EUROMEDITERRANEAN BIOMEDICAL JOURNAL
2021,16 (04) 17–20
(FORMERLY: CAPSULA EBURNEA)

Original article

IMMEDIATE MOBILIZATION FOR MASON TYPE II RADIAL HEAD FRACTURES: A CONE-BEAM CT STUDY

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ARTICLE INFO

Article history:
Accepted 15 January 2021
Revised 20 February 2021
Published 08 March 2021

Keywords:
Cadaver Model, Immediate Mobilization, Mason II, Radial Head, Fractures, Cone-Beam CT.

ABSTRACT

The management of Mason type II radial head fractures is still debated. Retrospective comparative studies suggest that long-term clinical results of both operative and non-operative treatments are very good. The proper mobilization protocol is one of the most critical point of discussion. Our study aim is to establish effects of an immediate active elbow mobilization (I-RAM) on cadaveric models of radial head fractures. We performed Mason II radial head fractures on 5 frozen intact human upper limbs. We than analyzed the effects of I-RAM on cadaveric models using Cone-Beam Computerized- Tomography (CBCT). A statistically significant reduction in fragments diastasis after fracture reduction and after 0-30° range of motion was found. The 30-110° motion range was not able to increase fragments diastasis too. Our study shows that an extremely early mobilization after a Mason II radial head fracture does not significantly increase fragments displacement. Principal limitations of this study are due to the use of a cadaveric model, mainly the absence the hematoma and swelling development and fracture-associated soft-tissue injuries. For this reason, we are planning a perspectival study to test results of early mobilization (I-RAM) also on living models.

1. Introduction

Radial head fractures are common traumatic lesions between the 3rd and 6th decades. The prevalent mechanism of injury is a fall on to the outstretched arm with the elbow in pronation and partial flexion[1]. Mason categorized these fractures into 4 types: nondisplaced, displaced, multifragmentary and fractures associated with elbow dislocation. The treatment choice is influenced by elbow stability, fragment displacement and radio-ulnar joint involvement. Generally, undisplaced fractures (Mason I) are conservatively managed [2,3], while surgical treatment is recommended for types III and IV [3]. However, the correct management of type II fractures is still debated.

Authors agree that these fractures show a low complication rate (loss of range of motion, pain, bony ankylosis, non-union and mal-union) with both surgical and non-surgical treatment [4,5]. Previous retrospective comparative studies have failed to demonstrate a statistically significant difference between operative and non-operative treatment methods in terms of long-term clinical results, but also in terms of risk of non-union and mal-union [5-7].

Conservative treatment of Mason type II fractures usually consists of 5-8 days of immobilization [8] in a fiberglass or a plaster splint with the elbow in 90° of flexion and the forearm in neutral rotation. After this first period of immobilization, a progressive active and passive mobilization can begin [8].

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DOI: 10.3269/1970-5492.2021.16.4

However, in clinical practice, the outstanding question remains about the correct length of the immobilization period in order to reduce both the risk of joint stiffness and secondary fragment displacement [2, 5].

The authors constructed a cadaveric model of Mason type II radial head fracture to investigate the effects of a simulated immediate active elbow mobilization (I-RAM) on fragment stability using a Cone-Bean Computer Tomography (CBCT).

2. Methods

Five fresh frozen intact human upper limbs (acromioclavicular included) were used. Before the test, each part was clinically examined in order to evaluate stability and range of motion (ROM). The humerus was fixed parallel to the floor. First of all, the elbow was investigated with a prototype of Cone Beam Computerized Tomography (CBCT) scan to localize bicepital tuberosity and to estimate the size of the radial head.

A series of eyelet screws were placed into the humeral shaft and the radial tuberosity to simulate the anatomical origins and insertions of the *Biceps Brachii*. A plastic wire was placed into the eyelet to replicate the biceps' anatomical line of action (Figure 1 and 2).

A volar Henry approach was adopted in order to expose the radial head saving the lateral collateral ligaments. A Mason type II fracture was performed with an osteotome involving the radial head postero-lateral (PL) quadrant, since this portion appears to be the most often involved in traumas [1]. Then, the articular capsule was sutured and the average fragment displacement into three planes was established using CBCT. Subsequently, the fracture was reduced moving the forearm from pronation to supination during progressive elbow flexion. After the reduction maneuver, a new measurement of fragment displacement was performed by means of CBCT. During the subsequent experimental steps the forearm was maintained in in a supine position. A weight of 50 N was then fixed to the wire at the shoulder level in order to simulate the effects of an active *Biceps Brachii* contraction (Figure 1 and 2). For each model, three load cycles were applied obtaining three complete flexion-extension excursions of the elbow. The fracture fragment diastasis (Ds) was then estimated into three planes using CBCT. The fracture fragment diastasis (Ds) was considered as the minimal distance between two points, one placed on the fragments and the second on the residual part of the radial head. An additional, complete elbow flexion was performed and the whole ROM was divided into two ranges: 0°-30° and 30°-110°. The mean Ds of three different measurements within the same range of flexion (0-30° and 30-110°) was calculated. Statistical analysis was performed using the Statistical Package for Social Sciences, Version 13 (SPSS Inc., Chicago, Illinois). Continuous variables were showed as mean ± standard deviation and discrete variables were expressed as frequency percentages. The non-parametric Kolmogorov-Smirnov test was used to analyze the difference in quantitative variables between groups. We used a 5% level of confidence for the test.

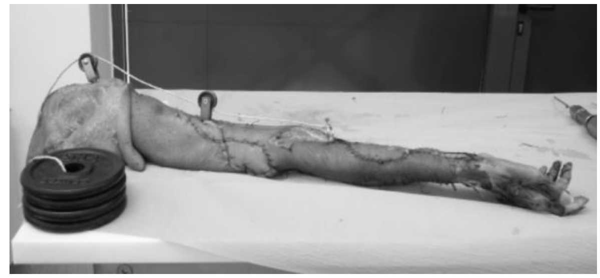

Figure 1. Upper limb cadaveric model before load application

Figure 2. Upper limb cadaveric model after load application

3. Results

The radial heads average size was 24.5 ± 3.4 mm in coronal plane and 23.7 ± 2.1 mm in axial plane. The radial head articular surface was involved in fracture for a mean of 36.2%. Mean Ds before and after the elbow mobilization are shown in Table 1.

	Pre-reduction (mm)	Post-reduction (mm)	0-30° motion (mm)	30-110° motion (mm)
Axial Ds	2.7±0.23	1.45±0.26	1.17±0.27	0.86±0.03
Coronal Ds	2.8±0.21	1.61±0.22	1.06±0.18	0.81±0.21
Sagittal Ds	2.97±0.32	1.46±0.39	0.99±0.11	0.99±0.03

Table 1. Mean Axial, Coronal and Sagittal Ds before and after motion (commas should be changed with points)

A statistically significant reduction in Ds was found after the reduction maneuver. The 0-30° range of flexion showed a significant reduction in term of Ds in all three planes we considered. We also found a significant reduction in axial and coronal Ds into the 30-110° range of flexion; instead, sagittal Ds was not modified. Figure 3, 4 and 5 offer a graphic explanation of these data.

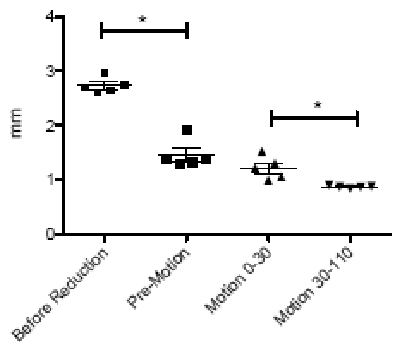

Figure 3. Axial plane diastasis variations during elbow motion

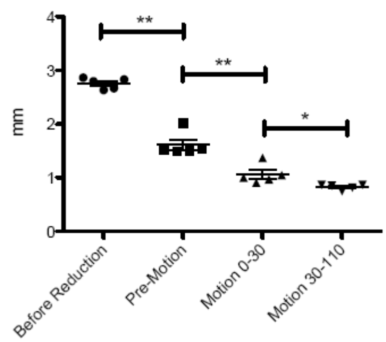

Figure 4. Coronal plane diastasis variations during elbow motion

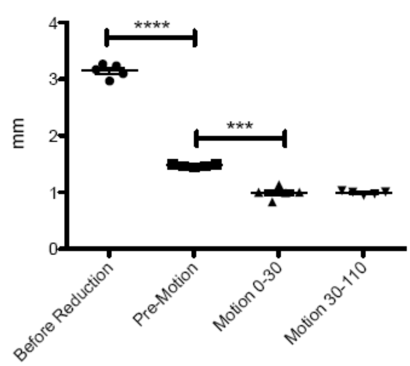

Figure 5. Sagittal plane diastasis variations during elbow motion

4. Discussion

Currently, the treatment for Mason type II radial head fracture is still debated. Conservative treatment mainly implies immobilization in a cast with 90° of elbow flexion and neutral rotation for approximately 5-8 days [8,9]. On the other hand, surgical treatment consists of open reduction and internal fixation (ORIF), followed by early mobilization [9]. Insufficient evidence due to lack of randomized trials and heterogeneity of retrospective studies hinders the drawing of any conclusions on the optimal treatment option for Mason II fractures [5,8].

In a recent review, Burkhart et al highlighted disagreement about whether Mason type II fractures need open reduction and internal fixation (ORIF) [10].

Since Akesson et al first reported good long-term results after nonsurgical treatment of 2 to 5 mm displaced Mason II fractures, the indication for surgery was again questioned [11]. In their retrospective study, they reported that 40 out of 49 subjects declared no symptoms after a mean follow-up of 19 years. Only minimal differences between injured and uninjured elbow were noted. Authors found a higher incidence of x-Ray-evident degenerative changes in the non-operative group but most of them remained asymptomatic. This observation has been confirmed by similar, recently published studies [12,13]. Conversely, Lindenhovius et Al reported a positive outcome in their retrospective case series of 16 surgically treated Mason type II fractures after a mean follow-up of 22 years [14]. In 2014, Yoon et al [13] retrospectively compared non-operative treatment and ORIF in subjects with isolated radial head fractures with a displacement of 2 to 5 mm. They could not find a clinical benefit of ORIF because of the subject-rated elbow evaluation score. ROM and grip strength did not show a significant difference. These results have aroused increasing interest in non-surgical treatment. The main concern regarding conservative treatment of Mason type II fractures is the risk of fracture fragment displacement as a consequence of early active mobilization [2,5]. Based on Morrey's biomechanical study [15], the authors conduced a TC-guided study on 5 cadaveric models of type II fractures to simulate the effects of very early mobilization after this kind of fracture. Morrey described the capitulo-humeral forces transmission during elbow mobilization. He calculated that the maximum strengths are transmitted during the first 30° of flexion, then they drastically decrease when the flexion progressively reaches 120°. Results of fragment displacement analysis by means of CBCT applying different ranges of motion are showed in Table 1. Surprisingly, the 0-30° range of mobilization was not a cause of fragment displacement, however it produced a statistically significant reduction of diastasis in all three planes. Also, the 30-110° range of motion did not show negative effects on fragment displacement: it was responsible for a significant diastasis reduction in axial and coronal planes and it did not modify the sagittal diastasis. From this point of view, an extremely early mobilization after radial head Mason type II fractures does not seem to be cause of significant fragment displacement.

Obviously, our study presents some limitations derived from the use of a cadaveric model. Indeed, in contrast to a living person, the cadaver does not develop hematoma and swelling after fracture and it does not complain of pain during elbow mobilization. The use of a cadaveric model also implies the adoption of a surrogate of the natural joint movement due to muscle contraction. In this study, pulleys were adequately disposed to re-create the biceps' force vector. This is an evident simplification of the real mechanism of elbow flexion, which is a complex result of contraction and relaxation of many other muscles. Moreover, our model employed an active elbow flexion (via bicipital contraction) and a passive elbow extension (tricipital contraction was not reproduced). Also, we did not analyze fragment displacement after prono-supination movements and varus and valgus stress. Moreover, using an iatrogenic fracture model, we did not take associated lesions such as medial and lateral collateral injury, interosseous membrane tears or the presence of chondral defects, the incidence of which is not significant, into consideration, [6, 16]. For all these reasons, we are planning a clinical perspectival study in order to confirm or reject the results of early mobilization on cadaveric models.

In conclusion, based on our cadaveric model, early active elbow flexion and passive elbow extension with the forearm in supination does not increase fragment displacement after a Mason type II radial head fracture.

Moreover, we surprisingly found a reduction in fracture fragment displacement with this mobilization protocol. However, additional clinical studies are needed to determine the effects of early AROM protocol (I-RAM) on Mason type II fracture fragment position in living models.

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