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Developments in treatments of ulnar coronoid process fracture.

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Abstract

Ulnar coronoid process (UCP) fracture is a complex intra-articular fracture, but not common in clinical practice. During surgeries, it is difficult to expose the coronoid process due to complicated surrounding anatomical structures. Moreover, UCP fracture also has a variety of clinical complications. Thus, its treatments have been a challenge and a focus in clinical studies. At present, it is widely accepted that early surgical treatment is required for UCP fracture. Different surgical approaches and fixation techniques have been proposed. However, the optimal approach/technique still remains unclear. In this study, the classification of UCP fractures, surgical approaches, internal fixation techniques, and other relevant issues were reviewed aiming to improve therapeutic efficacy of UCP fracture and reduce its complications.

Keywords: Ulnar coronoid process, Fracture, Complication, Therapy.

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Introduction

Ulnar coronoid process (UCP) fracture, a type of fracture uncommon in clinical practice, is a complex intra-articular fracture. The pathogenic mechanism of UCP fracture is very complicated and thus it is misdiagnosed or neglected usually. Moreover, it is difficult to expose UCP during surgeries due to the complicated surrounding anatomical structures, and it usually has a lot of clinical complications. Due to the above factors, UCP fracture has been a focus in recent years. UCP is the most important bony structure responsible for maintaining stability of the elbow joint and crucial for the stability of the elbow joint axis, posteromedial and posterolateral rotation, and prevention of cubitus varus [1,2]. Functional loss of UCP due to a fracture frequently causes joint instability. Bony defects in UCP fracture mean the loss of stability of surrounding soft tissues [2,3]. Currently, it is well recognized that UCP plays an important role in stability of elbow. However, there is still controversy on the surgical treatment of UCP fracture. It is harmful to patients with elbow joint instability if a defined treatment is not conducted. Clinicians have recognized the importance of coronoid process in the joint elbow stability, and thus increasing strategies have been developed for its treatments achieving favorable efficacy [4]. In this review, we briefly summarized the studies on the treatments of UCP fracture.

Classification of UCP Fracture

The treatments are distinct between different types of UCP fracture. It is important to select the treatment and bone fixation method for the recovery of elbow joint stability, which requires the accurate understanding of the classification of UCP fracture and the mechanisms of elbow joint injury.

Regan-Morrey's classification system of UCP fracture is commonly used [5]. It is based on the size of fracture fragments to classify UCP fractures into type I (avulsion of the coronoid tip), type II (single fracture or multiple fractures, less than 50% of coronoid involved), and type III (fracture of more than 50% of coronoid) UCP fracture. Each type is further subdivided into subtypes A and B based on the presence of displacement of fracture. This classification is based on height of fragment. It emphasizes the importance of coronoid height in the elbow joint stability, but the mechanism of UCP fracture and the location of coronoid fracture are not taken into account. Considering that coronoid fracture might involve tip, anteromedial and basal facet of coronoid, O' Driscoll et al. [6] proposed a new classification system which classifies UCP fracture into three types based on the anatomical location of fractures. Each type is further subdivided into several subtypes. Type I fracture refers to the coronoid tip fracture, which does not exceed sublime tubercle or coronoid body generally, and is mostly attached to joint capsule and associated with terrible triad of elbow. Based on the size of coronoid tip fracture fragments, Type I fractures are divided into two subtypes ($\geq$ 2 mm and >2 mm). Type II refers to anteromedial fractures and often has lateral collateral ligament injury and posteromedial rotatory instability of elbow joint. Subtype IIa does not involve the tip, and but involves the area ranging from the medial tip to the anterior sublime tubercle. The fracture line of subtype 2 extends from subtype IIa fracture to coronoid tip. Subtype IIc involves the anteromedial rim and sublime tubercle (where anterior bundle of medial collateral ligament MCL is attached). Type III refers to a basalt fracture involving more than 50%

height of the coronoid body, and generally has no soft tissue injury. Subtype IIIa only involves the coronoid process, usually presenting comminuted fracture; Subtype IIIb is complicated with olecranal fracture which extends to the coronoid body or base. O'Driscoll classification emphasizes the significance of medial facet of the coronoid process and also links morphologies of coronoid fractures to the type of injury, which provides a better guidance for clinical selection of appropriate surgical approach and fixation method, and hence offers instructions for the treatment of elbow joint trauma. Reichel et al. [7] measured the coronoid processes in 8 fresh specimens and identified three ridges (medial, intermediate, and lateral) regarding the native coronoid process anatomy. They also found that Regan-Morrey type I fracture and tip or anteromedial fracture in O'Driscoll classification system is generally related to the injuries to one ridge. Regan-Morrey type I fracture is mostly associated with injuries of the intermediate ridge accompanied by injuries to either medial or lateral ridge, causing increased instability of elbow joint. Regan-Money Type III fracture is often associated with injuries to three ridges causing severe instability. They speculated that injuries to different ridges are associated with different mechanisms of injuries. Reichel et al. [7] proposed a concept about the injury to the coronoid surface ridge, which provides additional information to the O'Driscoll classification. This also demonstrates that there is limitation in the Regan-Morrey classification. However, there is still difference between experimental models and actual injuries. Currently, O'Driscoll classification is accepted and recognized as a new guidance. We speculate that clinicians should also consider the type of fractures, size of fragments and mechanism of injury as well as tissue injuries associated with the elbow joint for the comprehensive analyses and clinical decision making.

Conservative Treatments

UCP fracture is mainly caused by severe high-energetic injuries and often accompanied by fractures of the capitulum radii and olecroanon, posterior dislocation of the elbow joint, and injuries of the medial and lateral collateral ligaments. It is more common in young adults. UCP fracture often has concomitant involvement of bones and ligaments. Therefore, it is less likely to employ conservative treatments for UCP fracture. However, Pugh et al. [8] proposed that conservative treatments are feasible for patients having following radiographical presentations: 1) The motion of humeroulnar and humeroradial joint reaches to the concentric central reduction. 2) The range of elbow extension reaches 30°; the joint has adequate stability; patients can perform functional exercise 2-3 weeks after fixation; 3) The radial head fracture does not present dislocation or has mild dislocation (<25%), which does not impact the functional activity of the forearm. 4) The fragment of coronoid fracture is small. Beingessner et al. [9] conducted an autopsy study and found that Regan-Morrey type I coronoid fracture had little impact on the elbow joint and a fixation was not necessary.

Guitton et al. [10] described terrible triad injury of the elbow in 4 patients who were treated with closed reduction followed by splint fixation, and three of them had good outcomes. They concluded that conservative treatments were feasible in patients with low-energetic injuries or insisting on conservative treatments. For isolated small coronoid fragments, conservative treatments are suitable for patients without concomitant ligament injuries when the elbow joint can flex and extend stably. However, it is better to limit the external fixation of the elbow joint within 3 weeks because long fixation may cause a reduction in the elbow motion range and severe stiffness.

Surgical Treatments

At present, there are different strategies for the surgical treatment of UCP fracture. Most clinicians postulate that the reduction and fixation are necessary when the fragments of UCP fracture involve 50% of the coronoid process [11]. With the increase in the size of fragments, the possibilities of elbow dislocation, treatment failure and joint stiffness increase [12]. However, there are many controversies concerning the treatment for Regan-Morrey type I coronoid fracture. Cohen [13] proposed that there was no need to repair Regan-Morrey type I coronoid fracture if the stability of radial head and lateral collateral ligament could be achieved. To date, no studies have shown that repair of anterior joint capsule and type I coronoid fracture may increase the stability of the elbow joint. O'Driscoll et al. [6] found that joints with isolated Regan-Morrey type I coronoid fracture were similar to normal elbow joint in the stability. When concomitant radial head fracture and lateral collateral ligament injury are present, restoration almost has no impact on the stability of the elbow joint. Further biomechanics investigations reveal that fixation is necessary for UCP fracture regardless the fragment size of coronoid fracture [11]. Ring et al. [14] retrospectively investigated 11 patients with triad injury of the elbow: seven showed elbow re-dislocation after plaster fixation; five were treated with internal fixation of the radial head; four received resection of the radial head; three received repair of the lateral collateral ligament; none received fixation of the coronoid fracture; all the patients showed re-dislocation after surgical treatments. Zeiders and Patel [15] proposed that the repair of Regan-Morrey type I coronoid fractures was as important as the repair of type II and III fractures. A treatment should be made and determined based on mechanism of injury, type of injuries, stability of joints and other relevant injuries. For patients who can't perform early functional exercises and do not respond to conservative treatments, surgical treatment and fixation should be employed.

Selection of Surgical Approach

Lateral elbow approach

Pugh et al. [8] found that most structures damaged in the terrible triad injuries of the elbow could be repaired by surgery with lateral approach alone. The surgery with lateral approach may repair the coronoid fracture, radial head fracture and

lateral ligamentous injury, which restore favorable functional outcomes and joint motion ranges postoperatively. As described by Ring and Jupiter [16], it was very difficult to perform an anterior to posterior fixation with screws using lateral approach though it could expose the coronoid process when the extensor carpi radialis muscle and brachialis were lifted from the distal humerus and the radial head was stretched or moved in case of subluxation of the elbow joint. A lateral approach for coronoid fracture still has limitation in the exposure of adequate surgical field. Thus, it is necessary to conduct an adequate analysis and comprehensive assessment before surgery, and individualized surgical plan should be made based on the preoperative disease condition.

Anterior elbow approach

Han et al. [17] used an anterior approach in the treatment of 11 patients who had Regan and Morrey type III coronoid fracture without valgus or varus instability. The median follow-up period was 21 months. The healing of fractures was satisfactory and the median Mayo score was 92.3. Reichel et al. [18] treated 6 patients with terrible triad with modified anterior arc approach for Regan-Morrey type II and III coronoid fractures, in combination with a lateral approach to fix the radial head and lateral collateral ligament. Favorable outcomes were obtained postoperatively. The mean range of extension and flexion was more than 30°-130°, and the range of pronation and supination was more than 50°/50°. Instability of the elbow joint and ectopic ossification were not observed during the 15-week follow-up. The anterior approach is the most direct approach to coronoid process with which the open anatomical reduction and fixation can be performed. Anterior approach is more suitable for the UCP fracture with isolated coronoid process. In real elbow injuries, isolated coronoid fracture is not common and often accompanied by the radial head fracture and injuries of the medial and lateral collateral ligaments. It is a complex injury of the bone and ligament. In addition to anterior approach, other surgical approaches are often combined for the treatment of coronoid fractures.

Medial elbow approach

O'Driscoll et al. [6] reported that the reduction and internal fixation through medial approach was required for fractures of the coronoid anterior and medial facets, because the anterior and medial facets of the coronoid process are attached to the anterior bundle of the medial collateral ligament and play an important role in the prevention against varus. In a study of Taylor and Scham [19], the coronoid process was exposed by elevating the whole flexor pronator teres of the interior ulna though it needed extensive dissection. Huh et al. [20] proposed that this approach required dissection of the flexor carpi ulnaris between two heads as well as adequate decompression and dissociation of the ulnar nerve. In most elbow joints, the bundle branches should be cut off. Hotchkiss et al. [21] used more anterior "over the top" approach to expose the coronoid process. The pronator teres, flexor carpi radialis and palmaris longus were stretched to the radial side, and the flexor carpi radialis was stretched to the ulnar side. Chen et al. [22] treated coronoid fractures by stretching the pronator teres to the radial side and the flexor carpi radialis and palmaris longus to the ulnar side. This approach provides a better exposure of the sublime tubercles and medial collateral ligament. Medial elbow approach is a reliable approach to fix the coronoid fractures, particularly when the coronoid anterior and medial fractures present with medial collateral ligament injuries, which allows individualized treatment for different types of injuries.

Posterior elbow approach

Marchessault et al. [23] conducted an autopsy study and made a posterior midline skin incision through medial osteotomy to fix the coronoid fractures. This approach provides a direct visualization for the operation of coronoid fractures and also preserves the pronator attachments to the humerus and flexor carpi ulnaris. Compared with medial and lateral approaches, posterior approach may increase the possibility of exudation and hematoma and the complications of cutaneous necrosis [13]. In our opinion, only ulnar nerve is the important structure involved when posterior elbow approach is used, and thus the coronoid fractures can be directly exposed, which has little impact on the elbow tissues. Multiple fixations can be performed with the help of posteromedial and lateral approaches, which is especially suitable for the terrible triad injuries of the elbow and coronoid fractures with varus and posteromedial rotatory instability.

Selection of Fixation Method for Coronoid Fractures

The selection of internal fixation should be based on the size of fragments, shape of fractures and bone masses. Common fixation methods include fixations with wire, kirschner, lag screws, plates, anchors, and suture lasso. Non-absorbable suture or anchor is used for the fixation of small fractures of the coronoid tip. Pai and Pai [24] used suture anchor to fix the coronoid process, anterior joint capsule and lateral collateral ligament, and replaced the radial heads for the treatment of terrible triad injury of the elbow in 6 patients, and satisfactory outcomes were obtained. Zeiders and Patel [15] found that the repair of Regan-Morrey type I coronoid fractures could be performed by using suture transmission device in which a hole was drilled in the coronoid tip from back of the ulna to suture the anterior joint capsule and small fragment with non-absorbable suture. The suture went across the hole and was fastened to the back of ulna for fixation. Lag screws can be used for large coronoid fractures. Spencer [25] and Regan [26] recommended the cannulated screw for the posterior to anterior fixations in these types of coronoid fractures. Beingessner et al. [9] found varus angulation as well as varus and valgus laxity increased with the increase in fragment size in type II and III coronoid fractures. They recommended it was better to fix type II and III coronoid fractures with screw plates. Chen et al. [22] found that the internal fixation with micro-plates or micro-screw plus micro-plates could achieve a better outcome (Figure 1). Reichel et al. [18] indicated that the anterior approach with

an anterior to posterior fixation with screw and buttress plates allowed anatomic reduction and strong fixation. Large fractures of the coronoid base are rare and can be fixed at anteromedial or medial proximal ulna using plates [27]. Garrigues et al. [28] proposed that a better stability with fewer complications could be achieved with the use of suture lasso techniques compared with other fixation techniques (cannulated screws and suture anchors) for the fixation of terrible triad injury.

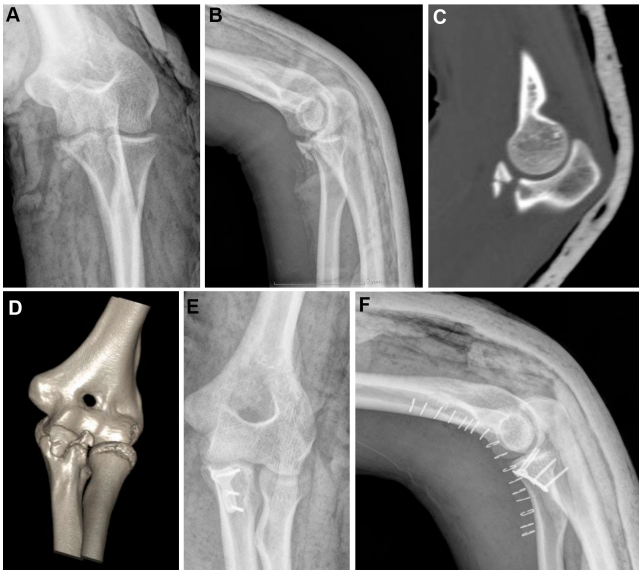

Figure 1. UCP fracture. A, B: Preoperative A and P lateral X-ray image indicates UCP fracture; C, D: Preoperative CT image indicates notable dislocation in UCP fracture; E, F: Postoperative A and P lateral X-ray image indicates UCP fracture following internal fixation.

For some patients with comminuted coronoid fractures or unable to receive internal fixations due to elbow instability, transportation with ulna olecranon, radial head and ilium may be used to restore the heights of coronoid process and the front supports. For patients with fractures of the radial head, a radial head with retained soft tissues as a graft is more consistent with a composition of ulnohumeral joint. During the restoration of the coronoid process, soft tissues attached to the coronoid process should also be repaired to restore the stability of the elbow joint [29,30]. Meanwhile, the coronoid process should be restored using the soft bones of the homolateral olecranon tip. When it is accompanied by olecranon fractures and the osteotomy of olecranon is infeasible, the ilium with three sides of cortical bone can be grafted to restore the coronoid process [29,31]. Although there are many autografts employed for the restoration of the coronoid process, some investigators [29,30] agree that autografts for the restoration of the coronoid process can be used in comminuted fractures and elbow instability. However, its effectiveness remains undefined due to lack of cases using this method. Alolabi et al. [32] proposed the prosthetic replacement for comminuted coronoid fractures which were unable to be repaired. Following surgery, patients with prosthetic replacements for the coronoid process had better outcomes than those with other approaches. Particularly, an extended implant could ensure the stability of the elbow joints when the stability of soft tissues including elbow ligaments was not good, but the elbow remained less stable than an intact elbow [33]. However, this study was at an early stage and the design of prosthetic models was based on defect of 40% coronoid process. Further studies are needed.

Treatments for UCP fracture remain controversial in clinical practice. Most investigators speculate that early active treatments are necessary. In addition, it is necessary to make comprehensive analyses and determine the individualized treatment protocols based on the mechanism of elbow injury, type of fractures and stability of the elbow joint. For patients who are unable to perform early functional exercises and non-responsive to conservative treatments and those requiring surgical treatments, early surgical treatments should be administered to repair the osseous anatomical structures and the injured soft tissues, restore the stability of the elbow joint during motion maximally, and help patients to perform early functional exercises. Meanwhile, the selection of surgical approaches and fixation methods requires comprehensive consideration of the type of coronoid fracture and relevant elbow injury. Although there is still controversy on the clinical treatment of UCP fracture, the outcomes of coronoid fractures will be further improved and the incidence of complications will be reduced with the development of biomechanics and clinical studies.

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