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### ORIGINAL ARTICLE

## Surgical treatment protocol for elbow “terrible triad”

D. Cecilia López \*, L. Suárez Arias, M.A. Porras Moreno, A. Díaz Martín, F. Jara Sánchez, and C. Resines Erasun

Orthopaedic Surgery and Traumatology Department, “12 de Octubre” University Hospital, Madrid, Spain

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#### KEYWORDS

Elbow;  
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#### Abstract

**Objective:** To analyse the results in patients with the combination of elbow dislocation and fracture of the radial head and the coronoid process (or «terrible triad» of elbow) using a standardised protocol.

**Material and methods:** A prospective longitudinal study of 24 patients, 10 women and 14 men, median age was 53 years, diagnosed and operated of elbow triad using a standardised protocol. The mean follow-up was two years (12-50 months). Treatment included replacement or osteosynthesis of the radial head, repair or osteosynthesis of the coronoid fracture and ligament repair. The results were evaluated clinically using the Mayo scale Elbow Performance Score (MEPS) and radiographically.

**Results:** The final average mobility was 105° of flexion-extension and 150° of pronosupination. The average score according to the MEPS level was 85 (65-100 points). No patient required re-intervention although there were two complications: one had a superficial infection and in another a residual fragment of the radial head remained that was not removed during surgery.

**Conclusion:** The treatment for the «terrible triad» of the elbow should maintain a stable joint, preserving or replacing the radial head, repairing the lateral collateral ligament complex, and synthesis of the coronoid fracture.

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#### PALABRAS CLAVE

Codo;  
Tríada;  
Cabeza radio

#### Tratamiento quirúrgico protocolizado de la «tríada terrible» de codo

#### Resumen

**Objetivo:** Analizar nuestros resultados en pacientes tratados quirúrgicamente por asociación de luxación de codo con fractura de la cabeza radial y fractura de la apófisis coronoides o «tríada terrible» de codo, con un protocolo estandarizado.

\* Corresponding author.

E-mail: dacecilia@hotmail.com (D. Cecilia López).

**Material y métodos:** Estudio longitudinal prospectivo de 24 pacientes, 10 mujeres y 14 hombres, con 53 años de edad media, diagnosticados de tríada de codo e intervenidos de forma protocolizada. El seguimiento medio fue de dos años (12-50 meses). El tratamiento incluye la sustitución u osteosíntesis de la cabeza radial, la reparación u osteosíntesis de la fractura de coronoides y la reparación ligamentosa. Los resultados se valoraron con la escala *Mayo Elbow Performance Score* (MEPS) y radiográficamente.

**Resultados:** La movilidad media final fue de 105° flexo-extensión y 150° de prono-supinación. La puntuación media en la escala MEPS fue de 85 (65-100 puntos). Ningún paciente precisó de reintervención aunque un caso presentó una infección superficial y en otro persistió un fragmento residual de la cabeza radial que no se extirpó durante la cirugía.

**Conclusión:** El tratamiento recomendado en la tríada terrible de codo debe mantener una articulación estable, preservando o sustituyendo la cabeza radial, reparando el complejo del ligamento lateral externo e intentando sintetizar la fractura de la coronoides.

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## Introduction

The so-called “terrible triad” of the elbow is the combination of dislocation of the elbow, fracture of the head of the radius and of the coronoid process.<sup>1</sup> Traditionally, treatment of this injury has been associated with poor results in terms of acute or chronic instability, stiffness, pain, and post-traumatic arthrosis.<sup>2-5</sup> The enhanced knowledge regarding the functional anatomy of the elbow, as well as of its primary and secondary stabilizers has contributed enormously to a better understanding of the physiopathology of these lesions and how to cope with their treatment. At present, efficacious treatment of the terrible triad of the elbow must be considered as a whole, and all the injured structures must be contemplated, both bone and capsule-ligamentous injuries.<sup>6-9</sup> A treatment has recently been described that includes the repair of all the injuries from the inside out. The application of a systemic treatment might improve the outcomes in this complex lesion.<sup>6,8,9</sup> The aim of our study was to evaluate the results obtained in the terrible triad of the elbow by implementing a protocolized approach.

## Material and methods

Prospective, longitudinal study including 24 patients surgically treated at our centre with a diagnosis of the terrible triad of the elbow. The mean age was 53 years, ranging from 17 to 73 years. Fourteen were male and 10 were female. The mean follow-up was 2 years (range: 1 year-50 months). In all cases, the pre-operative study included anteroposterior and lateral X-rays of the elbow, as well as computerized axial tomography (CT) with 3D reconstruction (fig. 1). The following were contemplated in the radiological assessment: the degree of post-traumatic arthrosis,<sup>10</sup> the presence of heterotopic ossifications, if any,<sup>11</sup> and whether or not osteolysis or areas of radiolucence were present in those cases where radial head implants were used (table 1).

Functional assessment was made by means of the *Mayo Elbow Performance Score* (MEPS, ‘Mayo Clinic Scale’).<sup>12</sup> The score obtained on this scale varies from 0 to 100 points,

with 100 points indicating the best outcome. The scale contemplates the following domains: pain (45 points), mobility (20 points), stability (10 points), and the use of the elbow during activities of daily living (25 points). Categorically speaking, the outcome was deemed to be excellent when a score of 90 to 100 points was obtained; the outcome was considered good with a score of 75 to 89, acceptable when the score was between 60 and 74 points, and poor when the score was less than 60 points. The result was deemed satisfactory when the outcome was good or excellent. Likewise, complications during follow-up were recorded, both those common to any other type of surgery, as well as those that might be more specific to the treatment of these injuries (residual instability, pain, stiffness, secondary surgeries..).



**Figure 1** Computerized axial tomography (CT) imaging is essential in the pre-operative assessment of these lesions and helps us to understand better which structures are involved and how to go about repairing them.

**Table 1** Patient data regarding characteristics, type of fracture, and treatment used

Sex	Age	Mason <sup>1</sup>	O’ Driscoll	Radial head treatment	Coronoid process treatment	External lat lig. repair	Medial lat lig. repair	External fixation
Male	45	II	Tip	Screws	Harpoon	Yes	No	No
Female	44	III	Tip	Prosthesis	Harpoon	Yes	No	No
Male	43	III	Tip	Prosthesis	Harpoon	Yes	No	No
Male	17	II	Tip	Plate	Harpoon	Yes	No	No
Female	65	III	Anteromedial	Prosthesis	Harpoon	Yes	Yes	No
Male	44	III	Tip	Prosthesis	Harpoon	Yes	No	Yes
Male	50	III	Anteromedial	Prosthesis	Plate	Yes	No	No
Male	35	II	Tip	Screws	Harpoon	Yes	No	Yes
Male	49	III	Tip	Prosthesis	Harpoon	Yes	No	No
Male	43	III	Tip	Prosthesis	Harpoon	Yes	No	No
Male	38	II	Tip	Screws	Harpoon	Yes	No	No
Male	23	III	Base	Prosthesis	Harpoon	Yes	No	No
Female	64	III	Tip	Prosthesis	Plate	Yes	Yes	No
Female	44	III	Tip	Prosthesis	Harpoon	Yes	No	Yes
Male	67	III	Anteromedial	Prosthesis	Plate	Yes	Yes	No
Female	68	III	Tip	Prosthesis	Harpoon	Yes	No	No
Female	69	III	Tip	Prosthesis	Harpoon	Yes	No	No
Male	68	III	Tip	Prosthesis	Harpoon	Yes	Yes	Yes
Female	66	II	Anteromedial	Prosthesis	Plate	Yes	Yes	No
Female	67	III	Tip	Prosthesis	Harpoon	Yes	No	No
Male	57	III	Tip	Prosthesis	Harpoon	Yes	No	No
Male	73	III	Tip	Prosthesis	Plate	Yes	No	No
Female	68	III	Tip	Prosthesis	Plate	Yes	No	No
Female	65	III	Tip	Prosthesis	Harpoon	Yes	No	No

## Surgical technique

Protocolized surgical treatment in elbow triads.<sup>6,8,9</sup> The principles of the technique were to restore stability of the coronoid process by means of osteosynthesis if the size of the fragment made it possible, or by means of capsular re-anchoring if it was very small; to restore the stabilizing role of the radial head through osteosynthesis or prosthetic replacement, to restore lateral stability by repairing the lateral ligamentous complex and the supinator-extensor musculature; to repair the medial ligamentous complex if instability persisted and the use of external fixation if, despite all the afore-mentioned, the repair was not stable enough to allow early mobility. A lateral approach was used in all cases (fig. 2), preferably using Kaplan’s approach<sup>13</sup> as it afforded the best access to the radial head fracture and, above all, to the fracture of the coronoid process. If a Kocher approach<sup>13</sup> was used, it had to be extended proximally to gain access to the coronoid process. From this access, osteosynthesis of the radial head was assessed and when it was not possible, we replaced it with a radial head prosthesis.

Treatment of the coronoid process fracture depended on its size; we attempted to repair the fractures involving the tip from a lateral approach. If the radial head had to be replaced, once it had been resected, there was good access to repair the coronoid process; in the case of osteosynthesis of the radial head, although more difficult, we also repaired

it using the lateral approach (fig. 3). In all cases, fractures affecting the tip were treated with sutures by means of harpoons, as they are too small to make stable osteosynthesis possible. Furthermore, the suture itself repaired the anterior capsular lesion. When the fracture of the coronoid process was larger, we performed osteosynthesis with screws or plates and complemented this with a conventional medial approach through which the fracture was fixed (fig. 4). Finally, the lateral collateral ligament complex (LCL) was also repaired by means of sutures with harpoons; this ligament was typically avulsed at the humeral origin. Once the repair had been completed, we evaluated stability intra-operatively. The aim is to achieve a concentric reduction without any posterior or posterolateral instability through a flexion-extension arc from 20° to 130°<sup>14</sup> and if the elbow was considered to be unstable, we proceeded to repair the medial collateral ligament (MCL) complex and to place an articulated external fixator to enable movement within a safe mobility arc (fig. 5).

In our series, the radial head was synthesized in 4 cases and in 20, arthroplasty was performed with a modular prosthesis made of pyrocarbon (Ascension Orthopedics®, Austin, TX, USA). Fracture of the coronoid process was synthesized using a plate (Acumed®, Beaverton, OR, USA) in 6 cases and in 18, it corresponded to a fracture of the tip that was treated by means of repair with harpoons. In 4 cases, residual instability remained; hence, an external fixator was added to the treatment.



**Figure 2** The lateral approach allows treatment of the fracture of the radial head and fractures of the tip of the coronoid process and repair of the external collateral ligament complex.



**Figure 3** Repair of the anterior capsule in a fracture of the tip of the coronoid process using a harpoon. Access is possible from a lateral approach even without removing the radial head.

The post-operative protocol kept the elbow immobilized with a brachial-antebrachial splint for 5-7 days, so as to reduce the oedema and soft tissue inflammation. Passive mobilization was then begun within a stable mobility arc using an articulated orthosis that can be locked as the surgeon sees fit. Treatment must be customized for each patient based on the degree of stability achieved during surgery; however, in general, full extension and supination were avoided during the first three weeks. Complete passive mobilization was started at 3 or 4 weeks and unlimited active mobility was allowed at 6 weeks.

## Results

The mean final arc of flexion-extension was 105° (80°-140°) and pronosupination was 150° (90°-160°). The mean score



**Figure 4** A,B) Treatment entails arthroplasty of the radial head (shatter fracture that is impossible to synthesize), osteosynthesis of the coronoid process with a specific plate for such purpose through an additional medial approach and repair of both ligament complexes with sutures and harpoons.



**Figure 5** External fixator placed when residual instability persists after repair.

on the MEPS scale was 85 points (65-100 points), with 10 outcomes rated as excellent, 10 considered good, and 4 deemed fair.



We did not detect any degenerative radiographic changes during follow-up, although one patient developed heterotopic ossifications, grade IIA according to the Hastings and Graham classification, with functional limitation in flexion-extension and loss of less than 30° of the total arc of flexion-extension. Another patient developed minor osteolysis, measuring 2 mm, at the point where the shaft of the radial head prosthesis meets the diaphysis, although it had no functional repercussion and did not progress radiologically.

None of the patients developed complications requiring re-intervention, although there was another patient who presented a superficial infection of the surgical wound that responded satisfactorily with antibiotic treatment and another patient, in whom the radial head was replaced, a residual fragment of the radial head was seen to remain in the peri-articular space without any functional repercussions; surgery to remove it was ruled out. Secondary surgery due to stiffness of the post-traumatic elbow was not required in any of the subjects. In those where the arc of mobility was incomplete, function was satisfactory enough not to require this type of surgery.

## Discussion

The functional anatomy of the elbow is dictated by capsule-ligament and bone structures. From a pathophysiological standpoint in a triad, there is injury to both levels, which translates into a situation of great instability in the joint. In order to restore stability and the functionality, in a worst case scenario, all the injured structures must be treated.<sup>6,9</sup> The ulnar lateral collateral ligament repair, osteosynthesis or replacement arthroplasty, and repair of the fracture in the coronoid process must all be effected.

Traditionally, there have been different approaches to the treatment of these lesions that are subject to debate; for instance, deciding upon the best approach for the radial head, whether or not to treat the fracture of the coronoid process, ligament repair, as well as the order in which this must be done.

Insofar as the approach is concerned, a lateral approach between the radial extensor muscles of the carpus and the common extensor muscle of the fingers can be used to provide visualization of the radial head, access to fractures of the tip of the coronoid process, and repair of the external lateral ligament complex. If necessary, an additional medial approach can be used and this is useful to treat major fractures of the coronoid process or if the medial ligament complex requires repair. Alternatively, a medial-posterior approach can be used and, if extended laterally or medially, this can also provide access to all the injured structures.<sup>9</sup>

The stabilizing function of the radial head is well documented and must therefore be preserved, either by means of stable osteosynthesis with reduction and internal fixation (ORIF), or by means of prosthetic replacement.<sup>15,16</sup>

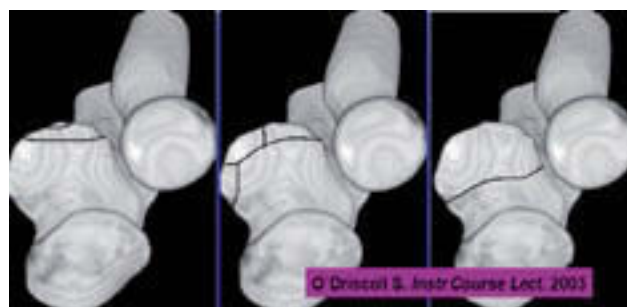
Restoration of the contact between the radius and the capitulum is essential in the context of such an unstable injury. Resection of the radial head is, therefore, contraindicated. Arthroplasty must be carried out whenever adequate reconstruction cannot be achieved by means of

stable osteosynthesis. This can be particularly difficult in injuries with multiple fragments, osteopenic bone, loss of subcortical bone, and impaction of the joint surface.<sup>17-22</sup> There are several different devices available on the market, most of which are uncemented and without any clear evidence of superiority of one implant over the others. Silicone implants have fallen into disuse as a result of their inability to restore stability to the lateral compartment, because they provoke synovitis (siliconitis), and in light of how often they rupture.<sup>23-25</sup> Metal implants have demonstrated good long-term results in terms of elbow stability, although there have been reports of cases of erosion of the humeral condyle due to the prosthesis, which has been attributed to the oversizing of the implant more than to the implants' finish. From a practical point of view, therefore, it is important to bear in mind that the prosthesis should not be too tight and, in the event of having to decide between two sizes, it is generally better to go with the smaller size.<sup>18,23,26</sup> Pyrolytic carbon implants are appealing based on their biomechanical characteristics as they have an elasticity modulus similar to that found in bone.<sup>27</sup>

One of the aspects that have most modified the approach to these lesions is the importance of fractures in the coronoid process, even when they are small.<sup>6,7</sup> This is due to the role of the coronoid process in stabilizing the elbow, since it provides anteroposterior and varus stability. The Regan and Morrey classification<sup>28</sup> has been the most widely used, but it has too much inter-rater variability and, consequently, the O'Driscoll classification,<sup>29</sup> which is based on the morphology on the CT (fig. 6), is preferred. A pre-operative CT forms part of the treatment protocol of these lesions.

It is difficult to achieve synthesis in fractures of the tip; however, it is important to undertake repair since they often go hand-in-hand with injury to the anterior capsule that, if not reinserted, leads to instability in the anteroposterior plane.<sup>6,7</sup> Reinsertion of these small fragments together with the articular capsule can be carried out by means of transosseous anchors or sutures with harpoons.

Fractures of the coronoid process involving the anteromedial facet (insertion of the most important fascicle of the MCL) or the base are too large to be treated with harpoons or transosseous suture. These fractures require synthesis that provides rigid fixation; consequently, an additional medial approach is necessary or, if a posterior approach has been used, dissection can be made toward the medial side. Depending on the size of the fragment,



**Figure 6** O'Driscoll classification of fractures of the coronoid alar process based on their morphology on the CT.

different types of osteosynthesis can be chosen, in accordance with the surgeon's preferences. There are pre-shaped plates available on the market for fractures of the anteromedial facet and, if the fragment is large, it might be possible to use a straight plate.

Repair of the LCL lesion is mandatory. It is common to find the ligament torn off in its entirety from the epicondyle; hence, after repairing the problem of the radial head and the coronoid process, the whole ligamentous complex can be reinserted at its point of humeral insertion.

The MCL can be repaired in cases where the elbow is still unstable after taking all the above steps. Some authors are of the opinion that MCL is not necessary, even when it is injured.<sup>30</sup> The rationale is that in the elbow, once the injured MCL has been reduced, it "heals" without any problem, although there are those who prefer to repair the MCL when facing residual instability and then place an external fixator if the instability persists.<sup>31</sup>

The triads of the elbow are complex osteoligamentous lesions in which treatment success depends on understanding the anatomical and biomechanical bases of the elbow joint. The importance of the primary and secondary stabilizers is fundamental, including the radial head, the coronoid process, and the lateral ligamentous complexes; consequently, the most comprehensive repair possible should be carried out on the structures injured in line with the surgical protocols available.

## Conflict of interest

The authors state that they have no conflict of interest.

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