Original article

Lasso plate – An original implant for fixation of type I and II Regan-Morrey coronoid fractures

P. Wang, Y. Zhuang, Z. Li, W. Wei, Y. Fu, X. Wei, K. Zhang*

Department of orthopedics and trauma, Xi'an Hong Hui Hospital, Xi'an Jiaotong University Health Science Center, No. 555, East Friendship Road, Xi'an City 710054, Shaanxi Province, China

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ABSTRACT

Introduction: Coronoid fractures are notoriously difficult to manage particularly when there is a small fragment. We report a retrospective analysis of our experience with consecutive type I and II Regan-Morrey coronoid fractures using a lasso plate. Hypothesis: Type I and II Regan-Morrey coronoid fractures can be effectively managed using a lasso plate.

Methods: From October 2011 and December 2013, 25 patients (21 males and 4 females, mean age 40.0 years) with type I and II Regan-Morrey coronoid fractures were treated with the open reduction and internal fixation (ORIF) using the lasso plate. Postoperative measurements of the elbow range of motion were recorded. Elbow function was evaluated by the Mayo Elbow Performance Score (MEPS) and Disabilities of the Arm, Shoulder and Hand (DASH) score.

Results: All patients were reexamined at a mean follow-up of 32.7 months (range: 24–49 months). The mean fractures healing time was 13.6 weeks (range: 6 to 18 weeks). The mean flexion range of the elbow was 121.8° (range: 90° to 135°) and the mean extension range of the elbow was 10.6° (range: 0° to 20°). The mean pronation of the forearm was 75.8° (range: 65° to 85°). The mean supination of the forearm was 80.4° (range: 70° to 90°). The mean DASH score was 10.2 (range: 0 to 28). The mean MEPS was 83.4 (range: 55 to 95), 8 patients (32%) were rated excellent, 14 patients (56%) were rated good, 2 (8%) patients were rated fair. One (4%) patient was rated poor. No patient was seriously infected but implant breakage was found in one case. Two cases of elbow heterotopic ossification (HO) were observed. Two cases of elbow medial instability were observed.

Discussion: The type I and II Regan-Morrey coronoid fractures combined with the instability of the elbow should be operated. The lasso plate reduces the pressure between the wire and the insertion of capsule. A tight wire results in greater stability than ordinary suture fixation, thus enabling early functional exercise. Conclusion: In the treatment of type I and II Regan-Morrey coronoid fractures, lasso plate can provide concentric fracture reduction of the elbow and stable fixation to allow for early rehabilitation. Good clinical outcomes can be anticipated.

Level of evidence: Level IV; retrospective study.

1. Introduction

The coronoid is one of the main constraints providing ulnohumeral joint stability. It plays a critical role as an anterior buttress against posterior displacement of the elbow joint. Fracture of the coronoid can be either an isolated finding following elbow dislocation or part of a terrible triad of the elbow. As for all articular fractures, anatomic reduction, stable fixation and early motion result in optimum outcome. Current recommendations are to repair all coronoid fractures associated with elbow instability, regardless of size [1,2]. However, the operative management of the coronoid fracture remains challenging. Several options exist for the fixation of the coronoid fractures, such as suture lasso technique [3], lag screws [4], site-specific plates [5], suture anchors [6–8] or no treatment [3,9,10]. For small fractures, joint stability from restoration of the anterior capsular buttress is more important than restoring articular incongruity of these small fractures. These fractures are often too small for reliable screw fixation and are usually best treated with suture fixation [7]. However, sometimes the results were unsatisfactory. The hypothesis of this study was that type I and II Regan-Morrey coronoid fractures can be effectively managed by a lasso plate.

* Corresponding author.
E-mail address: hhyyzk@126.com (K. Zhang).

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2. Materials and methods

2.1. Patients and methods

This study was approved by our institutional review board and all patients who had been treated with the procedure had signed the consent forms. Twenty-five consecutive patients with type I and II Regan-Morrey coronoid fractures were treated between October 2011 and December 2013 at our hospital. There were 21 males and 4 females, mean age was 40.0 (range: 18–49). The injury was in left arm in 5 patients and right arm in 20 patients. The injury occurred subsequent to a fall in 15 patients, to a traffic accident in 7 patients and to sport injury in 3 patients. The fractures were evaluated with plain radiographs, CT scan and three dimension reconstruction. Five patients had elbow dislocation. Terrible triad was present in 14 patients (elbow dislocation along with coronoid and radial head fractures; all of them were type IV according to Mason-Johnson classification). Six patients had fractures of the radial head. None of the patients sustained neurovascular injury (Table 1).

2.1.1. Preparation

The plain radiographs and 3D-CT were performed on all patients before surgery to evaluate the fracture configuration. Patients with elbow dislocation were reduced and fixed with plaster or brace in emergency room. The swelling in all patients was mitigated before surgery.

2.1.2. Operative technique

All the surgeries had been performed by the same surgeon (Kun Zhang). Under general or regional anesthesia, the patient was placed in the supine position on a radiolucent operation table. The tourniquet was used. The lateral and dorsal approaches were used routinely. The elbow was flexed slightly to expose the coronoid and articular surface of the trochlea. Structures were generally addressed sequentially starting with the coronoid process, followed by the radial head and finally the lateral ulnar collateral ligament (LUCI). According to the morphological characteristics and position of the coronoid fracture, a 2.0-mm-bore diameter mini-plate with 2 holes or 3 holes was shaped. The lasso plate was created with a 1.0-mm diameter wire placed through the two holes (the ends of the plate). A longitudinal incision was made along the ulnar dorsal ridge, about 1 cm in length. A 2.0-mm K-wire was used to drill holes at 0.5 cm to the ulnar crest bilaterally. The external points of the wire were on both sides of the coronoid base. The wire tails were placed through the tunnel by an epidural guider introducing the wire through the anterior to the posterior. Elbow was in flexed position at 90°, the coronoid was reduced and maintained by the curved hemostatic forceps. The lasso plate was placed in the gap between the coronoid and the anterior capsule. The wire was tightened to the rear to press the joint part of coronoid and articular capsule to the base of coronoid. Reduced and fixed the radial head with the headless cannulated screw (HCS) or mini-plate, in nine elbows with the use of mini-plates (IRENE, China) and five elbows with the use of HCS (IRENE, China). If the radial head was too comminuted to fix, radial head arthroplasty was performed in six elbows with the use of a modular prosthesis (LINK modular radial head system, Germany). Detachment of the LCL from the humeral origin was repaired with anchor sutures (Smith Nephew) placed through drill holes at the isometric point of the lateral epicondyle. The hanging arm test was performed to assess stability of the elbow. The supinated forearm was extended with a bump under the humerus. When the elbow was evaluated fluoroscopically from a lateral view, maintenance of concentric reduction with the weight of the hand and forearm acting as a dislocating force indicates stability [7]. If instability persisted, the medial collateral ligament (MCL) was repaired by the suture anchor through a medial approach (in three patients). Three patients were demonstrated unacceptable residual instability by hanging arm test after fixation of both the radial head and coronoid fracture and MCL ligament repair. The hinged external fixators were placed to maintain the concentric joint reduction. The hinged fixators were placed for six weeks. The wound was closed in layers (Fig. 1).

2.1.3. Postoperative management

Prophylactic use of cinnamatin lasted for 24 hours postoperatively. Patients were prescribed 25 mg of indomethacin thrice
daily for approximately four to six weeks after the surgery to prevent heterotopic ossification (HO). The elbows were immobilized in a brace with 90° of flexion and neutral forearm rotation for one week. As pain and swelling subsided, passive exercise of motion was taught by the physical therapist. Varus stress (shoulder abduction) and the most unstable points (30° extension and 120° flexion) should be strictly avoided for 1 month. For the three patients who had a hinged external fixator, the hinge was maintained static at 90° for the first three weeks and then the range of the motion was gradually increased until removal of the fixator at six weeks.

2.1.4. Evaluation

Follow-up evaluation was done at six weeks, three months and then every six months after the surgery. Patients were followed up clinically and radiographically until fractures union and until the plateau stage of elbow motion range was reached. The complication, the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH) score and the Mayo Elbow Performance Score (MEPS) [4,10] were determined for each patient at the final clinic visit.

3. Results

All patients were reexamined at a mean follow-up of 32.7 months (range: 24–49 months). The mean fractures healing time was 13.6 weeks (range: 6 to 18 weeks). The mean flexion range of the elbow was 121.8° (range: 90° to 135°), and the mean extension range of the elbow was 10.6° (range: 0° to 20°). The mean pronation of the forearm was 75.8° (range: 65°–85°). The mean supination of the forearm was 80.4° (range: 70°–90°). The mean DASH score was 10.2 (range: 0–28). The mean MEPS was 83.4 (range: 55–95), 8 patients (32%) were rated excellent, 14 patients (56%) were rated good, 2 (8%) patients were rated fair. One (4%) patient was rated poor. No patient was seriously infected but implant breakage was found in one case. Two cases of elbow heterotopic ossification (HO) were observed. Two cases of elbow medial instability were observed (Table 2).
Table 2
Summary of the results.

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M: male; F: female; wk: weeks; flex: flexion; ext: extension; pro/sup: pronosupination; FU (mo): follow-up (months); MI: medial instability; HO: heterotopic ossification; MEPS: Mayo Elbow Performance Score; DASH: Disabilities of the Arm, Shoulder and Hand score; MS: mean score.

4. Discussion

The ulnar coronoid is an anterior extension of the proximal ulnar metaphysis and therefore serves as an important stabilizer of the elbow joint providing a static restraint to posteriorly acting forces [12]. It plays an integral part in both hinge and rotatory components of the trocho-glyngmoid articulation of the elbow.

Coronoid fractures and dislocation of the elbow indicate a violent injury. Garrigues et al. [7] found that when the elbow is subjected to axial violence, the forearm rotation position is one of the major determinants of the elbow fracture dislocation. Axial force to the elbow along with a pronate forearm increase the likelihood of the “trial of the elbow injury”, and most coronoid fractures are type I and type II. Wake et al. [11] used two-dimensional finite element analysis and static load test to simulate the model of elbow fracture–dislocation, and found that the elbow injury type clearly correlated with the elbow joint position. When the elbow is subjected to force at a flexion of 30° to hyperextension 15°, the anterior ulnar coronoid fractures and the posterior dislocation of elbow joint are prone to occur. The coronoid fracture block size has a definite relationship with the degree of elbow extension. The greater the angle of extension, the smaller the coronoid fragments. Regan and Morrey classified coronoid fractures based on fragment size. The incidence of elbow instability increased with fragment size [13]. Type I fractures are typically a shear fracture of the tip. This is the most common fracture type and is usually found in conjunction with posterolateral instability or dislocation. Type II fractures are often seen in association with a “terrible triad” fracture dislocation. Budoff [12] proposed that coronoid fracture fragments, regardless of size and shape, should be fixed. Cadaveric dissections performed by Ablove et al. [14] found that the average coronoid tip to capsule insertion distance was 2.36 mm and the average coronoid tip to brachialis insertion was 10.13 mm with the average height of the coronoid measured at 16.98 mm. It is, therefore, likely that the capsule insertion will only be involved in type I and II Regan–Morrey. Chamseddine A [15] reported that the type I coronoid fracture indicated that the presence of elbow instability is often accompanied by damaged lateral ulnar collateral ligament, medial collateral ligament of the elbow and the anterior capsule. These structures are very important in stabilizing the elbow joint. These potentially provide further explanation of why fixation of small coronoid fractures can help restore stability in unstable elbow fracture dislocations.

According to the principles that the intra-articular fractures require anatomical reduction and rigid fixation, the treatment of open reduction and internal fixation (ORIF) should be performed. During the treatment of ORIF, joint cavity can be cleaned to lower the incidence of HO, joint adhesion and stiffness. Therefore, experts tend to prefer surgical treatment and early functional exercise. Garrigues et al. [7] recommend suture lasso fixation for patients with the coronoid fracture involved in triad of the elbow injury. Here, the authors use the lasso plate to reconstruct the anterior joint capsule in the insertion of coronoid. When the wire is tightened, the lasso plate presses the coronoid and the insertion of the capsule from anterior to posterior, it meets the biomechanics study [16]. Meanwhile, in the sagittal position, it plays as a buttress plate [11]. The lasso plate in the surgery increases the contact area between the soft tissue and implant and reduces the pressure between the wire and capsule insertion. A tight wire results in greater stability than ordinary suture fixation, thus enabling early functional exercise. In the dorsal side of ulna, Kirschner wire is used to drill holes to introduce the wire, thus avoiding incarceration of the medial wire into the ulnar joint space and damage to the ulnar nerve on the medial side. In the patients who underwent this treatment, no lasso plate broke or displacement occurred. One case of radial neck fracture was accompanied with nonunion, plate broken and radial neck absorption, but the function of elbow was excellent. Fourteen months after surgery, the internal fixation was removed. The patient refused radial head prosthesis replacement, so, radial head excision was performed, and 8 months after surgery, the function of the elbow was restored. Two patients followed up showed HO in the interspace of triceps but they were satisfied with the function, considering that the HO correlates with the violent passive activity postoperatively. Two patients followed up showed residual elbow instability but the range of the motion of the elbow can be accepted. Their external fixator was removed four weeks postoperatively. We
believe that the use of the external fixator promotes early rehabilitation and thereby contributes to good outcomes. No cases of deep infection were observed. One case had an acute superficial surgical site infection, treated by oral antibiotics and changing the surgical dress. One patient had a continuous pain, treated by oral nonsteroidal anti-inflammatory drugs (NSAIDs).

This study has limitations in that there was no control group to prove the merits. The lasso plate which was composed of mini-plate and wire results in certain hardness. When the wire was inserted through the hole in the pre-contoured plates, it was difficult to glide smoothly. Tightening of wire should be done in moderation to prevent excessive compression.

5. Conclusions

Type I and II Regan-Morrey coronoid fractures can be effectively managed using a lasso plate.

The lasso plate can provide concentric fracture reduction of the elbow and stable fracture fixation to allow for early stage rehabilitation. Good clinical outcomes can be anticipated.

Ethical committee approval

The study protocol was approved by the ethical committee of Xi’an Hong Hui Hospital, Xi’an Jiaotong University Health Science Center.

Fundings

None.

Author contributions

Pengfei Wang and Kun Zhang carried out the studies, participated in collecting data and drafted the manuscript. Yan Zhuang and Zhong Li performed the statistical analysis and participated in its design. Yahui Fu, Wei Wei and Xing Wei helped to draft the manuscript. All authors read and approved the final manuscript.

Disclosure of interest

The authors declare that they have no competing interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.otsr.2016.12.017.

References