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Surgical treatment of elbow dislocations accompanied by coronoid fractures

Koronoid kırıklarının eşlik ettiği dirsek çıkıklarında cerrahi yaklaşım

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Amaç: Regan-Morrey tip 2-3 koronoid kırıklarının eşlik ettiği dirsek çıkıklarının cerrahi tedavi sonuçları değerlendirildi.

Çalışma planı: Çalışmaya, koronoid kırığının eşlik ettiği dirsek çıkığı nedeniyle cerrahi tedavi uygulanan sekiz hasta (6 erkek, 2 kadın; ort. yaş 44; dağılım 23-76) alındı. Koronoid kırıkları, Regan-Morrey sınıflamasına göre, üç hastada tip 2, beş hastada tip 3 idi. Eşlik eden diğer yaralanmalar, Mason-Johnston tip 4 radius başı kırığı (n=6), olekranon kırığı (n=4), humerus lateral kondil kırığı (n=1), lateral (n=5) ve medial (n=2) kollateral bağ yırtığı idi. Koronoid kırıklarından birine eksizyon uygulanırken, diğerlerine serklaj, vida veya koronoid plağı ile tespit uygulandı. Radius başı kırıklarının ikisi plak veya vida ve K-teli ile tespit edilirken, dördüne radius başı protezi ile rekonstrüksiyon uygulandı. Olekranon kırıkları ise plak veya AO tension band yöntemiyle tedavi edildi. Fonksiyonel sonuçlar Mayo dirsek performans skoru ile değerlendirildi. Ortalama takip süresi 22.6 ay (dağılım 1-65.5 ay) idi.

Sonuçlar: Tüm olgularda kaynama sağlandı. Son kontrollerde Mayo dirsek performans skoru ortalama 84.3 (dağılım 50-100) bulundu. Koronoid kırığı için eksizyon uygulanan hasta hariç, tüm hastalar sonuçtan memnundu. Olekranon kırıklı hastalarda, kaynama sonrasında implanta bağlı ağrı nedeniyle olekranondaki tespit materyalleri çıkarıldı. Koronoid anteromedial faset kırıklı iki hastada ulnar sinir transpozisyonu yapıldı. İki hastada dirsek hareket açıklığını etkilemeyen heterotopik ossifikasyon saptandı.

Çıkarımlar: Regan-Morrey tip 2-3 koronoid kırıklarının eşlik ettiği dirsek çıkıklarında cerrahi tedavi dirseğin konsantrik redüksiyonu ve stabilitesini sağlamakta, erken hareketi mümkün kılmaktadır.

Anahtar sözcükler: Çıkık/cerrahi; dirsek eklemi/yaralanma; kırık tespiti, internal; radius kırığı; ulna kırığı.

Objectives: We evaluated the results of surgical treatment for elbow dislocations accompanied by Regan-Morrey type 2-3 coronoid fractures.

Methods: Eight patients (6 males, 2 females; mean age 44 years; range 23 to 76 years) underwent surgical treatment for elbow dislocations accompanied by a coronoid fracture. Three patients had Regan-Morrey type 2, five patients had type 3 coronoid fractures. Accompanying injuries were Mason-Johnston type 4 radial head fractures (n=6), olecranon fractures (n=4), lateral humeral condyle fracture (n=1), and lateral (n=5) or medial (n=2) collateral ligament ruptures. Coronoid fractures were fixed with a plate, screw, or a cerclage wire in all the patients except for one patient who underwent coronoid excision. For radial head fractures, plate or screw and K-wire fixation was performed in two patients and radial head prosthesis was used in four patients. Olecranon fractures were fixed with a plate or AO tension band. Functional results were assessed using the Mayo elbow performance score. The mean follow-up period was 22.6 months (range 1 to 65.5 months).

Results: Union was achieved in all the patients. At the latest assessments, the mean Mayo elbow performance score was 84.3 (range 50 to 100). All the patients expressed satisfaction with surgical treatment except for one patient who underwent coronoid excision. All the fixation materials used for olecranon fractures were removed after union due to implant-associated pain. Ulnar nerve transposition was required in two patients with fractures involving the anteromedial facet of the coronoid process. Two patients developed heterotopic ossification that did not affect the range of motion of the elbow.

Conclusion: Surgical treatment of elbow dislocations associated with Regan-Morrey type 2-3 coronoid fractures enables a concentric reduction of the elbow, stability, and early motion.

Key words: Dislocations/surgery; elbow joint/injuries; fracture fixation, internal; radius fractures; ulna fractures.

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Fracture dislocations of the elbow can be accompanied by fractures of the structures that constitute the bony stabilizers (radial head, coronoid process, olecranon process and distal humeral articular face) of the elbow joint. The coronoid process is a structure that prevents posterior dislocation of the elbow. In addition, the anterior fibers of the MCL (medial collateral ligament) and the middle half of the anterior capsule attach to the coronoid. The anterior supporting effect of the greater sigmoid fossa prevents anterior instability of the elbow. Injuries involving coronoid fractures are rare and difficult to treat. In our study, we present the results of treatment in elbow dislocations accompanied with Regan Morrey type II and III coronoid fractures. Fracture dislocations of the elbow are classified into 4 groups[1]:

Group 1: Anterior (transolecranon) fracture dislocations: There is a fracture of the olecranon which is together with a fracture of the greater coronoid that occurs as a result of anterior dislocation of the elbow. The radial head is intact.

Group 2: Posterior olecranon fracture dislocations (posterior Monteggia injury): A communited fracture of the proximal ulna that includes the coronoid, the radial head may be fractured.

Group 3: Terrible triad group: The radial head and coronoid are fractured as a result of posterior dislocation of the elbow.

Group 4: Varus posteromedial rotational instability. In addition to the varus subluxation in the elbow, there is a coronoid fracture. It may be associated with LCL injury or olecranon fracture.[1]

The first measure is to define the fractures in the elbow and classify fracture dislocation of the elbow. The recognition and determination of the type of

Figue 1. A 76 year old male patient with fracture dislocation of the posterior olecranon. **(a)** A shows the comminuted fracture of olecranon, coronoid and radius head. **(b)** Shows the CT where the olecranon and comminuted coronoid fracture is seen. **(c)** Shows postoperative X rays. The olecranon fracture was fixed with plate and screws. The radial head fracture was treated with a prosthesis due to comminution. The unlar plate was removed at postoperative first year. **(d)** Shows range of motion. Mayo performence score is 70.

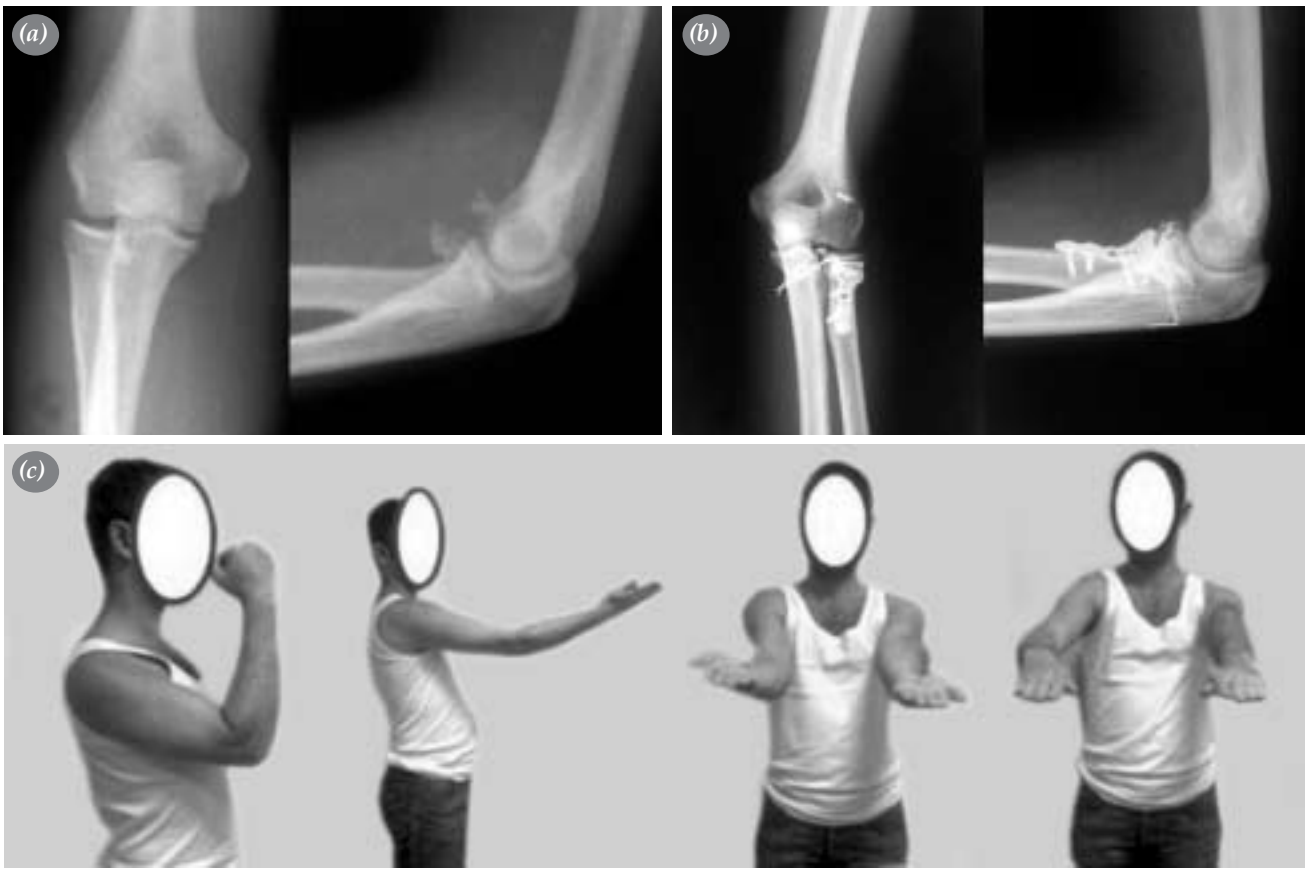

Figure 2. A 28 year old male patient with terrible triad **(a)** Shows preoperative X rays. **(b)** Shows the fixation of radial head and coronoid fractures with plate and Laso suture, respectively. **(c)** The range of motion of the same patient in final follow up control. Mayo elbow performance score is 100.

the fracture and understanding the morphology is very important in the planning of the surgery. This is the basis of the choice of appropriate fixation materials and surgical approach. In patients with varus posteromedial rotational injury, the anterior facet of the coronid is fractured and fixation with coronoid plate by the medial approach is the best treatment. Fracture fragments may not be visualized adequately by X rays, fractures must correctly assessed by performing CT examination in all patients, and even 3D in some.

Conservative treatment can be carried out if the radiocapitellar space does not open in varus X ray, if the coronoid fracture is a very small fragment, and the elbow does not subluxate.[2,3] Also conservative treatment can be applied in the following conditions: if there is a medical contraindication to surgery, the patient is noncompliant, the elbow is stable in 30-130 degrees in closed reduction and there is minimal displacement.[4] The recurrence of subluxation observed during follow up of fracture dislocations of the elbow treated conservatively.[5,6] Our treatment approach and results of our surgical experience in fracture dislocations of the elbow treated surgically are presented.

Materials and methods

This retrospective study includes 8 patients with fracture dislocation of the elbow associated with coronoid fracture and who were treated surgically between July 2002 and May 2008,. Mean follow up was 22.6 (1-65.5) months, mean age was 44 (range 23-76). There were 6 males and 2 females. The injury was in left arm in 7 patients and right arm in 1. The injury occurred subsequent to a fall in 6 patients, to a traffic accident in 1, and to sport injury (skiing) in 1 patient. The fractures were evaluated with X ray, computer tomography (CT), and 3 dimensional (3D) CT and classified according to AO classification. The coronoid fractures were classified according to O'Driscoll[7,8]

Figure 3. 23 year old male patient **(a)** CT images shows anteromedial facet fracture, **(b)** Shows avulsion fracture of the LCL from the humerus insertion point in MRI. **(c)** Shows plate and K wire fixation of the anteromedial facet fracture of the coronoid. **(d)** Shows postoperative CT, where the congruency of the joint surface. **(e)** Shows the adaption of the plate to the bone surface. **(f)** Shows elbow motion. In the final visit Mayo dirsek performance score is 100.

ve Regan Morrey[9,10] classifications. According to Regan- Morrey classification, 3 patients had type 2 fracture, and 5 patients had type 3 fracture. According to O'Driscoll classification, 3 patients had type 1 fracture, 3 patients had type 2, 2 patients had type 3 fracture. Six patients had radial head fracture (all of them were type 4 according to Mason-Johnston classification [11]), 4 had fracture of the olecranon, and 1 had fracture of the lateral condyle. Terrible triad (elbow dislocation along with coronoid and radial head fractures) was present in 2 patients. All operations were carried out under fluoroscopy. The coronoid fracture was treated with excision in 1 patient, cerclage in 1, screw in 4, and coronoid plate in 2. In the 2 patients with terrible triad, the fractured fragment of the coronoid was small, and therefore it was fixed with Lasso suture[12] (using the drill, 2 transverse holes are opened in the olecranon, and 1 hole is opened in the coronoid fracture fragment, and with the help of a steel wire, the cerclage passed through the olec-

ranon and coronoid is passed through the olecranon again and the two ends were tied on the posterior aspect of the olecranon). Two of the olecranon fractures were fixed with plates, and two with AO tension band technique. One of the radial head fractures was fixed with radial head plate, one with screw and K-wire, 4 reconstructed with radial head prosthesis. The LCL was repaired in all patients. Drains were inserted at the end of surgery. All patients received PCA (patient controlled analgesia) for pain control.

A splint with the elbow in stable position (90° flexion and neutral rotation position) was applied to all patients during the first 3 postoperative days, and on the third day passive motion in the moveable brace was initiated. Active movement was commenced on the postoperative 4th week. In patients with olecranon fracture, the splint was applied for 1-10 days. In compliant patients, active and active assisted rom exercises were initiated on the first postoperative day if stability was possible in 30 degrees flexion. Forearm rotation was allowed with the elbow in 90 degrees flexion. Shoulder and hand exercises were allowed from the day. The most instable point, 30 degrees extension, was allowed after the 4th week. All patients recevied indomethacin 100 mg 1x1 for at least 6 weeks to prevent heterotopic ossification. All patients were evaluated functionally and radiologically.

Results

The average Mayo Elbow Performance Score in the final assessment of the patients was found to be 84.3 (50-100).[8] All patients except for the patient who underwent coronoid resection were satisfied with the results. There no nonunions. There were 2 patients in the terrible triad group, and one of them is shown in Figure 2 A-B-C. Two patients with anteromedial facet fracture of the coronoid underwent ulnar nerve transposition. The anteromedial facet fracture of the patient with varus posteromedial rotational injury and the avulsion of the LCL an the attachment point in the humerus is shown in Figure 3 A and B. Postoperative X rays and clinical results are shown in Figure 3 C-D-E-F. An example to posterior olecranon fracture dislocations is shown in Figure 1 A-B-C-D. In patients with olecranon fracture, after bony union the fixation materials in the olecranon were removed due pain resulting from the implant. In two patients, heterotopic ossification was observed in soft tissues, however this did not interfere with range of motion.

Discussion

The treatment of elbow dislocation varies according to bone and ligament injuries. Simple elbow dislocations can be treated with conservative treatment. In fracture dislocations of the elbow, it is almost impossible to achieve stability with conservative treatment.[6] Successful functional treatment can be achieved with internal stable fixation of the fracture and initiation of early elbow motion. In conservative treatment, the rates of early arthritis, joint stiffness, and nonunion are higher due to inadequate reduction. Therefore coronoid fractures combined with elbow dislocation must be treated surgically.[1,3,4,6] The most important determinant of the results in elbow dislocations with coronoid fractures is residual stability, and this stability cannot be achieved with conservative treatment. The probability of recurrent dislocation after conservative treatment is high.[6] When decision for surgery is made, the operation should preferentially be carried out immediately.

Although the coronoid is a small bony prominence, it plays a significant role in elbow stability. The size of the fractured fragment is related to instability. Fractures involving 50% of the coronoid can result in elbow instability even when other structures are intact. During surgery, the coronoid fragment must first be evaluated and fixed.[3,6,13,14] Coronoid fractures seen in elbow dislocations are type 2 or 3 according to Regan Morrey classification. Although some fractures mimic type 1 fractures on the X ray, when it is considered that the capsular insertion point is at least 5 mm inferior to the coronoid type, these fractures whixh extend to the capsular insertion must be regarded at least as type 2.[1] We believe that, despite the difficulties, Driscoll type 1 fractures should be treated with small screws, cerclage, suture anchor or K wires. The important point of these fractures is the repair of the anterior capsule insertion point and the achievement of anterior bony support rather than solely re-inserting the fractured piece.[1,4] If the coronoid fracture is type 2 or 3, then open reduction needs to be carried out and the coronoid must be fixed wtih small fragment screws (3-3.5mm lag screws) that pass from the posterior aspect of ulna to the anterior. Type 1 coronoid fractures are very small. Lasso type sutures are passed around the fractured piece and through the anterior capsule and finally through hole in the base of the coronoid (K wires with a hole) and then these sutures are ligated.[4]

The mean height of the coronoid process 19 mm.[15] Terrible triad injuries is dislocation of the elbow in association with fractures of the coronoid and radius head. Coronoid fractures seen in terrible triad injuries are type 2 according to Regan Morrey classification and type 1 according to O'Driscoll classification. [14] CT studies have shown that the height of fracture fragment in terrible triad is approximately 35% of the mean height of the coronoid process.[15] Cadaver studies showed that when the radial head is removed with %50 or greater excision performed on the coronoid, then it is impossible to achieve elbow stability even when the radial head is replaced with a prosthesis.[16] The most frequently injured structure in terrible triad is lateral ulnar collateral ligament. During dislocation of the elbow, the structures that are injured in order from lateral to medial in order are as follows: lateral ulnar collateral ligament, anterolateral and posterolateral capsule, medial ulnar collateral ligament.[17] In all elbow dislocations with coronoid dislocation the LCL, extensor origin and posterolateral capsule must be evaluated and repaired if they are ruptured. [1,4] Residual posterior instability requires repair of MCL. If adequate fixation is not achieved with repair, external fixator must be used.[4]

O'Driscoll Type 2 are anteromedial facet fractures and require supportive plating. Type 3 fractures require fixation using plates, screws, medial plates, sutures or occasionally external fixation. Anteromedial facet fractures occur with varus posteromedial rotational injury and fracture of the radial head is very rare. MCL is intact and the elbow is subluxated rather than dislocated. These fracturescannot be exposed laterally, and often require a medial approach. We used this approach in 2 of our cases. Fixation of the anterior facet fracture in the coronoid prevents medial subluxation of the trochlea toward the medial aspect of elbow. The mechanism of injury in anteromedial facet fractures is posteromedial varus strain, the injury in the radial head and MCL is rare. Surgery requires medial access and fixation with supportive plates. The anteromedial facet is more medial compared to ulnar metaphysis and diaphysis. Posterolateral rotatory injury tears the lateral soft tissues and transversely fractures the radial head and coronoid. Anteromedial facet is fractured with varus posteromedial injury. Inadequate fixation of the anteromedial facet may result in dislocation. If the fragment is small, the flexor pronator muscle mass is split and elevated, holes are drilled in the coronoid, and fixation is acheived via sutures. Posterior approach can be used for for larger coronoid fragments. The best fixation is achieved with plates and screws. Access to the anteromedial facet can be gained with medial or lateral opening, between the two heads of flexor carpi ulnaris that forms the bed for the ulnar nerve. The ulnar nerve is transposed if necessary. The posterior branches of the nerve innervate the joint can be sacrificed during access in patients who are fixed with plates. The anterior branches are motor branches and must be preserved. In posterior fracture dislocations of the elbow, a single posterior incision will allow access to all parts of the joint. Medial and lateral incisions can be used in addition. In fracture dislocations of the olecranon, the trochlear notch is opened and olecranon fracture is used for transarticular access to the coronoid. The K wire for the cannulated screw is introduced from the posterior aspect of the ulna while the coronoid is under vision and largest fragment is fixed. This prevents posterior subluxation of the elbow.[2] It is necessary to completely examine the injury to diagnose the coronoid fracture. The stability must be assessed before closure. There must a concentric reduction in a 20-130 degree range of motion. If there is a residual instability, it has to be in extension or supination. Valgus instability per se is insignificant and can be tolerated. On the other hand, posterior or posterolateral instability is unacceptable. In the latter situation, fracture reduction and LCL is contolled.[4,18]

In radial head fractures, stable raduction with ORIF (open reduction and internal fixation) can only be achieved with screwing the mini fragments. The fragments are reduced and fixed with temporary K wires. The screw needs to be buried into the head. Comminuted fractures of the radial head require plate fixation.[4,19] It has been shown that screw placement while the forearm is in neutral position does not result in limitation in rotation. [20] The radial head may be replaced by a prosthesis if the radial head fractue cannot be fixed with plates or screws or joint congruency cannot be established. The size and height of the head must be adjusted.[4,21] If stability is a problem, then an external fixator whixh allows flexion can be used. None of the cases required an external fixator. Delayed healing and avascular necrosis in radial head fractures is related to comminution. None of our patients had nonunion or avascular necrosis. Our decision

on the type of fixation that will be used in fixation of coronoid fractures is based on the classification of the fracture. We prefer Lasso suture fixation in type 1 fractures, since the fragment is very small. In type 2 fractures and anteromedial facet fractures, we prefer supportive plating because it gives anterior support to the fracture fragment and is technically easier to apply. In type 3 fractures screws are preferred because the fragment is large. Also beacuse these fractures often coexist with olecranon fractures, we prefer to fix the coronoid fracture with screws passing through the olecranon plate. We believe that in all types of fractures, each fixation material has its own superiority depending on the classification.

In conclusion, in terrible triad injuries we recommend first the fixation of the coronoid followed by the radial head. The coronoid fracture can be fixed with Lasso sutures or miniscrews. LCL must be fixed. In patients with varus posteromedial rotational injury the anteromedial facet of the coronoid is fractured and we suggest fixation with coronoid plate using the medial approach and also the anterior transposition of the ulnar nerve. The repair of LCL and if injured, the MCL, must not be forgotten. In posterior olecranon fracture dislocations, the fractured olecranon will enable beter visualization of joit surfaces. Another alternative is the medial and posterolateral approach where first the coronoid and then the olecranon and finally the radial head is fixed. The aim is to achieve a stable and mobile elbow joint at the end of treatment. Therefore successful surgery can be achieved by a good definition of the fracture, good surgical planning , the choice of correct surgical approach, rigid fixation of the fracture and the initiation of motion as soon as possible.

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