Int J Clin Exp Med 2016;9(5):8858-8864
www.ijcem.com /ISSN:1940-5901/IJCEM0021586

Original Article

Efficacy and outcome of open reduction and internal fixation with mini-plate in ulnar coronoid process fractures

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Received December 10, 2015; Accepted March 19, 2016; Epub May 15, 2016; Published May 30, 2016

Abstract: Aim: This study aimed to investigate clinical efficacy of open reduction and mini-plate fixation for the ulnar coronoid process fractures. Methods: 21 cases of ulnar coronoid process fractures treated with open reduction and mini-plate fixation were enrolled. Causes of injury included traffic injuries in 4 cases and fall on the ground in 17 cases. There were 10 cases of type I, 9 cases of type II and 2 cases of type III. Time from injury to operation ranged from 2 hours to 10 days (mean, 3.7 days). Fractures were fixed with mini-plate. Results: All cases were followed-up for 12-25 months (average 15.1 months). The bony union time was 8~14 weeks with an average of 10.6 weeks. No 1 oosening or breakage of the internal fixation was found. Mean flexion at the last follow-up was 124° (range, 90°-140°), mean extension loss was 18° (range, 0°-50°), mean pronation was 65° (range, 40°-85°) while mean supination was 63° (range, 35°-85°), showing significant difference when compared with that before operation ($P < 0.05$). According to MEPS elbow performance score, the results were excellent in 14 cases, good in 5 cases, fair in 1 case and poor in 1 case. According to Broberg and Morrey elbow performance score, the results were excellent in 11 cases, good in 7 cases, fair in 2 case and poor in 1 case. Conclusion: Open reduction and mini-plate fixation, provides sufficient stability for early functional exercise, is a effective treatment of ulnar coronoid process fractures.

Keywords: Unlar coronoid process fracture, fracture fixation, mini-plate

Introduction

Coronoid process fractures are relatively uncommon injuries occurring in approximately 2% to 15% of patients with elbow joint dislocation, however, isolated fractures of coronoid process are rare [1]. The stability of the elbow joint is maintained by soft tissue and bony structures, in which the ulnohumeral articulation is most important. The coronoid process of the ulna is one of the main bony stuctures providing ulnohumeral stability, which acts as a key stabilizer against backwards dislocation and shares 52%-65% of the axis load in an extended elbow. However, it is critical that whether the fixation of coronoid process is dispensable for the recovery of the stability of the injuredjoint. Furthermore, the choice of the treatment of the coronoid process fractures is controversial, and the internal fixation of coronoid process fractures is challenging. Recently, the biomechanical studies and clinical observations have shown the importance of the coronoid process in maintaining the stability of the elbow by acting as an anterior buttress to prevent elbow's posterior dislocation. And it should be surgically stabilized when the coronoid process is fractured. The purpose of the present study was to determine the clinical outcome after open reduction and applying the coronid mini-plate fixation technique for whom had sustained coronoid process fractures.

Materials and methods

Materials

This study was approved by the Ethics Committee of Yiwu Central Hospital (2013-12-2K). Twenty-one patients with a fracture of coronoid process of the ulna were treated between April 2010 and December 2013 in the Second

Affiliated Hospital of Wenzhou Medical University. There were 14 men and 7 women with an average age of 34.3 years (range, 21 to 60 years). The fracture was in the left arm in 8 patients, and the right arm in 13. Causes of injury included traffic injuries in 4 cases and fall on the ground in 17 cases. There were 10 cases of type I, 9 cases of type II and 2 cases of type III according to O'Driscoll classification [2]. Of these 21 patients, there was isolated coronoid process fracture in 1 patient, associated dislocation of the elbow joint and concomitant fracture of the olecroanon in 2 patients, and associated dislocation of the elbow joint and concomitant fracture of the radial head in 9 patients. The mean arc of flexion-extension of the elbow was 60° (range, 40° to 90°), the mean forearm pronation was 43° (range, 30° to 70°), and mean supination was 40° (range, 30° to 65°). All were closed injuries without any open wound, and no neuro-vascular injury was detected. Time from injury to operation ranged from 2 hours to 10 days (mean, 3.7 days). The plain radiographs and computer tomography (CT) or multiplanar reconstruction (MPR) were performed on all patients before surgery, to evaluate the fracture displacement and fracture configuration.

Surgical technique

Under general or regional anesthesia, the injured arm of the patient was placed in the supine position on a radiolucent operation table under tourniquet control. The incision extended from 1-3 cm proximal to the medial epicondyle of the humerus, and runs straightly in a median direction towards the carpal joint to stop approximately 5 cm distal to the coronoid process. The vena basilica and the medial antebrachial cutaneous nerve were identified and protected when the skin and superficial fascia was incised. Bicipitalaponeurosis was exposed underneath of the subcutaneous tissue and incised longitudinally, and the intermuscular septum of the pronator teres and flexor carpi radialis was detached along the aponeurotic fibers. Pronator teres was retracted laterally, and flexor carpi radialis was retracted medially. Brachial muscle was exposed through the space between those retracted structures, and then it was retracted laterally or longitudinally split. The brachial muscle insertion was peeled off partly, and the anterior bundle of the medial collateral ligament should be protected. Joint capsul was incised longitudinally along the edge anterior edge of the humerus. The fractured coronoid process was visible once a curved hook was in position. The elbow was extended completely to expose the coronoid and articulate surface of the trochlea. The coronoid process was anatomic reduced and fixed provisionally with a thin Kirschner wire (K-wire). After confirming the accurate reduction using fluoroscopy, final stabilization was then achieved using a T-type mini-plate. Finally, the temporary K-wire was removed. For the patients with involvement of the radial head fractures, a radiol approach was performed simultaneously to fix or excise the fractured radial head. For the patients with involvement of the medial ulna collateral ligament injuries, suture anchors were used to repair these ligamentous injuries. After restoration of the coronoid process fracture and injured ligaments, remained instability was evaluated through direct inspection and image-intensified radiographic examination of the arm while varus, valgus, and posterior stress was being applied. Especially, the consistency of the ulnohumeral articulation should be confirmed.

Postoperative management

A long arm posterior plastic brace was applied to the elbow at 90° of flexion with the forearm in the neutral position for 4 weeks. Routinely, drugs of anti-inflammatory, detumescent and analgesic were used, and indomethacin was used as a prophylasis against heterotrophic ossification. On 7th day of operation, limited elbow exercise (flexion, extension and rotation with the elbow in flexion of 90°) was initiated under the supervision of by physical therapist, and the motion range increased gradually, and the maximum extension was restricted at terminal 30°. After a plain radiograph was taken on 28th day, the plastic brace was removed, and unlimited exercises are initiated 8 weeks after surgery. A roentgenogram was taken at each month in 3 months of postoperation to confirm the maintenance of a concentric reduction of the ulnohumeral articulation in the whole rehabilitation process.

Postoperative assessment

Patients were evaluated clinically and radiographically based on the union time, physical capacity, functional recovery, and incidence of

Figure 1. Posterior elbow dislocation with fracture of coronoid process and radial head. Anteroposterior image (A), lateral image (B) and 3-D CT scan image (C, D). (E-G) Radiographic view taken immediately after operation shows anatomical reduction of the coronoid process fracture and concentric reduction of the ulnohumeral articulation.

complications. Fracture union was judged to have occurred when a bridging callus was evident on the anterioposterior, lateral, and oblique radiographs of the elbow. The functional

Figure 2. The range of motion of patient in final follow-up of 18 months. A: Elbow joint extensed; B: Elbow joint inflexed; C: Forearm pronated; D: Forearm supinated.

outcomes were assessed using the Mayo elbow performance score (MEPS) and Broberg and Morrey score system [3, 4]. The MEPS system, with a total score of 100 100 points, includes the evaluation of pain (45 points), motion (20 points), stability (10 points), and function (25 points). A following categorical rating was assigned: excellent result, 90-100 points; good result, 75-89 points; fair result, 60-74 points; and poor result, 0-60 points. Broberg and Morrey score system is a 100-point system based on movement (40 points), strength (20 points), stability (5 points) and pain (35 points). Categorical rating were assigned, with 95-100 points as excellent, 80-94 points as good, 60-79 points as fair and <60 points as a poor result.

Statistical analysis

All statistical analyses were performed with SPSS version 15.0; Data were expressed as means ± SDs. The final outcome was evaluated by paired T-test comparing the movement of the elbow joint between preoperation and postoperation. We considered differences significant when $P < 0.05$.

Results

All the 21 patients were followed up with a mean time of 15.1 months (range, 12-25 months). All fractures united clinically according to the plain radiographswith a mean time of 10.6 weeks (range, 8-14 weeks) (**Figure 1**). All patients had maintained a concentric reduction of the elbow joint and did not have any objective or subjective signs of instability in both varus position and valgus position according to the final radiographs and clinical examinations (**Figure 2**). The mean flexion-extension-motionof elbow at the last follow-up was 124° (range, 90°-140°) and mean extension loss was 18° (range, 0°-50°). The mean rotation of forearm was 128° (range, 75°-170°) with a mean pronation of 65° (range, 40°-85°) and

mean supination of 63° (range, 35°-85°). Statistical analysis showed there was a significant difference between the preoperation and postoperation of patients with regard to the range of movement of the elbow joint ($P<0.05$). Of these 21 patients, according to the MEPS, there were 14 excellent results, 5 good results, 1 fair result and 1 poor result. Furthermore, according to the Broberg and Morrey score system, the results were categorized as excellent in 11 patients, good in 7, fair in 2, and poor in 1. None of the patients had any surgical neurovascular complications or reoccurrence of displacement of fractures. Three patients had mild heterotrophic ossification at 3 months after operation (Brooker 1) but it did not cause any severe restrictions in the elbow articulation. And one patient showed mild degeneration of the elbow but didn't deteriorate after rehabilitation exercise.

Discussion

Coronoid process of the ulna, act as an anterior bony buttress preventing posterior dislocation, has been recognized as a key stabilizer of the elbow joint. However, it is controversial that the recovery of the stability of elbow joint whether demands the internal fixation of coronoid process in patients with coronoid process fractures [5, 6], and the optimal treatment of coronoid process fractures is still remained unknown [7]. Closkey et al. demonstrated that the stability of elbow were maintained in patients with type I or type II coronoid process fractures, but for type III, the elbow were generally unstable, thereby the patients with type III coronoid process need open reduction and internal fixation [8]. Kim et al. insisted thatthe internal fixation for fractures of the tip of coronoid processcombined with injuries of lateral collateral ligament was unnecessary due to the repaired lateral collateral ligament would provide the sufficient confirmation for the stability of the elbow [9]. However, Ring et al. retrospectively analyzed a series of cases of terrible triad of the elbow with all the coronoid process fractures were type II according to the Regan and Morrey classification [10]. After closed reduction in 10 of above patients and none of the them were treated surgically, redislocation occurred in seven of them, reoccurrence of instability in one and finally need total elbow arthroplasty, and ulnohumeral arthritis in seven. Finally, there were 7 poor results in total 11 patients [11]. In recent years, more and more scholars have suggested that, regardless of the size of the fragment, fixation of the coronoid process fractures should be performed in elbow joint injury associated with articulation instability [12-14]. It was recommended by Pugh et al. that all the patients in coronoid process fractures should be surgically treated because they regarded the fracture of the coronoid process as an indicator of instability of the posterior of the elbow joint. For the type I fractures, the anterior joint capsule insertion should be repaired, and for type II and type III, the fractured coronoid process should be fixed [15]. Furthermore, Terada et al. reported that reduction of the small fragment in unstable dislocated elbow can improve the stability of the elbow and clinical outcomes. Thereby, despite the fragments were small, it is significant to reduce them in the dislocated elbow [16]. More recently, a series of biomechanical studies have proved that elbow joint instability, maybe potential in some type I and type II fractures, existed in all coronoid process. Coronoid process is the main stabilizer resisting the varus stress in elbow, and anatomical reduction of ulnohumeral articulation is significant in the treatment of the complex elbow injury [17]. In addition, Beingessner et al. found that the fixation of coronoid process achieved a more natural kinematics for injured elbow, especially when repair of the ligament was loose [18]. Currently, due to the importance status in maintaining the stability of elbow, more aggressive surgical treatment, anatomical reduction and early mobilization were recommended for achieving better outcomes in coronoid process fractures.

The fixation of coronoid process has been challenging, even for the experienced elbow joint surgeons [7]. There were several surgical methods, including suture anchors, suture lasso fixation, lag screws and mini-plate fixation, have been recommended in recent years. However, it was reported that it was difficult to fix the fracture fragment by suture anchors and there were high incidence of malunion and nonunion [7, 10]. Moreover, they insisted that greater stability with fewer complications was achieved with use of the suture lasso technique that using a tense suture thread passing the ulna, anterior capsule and brachial tendon to restore the anterior buttress of the elbow articulation. Whereas a cadaveric study performed by

Beingessner et al. showed that the changes in elbow stability and kinematic caused by type I coronoid process fractures cannot be corrected with suture repair [19]. On the other hand, fixation with 1 or 2 lag screws was performed by some surgeons recently, nevertheless the screw fixation is not only difficult to perform [20], but also maybe not reliable to resist the compressive forces pulling the fragment off coronoid's base. And the internal fixation may be failed because it is difficult to position screwsin the appropriate place of the fragment. In current studies, mini-plate fixation was promoted for achievement of stability and compression in type II and type III patients.Rigid fixationcould be achieved in intra-articulation fractures due to thatmini-plate could be easily shaped according to the bone configuration, fixed fragmentsintegrately and reliably, and made less impact on the motion of articulation and surrounding tissue, especially tendon activities. Moreover, functional exercise could be given earlier after surgery. In our study, we fixed all the patients by mini-plate and achieved satisfactory clinical outcomes. Our study has some limitations including that not only it was a retrospective analysis, but also it has no control group inwhich the patients were treated by other fixation methods to prove the advantages. However, we believe that open reduction and internal fixation with mini-plate is a valid method for coronoid process fractures of ulna with the advantages of rigid internal fixation and early functional exercise.

Conclusions

Open reduction and mini-plate fixation, provides sufficient stability for early functional exercise, is a effective treatment of ulnar coronoid process fractures.

Disclosure of conflict of interest

None.

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