Original Article

Title:

The Anterior Limited Approach of the Elbow for the treatment of capitellum and trochlea fractures. Surgical technique and clinical experience in 8 cases.

Abstract:

When a coronal fracture affects the capitellum and the trochlea, the Kocher lateral approach may be inadequate for the correct visualisation, reduction and fixation of the fracture. In such cases an associated medial elbow approach may be required, or a posterior transolecranon approach may be preferred. The anterior limited approach to the elbow (ALAE) could be a valid option when treating these types of fracture, as it does not involve the detachment of any muscle group or ligament, thereby facilitating the recovery process. We can also treat associated injuries such as fractures of the radial head or coronoid process with this approach.

We describe the surgical technique and the functional outcome of eight patients with a mean of 66 years (range, 53-76) who where treated with open reduction and internal fixation for capitellar and trochlear fractures through the ALAE. Patient outcomes were assessed with physical and radiological evolution, range-of-motion measurements with a follow-up from 24 to 60 months. Two different quality of life questionnaires were carried out: the EuroQol Five Dimensions Questionnaire (EQ-5D) and the patient-answered questionnnaire of the Liverpool Elbow Score patient (PAQ-LES).

Four fractures involved the capitellum, one involved the capitellum with the lateral ridge of the trochlea, and three involved the capitellum and trochlea as separate fragments. The patients presented a favorable clinical evolution at a median of 33 months (range, 24-60), with an average of motion of 10-138 degrees. Four patients presented a fracture of the head of the radius (Mason type 2) and 3 fractures of the coronoid (Bryan-Morrey Type 1) associated. All

the patients presented radiological consolidation without signs of osteonecrosis, being the average EQ-5D 0.857 (range, 0.36-1.0) and the PAQ-LES of 35 (range 17 to 36).

Patients with isolated capitellar fractures had better results than those with trochlear involvement. The presence of associated fractures does not seem to worsen the results. We believe that the ALAE is a technical option to consider for the open surgical treatment of a capitellar fracture with or without involvement of the trochlea.

Level of Evidence: Therapeutic Level IV.

Keywords: Capitellum fracture, trochlear fractures, Kocher approach, open reduction and internal fixation, anterior approach to the elbow, radial nerve.

Introduction

Coronal fractures of the distal part of the humerus involving the capitellum and the trochlea are complex injuries. These fractures may be associated with others lesions like a radial head fracture or a coronoid fracture[1-4]. Often the capitellar fragment has a small trochlear fragment attached (lateral trochlear ridge, classified as Dubberley type 1 fracture), and when the capitellum is reduced correctly, the affected trochlear part is also reduced. However, the trochlear involvement may be greater: in some cases the capitellar fragment is attached to a large fragment of trochlea (Dubberley type 2) while in others the fractured trochlear and capitellar fragments are separated (Dubberley type 3)[5]. In these cases, a lateral approach of the elbow (Kocher approach) may be inadequate, so some surgeons decide to either add a medial elbow approach or to use a single posterior elbow approach with an olecranon osteotomy for adequate exposure. Depending on the extent of the approach and the de-inserted structures that must be repaired after fracture has been fixed the time required for healing and functional recovery can increase[6-12].

In addition, whether an extended Kocher approach is performed or an osteotomy of the olecranon, the dissection and detachment of the periosteum of the posterior aspect of the capitellum may compromise the vascularisation of the capitellum (Figure 1)[13-19]. On the other hand, performing a olecranon osteotomy compromises the possibility of later implanting a total elbow prosthesis in one of these cases that could eventually evolve to early post-traumatic osteoarthritis[5].

On the other hand, we would like to mention that although Dubberley classifies fractures according to the absence (type A) or presence of posterior condylar comminution (B) in his work, we have found in our patients that the comminution rather than posterior, is distally allocated. It is true that the comminution when it exists is in a distal and posterior plane with respect to the trochlea and the capitellum, but the posterior aspect of the humerus (the columns) are usually intact (Figure 2 A ,B and C). This detail is important, because we need this area to be respected, in order to obtain a good fixation of the fragment by using cannulated screws implanted in the anteroposterior

direction[20,21]. Our preferred osteosynthesis technique to achieve fixation by cannulated headless screws. The use of cannulated screws guided by a Kirschner wire can help to confirm the correct position of the screw, and thus avoid the possibility of repeated attempts of broaching in the case of poor positioning of the drill bit when using non-cannulated screws[22-25]. When we perform an anterior approach, the patient is positioned supine, with the elbow in full extension, since it aids in the reduction of the fracture. In addition, placement of the Kirschner guidewires and definitive implants is performed in the anteroposterior direction and in a plane perpendicular to the plane of the fracture, which adds biomechanical advantages to the synthesis[23].

In some cases total or partial arthroplasty is an option to take into account given the technical difficulty for the open reduction and fixation of these fractures. However, for patients with high functional demands, such as manual workers or very young patients, elbow arthroplasty, elbow arthroplasty is not a good option because we know that the components are loosened early when the limb is subjected to intense physical activity[2,5,7,9,22,26,27]. That is why osteosynthesis in this group of patients should be the first option, despite the greater technical difficulty of this option.

The purposes of this current study were to describe a limited anterior approach for open reduction and fixation of a displaced capitellar and trochlear fracture and to perform an evaluation of the clinical outcomes and complications of this technique performed in 8 patients.

Materials and methods

Surgical technique:

The average time between injury and surgery was 3.0 days (range, 2–5). The plane formed between the two epicondyles is of paramount importance as a reference guide during the surgery, and must be maintained perfectly parallel to the table in order to maintain a stable relationship between anatomical structures[20-21]. When working with the upper extremity extended and supported by an ancillary table, the natural tendency is for it to be placed with some external rotation and the forearm in supination. A transverse incision is made and the subcutaneous tissue dissection is performed with scissors parallel to the longitudinal axis of the elbow. We must locate the radial tunnel: this initial step is the most demanding and probably the most important: the dissection between the brachialis and the brachioradialis muscles, locating the radial nerve that runs protected by fatty tissue, below the perimysium of the brachioradialis muscle. It must be taken into account that the branches that come from the radial nerve and innervate the mobile wad of Henry originate from its lateral aspect; as a consequence, the dissection should always be performed medial to the nerve (Figure 3 A, B and C).

We position two retractors, one that retracts the mobile wad of Henry laterally (including the radial nerve and the recurrent radial artery) and the other retracts the brachialis muscle and the biceps tendon medially. Once the joint capsule is open, the capitellum is exposed, and with the elbow in a position of full extension, it usually is self-reduced to its approximate anatomical position. After the reduction, we fix the fragment in position with 2 or 3 Kirschner wires, using fluoroscopy to check and measure the depth of screw to use (Figure 4 A, B, C and D). If there is an associated radial head fracture requiring reduction and internal fixation this is the best moment to perform it. We proceed to longitudinally open the annular ligament to expose and to reduce the fracture: it is recommendable to use a small blunt tip periosteotome (Figure 5 A,B,C and D).

The second step, is to expose the trochlea, once we have opened the fascia, we place two retractors (preferably wide-blade) superficially, one that

retracts the biceps tendon laterally and the other retracting the neurovascular bundle medially. We must keep in mind that the branches from the median nerve that innervate the flexo-pronator muscles run from the medial side of the nerve to the muscles, so, we must perform the dissection always laterally to the median nerve (Figure 6 A,B and C). Once the muscle belly of the brachialis is exposed through the window, transmuscular dissection in a longitudinal direction should be performed in order to gain access to the articular capsule. During a transmuscular dissection of the brachialis muscle, we may find the brachialis tendon, which can be as thick as the muscle. We prefer to wait to be sure that both fractures are fixed correctly before proceeding to definitive fixation as some of the Kirschner wires can be adjusted, but once the screws are inserted this is more difficult and risky as we could weaken and fragment the trochlear segment that is to be fixed (Figure 7 A, B and C). In all patients the fracture was repaired with small headless countersunk screws.

An error may be to fix the capitellum after its initial reduction, without being sure of the correct reduction of the trochlea, since the lack of medial references to the capitellum can cause a defect of poor rotation of the same, which we will detect when trying to reduce the trochlea. After reduction, we fix the fragments with headless screws, checking with the fluoroscopy that the screws are correctly positioned and the range of movement of the elbow without restrictions.

In fractures of capitellum and trochlea, we can find comminution in the most distal area of the humerus (Dubberley type B), however, the posterior aspect of the external and internal columns of the distal humerus is usually entire (Figure 2 and Figure 8). This is a very important detail, because the cannulated screws need to be fixed in this area, and if the CT scan shows a posterior comminuted fracture of the columns (a transcondylar pattern), the indication of the surgical approach and the technique to be used will change: it will be necessary to use lateral or posterior plates, approaching the fracture through an extended Kocher approach, or through a transolecranon approach.

In such cases we must take care when mobilising the elbow once the fracture has been reduced and fixed, because the radial head can impact and

displace the fracture. To flex the elbow, we prefer to do so slowly with the index finger controlling the capitellum, and making sure in every moment that the radial head passes above the capitellum. Therefore we recommend leaving the elbow flexed once we have checked on fluoroscopy that the profile is correct. The assistant must maintain the elbow flexed (between 80º to 90º); subcutaneous closure is with absorbable 4-0 sutures, and skin closure is with 4-0 monofilament. Next, and without extending the elbow, we proceed to its immobilisation with a long arm posterior splint for two weeks.

The elbow was immobilized at 90 degrees for 2 weeks and then an articulated elbow brace was used, with the extension limited until 45 degrees. Therapy was started, and the patient was encouraged to perform elbow flexion and extension exercises (against resistance) every 2 or 3 hours. Two weeks later the restriction for a complete extension of the elbow was suspended.

Classification

According to the classification of Dubberley, there were 3 patients with a type 1A fracture (fracture of the capitellum without comminution); 1 patient with a type 1B fracture (fracture of the capitellum with comminution); and 3 patients with a type 3B fracture (consisting of fractures of both, the capitellum and the trochlea as separate fragments with comminution)[5]. Two of the 8 cases presented a Mason type 2 radial head fracture; and three a Bryan and Morrey type 1 coronoid fracture[28].

Clinical Patient Review

Eight patients were independently evaluated with use of questionnaires, physical and radiographic examinations, Anteroposterior and lateral radiographs of the elbow were made to assess the presence of osteonecrosis, heterotopic ossification, and posttraumatic osteoarthritis. Arthritis was graded as described by Broberg and Morrey[28]. Two surgeons who did not participate in their original management reviewed the case of each patient.

Outcome measures

Two different final quality of life evaluation questionnaires were performed: the EuroQol Five Dimensions Questionnaire (EQ-5D) and the patient answered questionnaire portion of the Liverpool Elbow Score (PAQ-LES).

Results

Fracture classifications are summarised in Table 1. The patients presented a favorable clinical evolution clinical evolution after a median follow-up of 33 months (range 24-60), with 10 degrees average extension, 138 degrees average flexion, 85 degrees average pronation and supination. Four patients presented a fracture of the head of the radius (Mason type 2 fracture) and 3 presented a fracture of the coronoid process (Bryan-Morrey type 1 fracture) associated.

Subsequent surgical procedures were not required. A diagnosis of complex regional pain syndrome was made in one patient, which improved after management by the pain unit during 4 months.

Radiographs of the operative side were assessed for hardware loosening, heterotopic ossification, posttraumatic arthritis, and osteonecrosis. Neither patient had a back out screw, nor any had a screw that appeared to be impinging on the joint. Minor periarticular calcification was present in two patients. No patients had posttraumatic arthritis classified according to the system of Broberg and Morrey.

All fractures healed and no residual elbow instability was noted. All the patients presented radiological consolidation without signs of osteonecrosis of the capitellum or trochlea, being being the average EQ-5D 0.857 and the PAQ-LES 35, which represents a clinical situation of minimal pain and disability. All employed patients returned to their previous occupation.

Discusion

The purpose of this study was to review the clinical results of 8 patients with capitellar and trochlear fractures treated with ORIF through an ALAE. Compared to results in recently published literature, this study reached similar clinical results in elbow function and quality oif life.

The anterior (Henry) approach to the elbow has been widely used in upper limb surgery. It has been described as a valuable choice in the synthesis of proximal radius fractures, reinsertion of the distal biceps tendon, excision of anterior elbow tumors and debridement in case of soft tissue infections[29]. However, due to the anatomical characteristics of the area, and because the elbow can be approached from other directions which involve lower surgical risk, the anterior approach is seldomly used in everyday practice[7-9,13-16, 18,19].

In this paper, we present an alternative to Henry's anterior approach, which involves an inter-nervous window bypassing the major vasculo-nervous structures of the anterior surface of the elbow and thus allows access to the anterior plane of the elbow (capitellum, trochlea, radial head and coronoid processes), albeit in a very limited space. We recognise that this approach is technically demanding but it may be a valid alternative in complex lesions of the elbow in which access via classical routes is limited[20,21,30-33].

In fractures of the distal humerus, the position of the limb in extension during surgery facilitates the reduction of the articular fragments that are attached to the humerus by means of a proximal periosteal flap responsible for its vascularization. The other hypothetical advantage of approaching these fractures via the anterior route is the possibility of implanting the screws in an anteroposterior position in a plane that is truly perpendicular to the fracture. Elkowitz et al, found that fixation by the headless screws was significantly more stable than posteroanterior cancellous screws at 2000 cycles. When the capitellum is approached in the classic way using a Kocher approach, despite the detachment of the origins of the lateral collateral ligament and the extensor supinator muscle the lack of space forces the implantation of the screws from lateral to medial, with a considerable inclination with respect to the plane of the fracture.

Other authors have performed internal reduction and fixation by arthroscopy[34-36]. In these cases, the arthroscopic view of the anterior part of the elbow helps in the reduction of the fracture, although in the cases described in the literature the implantation of the osteosynthesis screws carried a posteroanterior direction, and arthroscopic reduction is not always possible, being necessary the realization of a lateral approach of complementary Kocher. Kuriyama in his study on the arthroscopic treatment of fractures of capitellum comments that in one of the two cases he describes, he required a conversion to open reduction through a Kocher approach, due to difficulties in reduction[34].

There are few references to this approach in the bibliography although radial nerve lesions have been reported in the approach for the radius, but we stress that the approach described here is more proximal to the one required, for example, for biceps reinsertion[20,21,26,27,30-33]. We recommend the use of a wide-blade separator to retract the mobile wad of Henry laterally along with the radial nerve, thus minimising the possible insult to the nerve.

As fractures of the capitellum rarely occur, larger case series report only up to 30 patients treated with different fixation devices[4] (Table 2). This study is one of very few studies which presents more than 8 patients treated with the same implant[10,37,38]. Our preferred osteosynthesis technique is fixation by cannulated headless screws. The use of cannulated screws guided by a Kirschner wire can help confirm the correct position of the screw, and thus avoid the possibility of repeated attempts at broaching in the case of poor positioning of the drill bit when using non-cannulated screws. When we perform an anterior approach, the placement of the Kirschner guidewires and the definitive implants is done in a plane that is truly perpendicular to the plane of the fracture from anterior to posterior[20-21]. Treatment of capitellar fractures using the same implant was reviewed by Ruchelsman et al.[37], with a mean ulnohumeral arc of 123 degrees, a mean MEPI score of 92 points, corresponding with a good to excellent result in fifteen of the sixteen patients. Mighell et al.[10] presented their results in 18 patients using headless compression screws (11 type-1A , and 7 type-2B of Dubberley) with a flexoextension of 128 degrees and a pronosupination of 176 degrees. Most recently, Heck et al.[38] , published a case serie with 15 patients with a flexoextension of 124 degrees and a

pronosupination of 174 degrees (9 patients with a Type 1, 3 patients with a Type 2, and 3 patients with a Type 3 of Dubberley).

However, there is a concern about the use of screws through the cartilage. Intra-articular screws are used for internal fixation of osteochondral fragments in fractures (scaphoid, radial head, capitellum, distal femur, talus) and in chronic joint disorders such as osteochondritis dissecans even though we know that this will cause damage to the cartilage[39-40]. The type and degree of cartilage injury created from insertion of screwsand K-wires has not been characterised at all. Houston in their study quantified the hole and zone of cell death caused in articular cartilage after drilling and insertion of various articular screws[41]. They noted that cartilage hole diameters were smaller than those created by the device inserted, probabley as a consequence of a proteoglycan swelling causing the injured matrix to spread into the hole leading to an apparent reduction in diameter[42]. This study also demonstrated the protective effects of saline irrigation during cartilage drilling through its cooling effect.

The other option is the posteroanterior fixation of the screws; for this technique we need to detach and expose the posterior area of the lateral column. Nevertheless, the local vascular supplies to the capitellum and lateral aspect of the trochlea came from posterior condylar perforating vessels[13,18,43]. That is the reason why subperiosteal dissection in posterior aspect of the lateral columna (which is the most used area for the fixation of fractures) should be minimized.

Our patients have presented a satisfactory evolution from the clinical point of view (both functional and aesthetic), from the radiological point of view, and quality of life. The patients presented a favorable clinical evolution reaching a postoperative range of motion in extension and flexion averaged 124 degrees, as well as a pronosupination of 174.6 degrees. The results have varied depending on the type of fracture that patients presented. The best results were obtained in the group of patients with a Dubberley type 1 fracture, with a flexoextension of 141 degrees and a pronosupination of 176 degrees. However, the results were worse in the group of 3 patients with a Dubberley type 3B fracture, with a flexoextension of 108.3 degrees and a pronosupination of 173.2

degrees (Table 3). This functional result, compared with the results of Dubberley's study, is similar to its series of 28 patients where the average final extension is 19 +/- 15 degrees, although it is true that the average of specific extension of the group of patients with a Dubberley type 3B fracture is 26.9 degrees (the average extension is 20 degrees in our 3 cases)[5]. In the series of 16 patients of Ruchelsman et al[37], of which 8 presented a fracture with involvement of the trochlea and capitellum, the mean flexoextension arch was 123 degrees. Heck et al[38], in their study, presented a flexion-extension of 123.3 degrees and a pronosupination of 171.7 degrees in the group of patients with a Dubberley type IA fracture. They report 90 degrees of flexo-extension and 167.5 degrees of pronosupination in their three patients with a Dubberley type 3 fractures.

All the patients in our series had radiological consolidation without signs of osteonecrosis, with the EQ-5D reaching 0.885 and PAQ-LES 35.1. No patient had residual elbow instability or weakness. Additional injuries of the elbow joint reach an incidence of up to 50%, especially prevalent in the case of radial head fracture, present in 25% of cases [1,2,5,8,9]. We have found in our serie, associated injuries such as the fracture of the coronoid process and the head of the radius, being possible the treatment through the anterior approach of the elbow. These injuries were diagnosed before the surgical treatment. We were pleasantly surprised to see that despite the fracture of the head of the radius in three of the 4 cases, two of them being treated surgically by reduction and fixation using a cannulated screw without a head, the pronosupination has not been affected, having obtained a satisfactory range of mobility. We can not give an explanation for the little involvement of pronosupination in these patients, although we assume that since it could be a consequence of not damaging the annular ligament of the radius, nor the lateral collateral ligament system with the ALAE. In the series reviewed by Heck, ROM reaches 139.1 degrees in patients without associated injuries, while it is only 113.9 degrees in the group with associated injuries, with a DASH score of 5.8 versus 14.2 respectively.

Limitations

We are aware that the data we show is insufficient given the few cases that we present to ensure that we are facing a proven superior approach. This is a small series of 8 cases treated by elbow surgeons in a reference center, which may not be representative of all fractures of capitellum and trochlea. We are aware of the technical difficulty of the approach described here, but with an anatomical knowledge of the area and careful dissection, the possibility of injuring the anterior neurovascular structures is minimised. Another concern is about the use of screws through the cartilage, which cause a zone of cell death. However, the type and degree of cartilage injury created from insertion of screwsand K-wires has not been characterised at all.

Conclusions

In this study we describe the anatomy and technique of the anterior approach to the elbow for the management of fractures affecting the anterior plane of the distal humerus: the capitellum and the trochlea. It can also be used to treat associated lesions of the radial head and the coronoid processes. These lesions have classically been treated via the Kocher approach or via transolecranon osteotomy. Technically we think that it has advantages in terms of accessibility, correct reduction of the fracture, placement of the implants, and postoperative recovery and disadvantages in terms of the need for a careful surgical technique. Our patients have presented a satisfactory evolution from the clinical point of view (both functional and aesthetic), from the radiological point of view, and quality of life, similar to other series. However, comparative studies are needed to assess the merits of this approach with respect to the classical techniques in order to draw further conclusions about its superiority and safety.

References

1-Guitton TG, Doornberg JN, Raaymakers EL, Ring D, Kloen P. Fractures of the capitellum and trochlea. J Bone Joint Surg 2009;91A:390–97.

2- Ring D, Jupiter JB, Gulotta L. Articular fractures of the distal part of the humerus. J Bone Joint Surg 2003;85A:232–38.

3- Watts AC, Morris A, Robinson CM. Fractures of the distal humeral articular surface. J Bone Joint Surg 2007;89B:510–15.

4- Brouwer KM, Jupiter JB, Ring D. Nonunion of Operatively Treated Capitellum and Trochlear Fractures. J Hand Surg 2011;36A:804–07.

5- Dubberley JH, Faber KJ, Macdermid JC, Patterson SD, King GJ. Outcome after open reduction and internal fixation of capitellar and trochlear fractures. J Bone Joint Surg 2006;88A:46 –54.

6- Bryan RS, Morrey BF. Fractures of the distal humerus. In: Morrey, BF., ed. The Elbow and its disorders. Philadelphia, W. B. Saunders, 1985; pp.302–339

7- Trinh T, Harris J, Kolovich G, et al. Operative management of capitellar fractures: a systematic review. J Shoulder Elbow Surg 2012;21:1613-22.

8- Ring D. Open reduction and internal fixation of an apparent capitellar fracture using an extended lateral exposure. J Hand Surg 2009;34A:739–744.

9- Ruchelsman D, Tejwani N, Kwon Y, Egol K. Coronal plane partial articular fractures of the distal humerus: current concepts in management. J Am Acad Orthop Surg 2008;16:716-28.

10- Mighell M, Virani M, Shannon R, et al. Large coronal shear fractures of the capitellum and trochlea treated with headless compression screws. J Shoulder Elbow Surg 2010;19:38-45.

11- McKee MD, Jupiter JB, Bamberger HB. Coronal shear fractures of the distal end of the humerus. J Bone J Surg A 1996;78:49-54.

12- Carroll MJ, Athwal GS, King GJ, et al. Capitellar and trochlear fractures. Hand Clinic 2015;31(4):615-30.

13- Morrey BF, Llusá-Pérez M, Ballesteros-Betancourt JR. Anatomy of the elbow joint. In: Morrey BF,Sanchez-Sotelo J, Morrey M, ed. The Elbow and its Disorders, 5th Ed. Philadelphia, W. B. Saunders, 2017; pp.9–32.

14- Barco R, Ballesteros JR, Llusá M, Antuña S. Applied anatomy and surgical approaches to the elbow. En: Essentials in Elbow Surgery. A Comprehensive Approach to Common Elbow Disorders. Antuna S, Barco R (Eds.). London: Springer-Verlag;2014.

15- Barco R, Forcada P, Ballesteros JR, Llusa M, Antuña S. Surgical approaches to the elbow. En: Operative Elbow Surgery. Stanley D, Trail I (eds). Edinburg: Churchill Livingstone;2012.ISBN: 978-0-7020-3099-4.

16- Ballesteros-Betancourt JR, LLusá M, Sanchez-Sotelo J. Surgical Exposures of the Forearm. In: The Elbow and its Disorders, 5th Ed. Morrey BF,Sanchez-Sotelo J, Morrey M, ed. W. B. Saunders, 2017; pp.151-156.

17-Yamaguchi K, Sweet FA, Bindra R, Morrey BF, Gelberman RH. The extraosseous and intraosseous arterial anatomy of the adult elbow. J Bone Joint Surg Am 1997;79:1653-62.

18- Llusá M, Ballesteros-Betancourt J, Forcada P, Carrera A. Atlas de Disección Anatomoquirúrgica del Codo. Elsevier, Barcelona, España, 2009.

19- Llusá M, Meri A, Ruano D. Surgical Atlas of the Musculoskeletal System. Rosemont, IL, American Academy of Orthopaedic Surgeons 2008.

20- Ballesteros-Betancourt JR, Fernández-Valencia JA, García-Tarriño R. et al. The limited anterior approach of the elbow for open reduction and internal fixation of capitellum fractures. Surgical technique and clinical experiencia in 2 cases with more tan 2 years follow-up. Rev Esp Cir Ortop Traumatol 2017;61(3):176-83.

21- Ballesteros-Betancourt JR, García-Tarriño R, Gutierrez-Medina D, et al. Surgical anatomy and technique for the treatment of Dubberley type 1, 2 and 3 capitellar fractures via a limited anterior approach to the elbow. Int J Adv Jt Reconstr 2017;4(2):52-64.

22- Brouwer KM, Jupiter JB, Ring D. Nonunion of Operatively Treated Capitellum and Trochlear Fractures. J Hand Surg 2011;36A:804–807.

23- Elkowitz SJ, Polatsch DB, Egol KA, et al. Capitellum fractures: a biomechanical evaluation of three fixation methods. J Orthop Trauma 2002;16:503–506.

24- Sen RK, Tripahty SK, Goyal T, Aggarwal S. Coronal shear fracture of the humeral trochlea. J Orthop Surg (Hong Kong) 2013;21(1):82–6.

25- Singh AP, Singh AP, Vaishya R, Jain A, Gulati D. Fractures of capitellum: a review of 14 cases treated by open reduction and internal fixation with Herbert screws. Int Orthop 2010;34(6):897–901.

26- Dressler HB, Borges de Paula RN. Bryan and Morrey type IV intra-articular fracture of the distal extremity of the humerus treated surgically with anterior access: case report. Rev Bras Ortop 2015;50(3):352-5.

27- Bertani H, Nunes R. Bryan and Morrey type IV intra-articular fracture of the distal extremity of the humerus treated surgically with anterior access: case report. Rev Bras Ortop 2015;50:352–55.

28- Broberg MA, Morrey BF. Results of delayed excision of the radial head after fracture. J Bone Joint Surg Am 1986;68:669-74.

29- Henry A.K. Extensile Exposures. Churchill Livingstone, Edinburgh, UK, 1957.

30- Mekhail AO, Ebraheim NA, Jackson WT, et al. Anatomic considerations for the anterior exposure of the proximal portion of the radius. J Hand Surg1996;21:794–801.

31- Mekhail AO, Ebraheim NA, Jackson WTet al. Vulnerability of the posterior interosseous nerve during proximal radius exposures. Clin Orthop Relat Res 1995;315:199–208.

32- Ballesteros-Betancourt J, A Méndez, P Forcada, M León, M Llusá. Nervio Radial, Anatomía quirúrgica. En: Anatomía Quirúrgica del Plexo Braquial y de los Nervios Periféricos de la Extremidad Superior. M. Llusá, S. Palazzi (eds) Barcelona: Editorial Médica Panamericana; 2012. ISBN: 978-84-9835-610-6.

33- Heidari N, Kraus T, Weinberg AM, Weiglein et al. The risk injury to the posterior interosseous nerve in standard approaches to the proximal radius: a cadaver study. Surg Radiol Anat 2011;33(4):353–357.

34- Kuriyama K, Kawanishi Y, Yamamoto K. Arthroscopic-assisted reduction and percutaneous fixation for coronal shear fractures of the distal humerus: report of two cases. J Hand Surg Am 2010;35:1506-9.

35- Fink Barnes LA, Parsons B, Hausman M. Arthroscopic management of elbow fractures. Hand Clin 2015; 31:651-61.

36- Stothers K, Day B, Regan WR. Arthroscopy of the Elbow: Anatomy, Portal Sites, and a Description of the Proximal Lateral Portal. Arthroscopy 1995;11(4):449-457.

37- Ruchelsman DE, Tejwani NC, Kwon YW, Egol KA. Open reduction and internal fixation of capitellar fractures with headless screws. J Bone Joint Surg Am 2008;90:1321–9.

38- Heck S, Zilleken C, Pennig D, et al. Reconstruction of radial capitellar fractures using fine-threaded implants (FFS). Injury 2012;43(2):163–7.

39- Muller ME, Allgower M, Schneider R, Willenegger H. Manual of Internal Fixation: Techniques Recommended by the AO-ASIF Group. 3rd edn. Heidelberg: Springer-Verlag; 1991.

40- Kocher MS, Tucker R, Ganley TJ, Flynn JM. Management of osteochondritis dissecans of the knee: current Concepts review. Amer J Sports Med 2006;34:1181-92.

41- Houston DA, Amin AK, White TO, Smith ID, Hall AC. Chondrocyte death after drilling and articular screw insertion in a bovine model. Osteoarthritis Cartilage 2013;21(5):721-9.

42- Urban JPG, Maroudas A, Bayliss MT, Dillon J. Swelling pressures of proteoglycans at the concentrations found in cartilaginous tissues. Biorheology 1979;16:447-64.

43- Yamaguchi K, Sweet FA, Bindra R, Morrey BF, Gelberman RH. The extraosseous and intraosseous arterial anatomy of the adult elbow. J Bone Joint Surg Am 1997;79:1653-62.

Figure Legends

Figure 1. Anatomical preparation of the distribution of the arterial vessels of the elbow with a technique of corrosion in an alkaline medium. It can be seen how the vascularity of the capitellum comes from the posterior appearance of the capitellum and from the lateral column of the distal humerus.

Figure 2. A) Anterior view of a CT with 3D reconstruction in a Dubberley type 3 fracture: you can see that the fractured trochlear and capitellar fragments are separated. B and C) There is comminution in the most distal area of the humerus, but the posterior aspect of the external and internal columns of the distal humerus are conserved.

Figure 3. External bicipital groove. A) The radius is situated in the radial tunnel, in close relation to the deep aponeurosis of the mobile wad of Henry. B) Dissection of the radial nerves and its branches. C) In this transverse section of the forearm we see the close relationship that exists between the radial nerve, the recurrent radial artery, and the veins and the joint capsule of the elbow at the level of the humero-radial joint.

Figure 4. A) After performing capsulotomy, the capitellum is easily exposed and is reduced to its anatomical positon. B) Positioning of Kirschner wires in divergent directions to each other, and in a plane that is truly perpendicular to the fracture. C) Anteroposterior projection of fluoroscopy check of correct fragment reduction, checking that the articular profile of the distal humerus has been restored. D) Lateral projection of the elbow, which we use to check the correct reduction of the fracture as well as the length of the Kirschner wires for subsequent measurement of the cannulated screws.

Figure 5. A) Using a Freer retractor, we carefully reduce the articular fragment, this retractor can also be used to maintain reduction during Kirschner wire fixation. B, C and D) Checking the correct temporary reduction with Kirschner wire and position of cannulated screw fixing the radial head fragment.

Figure 6. Internal bicipital groove. A) The neurovascular bundle of the arm formed by the concomitant artery and humeral veins and more medially the median nerve. B) The nerve branches of innervation from the epitrochlear branch of the median nerve for the flexo-pronator muscles of the forearm. C) In this transversal section at the level of the distal humerus, we can see from a different perspective the relationship between the neurovascular bundle and the joint: the neurovascular bundle is not in close relation with the joint, since the brachialis muscle is interposed between both.

Figure 7. A) The location of the capitellum and trochlea is drawn on the skin. See how the trochlear axis coincides with the flexion crease of the elbow. B) A skin incision is made that coincides with that line drawn. C) Subcutaneously, we dissect the cubital fossa with scissors. In the medial cubital fossa, once the superficial fascial plane is exposed, the bicipital aponeurosis is opened longitudinally, more medial to the biceps tendon depending on the type and extent of fracture. D) Positioning of Kirschner wires in both sides of the cubital fossa and radiological confirmation.

Figure 8. A) Transverse section of the distal humerus: you can see the optimal direction of the K-wires for fixation of the capitellum and trochlea: you need to fix de screws in the posterior area of the columns. B) Anteroposterior projection check image once definitive fixation of the fracture is finished.