the study: in six patients, the coronoid was not addressed, four patients were not located, ten did not return for postoperative follow-up, two patients did not have preoperative radiographs and one patient underwent primary resection of the radial head without its replacement. The remaining 25 patients were divided into two groups: NC group, including patients with coronoid nonunion and group C, including patients with coronoid healing. The groups were compared regarding gender, affected side, type of fracture of the coronoid process, type of coronoid osteosynthesis, type of radial head approach, follow-up, time between fracture and surgery, range of motion, functional scores and number of complications. The DASH and MEPI questionnaires were administered to the patients [11,12]. They were evaluated for pain by the Visual Analog Scale (VAS) and their ROM was measured using a goniometer. Elbow stability was clinically evaluated by varus-valgus stress and pivot-shift tests [8]. Coronoid healing was evaluated by a lateral radiography of the elbow. A distance between the detached fragment and the bone base equal to or greater than 2 mm, was considered a nonunion. In these patients, the distance between the detached fragment and the bone base was measured using the Vue PACS imaging program (Fig. 1). In cases in which the coronoid process was covered by the overlapping of the radial head arthroplasty, a coronoid-trochlea incidence was performed [13].

The radiographic evaluation was also used to determine the presence of heterotopic ossification and degenerative changes of the elbow. The latter was classified according to the Broberg and Morrey criteria [12]. The fractures of the coronoid process were classified according to Regan and Morrey's classification [14]. Type 1 fractures were identified in 10 patients and type 2 fractures were identified in the other fifteen.

Figure 1: Coronoid process nonunion after its fixation with screw and K-wire plus LCL transosseous repair and partial resection of the radial head.

C Group	Coronoid Fix	RH Approach	LCL Repair	LCM Repair
Patient 1	TO Suture	Arthroplasty	Anchor	No
Patient 2	kw + screw	Herbert + kw	TO Suture	No
Patient 3	TO suture	Herbert + kw		No
Patient 4	kw + TO suture	Herbert + kw	TO Suture	No
Patient 5	TO suture	Partial Resection	Anchor	No
Patient 6	TO suture	Herbert	Anchor	No
Patient 7	Kw + TO suture	Herbert	Anchor	No
Patient 8	Screw	Arthroplasty	TO Suture	No
Patient 9	Anchor suture	Arthroplasty	Anchor	No
Patient 10	TO suture	Herbert	Anchor	No
Patient 11	TO suture	Herbert	Anchor	No
Patient 12	Screw	Herbert	TO Suture	No
Patient 13	TO suture	Herbert	Anchor	Yes
Patient 14	TO suture	Arthroplasty	TO Suture	No
Patient 15	TO suture	Arthroplasty	Anchor	Yes
Patient 16	TO suture	Arthroplasty	Anchor	No
Patient 17	TO suture	Arthroplasty	TO Suture	No
Patient 18	Screw	Herbert	TO Suture	No
NC Group				
Patient 19	TO suture	Arthroplasty	TO Suture	No
Patient 20	TO suture	Arthroplasty	TO Suture	No
Patient 21	Screw	Arthroplasty	TO Suture	No
Patient 22	kw	Plate	TO Suture	No
Patient 23	Screw + Kw	Partial Resection	TO Suture	Yes
Patient 24	Screw	None	Anchor	No
Patient 25	TO suture	Plate	Anchor	No

Table 1: Approach to the coronoid process, radial head and medial and lateral collateral ligaments. TO: Transosseous; kw: K-wire.

Statistical Analysis

Statistical analysis was performed using the SPSS Statistics version 22.0 (IBM SPSS Statistics). The sample was conveniently selected due to the low, justified by the low incidence of the pathology. An abnormal distribution of data was observed and non-parametric tests were used. Fisher's Chi-square and Mann-Whitney tests were applied with descriptive analysis of categorical and quantitative variables. We used a confidence interval of 95% and a p-value <0.05. The effect size of the variables was calculated through eta (categorical variables) and Cohen's d coefficient (quantitative variables). The effect sizes were evaluated according to the following classification: insignificant (<0.19), small (0.20-0.49), medium (0.50-0.79), large (0.80-1.29) and very large (>1.30).

Results

Of the 25 patients who underwent osteosynthesis, coronoid union was achieved in 18 cases, constituting C Group. The NC group included the other seven patients who underwent osteosynthesis without subsequent bone healing. The average age of the patients was 43 years, 44 years in C group and 42 years in the NC group. Patients in C group were operated, on average, six days after trauma, while those in NC group were operated, on average, after 10 days, with no statistically significant difference between the two groups (p=0.157). Table 2 shows that there was no significant difference when comparing the two groups regarding gender, affected side and coronoid fracture classification. Table 3 shows that there was no difference between the type of osteosynthesis that was used and the healing of the coronoid process (p=0.305). The eta was 0.560.

The mean final flexion contracture was 19.2° (±15.6), ranging from 0° to 65°. The mean final flexion was 135° (±25), ranging from

105° to 150°. The mean final flexion-extension arc was 111.6° (±27). The mean pronation was 68° (±22.4), ranging from 0° to 85°. The mean supination was 63° (±22), ranging from 0° to 80°. The mean final pronosupination arc was 130° (±41). The mean DASH value was 12.24 (±14), ranging from 0 to 50. The mean final MEPI was 86.6 (±13). According to the MEPI score, 11 patients had excellent results, 9 good results and 5 fair results. Table 4 shows that there was no statistically significant difference between the groups regarding follow-up, final ROM and functional scores.

Twenty-four complications were observed in our patients, 20 of them in C group (Table 5). No patient had infection, surgical wound dehiscence or neurovascular lesions associated with the surgical procedure. Ten reinterventions were performed. Four patients, three in C group and one in NC group, were treated for elbow stiffness. A cement spacer was removed in the two cases in which it was used after eight weeks. A radial head prosthesis was removed due to pain associated with osteolysis in its stem, 31 months after the index surgery. The radial head was removed in one patient three months after the index surgery due to avascular necrosis. In a patient with persistent olecranon bursitis, a bursectomy was performed, with the removal of screws from the coronoid, three months after the index surgery.

Description	Gender		Dominance		Affected Side		Type of Fracture	
	M	F	R	L	R	L	I	II
Total	15	10	19	6	10	15	10	15
C Group	11	7	16	2	7	11	8	10
NC Group	4	3	3	4	3	4	2	5
P- VALUE	0.856		**0.032**		0.856		0.467	
eta	0.036		0.484		0.036		0.145	

Table 2: Comparison of groups C and NC according to gender, dominance, affected side and type of fracture of the coronoid process.

Description	Type of Fracture	Suture	Cannulated Screw	Cannulated Screw + K-Wire	Suture + K-Wire	K-Wire
TOTAL		15	5	2	2	1
C GROUP	MORREY 1	8	-	-	-	-
	MORREY 2	4	2	2	2	-
NC GROUP	MORREY 1	2	-	-	-	-
	MORREY 2	1	3	-	-	1

Table 3: Consolidation of the coronoid process and its fixation types.

Description	Follow –Up (In Months)	FE ARC (in degrees)	PS ARC (in degrees)	MEPI	DASH
C Group	28	110	127	86	13
NC Group	25	123	138	88	12
P-value	0.540	0.270	0.745	0.652	0.357
Cohen's d	0.284	0.481	0.243	0.071	0.062

Table 4: Results of C and NC groups according to follow-up time, final range of motion and elbow evaluation scores.

Description	C Group	NC Group	Total
Total	20	4	24
Arthritis	8	3	11
Stiffness	3	1	4
Radio-Ulnar Synostosis	1	0	1

Radial Head Avascular Necrosis	1	0	1
Heterotopic Ossification	2	0	2
Spacer Removal	2	0	2
Steam Osteolysis	1	0	1
Residual Pain	1	0	1
Olecranon Bursitis	1	0	1

Table 5: Description of the types and number of complications in C and NC groups.

Discussion

The satisfactory results of surgical treatment of terrible triad of the elbow have increased considerably in the last decades, but the percentage of complications still relevant. About 22% of patients have complications that require reoperations [10,15]. Among these complications, ulnar neuropathy, stiffness and problems related to osteosynthesis of the radial head are the most common ones [10]. Few studies provide data on the impact of these complications in patients treated for terrible triad of the elbow [10,15]. This study compares patients who were treated for terrible triad of the elbow in whom there was union of the coronoid process with others in whom the union did not occur. In this study, the mean flexion-extension arc was 110° in the union group and 123° in the nonunion group. The mean DASH and MEPI were 13 and 86 in the first group and 12 and 88 in the second group, respectively. The functional results were good in both groups and were similar to the findings reported in the literature [5,16]. Pugh, et al., reported a mean flexion-extension arc of 112° and a mean MEPI of 88 in 36 patients [5]. Egol, et al., reported a mean flexion-extension arc of 109°, a mean DASH of 28 and mean MEPI of 81 in 29 patients operated on [16]. Chen, et al., reported an MEPI between 78 and 95 points, with 82% of them having good and excellent results and a DASH ranging from 9 to 31 points [10].

The osteosynthesis of the coronoid was performed through three methods in this study: trans-osseous suture in 15 patients, cannulated screws in five patients, a combination of k-wire and the two previous methods in other four patients and finally, two isolated k-wires in one patient. The nonunion of the coronoid process was present in three patients who underwent trans-osseous suture, three others who underwent screw osteosynthesis and in the only patient who underwent isolated k-wire fixation, totaling seven patients with pseudarthrosis after osteosynthesis (28%). This study showed a higher number of nonunion than that usually reported in the literature [5,17] even thought there was no statistical difference when comparing different types of osteosynthesis and the presence of nonunion. The literature shows good results for the three options of osteosynthesis [17,18]. Giannicola, et al., described the use of threaded Kirschner wires in the fixation of the coronoid in 12 patients presenting with terrible triad of the elbow. All had good or excellent results [17]. Garrigues, et al., evaluated 40 patients presenting with terrible triad of the elbow who underwent osteosynthesis of the coronoid with the use of trans-osseous sutures, metal anchors and cannulated screws. They obtained an average MEPI of 90 and an average DASH of 16 [18].

The number of complications is still high in the surgical treatment of terrible triad of the elbow [10]. Gupta, et al., reported that 59% of their patients presented with elbow stiffness after treatment and 26% underwent surgical reintervention [15]. Pugh, et al., reported that 22% of patients had complications that required reintervention [5]. In the present study, a total of 24 complications were observed, 20 of them in patients in whom the coronoid healed. The main complication of this study was arthritis, occurring in 44% of patients. Ten patients underwent reinterventions (40%).

This study has some limitations. It is retrospective, observational and has a short follow-up time (26 months), even though many of the studies published on this subject have the same characteristics [10]. The short follow-up time makes it impossible to correctly assess the incidence, progression and clinical repercussion of secondary degenerative osteoarthritis. Moreover, the small number of patients in each group makes the final analysis of the study weaker. Additionally, the heterogeneity of coronoid fixation methods used in the present series (trans-osseous sutures, cannulated screws Kirschner wires and combined techniques) reflects the fact that there is no universal or standardized approach for coronoid fixation in terrible triad injuries, with technique selection typically influenced by fragment size, fracture morphology and intraoperative stability. Although no statistically significant association was observed between the type of fixation and the presence of nonunion, variability in construct stability and compression may affect coronoid healing and could therefore act as a confounding factor when interpreting consolidation and clinical outcomes, potentially limiting the generalizability of the conclusions. The significant follow-up loss of 29% of patients must be considered. The patients were treated in quaternary level hospitals, references in trauma for patients from other

municipalities and states. Often, these patients did not return for follow-up after surgical treatment or were not located by the data in their medical records. Nevertheless, this number is similar to that of other studies [15,16].

Despite these limitations, the present study also has relevant strengths. To our knowledge, it is the first study to specifically evaluate coronoid nonunion as a variable potentially associated with outcomes after surgical treatment of the terrible triad of the elbow. Furthermore, all surgeries were performed by the same surgeon, which reduces inter-surgeon variability and supports internal consistency, even though the treatment strategy was individualized according to the particular anatomical and instability findings of each patient.

Conclusion

There is no difference in clinical, functional and radiographic results of patients with union or not of the coronoid process after the surgical treatment of terrible triad of the elbow. Therefore, it can be concluded that nonunion of the coronoid does not affect the outcome of patients treated for terrible triad of the elbow.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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None.

Data Availability Statement

Not applicable.

Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Informed Consent Statement

Informed consent was taken for this study.

Authors' Contributions

All authors contributed equally to this paper.

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