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ELBOW

No neurovascular damage after creation of an accessory anteromedial portal for arthroscopic reduction and fixation of coronoid fractures

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Abstract

Purpose Arthroscopic reduction and internal fixation for coronoid process fractures has been proposed to overcome limitations of open approaches. Currently, arthroscopy is most frequently used to assist insertion of a retrograde guide wire for a retrograde cannulated screw. The present anatomical study presents an innovative arthroscopic technique to introduce an antegrade guide wire from an accessory anteromedial portal and evaluates its safety and reproducibility.

Methods Six fresh-frozen cadaver specimens were obtained and prepared to mimic an arthroscopic setting. The coronoid process was localized and a 0.9 mm Kirschner wire was introduced from an accessory anteromedial portal, located 2 cm proximal to the standard anteromedial portal. At the end of the procedure, a lateral radiograph was taken to verify the Kirschner wire position and open dissection was conducted to evaluate possible damage to neurovascular structures.

Results The Kirschner wire was drilled without complications in the coronoid process of all six specimens. Damage of the brachial artery, the median nerve, and the ulnar nerve did not occur in any specimen. A corridor between the brachialis muscle, the median intermuscular septum, and the pronator teres could be identified as suitable for the wire passage.

Conclusion This study presents a safe and reproducible technique combining the possibility to introduce a guide wire from the anteromedial part of the coronoid, under direct visual control, with a completely arthroscopic approach. This wire can guide the introduction of a retrograde cannulated screw from the dorsolateral ulna to the tip of the coronoid. This new arthroscopic approach permits to obtain improved visual control over coronoid process fixation, without endangering neurovascular structures.

Keywords Elbow · Arthroscopy · Cononoid · Safety · Fracture · Fixation · Anatomical study

Introduction

The coronoid process (CP) plays an important role in maintaining elbow stability [3, 5, 6, 12, 14, 18, 19, 21, 23, 25]. For this reason, CP reduction and fixation is indicated in

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every case of CP fracture associated with elbow instability [4, 8, 10, 13, 24, 26]. Ideal treatment should combine a biomechanically stable fixation with the avoidance of unnecessary soft-tissue damage. Classical surgical techniques, which require an anterior open approach to reach the CP, are technically challenging and could endanger neurovascular structures and the residual elbow capsule. Arthroscopic reduction and internal fixation (ARIF) for CP fractures has been proposed to overcome these limitations of open approaches. In this setting, arthroscopy is nowadays most frequently used to assist insertion of a retrograde guide wire for a retrograde cannulated screw from the dorsal aspect of the ulna with a very challenging technique.

The present anatomical study presents an innovative arthroscopic technique to introduce an antegrade guide wire from an accessory anteromedial (aAM) portal and evaluates its safety and reproducibility. The study hypothesis to verify was that this wire does not endanger neurovascular structures.

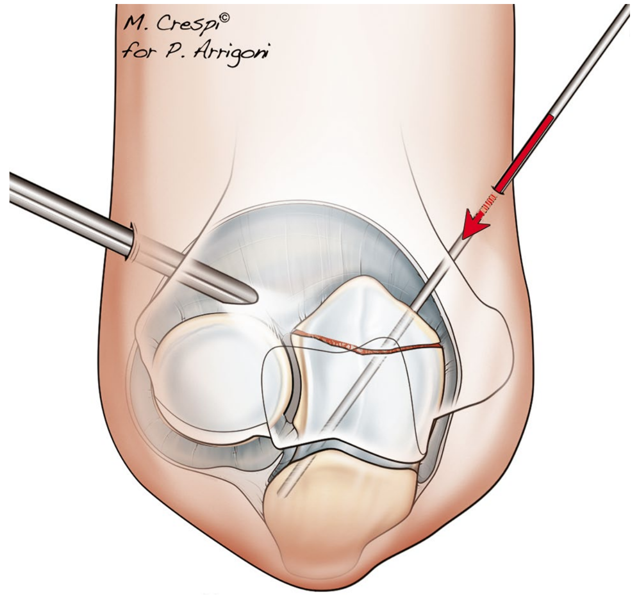

Fig. 1 Schematic drawing of the introduction of a Kirschner wire through an accessory anteromedial portal for coronoid process arthroscopic reduction and internal fixation: this Kirschner wire could serve as a guide wire for a cannulated screw, which can be introduced retrogradely from the dorsolateral ulna to the tip of the coronoid process

Materials and methods

The primary goal of this study was to verify if the introduction of a 0.9 mm Kirschner wire (K-wire) from the aAM portal for simulated CP ARIF endangers neurovascular structures.

During a dedicated session of a cadaver course in June 2017 (Arezzo, Italy), six fresh-frozen upper limb cadaveric specimens were prepared to mimic an arthroscopic setting. Arthroscopy was performed with the elbow positioned at 90° of flexion, with the hand and forearm hanging free with only gravity force. Standard anterolateral (AL) and anteromedial (AM) portals were established. A 30° arthroscope was introduced in the AL portal and diagnostic arthroscopy of the anterior compartment was performed.

The CP was localized and a 0.9 mm K-wire was introduced from an aAM portal, located 2 cm proximal to the standard AM. A cannulated hip arthroscopy needle that allows the insertion of a 0.9 mm K-wire was first introduced perpendicularly to the long axis of the arm, until contact with the anterior humeral cortex was achieved; then, the tip was advanced distally keeping contact with the anterior humeral cortex, until its tip could be seen from the intra-articular view. At this point a 0.9 mm K-wire was introduced into the needle sleeve and pointed on the top of the CP. The K-wire was drilled until perforation of the dorsolateral forearm skin. Such a K-wire is intended to serve as a guide wire for a cannulated screw, which can be introduced retrogradely from the dorsal ulna to the tip of the CP (Fig. 1).

At the end of the arthroscopic procedure, the K-wire was left in place and a lateral radiograph of the elbow was taken to verify K-wire position. Finally, open dissection was conducted with an extended medial approach, to evaluate possible damage to neurovascular structures. In particular, the courses of the brachial artery, the median nerve, and the ulnar nerve were marked (Fig. 2). In case of contact or transfixion of a structure, this was recorded. All arthroscopic

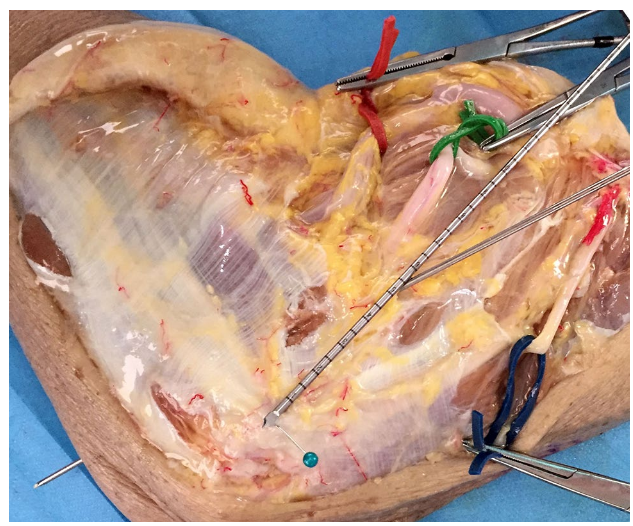

Fig. 2 Superficial dissection of the medial elbow with isolation of the brachial artery (red), the median nerve (green), and the ulnar nerve (blue). The medial epicondyle is marked with a pin. A graduated rod indicates the distance between the medial epicondyle and the entry point of the Kirschner wire in the muscle fascia

preparations were conducted by a group of surgeons experienced in arthroscopic elbow procedures.

Institutional approval of the study protocol was obtained by the Nicola's Foundation & ICLO Research Center (ID10601).

Statistical analysis

Statistical analysis was performed using GraphPad Prism v 6.0 software (GraphPad Software Inc.). The Shapiro–Wilk normality test was used to evaluate the normal distribution of the sample. Continuous variables were expressed as median and interquartile range as appropriate. The sample size was chosen to reproduce the methods of the most recent publication regarding this topic [20].

Results

Six specimens [median age at death: 75.5 years (69.5–78.5); left elbow: 66.6%; interepicondylar distance 59.0 mm (51.0–66.3)] were evaluated. The K-wire was drilled without complications in the CP of all specimens. Damage of the brachial artery, the median nerve, and the ulnar nerve did not occur in any specimen. A corridor between the brachialis muscle and the median intermuscular septum and the pronator teres could be identified as suitable for the guide-wire passage (Fig. 3).

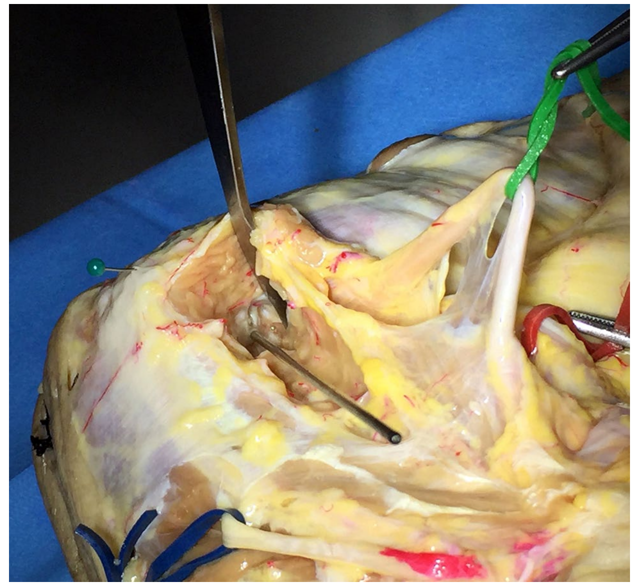

Fig. 3 Deep dissection of the medial elbow with isolation of the brachial artery (red), the median nerve (green), and the ulnar nerve (blue). The tip of a Homann retractor is placed on the radial head, to displace the pronator teres and the brachialis anteriorly. The medial epicondyle is marked with a pin

Discussion

The main finding of this study is that an antegrade 0.9 mm K-wire can be safely introduced from an accessory anteromedial portal to guide cannulated screw positioning in arthroscopic CP fixation, without damaging any neurovascular structure. This K-wire can serve as a guide wire for introduction of a retrograde cannulated screw from the dorsal ulna to the tip of the CP. This study showed the safety and reproducibility of this new, completely arthroscopic approach, which permits to obtain improved visual control over coronoid process fixation. CP fractures are divided into three groups according to the Regan–Morrey classification [22]. Subsequently, O'Driscoll introduced a more comprehensive coronoid fracture classification that emphasizes the importance of the anteromedial facet [19]. The role of the CP in maintaining elbow stability is crucial [3, 5, 6, 12, 14, 18, 19, 21, 23, 25]. For this reason, CP reduction and fixation is indicated in every case of CP fracture associated with elbow instability, either deriving from massive bone loss (Regan–Morrey type III fractures) or from combined osseous and ligamentous injuries [8, 10, 13, 26]. In facts, a minor CP bone loss is sufficient to destabilise the elbow in case of associated radial head or ligamentous injuries [4, 24].

Ideal treatment should ensure prompt anatomical reduction, stable fixation, and avoid unnecessary soft-tissue damage. Various surgical techniques have been proposed to fix a CP fracture: screws, plates and screws, K-wires, sutures, suture buttons, and metal tension band wiring.

Classical surgical techniques require an anterior open approach to reach the CP, reduce the fracture, and fix it with an anterior screw or plate [11, 21–23]. This may be technically challenging and could damage the residual anterior capsule or the blood supply to bone fragments [11, 20, 21].

More recently, arthroscopy was proposed to assist CP reduction and fixation and numerous, different arthroscopically assisted techniques for CP fracture fixation were developed [1, 2, 15]. In most publications, arthroscopy is used to confirm reduction and stabilize the fragment, while inserting a retrograde guide wire for a retrograde cannulated screw from the dorsal aspect of the ulna, which has been demonstrated to be biomechanically superior to a retrograde screw [17]. A challenging step of this technique is to reach the desired exit point for the retrograde guide wire in the fracture fragment [7]. A cruciate ligament guide system may be used to assist guide-wire position. However, elbow anatomy, portal position, and fracture configuration may impede to obtain a suitable positioning of both the anterior and the posterior cruciate ligament guide systems. Up to date, no specific coronoid guide systems have been developed and freehand techniques have been necessary to position the K-wire [1] However, also with this last technique, even experienced surgeons may encounter difficulties while directing a retrograde guide wire towards the tip of the coronoid. The introduction of a safe and reproducible arthroscopic antegrade fixation system can overcome this difficulty and improve the precision of CP ARIF.

Arthroscopically assisted approaches for CF fixation involving violation of the anterior area of the elbow have rarely been described, either to introduce a suture passer [2] or an "exchange rod" in a mini-open technique [20]. Our study presented an innovative technique combining the possibility to introduce a guide wire from the anteromedial part of the coronoid, under direct visual control, with a completely arthroscopic approach. The safety and reproducibility of this technique were demonstrated on a small set of cadaveric specimens.

As compared to the "exchange rod" technique recently proposed, this new approach abolishes completely the need of an anterior incision and a blunt dissection to the elbow capsule [20]. A further difference is that the aAM portal is created more medially than the described "10-mm incision transverse to the surface of the bicep tendon" [20]. This permits to avoid contact with neurovascular structures also without a blunt dissection to the elbow capsule. Safety and reproducibility of the approach are ensured by several tricks: using a cannulated system, inserting the K-wire in a "safe zone", directing the K-wire perpendicularly to the long axis of the arm until contact with the anterior humeral cortex is achieved, and maintaining constant K-wire contact with the anterior humeral cortex until the elbow capsule is reached.

Delicate neurovascular structures are present in the anterior area of the elbow [16]: at the level of aAM portal creation, the brachial artery and the median nerve lie superficial in a groove between the biceps brachii and the brachialis bellies and follow the medial borer of the biceps brachii in anterolateral direction. At the bend of the elbow, the brachial artery sinks deeply into the anticubital fossa, where it divides in the radial and the ulnar arteries above the CP. The median nerve enters the antecubital fossa medial to the brachial artery and passes in the forearm between the two heads of pronator teres muscle. All lateral structures are considered safe with anteomedial approaches [9].

In the newly proposed approach, these structures are protected by creating the portal far away from the midline and directing the K-wire posteriorly, towards the humerus and perpendicularly to its long axis, until contact with the anterior cortex is felt. From this position, no neurovascular structures cross the K-wire trajectory to the elbow capsule, because they will all remain anterolateral to the K-wire. To guarantee maximal safety, we recommend furthermore to use a cannulated system and to bend the elbow joint when inserting the K-wire, so that tension on blood vessels and nerves is reduced.

Limitations of this study include that it is an anatomical study on a limited number of specimens; this does not allow differentiating between anatomical variants and may amplify bias related to technical aspects of the procedure. Moreover, the aim of this study was to evaluate the course of a guide wire to simulate CP fracture fixation and not to perform a complete CP fixation: for these reasons, no fracture was created and no screws were inserted: care must hence be taken when extrapolating these results in a real fracture setting, with possible associated lesions. Nevertheless, attention was paid in evaluating the specimens for any visible signs of previous trauma, gross instability, or deformity. Finally, this experimental setting was designed to evaluate the performance of an arthroscopic technique and no investigations were directed to the evaluation of possible alternative treatments.

Future anatomical studies to enlarge the sample size of this study and to evaluate the performance of this technique in simulations of different fracture types are expected.

Conclusions

The innovative, full-arthroscopic technique presented allows introducing safely an antegrade guide wire for arthroscopically assisted coronoid process fixation from an accessory anteromedial portal. This wire can guide the introduction of a retrograde cannulated screw from the dorsal ulna to the tip of the coronoid.

The safety and reproducibility of this technique were demonstrated on a set of cadaveric specimens: no neurovascular structures were damaged and a corridor between the brachialis muscle and the median intermuscular septum and the pronator teres could be identified as suitable for the guide-wire passage.

Author contributions PA: study design, surgical procedures, and manuscript correction; DC: study design, data collection, and original draft preparation; EG: surgical procedures; FL: data collection and figures; SN: surgical procedures; AM: statistical analysis; PR: manuscript correction.

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Compliance with ethical standards

Conflict of interest Author PA declares payment for development of educational presentations from Arthrex, outside the submitted work. Author DC declares that he has no conflict of interest. Author EG declares that he has no conflict of interest. Author FL declares that he has no conflict of interest. Author AM declares that she has no conflict of interest. Author SN declares that he has no conflict of interest. Author PR declares personal fees from Arthrex and Depuy (Johnson&Johnson), outside the submitted work.

Ethical approval Nicola's Foundation & ICLO Research Center (ID10601).

Informed consent Not required (cadaver study).

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