Complex Articular Fractures of the Distal Humerus. Recommendations to Optimize Outcomes and Reduce Complications

Marcos Maiorano,[*] Santiago Argüelles,[**] Enrique Pereira,[#] Carlos Zaidenberg[##]
[*]*Orthopedics and Traumatology Service, Hospital "Carlos A. Bocalandro", Buenos Aires, Argentina*
[**]*Department of Orthopedics and Traumatology, Hospital Municipal "Bernardo Houssay", Vicente López, Buenos Aires, Argentina*
[#]*Instituto Argentino de Diagnóstico y Tratamiento, Autonomous City of Buenos Aires, Argentina*
[##]*Locomotor System Study Unit, Department of Anatomy, School of Medicine, Universidad Nacional de Buenos Aires, Autonomous City of Buenos Aires, Argentina*

ABSTRACT
Complex articular fractures of the distal humerus represent a real challenge for orthopedic surgeons. The complexity of the anatomy, fracture patterns, the presence of multiple fragments, and low bone density in the elderly represent some difficulties to address. The relatively low frequency of these fractures directly undermines training and systematization of the surgical procedure and therefore has an impact on the final functional outcome and complication rate. The aim of this article is to provide practical tools to the novel surgeon, through the review of the literature and the author´s experience, to reduce complications and optimize the treatment of these fractures.
Key words: Fractures; distal humerus; planning; osteosynthesis.
Level of Evidence: V

Fracturas articulares complejas del húmero distal. Recomendaciones para optimizar los resultados y disminuir las complicaciones

RESUMEN
Las fracturas articulares complejas del húmero distal suponen un gran desafío para el cirujano ortopédico. La complejidad de la anatomía, la presencia de múltiples fragmentos y la mala calidad ósea representan algunas de las principales dificultades para resolver. La relativa infrecuencia de estas fracturas atenta directamente contra el entrenamiento y la sistematización del procedimiento quirúrgico y, por consiguiente, tiene impacto sobre el resultado final y la tasa de complicaciones. El objetivo de esta comunicación es proporcionar herramientas al cirujano a través de la revisión de la bibliografía y la experiencia de los autores para disminuir las complicaciones y optimizar los resultados en el tratamiento de estas fracturas.
Palabras clave: Fractura; húmero distal; planificación; osteosíntesis.
Nivel de Evidencia: V

INTRODUCTION

Distal humerus fractures are relatively uncommon in adults and their treatment represents a challenge for the orthopedic surgeon. They have an estimated annual incidence of 5.7 per 100,000 adult inhabitants and represent between 0.5 and 7% of all fractures, and around 30% of fractures that occur around the elbow.[1,2] They have a bimodal presentation: in young people suffering from high-energy trauma and in the elderly with medium- and low-energy trauma.

Received on December 12th, 2021. Accepted after evaluation on January 30th, 2022 • Dr. MARCOS MAIORANO • marcosmaioranocx@gmail.com ID https://orcid.org/0000-0002-7135-2535
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Surgical treatment is the method of choice for complex fractures of the distal humerus. However, in patients whose comorbidities significantly increase surgical risk or those who, due to their own factors or those of their environment, are not able to comply with the postoperative indications and rehabilitation, the classic 'bag of bones' conservative treatment is an option to consider that can provide acceptable functional outcomes in this group of patients with low functional demand. It consists of a short period of cast immobilization or the use of a sling, followed by mobilization as tolerated by the patient.[3,4]

Currently, there is consensus regarding the impact that the quality of fracture fixation and postoperative rehabilitation have on the final outcome of treatment. Although the evolution of the surgical technique and the development of implants have made it possible to significantly improve the quality of fixation and therapeutic outcomes, the relative infrequency of these fractures hinders the training of the surgical team and conspires against the 'systematization' of the procedure.

Finally, and despite this progress, there are still some controversial aspects regarding the ideal management of these fractures.

The objective of this publication is to list and describe the aspects that, based on our experience and review of the literature, we consider essential to optimize outcomes and minimize complications in the management of complex articular fractures of the distal humerus.

SITUATION DIAGNOSIS

The initial physical examination is vitally important and should be performed at the first consultation. It is essential to remove all immobilization and bandages in order to identify any associated soft tissue injury, whether directly related to the initial trauma or subsequent to it. Its possible relationship with an open fracture or with iatrogenic decubitus injuries caused by cast immobilization should be evaluated. The neurovascular examination should be performed in detail and documented in the clinical record, taking into account that up to 25% of complex joint fractures cause symptoms associated with the ulnar nerve.[5]

Anteroposterior and lateral radiological projections of the elbow are usually sufficient for diagnosis. In complex joint fractures, a computed tomography with three-dimensional reconstruction should always be requested, as it allows a better understanding of the fracture pattern and facilitates preoperative planning.[6]

The age, functional demand, and bone quality of the patient are three important aspects that must be considered for decision-making.[7] In patients with good bone quality, the treatment of choice is osteosynthesis. In the elderly with osteoporotic bone, or comminuted or very distal fracture patterns, in whom fixation may be technically difficult, total elbow arthroplasty is an option to consider, as it has achieved predictable outcomes for this group of patients.[8]

PREOPERATIVE PLANNING

Due to the relative rarity of these fractures and the wide variety of fracture patterns, preoperative planning is of paramount importance. Predicting and anticipating intraoperative difficulties and complications will have a direct impact on reducing surgical time.

Early understanding of the fracture pattern through imaging studies is very helpful. Traction radiographs, computed tomography, and especially three-dimensional reconstruction, provide valuable information for the surgeon in interpreting the injury (Figure 1).

The identification and preoperative drawing of the main fragments and the 'key' fragments are usually very useful to anticipate the dynamics of the reduction, anticipate and define the type of temporary fixation, and pre-establish the most convenient definitive arrangement of the implants.

Bone quality, the degree of metaphyseal or joint comminution, and the quantity and height of the fracture lines are aspects that we must take into account in planning and that will have implications for the surgical approach and the choice of implants according to their features.

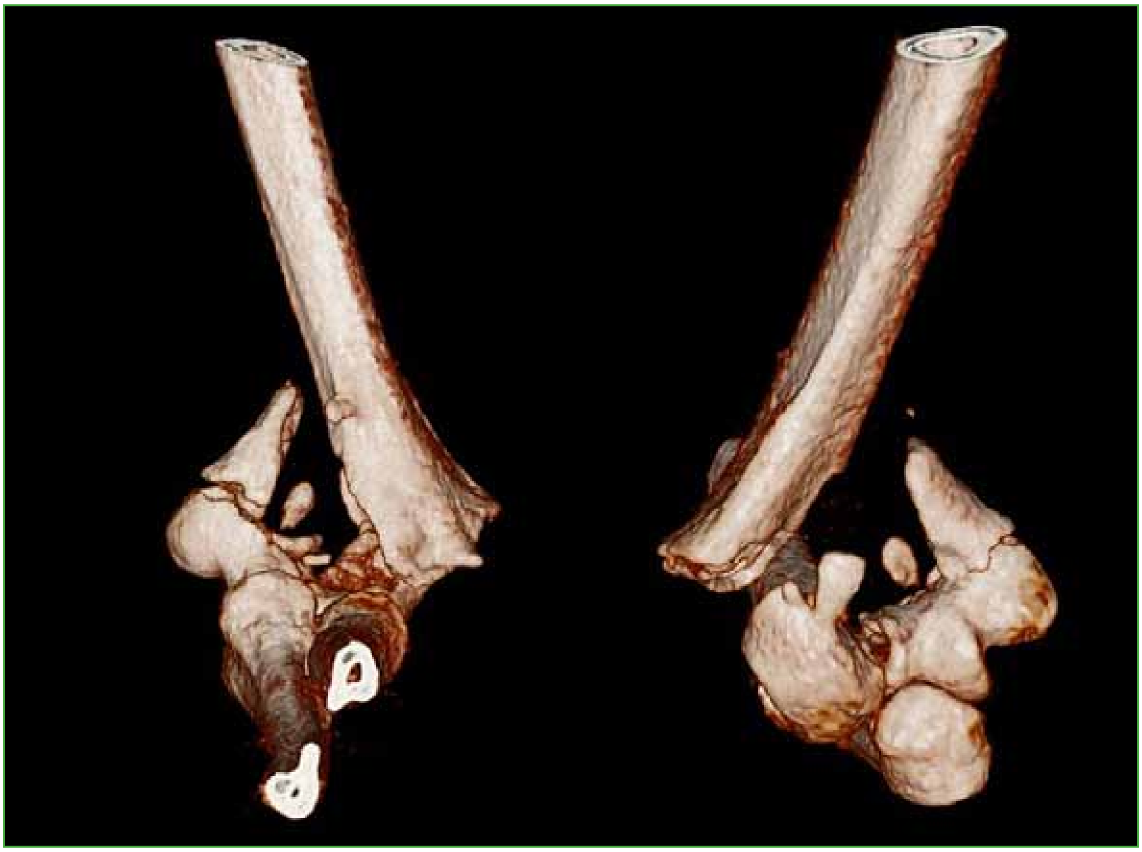

Figure 1. Computed tomography with three-dimensional reconstruction of an articular fracture of the distal humerus.

CHOICE OF IMPLANTS

The goal of surgical treatment of distal humerus fractures is to restore the anatomy and the relationship between the two columns and the articular surface through stable fixation. Although the use of 3.5 mm reconstruction plates is currently a valid option, the introduction and evolution in the designs of anatomical plates with angular stability have made it possible to improve the quality of osteosynthesis, mainly when there is comminution and poor bone quality.

The availability of these implants allows for adequate fixation even of those complex fractures that cannot be fixed with conventional implants. The incorporation of variable angle locking technology represents an additional benefit in the fixation of fractures with multiplanar and very distal lines, as it allows a fixation that is stable enough to be able to establish a rehabilitation protocol based on early mobilization.

However, many of the so-called 'anatomical' plates do not meet this characteristic, since not only do they not adapt to the anatomy of the distal humerus, but they also sometimes do not allow satisfactory fixation of the articular surface (Figure 2).

Therefore, we strongly recommend that surgeons who are beginning to take their first steps in the treatment of these fractures know the characteristics of the implants available in our market.

On the other hand, the availability and use of headless self-compressing cannulated screws should be foreseen in those fracture patterns that present coronal or axial lines at the level of the capitellum or the trochlea and that cannot be fixed by the screws arranged through the plates.

Figure 2. Plastic bone demonstration of poor anatomical reproduction and insufficient joint fixation of a given implant.

PATIENT POSITIONING

The procedure can be carried out with the patient in the prone position (Figure 3) or in the lateral position (Figure 4). The choice must take into account multiple factors, including the available equipment, the patient's physical characteristics and comorbidities, and, ultimately, the surgeon's preference.

The prone position has the advantage of improving the relationship between ventilation and perfusion, and allowing better ventilation of the patient; however, it makes airway access and instrumentation difficult. For these reasons, this last aspect must be considered when said position is chosen by the surgeon, because the procedure must be carried out under general anesthesia.

In our case, we prefer lateral decubitus, since it allows us to perform the surgery under regional anesthesia of the limb and with the patient awake, which represents an advantage if the procedure is to be carried out on an outpatient basis. It is worth clarifying that, if it is done in this way, a trained and familiarized team is required in order to optimize surgical time. In any case, if the time of surgery is prolonged as a result of some unforeseen event or complication, lateral decubitus allows good access to the airway for its instrumentation and conversion to general anesthesia, if necessary. We also recommend having an arm stabilizer support, because it facilitates the procedure regardless of the chosen position.

Figure 3. Patient placed in the prone position.

Figure 4. Patient placed in the lateral decubitus position.

SURGICAL APPROACH

The approach is determined by the 'personality' of the fracture, from which the degree of exposure necessary to achieve the previously planned synthesis is deduced. According to O'Driscoll, the entryway to the elbow is in the back (Figure 5) and, in published articles, the advantages of different posterior approaches have been described, although there is no clear consensus about the superiority of one or the other in terms of efficacy, safety and functional outcomes.

Dakouré et al. compared the percentage of exposure of the articular surface between the Alonso-Llamas bilateral paratricipital approach, the Campbell triceps division, and the olecranon osteotomy, with values of 26%, 37%, and 52%, respectively, which shows that olecranon osteotomy is the route that provides greater exposure of the joint surface.[9] The need for joint exposure should be evaluated in each case, taking into account that the overall rate of complications for the transolecranon approach is 36% and the revision rate is around 14%.[10] Therefore, the benefit of joint exposure must be considered taking into account this relatively high rate of complications.

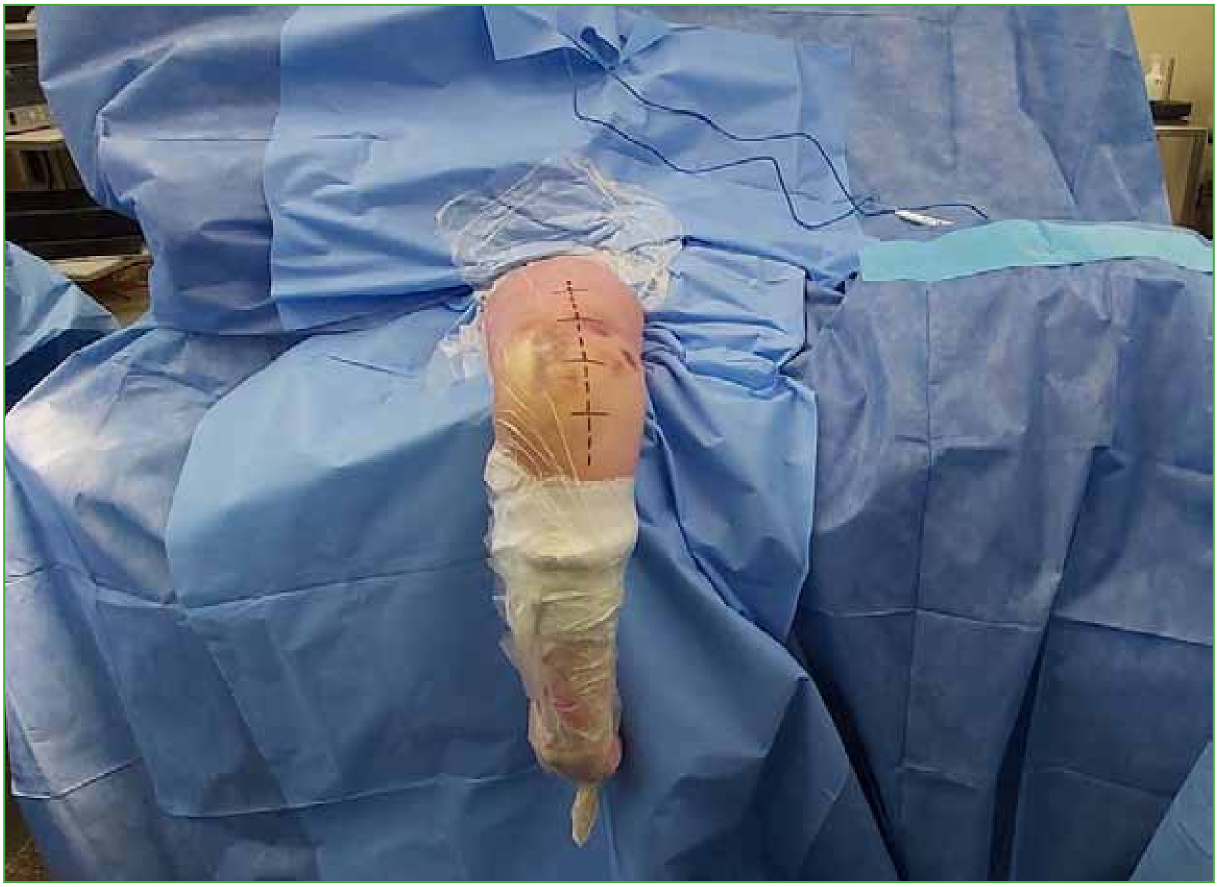

Figure 5. Posterior approach to the elbow.

In our practice, when we are faced with a type C1 or C2 fracture according to the AO classification, we avoid olecranon osteotomy and resort to a bilateral paratricipital approach, which allows good reduction of the articular surface and placement of the plates both orthogonally and in parallel (Figures 6 and 7).

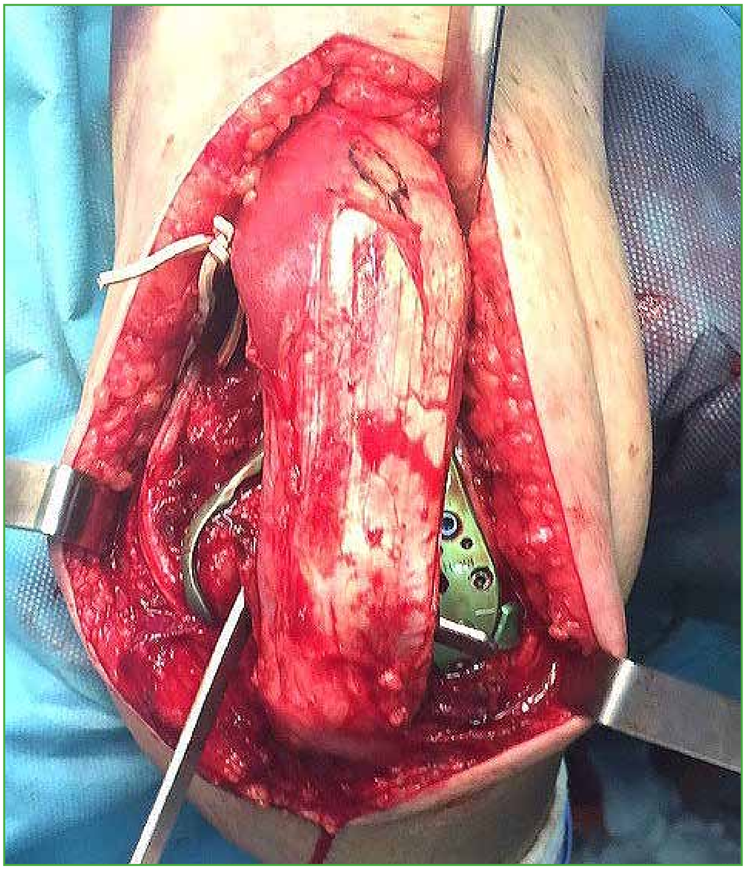

Figure 6. Arrangement of orthogonal plates using the paratricipital approach.

Figure 7. Arrangement of parallel plates using a paratricipital approach.

In the context of a type C3 fracture, bone quality and the degree of comminution must be evaluated, since these two variables condition the viability of osteosynthesis. When the bone quality is adequate and the fracture pattern allows its instrumentation to be foreseen, we opt for the chevron osteotomy of the olecranon (Figure 8).

On the other hand, when the scenario is that of an elderly patient with poor bone quality and extensive joint comminution or in very distal lines, arthroplasty may become an advisable option and, then, the approach with reflection of the extensor apparatus proposed by Bryan -Morrey may be the alternative of choice.

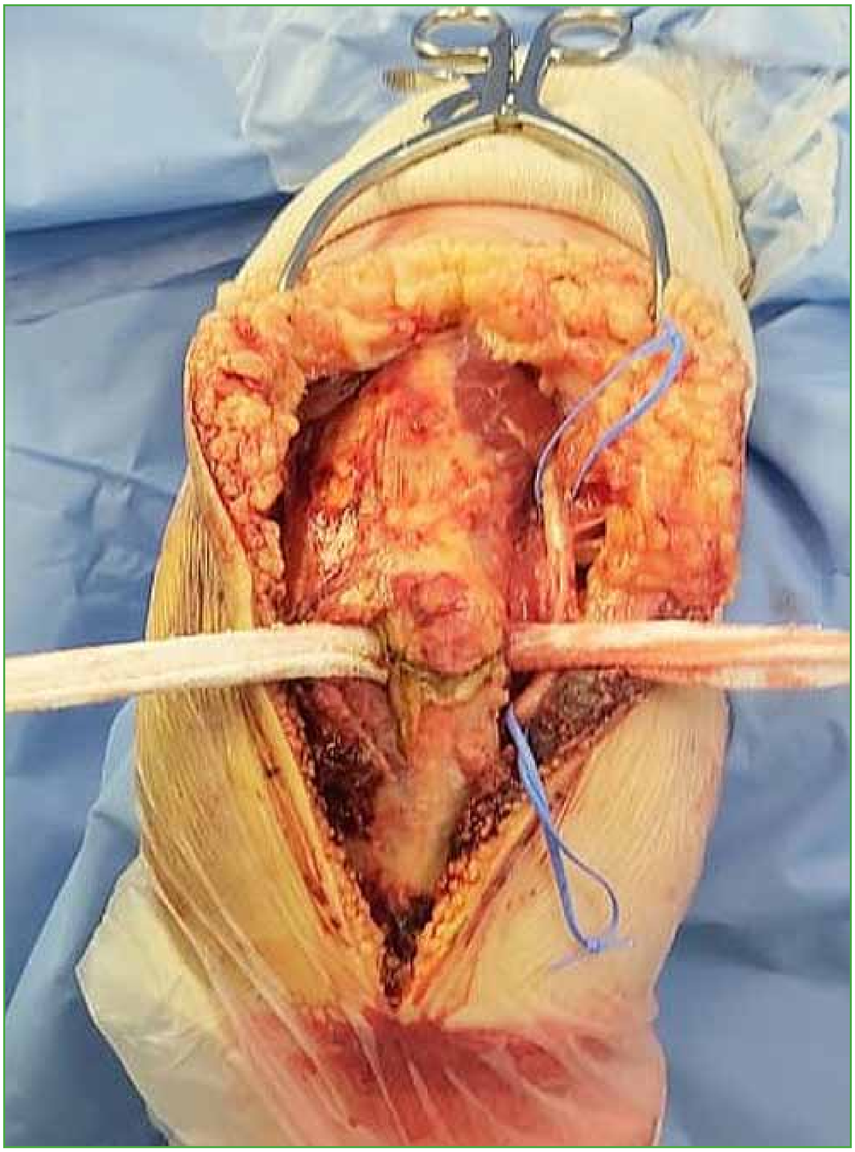

Figure 8. Preparation of the chevron olecranon osteotomy.

REDUCTION AND TRANSIENT FIXATION

Reduction should begin with the fragments that compromise the articular surface. The restoration of the anatomy at this level is essential to achieve a satisfactory outcome. Pointed forceps can be used, and sometimes a periodontal probe is helpful to maintain reduction and then temporarily fixate the articular surface with Kirschner wires. These wires must be placed strategically, in such a way that they do not interfere with the subsequent placement of the definitive plates. The triangle arrangement (Figure 9) is usually sufficient and effective to maintain reduction until definitive fixation.

Fixation using high-strength sutures for metaphyseal-diaphyseal fragments is a valid alternative that, according to our experience, is very useful and easy to perform, does not interfere with the subsequent placement of the plates as sometimes occurs with interfragmentary screws, and avoids the risk of migration that the pins present when used as a definitive method.

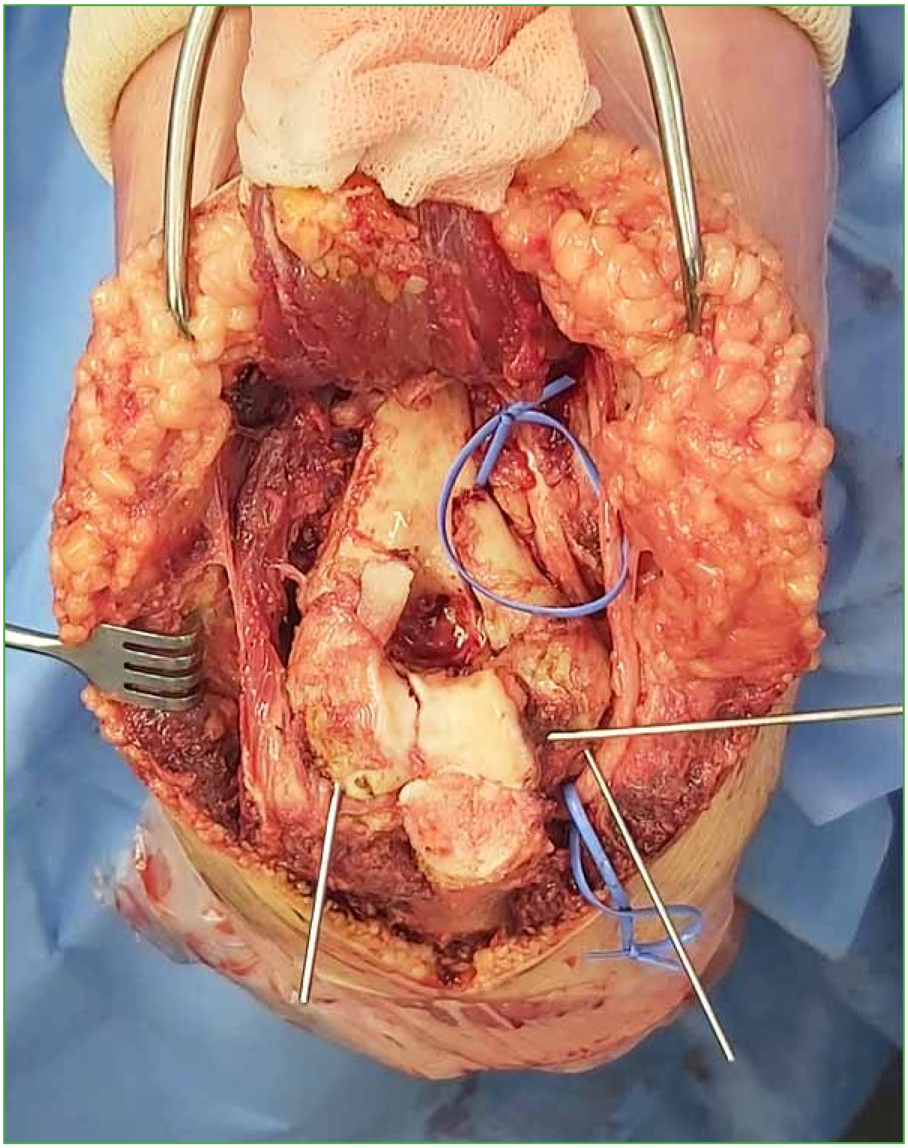

Figure 9. Temporary fixation using Kirschner wires in a triangular arrangement. Note that the arrangement of the wires does not interfere with the placement of the plates.

DEFINITIVE FIXATION

Once the articular surface has been temporarily reduced, fixated, and solidified to the metaphysis, the definitive fixation of the fracture must be carried out. The plates can be arranged in an orthogonal or parallel configuration, and this has probably been the most discussed topic in the last 20 years (Figures 10 and 11).

Multiple clinical and biomechanical studies have evaluated these two configurations. In a 2016 biomechanical study, Taylor et al. reported a significantly higher stiffness of the parallel plate configuration compared to the orthogonal ones.[11] One year later, Atalar et al. compared the biomechanical stability of both assemblies and did not find significant differences.[12] Through a prospective randomized clinical study, Lee et al. compared parallel and orthogonal fixation using locked implants, and found no significant differences in outcomes between the two groups after a minimum follow-up of two years.[12]

The most recent evidence supports that both arrangements are effective and that the parallel plate configuration could be superior to the orthogonal one in terms of bone union time.[14]

The choice of the construct type will depend on the fracture pattern. In our team, we prefer the arrangement of parallel plates proposed by O'Driscoll,[15] considering that interdigitation of the distal screws and taking the joint fragments from both sides allow achieving a solid and reliable construct for the range of motion of the joint.

As we mentioned in the choice of implants, we choose to place orthogonal plates when the lateral column presents associated traces in the coronal plane. Firstly, because the capitellum can be fixed with screws in the postero-anterior direction through the posterolateral plate, reducing to a minimum the need to place screws 'outside the plates'. The second reason is that we seek to avoid the placement of screws whose direction is in the same plane as the fracture, since, on occasion, they interpose themselves between the fragments on their way to the trochlea, and cause a diastasis that interferes with their reduction and fixation.

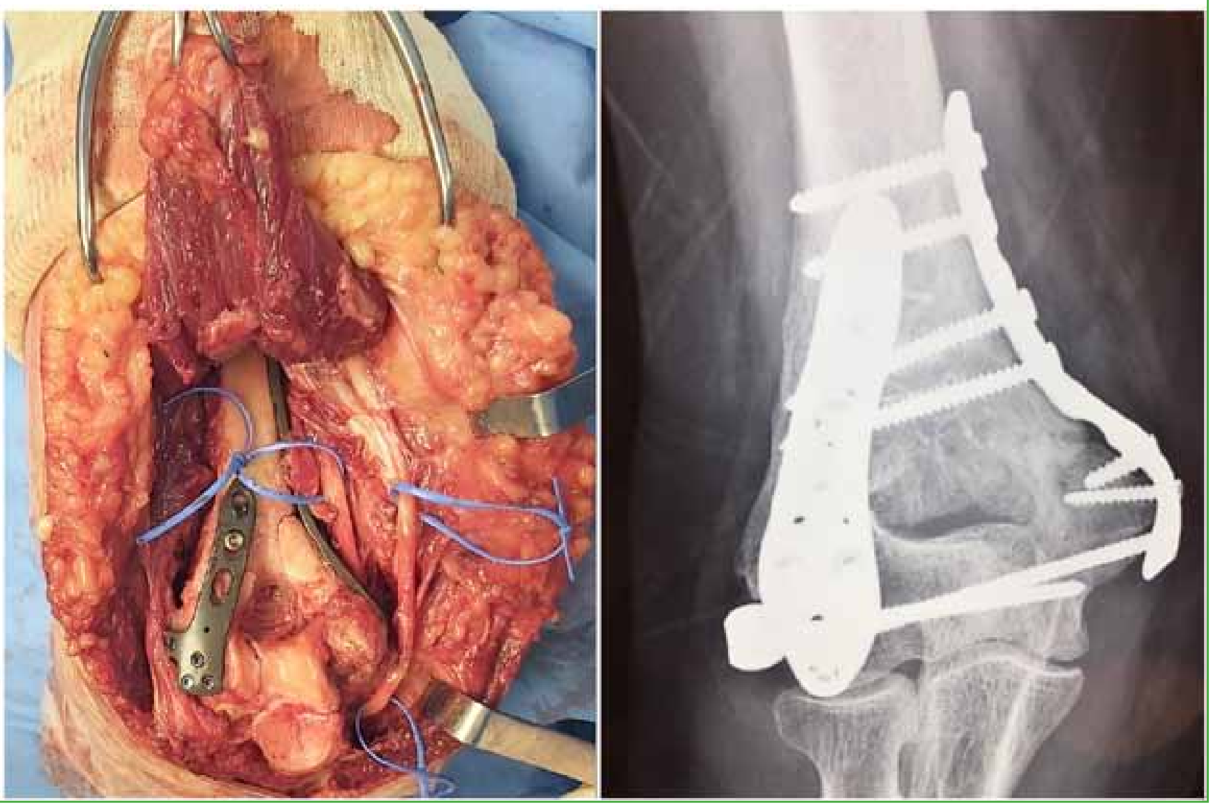

Figure 10. Definitive fixation through an arrangement of orthogonal plates.

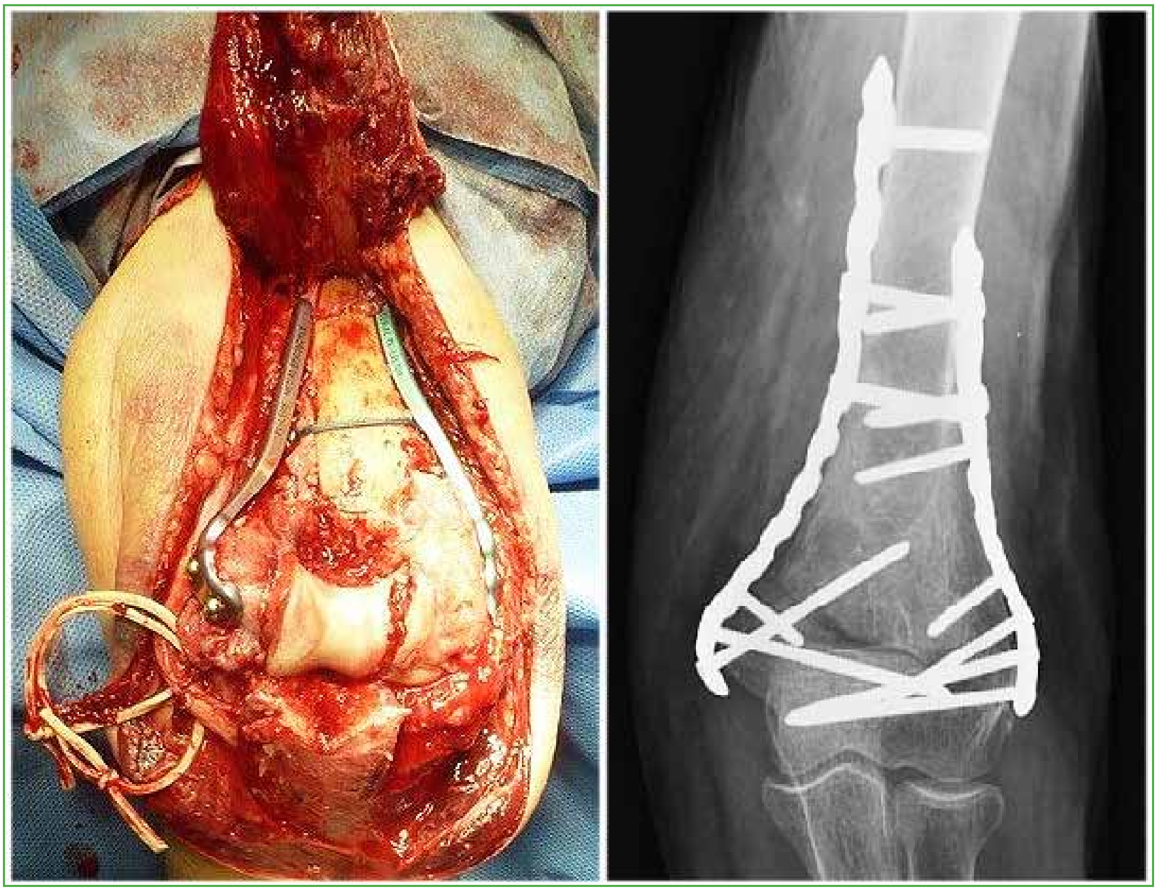

Figure 11. Definitive fixation by means of an arrangement of parallel plates.

MANAGEMENT OF THE ULNAR NERVE

As already mentioned, up to 25% of complex articular fractures of the distal humerus may present with symptoms related to the ulnar nerve and, for this reason, an adequate initial inspection is of the utmost importance to investigate these alterations, record them in the clinical history, and duly communicate them to the patient.

Early in the procedure, the identification, neurolysis, and repair of the nerve with rubber bands should be performed as a routine (Figure 12). Both traction and excessive or careless manipulation of the nerve during surgery are predisposing factors for the development of postoperative ulnar neuropathy that reaches rates of up to 38%.

Currently, the most appropriate method for intraoperative management of the ulnar nerve after fracture fixation is unknown. Both the anterior transposition and the *in situ* release have advocates and detractors. In 2018, Shearin et al. performed a meta-analysis that included 366 cases, and reported that postoperative ulnar neuropathy was higher in the anterior nerve transposition group (23.5%) than in the *in situ* decompression group (15.3%).[16] However, it is interesting to note that none of the publications included in this study discriminated between patients who had symptoms before surgery and those who did not.

Once the definitive fixation of the fracture has been carried out, the situation of the ulnar nerve must be evaluated by means of passive mobilization of the joint and it must be observed whether there is extensive contact with the medial implant or instability that may predispose it to irritation. If the nerve is unstable, according to what has been proposed in the literature,[17] we opt for anterior subcutaneous transposition of the nerve. On the contrary, if the nerve is stable upon passive range of motion, but has contact with the medial implant, we prefer, when the tissue allows it and unlike what was proposed by the aforementioned authors, to make a local flap of adipose tissue to cover the implant, keeping the nerve *in situ*.

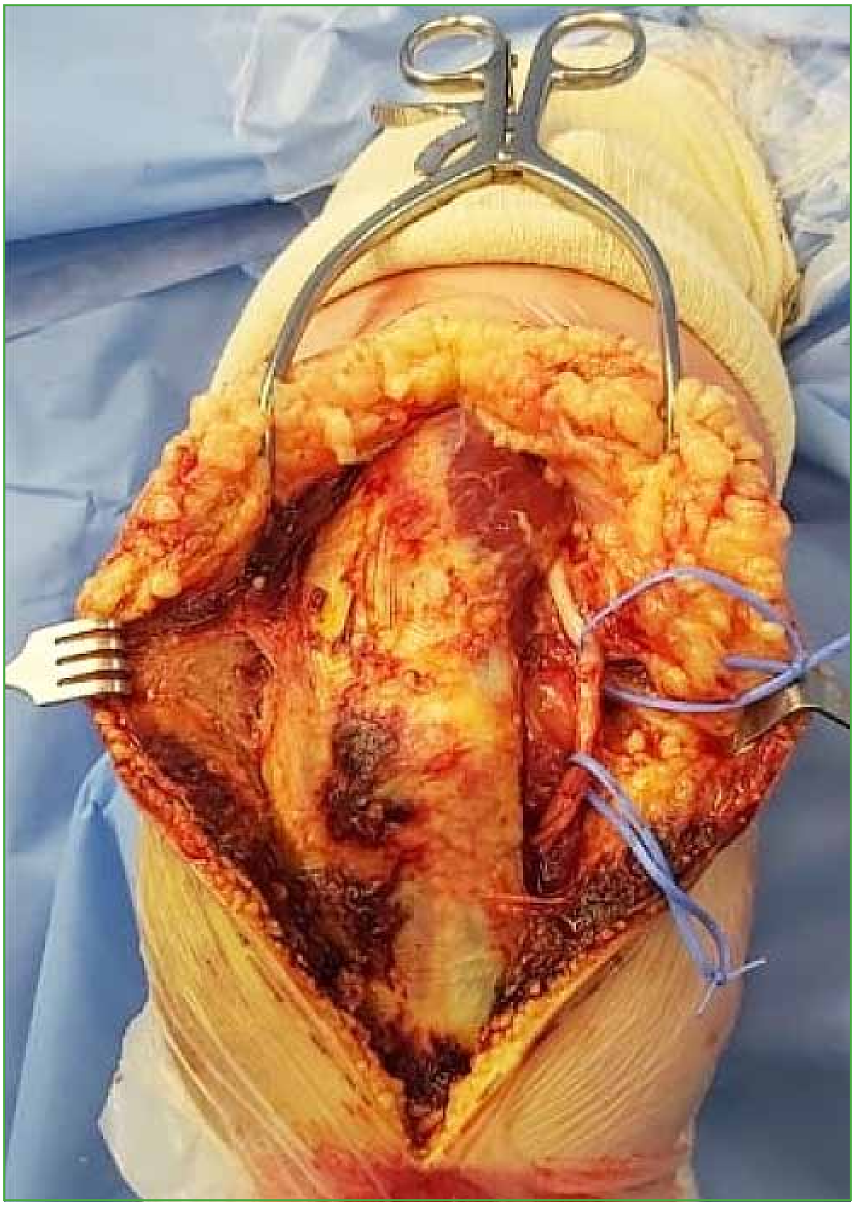

Figure 12. Identification and repair of the ulnar nerve with rubber bands.

On the other hand, the formation of edema and hematoma is recognized as a predisposing cause for the development of postoperative ulnar neuropathy; therefore, meticulous surgical technique and adequate hemostasis are of paramount importance.

POSTOPERATIVE PERIOD

In the immediate postoperative period, the elbow is immobilized in 90° flexion in order to protect the soft tissues, reduce edema and inflammation, and reduce pain. The immobilization time may vary according to the clinical evolution of the patient, but should not exceed 14 days. Early mobilization, as stated, is one of the key premises, since it will not only influence the final range of motion, but will also favor ulnar nerve gliding, reducing the formation of perineural adhesions and the development of postoperative neuropathy. For this, we use a self-adjusting articulated orthosis that allows the patient to move early within a controlled range and supervised by the surgeon and the therapist.

CONCLUSIONS

Articular fractures of the distal humerus pose a demanding scenario for the orthopedic surgeon. Their relative rarity, the complexity of the anatomy, and the rapid tendency of the elbow to stiffen lead to a high rate of both intraoperative and postoperative complications.

Determining the 'personality' of the fracture, the precise diagnosis of the fracture pattern by means of imaging studies, and adequate preoperative planning allow the selection of the most convenient surgical approach and the most appropriate arrangement of the osteosynthesis.

The training of the treating team and the systematization of the procedure could reduce surgical time and obtain more anatomical and stable fixations. This enables early rehabilitation and mobility, thus reducing the rate of complications and optimizing function

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S. Argüelles ORCID ID: https://orcid.org/0000-0002-9002-5687
E. Pereira ORCID ID: https://orcid.org/0000-0001-7307-7824
C. Zaidenberg ORCID ID: https://orcid.org/0000-0001-5921-0828

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