

ORIGINAL ARTICLE

Protocolised surgical treatment of terrible triad of elbow. Results and complications[☆]



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KEYWORDS

Elbow triad;
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ligament

Abstract

Background: Terrible triad of elbow is a complex lesion with a high rate of complications. Our goal is to analyse both clinical results and complications after performing protocolised surgery. **Material and methods:** We performed a prospective longitudinal study using our hospital database. We obtained a total of 62 triads. The initial approach was lateral and when necessary we added a medial approach. We treated 3 main pillars, the radial head, the coronoid process, and the lateral collateral ligament. If needed, we repaired the medial collateral ligament or we performed an external fixator.

Results: In our series, the radial head was synthesised in 14 (22.5%), an arthroplasty was performed in 45 (72.5%), and other actions in 3 (5%). The coronoid could be synthesised in 12 (19.3%). In 41 (66.2%) a transosseous suture or an anchor were performed, and in 9 (14.5%) no treatment was given. The LCL was repaired in 100% of cases, in 9 (14%) the MCL had to be repaired, and 22% of the patients required Ex-Fix.

There were 17 (27%) complications. Three (17.5%) cases of infections, 4 (23.5%) neurological lesions, 3 (17.5%) cases of stiffness, 1 (6%) ulnar impaction syndrome, and 1 (6%) case with an intraarticular fragment postoperatively. Four (23.5%) heterotopic ossification, and 1 (6%) osteolysis of radial prosthesis were observed.

Regarding functional results, range of mobility (ROM) of 120°/–20° flexo-extension, and 98°/85° of pronosupination were obtained.

Conclusions: Elbow triads are complex lesions where protocolised surgery is necessary, nevertheless the complication rate was 27% in our series.

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PALABRAS CLAVE

Triada codo;
Inestabilidad;
Cabeza radial;
Coronoides;
Ligamento colateral
lateral

Tratamiento quirúrgico protocolizado de las triadas terribles de codo. Resultados y complicaciones**Resumen**

Introducción: La triada terrible de codo es una enfermedad asociada a altas tasas de complicaciones, por ello queremos estudiar los resultados y las complicaciones.

Material y métodos: Se ha utilizado la base de datos de nuestro hospital durante 2005-2015, recogiendo características del paciente, de la fractura, de la cirugía y las complicaciones asociadas, así como resultados funcionales y rango de movilidad.

Resultados: Se obtuvieron un total de 62 triadas, de las cuales 27 (43%) eran mujeres y 35 (56%) eran hombres.

A todos se les realizó un abordaje lateral de Kaplan y en aquellos que lo necesitaron se complementó con un abordaje medial para reparar el LCM. La cabeza radial se sintetizó en 14 (22%) casos, se colocó una prótesis en 45 (74%) de casos y otras actuaciones en 3 (5%) casos. La osteosíntesis de la apófisis coroides se realizó mediante arpón ± sutura transósea en 41 (62%) pacientes y mediante síntesis en 12 (19%) casos. En 9 (14%) casos no se realizó ninguna actuación. En el 100% de los casos se reparó el LCL y en 9 (14%) hubo que reparar también el LCM. Un 22% de los pacientes precisaron FE por inestabilidad tras la técnica quirúrgica.

Respecto a resultados, se obtuvo un rango de movilidad de entre 120° / -20° de flexoextensión y 98° / 85° de pronosupinación.

En cuanto a complicaciones, obtuvimos un total de 17 (27%).

Conclusiones: Las triadas de codo son lesiones osteoligamentosas complejas donde es necesario realizar una cirugía protocolizada, a pesar de lo cual, existen un 27% de complicaciones.

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Introduction

Terrible triad of elbow is the combination of elbow dislocation, radial head fracture and coronoid process fracture¹⁵ (Fig. 1). It is a complex injury involving bony and ligamentous elements, which necessitates a comprehensive and protocolised approach. Despite this, it is still an injury with a high rate of complications (including instability, stiffness, premature arthrosis or chronic pain.^{1,2,6,7,22,24,26,28}

Although much has been reported in the literature on this subject many points of controversy remain regarding different approaches, whether or not to synthesise fractures of coronoid process which only affect the tip, and whether the



Figure 1 Lateral X-ray of a terrible triad of elbow.

medial collateral ligament (MCL) should be systematically repaired or not.

Objective

The objective of our study was to apply protocolised surgical treatment for these injuries and analyse the clinical results and complications obtained.

Material and methods

A retrospective study using the database of our hospital, between the years 2005 and 2015. A total of 62 triads was obtained, collecting patients' demographic data, fracture data (Mason and O'Driscoll classification), surgical data (approach, radial head treatment), coronoid process, lateral collateral ligament [LCL] and MCL) and associated complications, both intraoperative and during follow-up. Functional results were collected using the Mayo Elbow Performance Score (MEPS).¹⁰

Surgery performed in all cases followed a protocolised surgical technique which is detailed below.

Surgical technique

In all cases antibiotic perioperative prophylaxis with 2 g of intravenous cephazolin was administered.

The patient was positioned in supine position with a side table and ischaemia cuff at axillary level.



Figure 2 Incision for lateral elbow approach.

Initial approach was always the Kaplan lateral approach (Fig. 2), between the extensor carpi radialis longus and the extensor communis digitorum, which provided better viewing of the radial head and the coronoids.

The 3 essential pillars of treatment of these lesions are coronoid process, radial head and LCL.

If lateral access allows for coronoid approach (especially in cases where the radial head is prosthesis) we repair it from this approach. In O’Driscoll types II or III, where a lateral approach is insufficient for performing osteosynthesis, we complement this with a medial approach. The repair technique of the coronoid process essentially depends on

its size, if there is sufficient entity, synthesis may be made with cannulated screws or a plate, but if there were process tip fractures (O’Driscoll type I), a transosseous suture was performed or a re-anchoring of the anterior capsule using harpoon sutures.

Once the lateral approach has been used, this access route enables us to assess the possibility of synthesising the radial head. In cases where this was possible it was synthesised either with cannulated screws or with plates (Fig. 3). When comminution of the radial head made synthesis impossible, a radial head prosthesis was inserted.

The LCL was repaired using harpoon sutures in all cases, anchored at humeral level, since the majority of extractions occur in its proximal insertion.

Once the 3 essential pillars have been repaired we may assess the stability of the elbow with intraoperative scope (appropriate ulnar humeral reduction) and clinical control (elbow stability during a flexion extension arc of 20–130°¹⁸) (Fig. 4). If the elbow remains unstable when performing these 2 tests, we would proceed in 2 different ways.

- In those cases where we had already used the coronoid process approach with a medial approach, we would proceed to repair the MCL using harpoon suture.
- In those cases where only a lateral approach had been made, we would insert an external fixator.

Lastly, if we had repaired the radial head, the coronoid process, the LCL and the MCL, and the elbow remained unstable, we would also proceed with an external fixator (Fig. 5).

Results

Mean age was 49 years, with a range between 17 and 78 years. Mean follow-up time was 18 months (with a minimum follow-up of 12 months and a maximum of 36 months).

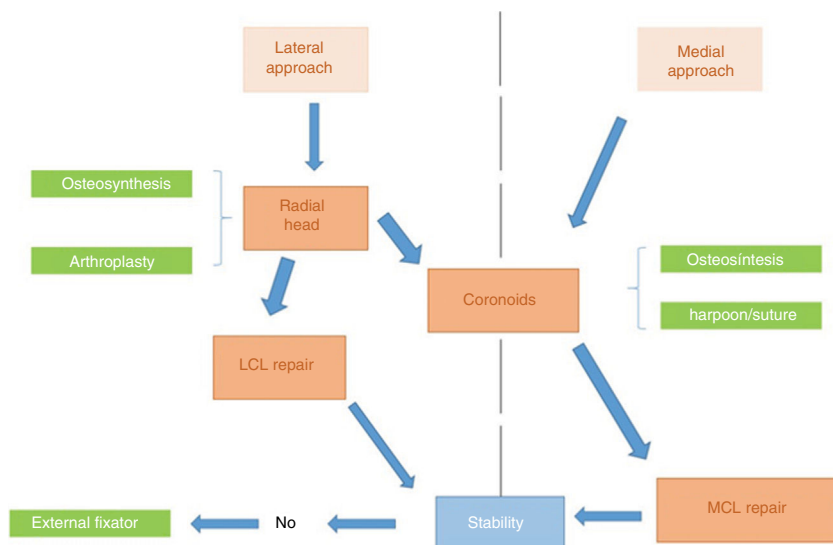


Figure 3 Reconstruction of the radial head using cannulated screws. Reconstruction of the lateral collateral ligament. Observe the fracture associated with the epicondyl.

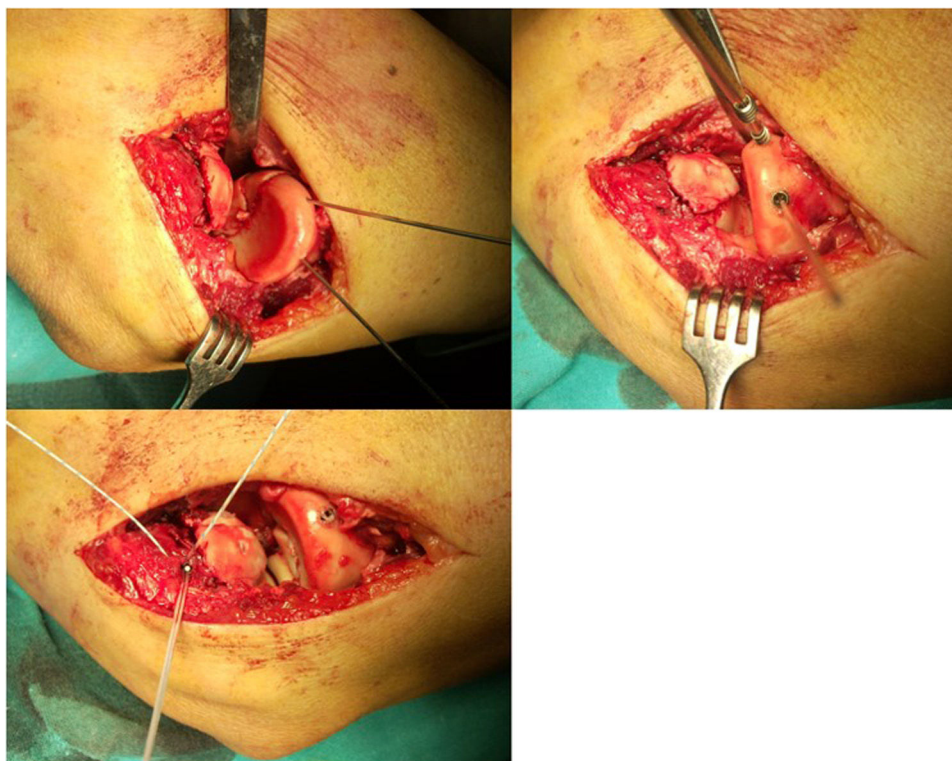


Figure 4 Algorithm in treatment of terrible triad of elbow.

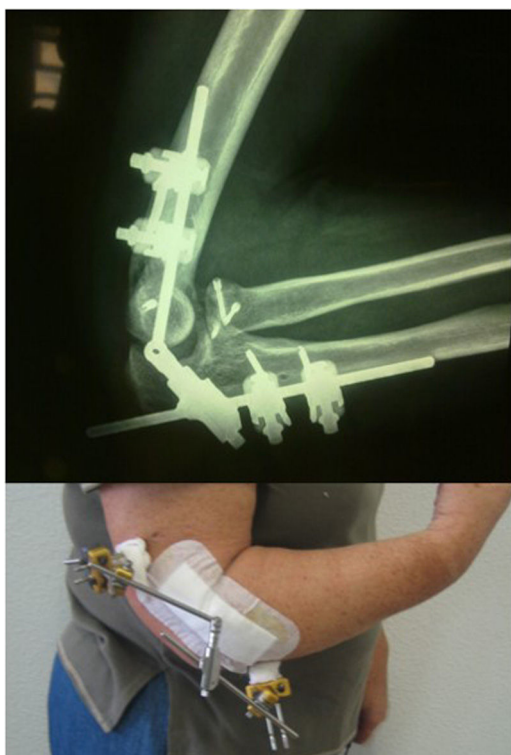


Figure 5 External fixator as treatment for terrible triad of elbow.

Out of the total patients, 27 (44%) were women and 35 (56%) were men. The most common lesional mechanisms was falling from the individual's own height, although in up to 28% of cases high energy trauma (traffic accidents, hastiness, bicycle accidents, etc.) was the cause.



Figure 6 3D reconstruction imaging.

In all cases an X-ray was performed (anteroposterior and lateral projection) with additional computerised axial tomography (CAT) always being performed postreduction (Fig. 6).

In all cases a lateral Kaplan approach was performed, with the addition of a medial approach in 9 (14%) of cases.

In our series, the radial head was synthesised in 14 (22.5%) of cases, arthroplasty was performed in 45 (72.5%) with a pyrocarbon modular prosthesis (AscensionOrthopedics®) (Fig. 7) and no action was taken in 3 (5%) cases. The coronoid process was synthesised in 12 (19.3%) cases, with an (Acumed®) plate in 6 cases or with HCS (DePuy-Synthes®) screws or Acutrak (Acumed®) screws, in accordance with the senior surgeon's preference



Figure 7 Postoperative imaging of repair using radial head arthroplasty, repair with harpoon of the joint capsule and repair with the harpoon of the lateral collateral ligament.

in the remaining cases. In 41 (66.2%) patients a transosseous suture was performed and in 9 (14.5%) no suture of this type was required.

In 100% of cases the LCL was repaired and in 9 (14%) the MCL had to be repaired as well due to insufficient stability. Furthermore, 22.5% of the patients required an EF due to instability, following all previously described procedures.

As we can see, the lesional spectrum is extremely wide, despite the fact that the injuries are encompassed within the terminology “terrible triad of elbow”, and there is a great variety of surgical techniques. We therefore consider that protocolised treatment should serve as a guide for taking one route or another, depending on the characteristics of each case.

In the immediate postoperative period the arm was kept immobile with a brachial antebrachial splinter at 100° extension and with the wrist in a neutral position for 3 weeks. After this, active assisted exercises of flexion and extension were allowed, avoiding the last 30° of extension. At week four the patient was referred for physiotherapy so as to progress with their range of movement. It should be taken into account that the post-surgical protocol was variable depending on the degree of stability obtained during surgery, to the extent that those who presented with high intra-operative stability were kept immobilised one or 2 weeks more.

Regarding functional results, a range of movement between 120° / -20° of flexoextension and 98° / 85° of pronosupination and clinical assessment using the MEPS scale, obtained mean values of 92, being higher than or equal to 90 points in 54 (87.1%) of cases, between 75 and 89 points

in 6 (9.7%) cases, between 60 and 74 points in 2 cases (3.2%) and below 60 points in no cases.

With regards to complications we obtained a total of 17 (27%) complications of different types. In 3 (17.5%) of cases infections were observed, 4 (23.5%) neurological lesions which consisted of 2 ulnar nerve entrapments and 2 radial nerve entrapments. There were 3 (17.5%) cases of stiffness, one (6%) ulnar impaction syndrome and one (6%) case where it was post-surgically observed that an intra-articular fragment had remained. From a radiologic viewpoint, 4 (23.5%) heterotopic ossifications were observed and one (6%) case of osteolysis of the radial prosthesis. In total, 6 further operations were performed, bringing the rate of reintervention to 9.6%. Two of these interventions were arthrolysis (arthroscopies or open surgery), 3 extractions of matter and one case of ulnar shortening after ulnar impaction syndrome.

Discussion

In order to understand the approach to this lesion, we have to understand its physiopathology. Two types of stabilisers have been described: *dynamic*, which are those muscles that cross over the elbow joint and *static*. In addition to this, static stabilisers comprise those with greater entity or primary which are: the ulnar-humeral (the most important), the LCL, especially the lateral ulnar collateral fascicle, and the MCL, mainly the anterior fascicle. The radial humeral joint, musculature inserted into the epicondyle and epitrochlear with a flexion pronator and extension supinator function and the joint capsule are considered secondary stabilisers.²⁸

Although several studies describe conservative treatment in selected cases,^{3,12} our criteria is that this is a lesion requiring surgical treatment for bony lesions and for ligamentous lesions. There is consensus in the literature regarding the bases for appropriate treatment of the terrible triad of elbow being appropriate restoration of the bone and ligamentous elements so as to provide the elbow with enough stability to start exercising early movements.^{1,4,6,18,24}

Although there is some consensus regarding the establishment of steps during terrible triad of elbow surgery, many controversial points remain, such as the approach route, whether the coronoid process should be repaired, or in which cases it would be necessary to repair the MCL.

The 2 most commonly used approaches are the Kaplan and Kocher approaches, which both allow for the radial head to be reached and synthesised, although repair of the LCL is easier from a Kocher approach since with the Kaplan approach difficulties may arise in repairing this ligament on having to liberate the residual part of the extensor digitorum communis of the epicondyl. Both approaches pose a risk to the posterior interosseous nerve, although we may reduce the risk, pronating the forearm to its maximum. On occasions, surgery should be complemented with a medial approach, either because we do not succeed in gaining access to the coronoid process through lateral approach, or because we wish to repair the MCL for greater elbow stability. If the fragment of the coronoid process is very large, it is usually necessary to raise the flexor carpi ulnaris, including the proximal flexor pronator mass.^{5,8}

With regard to the radial head, the most frequent location of fractures is its anterior lateral quadrant.³⁰ The current consensus is to maintain the radial head to achieve elbow stability,^{16,17,25} and therefore the option of its resection is rejected, but it is not yet clear which surgical technique is most recommendable. Warren et al.³³ studied 24 elbows. They performed synthesis in 13 and arthroplasty in 11, but no statistically significant differences were found.

However, in general clinical practice, arthroplasty is reserved for fractures which may not be reconstructed, either because there are 3 or more fragments, because they are highly comminuted or because the joint surface has been greatly compromised.¹⁷ There are many different implants on the market, the most highly used at present are the metallic implants, which provide good stability to the elbow and have good long-term results. Complications of this type of prosthesis are connected to the loosening of it and erosions of the humeral condyl, which appear to be related to the over dimensions of the implant head and high location of it. For this reason we should select smaller head sizes.^{13,31} Recently, Gauci et al.⁹ studied 65 patients with radial head arthroplasty, out of which 92% presented with reabsorption at radial neck level but they did not present with mechanical failure and remained stable one year post-operatively. This was related to stress shielding, but without clinical repercussion. However radial head prostheses made of other materials such as silicon, have been withdrawn due to silicon synovitis and a high rate of implant rupture.³² In our series we initially tried synthesis of the radial head and if this was not possible due to extensive comminution, we opted for radial head arthroplasty. In our series we obtained a similar percentage of postoperative complications (35% in synthesis and 26% in arthroplasty). However, we consider that we should continue long-term follow-up to discern whether there are differences between both treatments.

Another key discussion relates to the treatment of coronoid process fractures. Traditionally, they were classified according to the Regan and Morrey²³ classification but the O'Driscoll et al.²⁰ classification is now used increasingly, based on CAT findings.

Type I fractures (those affecting the coronoid process tip) are often difficult to synthesise but according to some authors should be repaired since they are lesions which also affect the anterior capsule and may lead to instability in the anterior posterior plane.¹⁸ Synthesis of these small fragments may be achieved through harpoon or transosseous Lasso type sutures.¹¹ Other authors consider that this type of lesions which only affect the most distal part of the coronoid process do not lead to instability in themselves and therefore when the radial head and LCL are repaired this would suffice.²¹ The type II fractures (antero-medial surface) and III (base of the coronoids) are larger fractures, and we frequently have to resort to a medial approach and to preshaped screws or plates for proper synthesis. Grant et al.¹¹ analysed a total of 40 elbows, where a Lasso type suture was performed (28) or synthesis with harpoon suture or screws (12). We found that those which were sutured were more stable, and those which were synthesised with screws had a greater tendency to implant failure and for those where anchorage was implanted there was a higher rate of pseudoarthrosis, which was statistically significant. In their work they concluded that the best results were achieved

Table 1 As the O'Driscoll and the Mason classification increases the external fixator usage rate increases too.

	Mason			O'Driscoll		
	I	II	III	I	II	III
External fixator	0%	22%	33%	27%	44%	0%

with Lasso type suture, but this was possibly due to the fact that this technique was used in smaller lesions which therefore had a lower instability component.

In our opinion O'Driscoll type I coronoid process should always be repaired when possible (e.g. if we resect the radial head for implantation of a prosthesis) and always in cases of instability after the radial head and LCL have been repaired.

LCL is a primary elbow stabiliser in the lateral area and we therefore always repair it. The most common lesion is a proximal avulsion at humeral level which occurs in 52% of cases. Avulsions of the humeral epicondyl (8%), intra-substance ruptures (29%), avulsion in the distal ulnar (5%), avulsion in the proximal ulnar (2%) or a combination of them (5%)¹⁹ may also occur.

Lastly, there is no consensus as to whether the MCL should be systematically repaired. Several authors have found higher rates of heterotopic calcifications and lower ranges of movement in patients in which this ligament has not been repaired and they therefore recommend a "prophylactic" repair to improve postoperative results and to avoid the complications derived from ulnar neuropathy.²⁹ Furthermore, there are authors who do not find any differences in the functionality scales and in the movement ranges and who therefore question the need for this repair.¹⁴ We have opted to repair it in the cases in which we have performed a medial approach to synthesise the O'Driscoll type II and III coronoid process lesions. In these cases we repaired the MCL with harpoon sutures.

When we have performed all these operations and if appropriate stability has not yet been obtained, some consensus exists for the use of an external fixator. Usage percentages vary between 8% and 26% according to the references,^{2,10,11,26} which is similar to the data found in our study.

In our series we observed that the higher the classification by Mason or O'Driscoll (Table 1) the higher the increase in the external fixator rate, which may help us to plan pre-operatively. The more complex the fracture, the higher the rate of external fixators required. The exception to this was that no O'Driscoll type III fracture needed an external fixator, the explanation for which may be that the fragment was larger, and once synthesised achieved greater stability than in types I and II, which were smaller fragments and more difficult to synthesise accurately.

The most common complication was that relating to heterotopic calcifications (12–43% depending on the series), but there were no related factors from a demographic viewpoint or surgical viewpoint or from time of surgery,²⁷ with all data being similar to ours.

Notwithstanding, the clinical results which were assessed using the MEPS scale are satisfactory. This is so partly because the complications were temporary (neurapraxias)

and because although complete mobility was not obtained, a useful range of movement for the patient's daily activities was.

Conclusions

Terrible triad of elbow are complex bony and ligamentous lesions where it is necessary to perform protocolised surgery but where there is still a complication rate ranging between 0% and 54%, depending on the study,² and which was 27% in our series with the majority being minor or temporary.

Treatment should be sequential and its objective is to maintain a reduced, stable joint. The radial head must be synthesised and should this not be possible, prosthesis introduced. The coronoid process fracture should be synthesised when possible and the larger its size the more so. The lateral ligamentous complex must always be repaired and when there is residual instability the use of an external fixator should be assessed.

Level of evidence

Level of evidence iv.

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Conflict of interests

The authors have no conflict of interests to declare.

Uncited reference

34.

References

1. Bohn K, Ipaktchi K, Livermore M, Cao J, Banegas R. Current treatment concepts for "terrible triad" injuries of the elbow. *Orthopedics*. 2014;37:831-7, <http://dx.doi.org/10.3928/01477447-20141124-06>.
2. Cecilia D, Suárez L, Porras MA, Diaz A, Jara F, Resines C. Tratamiento quirúrgico protocolizado de la «triada terrible» de codo. *Rev Esp Cir Ortop Traumatol*. 2010;54:357-62, <http://dx.doi.org/10.1016/j.recot.2010.06.008>.
3. Chan K, MacDermid JC, Faber KJ, King GJ, Athwal GS. Can we treat select terrible triad injuries nonoperatively? *Clin Orthop Relat Res*. 2014;472:2092-9, <http://dx.doi.org/10.1007/s11999-014-3518-9>.
4. Chan K, King GJ, Faber KJ. Treatment of complex elbow fracture-dislocations. *Curr Rev Musculoskelet Med*. 2016;9:185-9, <http://dx.doi.org/10.1007/s12178-016-9337-8>.
5. Chen HW, Bi Q. Surgical outcomes and complications in treatment of terrible triad of the elbow: comparisons of 3 surgical approaches. *Med Sci Monit*. 2016;22:4354-62.
6. Chen NC, Ring D. Terrible triad injuries of the elbow. *J Hand Surg Am*. 2015;40:2297-303, <http://dx.doi.org/10.1016/j.jhsa.2015.04.039>. Epub 2015 Oct 1.
7. Chen H, Liu GD, Wu LJ. Complications of treating terrible triad injury of the elbow: a systematic review. *PLOS ONE*. 2014;9:e97476, <http://dx.doi.org/10.1371/journal.pone.0097476>, eCollection 2014.
8. Cheung EV, Steinmann SP. Surgical approaches to the elbow. *J Am Acad Orthop Surg*. 2009;17:325-33.
9. Gauci MO, Winter M, Dumontier C, Bronsard N, Allieu Y. Clinical and radiologic outcomes of pyrocarbon radial head prosthesis: midterm results. *J Shoulder Elbow Surg*. 2016;25:98-104, <http://dx.doi.org/10.1016/j.jse.2015.08.033>.
10. Gill DR, Morrey BF. The Coonrad-Morrey total elbow arthroplasty in patients who have rheumatoid arthritis. A 10 to fifteen-year follow-up study. *J Bone Joint Surg Am*. 1998;80:1327-35.
11. Grant E, Garrigues MD, Walter H, Wray MD 3rd, Anneluuk LC, Lindenhovius MS, et al. Fixation of the coronoid process in elbow fracture-dislocations. *J Bone Joint Surg Am*. 2011;93:1873-81.
12. Guitton TG, Ring D. Nonsurgically treated terrible triad Injuries of the elbow: report of our cases. *J Hand Surg Am*. 2010;35:464-7, <http://dx.doi.org/10.1016/j.jhsa.2009.12.015>.
13. Harrington IJ, Sekiyi-Out A, Barrington T, Evans DC, Tuli V. The functional outcome with metallic radial head implants in the treatment of unstable elbow fractures: a long-term review. *J Trauma*. 2001;50:46-52.
14. Hatta T, et al. Comparative analysis of surgical options for medial collateral ligament repair in terrible triad injury of the elbow. *Orthop Rev (Pavia)*. 2016;8:6666, eCollection 2016.
15. Hotchkiss RN. Fractures and dislocations of the elbow. In: Rockwood CA, Green DP, Bucholz RW, Heckman JD, editors. *Rockwood and Green's fracture in adults*. 4th ed. Philadelphia: Lippincott-Raven; 1996. p. 929-1024.
16. Ikeda M, Sugiyama K, Kang C, Takagaki T, Oka Y. Comminuted fractures of the radial head. Comparison of resection and internal fixation. *J Bone Joint Surg Am*. 2005;87:76-84.
17. Leigh WB, Ball CM. Radial head reconstruction versus replacement in the treatment of terrible triad injuries of the elbow. *J Shoulder Elbow Surg*. 2012;21:1336-41, <http://dx.doi.org/10.1016/j.jse.2012.03.005>. Epub 2012 Jun 15.
18. McKee MD, Pugh DW, Wild LM, Schemitsch EH, King GJ. Standard surgical protocol to treat elbow dislocation with radial head and coronoid fractures. Surgical technique. *J Bone Joint Surg Am*. 2005;87 Suppl. 1(Pt 1):22-32.
19. McKee MD, Schemitsch EH, Sala MJ, O'Driscoll SW. The pathoanatomy of lateral ligamentous disruption in complex elbow instability. *J Shoulder Elbow Surg*. 2003;12:391-6.
20. O'Driscoll SW, Jupiter JB, Cohen H, Ring D, McKee MD. Difficult elbow fractures: pearls and pitfalls. *Inst Course Lect*. 2003;52:113-34.
21. Papatheodorou LK, Rubright JH, Heim KA, Weiser RW, Sotereanos DG. Terrible triad injuries of the elbow: does the coronoid always need to be fixed? *Clin Orthop Relat Res*. 2014;472:2084-91, <http://dx.doi.org/10.1007/s11999-014-3471-7>.
22. Pugh DM, Wild LM, Schemitsch EH, King GJ, McKee MD. Standard surgical protocol to treat elbow dislocations with radial head and coronoid fractures. *J Bone Joint Surg Am*. 2004;86:1122-30.
23. Regan W, Morrey B. Fractures of the coronoid process of the ulna. *J Bone Joint Surg Am*. 1989;71:1348-54.
24. Ring D, Jupiter JB, Zilberfarb J. Posterior dislocation of the elbow with fractures of the radial head and coronoid. *J Bone Joint Surg Am*. 2002;84-A:547-51.
25. Ring D, Quintero J, Jupiter JB. Open reduction and internal fixation of the radial head. *J Bone Joint Surg Am*. 2002;84-A:1811-5.

26. Rodriguez-Martin J, Pretell-Mazzini J, Andres-Esteban EM, Larrainzar-Garjito R. Outcomes after terrible triads of the elbow treated with the current surgical protocols. A review. *Int Orthop*. 2011;35:851–60, <http://dx.doi.org/10.1007/s00264-010-1024-6>. Epub 2010 May 8.
27. Shukla DR, Pillai G, McAnany S, Hausman M, Parsons BO. Heterotopic ossification formation after fracture-dislocations of the elbow. *J Shoulder Elbow Surg*. 2015;24:333–8, <http://dx.doi.org/10.1016/j.jse.2014.11.037>. Epub 2015 Jan 16.
28. Tarassoli P, McCann P, Amirfeyz R. Complex instability of the elbow. *Injury*. 2017;48:568–77, <http://dx.doi.org/10.1016/j.injury.2013.09.032>. Epub 2013 Sep 27.
29. Toros T, Ozaksar K, Sgn TS, Kayalar M, Bal E, Ada S. The effect of medial side repair in terrible triad injury of the elbow. *Acta Orthop Traumatol Turc*. 2012;46:96–101, <http://dx.doi.org/10.3944/AOTT.2012.2632>.
30. Van Leeuwen DH, Guitton TG, Lambers K, Ring D. Quantitative measurement of radial head fracture location. *J Shoulder Elbow Surg*. 2012;21:1013–7, <http://dx.doi.org/10.1016/j.jse.2011.08.056>. Epub 2011 Nov 9.
31. Van Riet RP, van Glabbeek F, Verborgt O, Gielen J. Capitellar erosion caused by a metal radial head prosthesis. *J Bone Joint Surg Am*. 2004;86-A:1061–4.
32. Worsing RA, Engber WD, Lange TA. Reactive synovitis from particulate silastic. *J Bone Joint Surg Am*. 1982;64:581–5.
34. Leigh WB, Ball CM. Radial head reconstruction versus replacement in the treatment of terrible triad injuries of the elbow. *J Shoulder Elbow Surg*. 2012;21:1336–2134.