International Orthopaedics (2019) 43:1413–1420
https://doi.org/10.1007/s00264-018-3888-9

REVIEW ARTICLE

Chronic Essex-Lopresti injury: a systematic review of current treatment options

Stefano Artiaco[1] · Federico Fusini[1] · Giulia Colzani[2] · Alessandro Massè[1] · Bruno Battiston[1]

Received: 23 October 2017 / Accepted: 12 March 2018 / Published online: 23 March 2018

Abstract

Introduction Essex-Lopresti lesion (ELL) is a severe injury. Most of ELL is recognized in chronic phase representing a therapeutic challenge for orthopaedic surgeons. The aim of this systematic review is to highlight and criticize current concepts in the surgical treatment.

Materials and methods The search was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guideline. A comprehensive research of Pubmed database was made using the following Mesh term: ((Essex-Lopresti injury) OR (Essex Lopresti) OR (distal radio ulnar dissociation) OR (distal radio ulnar dislocation) OR (longitudinal forearm instability)). Quality assessment of each article was performed according to Coleman score by two authors.

Results Eight full articles were included to the systematic review. Surgical treatment was differentiated in five categories according to the most common procedure reported in clinical series. The mean Coleman Score was 51.13 ± 9.76.

Discussion Case series reported in the literature include a limited number of patients with chronic ELL. Currently, salvage procedure devoted to treat a wrong diagnosis and an incorrect treatment is used. Radial head replacement together with ulnar shortening osteotomy and interosseous membrane reconstruction are the most common treatments of choice, but at present, there is not yet a shared scheme of management for patients with chronic ELL.

Conclusions According to current literature, a case-by-case treatment must always be considered. Further investigations, with higher level of evidence, quality of study design, and number of patients, are needed to better assess clinical results and complication of each technique.

Level of evidence: IV.

Keywords Radial head fractures · TFCC injury · Interosseous membrane injury · Longitudinal forearm instability

Introduction

Essex-Lopresti lesion (ELL) is a severe injury of the forearm involving dislocation of distal radio-ulnar joint (DRUJ), radial head fracture, and disruption of interosseous membrane (IOM) [1]. The injury was described by Curr and Coe [2] in 1946, but Essex-Lopresti reporting two cases in 1951 was the first who highlighted the concept of forearm instability caused by the lesion. The current classification of ELL is reported in Table 1.

Due to predominant symptoms referred to radial head fracture, associated lesions can be sometimes missed with delay of diagnosis in the acute phase and worsening of outcomes [3] (Fig. 1). In fact, while treatment of acute phase showed an 80% of success, 80% of failure of chronic incorrectly diagnosed lesions was reported [3–5]. In this scenario, a full radiological assessment of wrist and forearm must always be performed in case of radial head fracture, especially in Mason type 2 fracture or above [4, 6, 7]. In acute setting, dynamic sonography (DS) and forearm magnetic resonance (MR) may help in detecting IOM injury. DS identifies herniation of anterior forearm muscles by compression of anterior compartment [8], and MR may allow direct visualization of the lesion of the central band of IOM in middle third of the forearm [7].

✉ Federico Fusini
fusinif@hotmail.com

[1] Department of Orthopaedics and Traumatology, Orthopaedic and Trauma Center, Azienda Ospedaliero Universitaria Città della Salute e della Scienza di Torino, Via Zuretti, 10126 Torino, Italy

[2] Department of Orthopaedics and Traumatology, Policlinico di Modena, Azienda Ospedaliera Universitaria, Modena, Italy

Table 1 Edward and Jupiter classification of Essex-Lopresti injury

Type of Essex-Lopresti lesion	Description
1	Fracture of the radial head with a large displaced fragment and minimal or no comminution which is amenable to open reduction and internal fixation.
2	Comminuted fracture which cannot be reconstructed. Excision of radial head with radial head prosthesis is advocated to prevent proximal migration of the shaft of the radius.
3	Chronic cases with irreducible proximal migration of the radius. Radius is irreducible at intra-operative traction, ulnar shortening osteotomy must be evaluated in order to restore radial length. More surgical procedure might be necessary.

Despite improvement in diagnostic imaging tools, clinical suspect is the most important factor to promptly recognize an Essex-Lopresti injury. Nevertheless, clinical diagnosis is not easy and many injuries are still diagnosed in chronic phase. Surgical repair or reconstruction of anatomical injured structures and a functional pain-free forearm joint is the ideal goal of treatment in acute phase, but these lesions are difficult to treat and repair without sequelae. In the chronic phase, Essex-Lopresti injuries are even more complex to treat representing a tough challenge for orthopaedic surgeons. At present, there is not a shared scheme of management for patient presenting with chronic Essex-Lopresti injuries. Many different surgical strategies have been proposed in the literature including a limited number of small case series [3, 4, 9–13]. Treatment approach is focused to restoration of normal radio-ulnar length, radial head fracture through repair or replacement, IM reconstruction, and stabilization of DRUJ with pinning to help triangular fibro-cartilage complex (TFCC), and capsular healing process [14].

The aim of this systematic review is to highlight and criticize current concepts in the surgical treatment of chronic ELI.

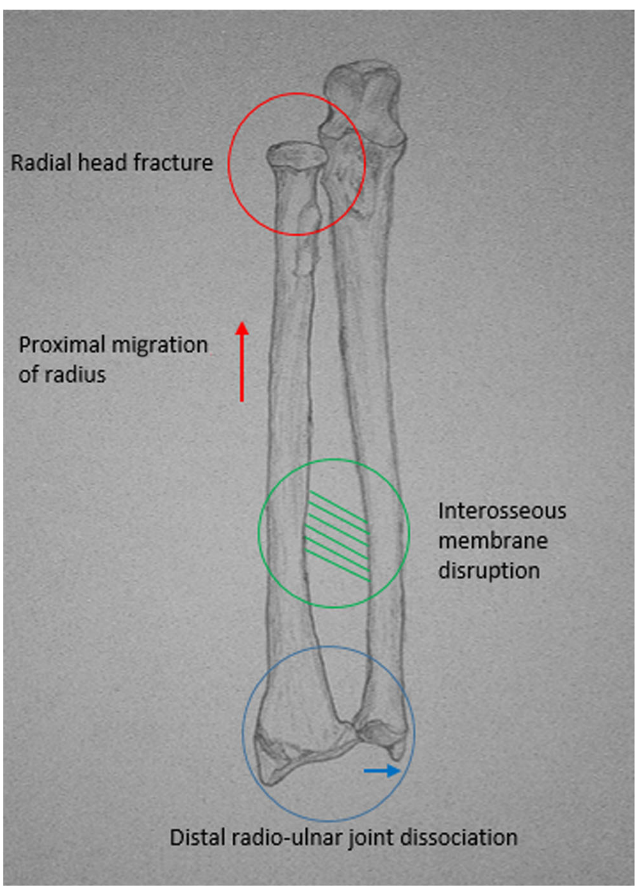


Fig. 1 Overview of (ELL): radial head fracture, distal radio-ulnar dissociation with proximal radial migration and IOM disruption

Materials and methods

The search was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guideline [15]. Nowadays, the optimal surgical treatment for this type of lesion is still not well coded. With our research, we wished to ascertain current evidence in the treatment options of chronic Essex-Lopresti injury.

Source of studies and search strategy

During August 2017, a comprehensive research of Pubmed database was made using the following keywords: Essex-Lopresti injury and distal radio ulnar dissociation. Mesh term was the following: ((Essex-Lopresti injury) OR (Essex Lopresti) OR (distal radio ulnar dissociation) OR (distal radio ulnar dislocation) OR (longitudinal forearm instability)).

Study selection and eligibility criteria

Two authors (SA and FF) performed the search and evaluated the articles independently. A third author (GC) was involved to solve any disagreement. Each researcher reviewed the title and abstract of all the articles. Furthermore, the reference list of each article was screened in order to find any additional original articles. Only articles focused on longitudinal forearm instability treatment of chronic Essex-Lopresti injury were included.

We excluded from our research all repeated articles, radiological and diagnostic studies, case reports, editorials, technical notes, and review articles. Articles not in English or Italian and preclinical studies were also excluded.

Quality assessment

Clinical article quality was assessed independently by two reviewers using Coleman Methodology Score [16]. In many cases, the authors of each paper did not specifically report all the data necessary to determine the score (i.e., assessors, number of procedures); in such a case, data were extracted (if possible) and calculated by two independent authors of the current manuscript. Disagreements between these two assessors were resolved by discussion.

Results

Thirty hundred and forty-nine articles were identified through database search. After duplication removal and study screening, 37 articles were selected. According to the inclusion and exclusion criteria, six full-text articles were included. References of each article were screened in order to find additional articles. Finally, two additional articles were included to the systematic review. The corresponding flow diagram is shown in Figs. 2 and 3.

Since chronic ELLs are undiagnosed by definition after initial trauma, the correct diagnosis is always missed initially. For that reason, first treatment is focused on major symptoms with no attention for other lesions. In this setting, patients underwent an early inappropriate treatment and required further surgery after the correct diagnosis. A summary of main procedures performed are shown in Table 2.

Radial head prosthesis or radial head allograft

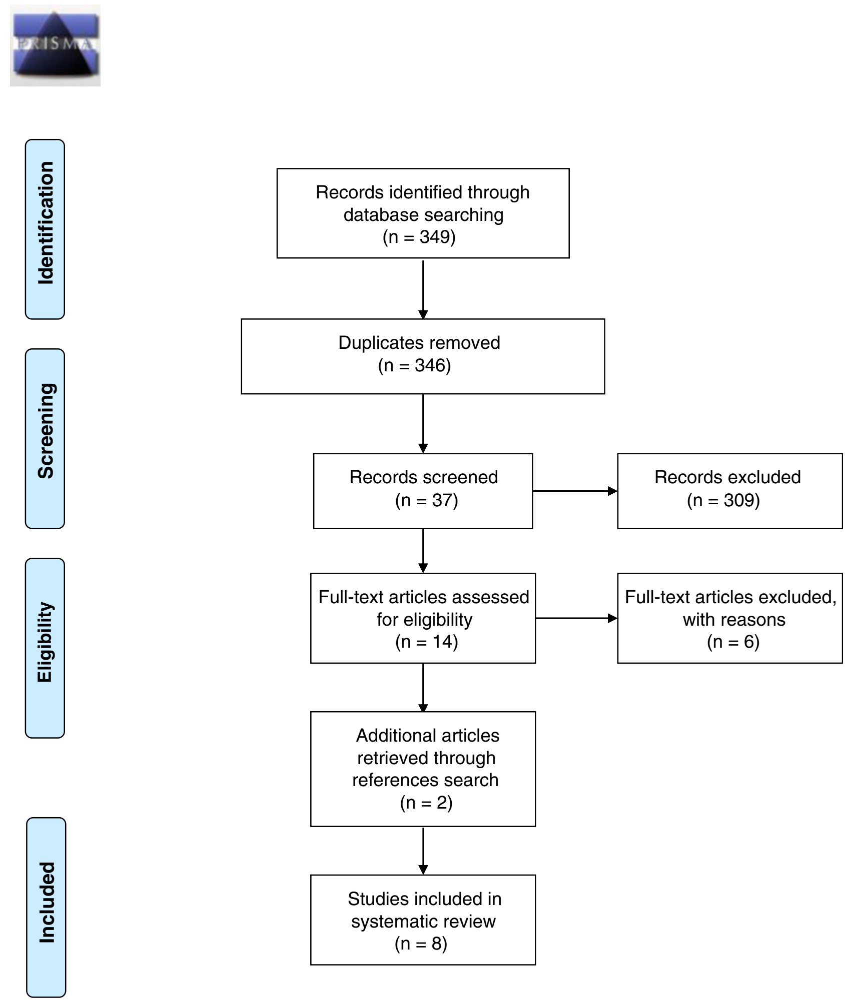
The treatment of complex radial head fractures sequelae in chronic phase of Essex-Lopresti injury has been performed by several authors with radial head replacement with prosthesis [2, 11–13]. Frozen allograft was only used in a small case series, and it has not been reported anymore in the last two decades [12].

Regarding radial head prosthesis, Trousdale et al. described the implant of silicon prosthesis with resolution of elbow and wrist pain, improvement of elbow and wrist range of motion (ROM), and clinical wrist and elbow scores (Morrey Elbow Performance Score (MEPS), Green O'Brien modified score). The patient required further surgery due to heterotopic ossification and laxity of DRUJ [3]. Jungbluth reported in 50% of patients treated with radial head replacement good or satisfactory post-operative Disabilities of the Arm, Shoulder and Hand (DASH) and MEPS scores while ROM highlighted limited extension and prono-supination with a fair flexion. Wrist function was good with no signs of instability while grip strength reached the 89.2% of unaffected side. Other four patients however reported only average or poor functional outcome with weak grip strength [10]. Heijink et al. reported failure of four out of six primary monoblock radial head replacements due to radio capitellar arthritis (one case), aseptic prosthetic stem loosening, and aseptic loosening of radial head prosthesis (three cases), treated with total elbow arthroplasty or cemented bipolar metallic radial head replacement. While primary successful prosthesis trends to good MEPS and fair Mayo Wrist Score and improvement of elbow ROM from pretreatment values, secondary replacement prosthesis showed comparable Mayo Wrist Score, lower MEPS, but better ROM than successful primary prosthesis [9].

In patients treated with frozen allograft, Szabo described a significant improvement of wrist pain, ROM, and forearm rotation after treatment, along with radiological union sign of bone interface, starting two months after surgery. Also, grip strength had comparable value with uninjured side. If patients had length defect, it was corrected with Ilizarov external fixation device. Author also reported some complications: dislocated allograft requiring revision surgery and Ilizarov pins track inflammation, requiring delay of allograft [12].

Fig. 2 **a** AP X-ray evaluation of a typically missed ELL, treated with radial head resection. The patient was evaluated after high energy trauma of the upper limb. Attention was focused to comminute radial head fracture due to major complains referred to elbow and was treated with radial head resection. After 2 months, patients reported worsening of grip strength, wrist pain, and ROM loosening, with this roentgenological picture. **b** AP X-ray of the wrist shows DRUJ widening, with proximal radial migration and loss of distal ulnar negative variance

Fig. 3 PRISMA (Preferred Reporting Items for Systematic review and Meta-Analysis) flow diagram of articles screened, selected, and included in the systematic review



Radial head prosthesis and ulnar shortening osteotomy

Edwards et al. described the treatment of two chronic ELL with radial head substitution and ulnar shortening osteotomy. After treatment, patients showed fair and good Morrey score, grip strength, and supination with improvement from preoperative score. No complications were reported; however, the association with transcaphoid-perilunate dissociation worsened the outcomes of 1 patient [4].

After early inappropriate treatments, Trousdale et al. reported improvement of patients' symptoms and good to fair MEPS and poor Green and O'Brien score. Authors also reported lack of complete elbow extension, supination with good wrist ROM, and moderate residual elbow pain. Some complications were recorded: snapping of radial head stump, elbow instability, and heterotopic ossification. Rupture of prosthetic implant required radial prosthesis substitution and Darrach resection to preserve functionality [3]. Jungbluth et al. reported a case of failure of radial head prosthesis in a patient with concomitant ulnar osteotomy requiring revision surgery with a specially designed bipolar prosthesis [10].

After treatment, Heijink et al. reported improvement of elbow pain and stability, prono-supination, and MEPS with fair and good results; however, the primary treatment of radial head prosthesis failed in one out of two patients with the needing of further surgery [9].

Venouziou et al. in a recent study reported interesting results in a long-term follow-up. Pain drastically improved along with MEPS, elbow flexion-extension, forearm pronation-supination, wrist flexion-extension and Mayo wrist performance score. A little limitation in elbow extension and forearm pronation was reported. Finally, most of patients achieved good clinical results while only two reached fair results. Those patients where procedures were simultaneous showed comparable results with other patients. Only one delayed union was reported in a smoker that finally healed spontaneously [13].

Radial head resection alone or associated with ulnar shortening osteotomy

Radial head resection was already described by Trousdale et al. in 1992 as a successful treatment choice. Morrey score ranged

Table 2 Overview of main procedures performed by the authors in patients with chronic Essex-Lopresti lesion and initially missed diagnosed. Radial head resection (RHR), radial head prosthesis (RHP), interosseous membrane (IOM), ulnar shortening osteotomy (USO), frozen radial head allograft (FRA), open reduction and internal fixation (ORIF)

Author	Year	Number of patients/ gender/age (range)	Surgical procedure (number of patients)
Edwards et al. [7]	1988	2/2M/(19–29)	RHR, followed by RHP and USO (2)
Trousdale et al. [17]	1992	15/7M–8F/(8–74)	RHR (15) (associated with Darrach resection (2), USO(6), DRUJ ligament reconstruction (1), tightening of IOM (1)
Szabo et al. [18]	1997	5/5M/(22–47)	RHR and silicone prosthesis, followed by FRA (associated with radial lengthening through Ilizarov frame (1) and pinning of DRUJ (1))
Jungbluth et al. [12]	2006	12/5F–7M/(26–54)	RHP (10)(associated with USO (1) and Sauve-Kapandji (2)) Sauve-Kapandji (2) (associated with RHR(1))
Heijink et al. [11]	2010	8/4M–4F/(25–51)	RHP (6), USO and RHP (2)
Venouziou et al. [19]	2014	7/5M–2F/(37–58)	RHP and USO (7)
Gaspar et al. [9]	2016	8/2M–6F/(40–59)	Interosseous membrane reconstruction with tightrope associated with ulnar shortening osteotomy(8) (associated with radial head replacement (4) or ORIF of radial head (1))
Schnetzke et al. [20]	2017	15/10M–5F/(27–60)	Conservative management of radial head fracture (6), ORIF radial head fracture (5), RHP (2), RHR (1) (associated with elbow release (6), metal removal (1), removal of RHP (2), reconstruction of IOM (2), surgical wrist release (3), denervation of posterior interosseous nerve (2), USO (1), neurolysis of ulnar nerve (3) and secondary RHP (3))

from poor to excellent with a predominance of fair values, Green and O'Brien score ranged from poor to good score with a prevalence of fair results. Incomplete elbow extension was also reported, and prono-supination was also very limited. Wrist flex-extension had variable results ranging from complete to highly limited. When associated with ulnar shortening osteotomy, MEPS showed fair or excellent score, Green and O'Brien score ranged from poor to fair with a prevalence of poor; elbow extension, pronation-supination, and wrist flexion-extension were limited in all patients. Patients also reported moderate elbow pain in 50% of cases. These patients also reported some complications: heterotopic ossification, instability of the elbow, radio-ulnar synostosis, elbow degeneration, ulnar nerve palsy, and reflex sympathetic dystrophy [3].

After radial head resection, Jungbluth et al. described in one patient unsatisfactory results with the needing of Sauve-Kapandji procedure to preserve stability of DRUJ and ulnar osteotomy to preserve forearm rotation [10].

Interosseous membrane reconstruction

Gaspar et al. proposed the reconstruction of IOM using Mini TightRope Device® along with ulnar shortening osteotomy and simultaneously arthroscopic TFCC repair. After IOM reconstruction, patients demonstrated improvement of elbow and wrist ROM, grip strength, and QuickDASH score compared to pre-operative evaluation. Patients reported also high satisfaction for this treatment. Some patients however needed revision with ulnar osteotomy (secondary to ulnar impingement), fixation of radial shaft fracture (secondary to ground level fall at the site of radial device tunnel), and removal of Mini ThightRope (due to lack of supination) [21].

Other procedure (Sauve-Kapandji, radial head ORIF)

In some cases, the author described other procedure after failure of early inappropriate treatment.

Sauve-Kapandji procedure was reported alone or in association with radial head resection and radial head prosthesis removal in limited cases. Jungbluth et al. proposed this procedure after restoration of correct radio-ulnar alignment when DRUJ remained unstable, resulting in weak grip strength. After Sauve-Kapandji procedure all the patients regained good grip strength having a stable fused DRUJ. No complications related to this technique were reported in this case series [10].

After inappropriate primary treatment of undiagnosed ELL, Schnetze et al. proposed a treatment on an individual basis according to the major symptoms. In particular, patients with conservative approach or ORIF of radial head fracture endured elbow and wrist stiffness which required arthroscopic or open release. Some patients also suffered from nerve compression symptoms or neuropathic pain and required neurolysis of ulnar nerve or interosseous nerve denervation. When compared with early treated ELL, patients had lower functional scores (MEPS, Mayo Wrist Score, DASH) and more pain; however, elbow and wrist ROM are comparable in both groups. However, some patients needed a secondary radial head replacement to mitigate elbow symptoms [11].

Methodological quality evaluation for clinical studies

The majority of studies included in the review had some methodological limitations with an average Coleman Methodology Score of 51.13 points and SD of 9.76 points (range 36–66). Only two out of eight studies reach a methodological score of at least 60 points. In particular, all studies have a poor design because they are all retrospective series, with the lack of a rehabilitation protocol or the description of selection process. Sample size was often really low, since only one study reaches at least 20 participants. Moreover, in some cases, it is not clear who evaluated the patients at enrolment and at follow-up (the treating physician or an independent investigator). No randomized control trials or prospective cohort study were retrieved in our analysis.

Discussion

A thorough understanding of anatomy and biomechanics of the forearm joint is the basis for the rationale treatment of acute and chronic Essex-Lopresti injuries. The forearm acts as a functional joint with a single axis of rotation and three lockers that should be mobile and stable in order to allow load transfer and full range of movement [22]. In Essex-Lopresti injury, the proximal radio-ulnar joint (PRUJ), the middle radio-ulnar joint (MRUJ), and the distal radio-ulnar joint (DRUJ) that represent the three forearm lockers are damaged and unstable impairing forearm functional unit. Instability occurs longitudinally with loss of relationship among radius and ulna, and transversally with dislocation of PRUJ and/or DRUJ [22]. In acute phase, Essex-Lopresti injury may be classified according to Edwards and Jupiter in the following: type I with large displaced radial head fractures that can be fixed with open reduction and internal fixation (ORIF) and type II with comminuted fractures requiring radial head replacement [4]. In chronic phase, patient with ELL sequelae presented with pain and loss of strength and mobility at the elbow and/or wrist joint. In this scenario, corresponding to type III Essex-Lopresti injury, the impairment of peripheral lockers with irreducible proximal radial migration may lead to radio-capitellar abutment syndrome and radio-capitellar arthritis (PRUJ) and posterior dislocation and overload of the ulnar head (DRUJ) becoming a major source of pain. The impairment of the central locker (MRUJ) even if not directly responsible for elbow and wrist pain is in chronic phase part of the problem and should be addressed increasing stability and balancing load transfer at forearm.

Several authors agree that the most important factor that should be reached with surgery is to re-establish the appropriate longitudinal relationship between the radius and the ulna [10, 22]. Dumontier and Saubeyrand stated that the PRUJ and DRUJ should be reduced to stabilize the forearm [22] and that this might be achieved by radial head replacement correcting proximal migration [23] and/or by shortening of distal ulna [22].

Theoretically, in acute cases, repair or replacement of anatomical lockers should be the most appropriate treatment of Essex-Lopresti injuries. On the contrary, in chronic cases, symptoms and features of locker lesions can be different preventing a standard surgical technique to be used in all the patients.

Historically, as already stated by Essex-Lopresti, surgical treatment is mainly based on radial head replacement that may be used for sequelae of comminuted fracture and resection of radial head [1]. Silicone implants and radial head allograft have been used in the past for radial head replacement, but they have been abandoned because of high rate of complication and insufficient support to force transmission trough the radius [12]. At present, the most common and reliable replacement technique is radial head prosthesis that may prevent proximal radial migration allowing radio-ulnar reduction and load transmission through the radius [24].

Radial head resection showed a prevalence of fair results with Morrey and Green and O'Brien score in the clinical series reported by Trousdale, and this procedure alone was considered an inappropriate intervention according to Jungbluth and Daecke [3, 10, 20].

At the moment, there is no available information in the literature about the treatment of established humerus-radial arthritis in chronic Essex-Lopresti and just one patient included in clinical series reported by Jungbluth sustained a specially designed humeral radial prosthetic implant after removal of a loosened radial head prosthesis with capitellum humeri degeneration [10].

The role of IOM reconstruction in chronic Essex-Lopresti injuries has still to be established. From mechanical point of view, IOM reconstruction might improve longitudinal instability and allow load transmission from radius to ulna balancing and sharing force stresses at forearm and elbow joint [24–27]. Promising results of IOM reconstruction for treatment of chronic forearm instability have been recently reported by Gaspar in eight patients with short to midterm follow-up (mean 34.6 months) improving grip strength, QuickDASH scores, wrist and elbow range of motion, and ulnar variance [21]. Nonetheless, clinical experience of IOM reconstruction is still limited and most cases reported are single patient or patients included in limited case series preventing definitive conclusions about this issue [17–19, 21, 23, 28].

The wrist surgical strategy involves procedure aimed to correct radio-ulnar variance, reduce dorsal ulnar dislocation, and stabilize DRUJ [22]. Ulnar shortening has been performed by several authors together with radial head replacement in order to address radio-ulnar length discrepancy allowing ulnar head reduction [3, 4, 9, 10, 13]. Nevertheless, none of the case series were analyzed in this systematic review and including ulnar shortening for chronic Essex-Lopresti injury grouped patients with the same procedure. When radio-ulnar relationship is restored and fibrosis removed, a stabilization of DRUJ may be indicated with TFCC reconstruction provided that the DRUJ is not yet degenerated [18, 29, 30]. On the contrary, when DRUJ remains unstable despite correct radio-ulnar relationship, the Sauve-Kapandji procedure may represent a valuable option to recover a stable wrist [10]. Moreover, this procedure may be used in chronic phase of Essex-Lopresti injury if both residual instability and degenerative changes of DRUJ are observed.

Study limits

Our review is limited by the low number of article retrieved. Furthermore, most of the patients with a chronic ELL underwent an early inappropriate treatment due to the missing of correct diagnosis. These procedures may have influenced negatively functional score and commonly clinical score differed between studies. Moreover, all articles have a low number of patients and sometimes it was not possible to retrieve which patient underwent each procedure or series of procedure.

Conclusion

Essex-Lopresti injuries are still a challenge for orthopaedic surgeon. These lesions are uncommon, severe, and difficult to recognize in acute phase. For this reason, many patients are identified and treated when symptoms persist impairing elbow and wrist function. Surgical strategy should ideally restore longitudinal relationship between radius and ulna ensuring transversal forearm stability at the three lockers. Unfortunately, case series reported in the literature included a limited number of patients and were often nonhomogeneous with various combinations of procedures performed. Several treatments were proposed in order to relieve pain and improve forearm function, but no one demonstrated an overwhelming superiority among studies.

Even if radial head replacement, ulnar shortening osteotomy and IOM reconstruction alone and in combination are the most common surgical treatments reported in the literature; at present, there is not yet a shared scheme of management for patients with chronic Essex-Lopresti injuries. A case-by-case surgical treatment must always be considered. Further investigations, with higher level of evidence, quality of study design, and number of patients, are needed to better assess clinical results and complication of each technique.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Essex-Lopresti P (1951) Fractures of the radial head with distal radio-ulnar dislocation; report of two cases. J Bone Joint Surg Br Vol 33b(2):244–247
2. Curr JF, Coe WA (1946) Dislocation of the inferior radio-ulnar joint. Br J Surg 34:74–77
3. Trousdale RT, Amadio PC, Cooney WP, Morrey BF (1992) Radio-ulnar dissociation. A review of twenty cases. J Bone Joint Surg Am Vol 74(10):1486–1497
4. Edwards GS, Jr., Jupiter JB (1988) Radial head fractures with acute distal radioulnar dislocation. Essex-Lopresti revisited. Clin Orthop Relat Res 234:61–69
5. Karlstad R, Morrey BF, Cooney WP (2005) Failure of fresh-frozen radial head allografts in the treatment of Essex-Lopresti injury. A report of four cases. J Bone Joint Surg Am 87(8):1828–1833. https://doi.org/10.2106/jbjs.d.02351
6. Hausmann JT, Vekszler G, Breitenseher M, Braunsteiner T, Vecsei V, Gabler C (2009) Mason type-I radial head fractures and interosseous membrane lesions—a prospective study. J Trauma 66(2):457–461. https://doi.org/10.1097/TA.0b013e31817fdedd
7. McGinley JC, Gold G, Cheung E, Yao J (2014) MRI detection of forearm soft tissue injuries with radial head fractures. Hand (New York, NY) 9(1):87–92. https://doi.org/10.1007/s11552-013-9561-2
8. Soubeyrand M, Lafont C, De Georges R, Dumontier C (2007) Traumatic pathology of antibrachial interosseous membrane of forearm. Chir Main 26(6):255–277. https://doi.org/10.1016/j.main.2007.09.004
9. Heijink A, Morrey BF, van Riet RP, O'Driscoll SW, Cooney WP 3rd (2010) Delayed treatment of elbow pain and dysfunction following Essex-Lopresti injury with metallic radial head replacement: a case series. J Shoulder Elbow Surg 19(6):929–936. https://doi.org/10.1016/j.jse.2010.03.007
10. Jungbluth P, Frangen TM, Arens S, Muhr G, Kalicke T (2006) The undiagnosed Essex-Lopresti injury. J Bone Joint Surg Br Vol 88(12):1629–1633. https://doi.org/10.1302/0301-620x.88b12.17780
11. Schnetzke M, Porschke F, Hoppe K, Studier-Fischer S, Gruetzner PA, Guehring T (2017) Outcome of early and late diagnosed Essex-Lopresti injury. J Bone Joint Surg Am Vol 99(12):1043–1050. https://doi.org/10.2106/jbjs.16.01203
12. Szabo RM, Hotchkiss RN, Slater RR Jr (1997) The use of frozen-allograft radial head replacement for treatment of established symptomatic proximal translation of the radius: preliminary experience in five cases. The Journal of Hand Surgery 22(2):269–278. https://doi.org/10.1016/s0363-5023(97)80163-3
13. Venouziou AI, Papatheodorou LK, Weiser RW, Sotereanos DG (2014) Chronic Essex-Lopresti injuries: an alternative treatment method. J Shoulder Elbow Surg 23(6):861–866. https://doi.org/10.1016/j.jse.2014.01.043
14. Stabile KJ, Pfaeffle HJ, Tomaino MM (2002) The Essex-Lopresti fracture-dislocation factors in early management and salvage alternatives. Hand Clin 18(1):195–204
15. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D (2009) The PRISMA statement for reporting systematic reviews

and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol 62(10):e1–e34. https://doi.org/10.1016/j.jclinepi.2009.06.006

16. Coleman BD, Khan KM, Maffulli N, Cook JL, Wark JD (2000) Studies of surgical outcome after patellar tendinopathy: clinical significance of methodological deficiencies and guidelines for future studies. Victorian Institute of Sport Tendon Study Group. Scand J Med Sci Sports 10(1):2–11
17. Miller AJ, Naik TU, Seigerman DA, Ilyas AM (2016) Anatomic Interosseus membrane reconstruction utilizing the biceps button and screw tenodesis for Essex-Lopresti injuries. Tech Hand Upper Extrem Surg 20(1):6–13. https://doi.org/10.1097/bth.0000000000000107
18. Chloros GD, Wiesler ER, Stabile KJ, Papadonikolakis A, Ruch DS, Kuzma GR (2008) Reconstruction of Essex-Lopresti injury of the forearm: technical note. J Hand Surg 33(1):124–130. https://doi.org/10.1016/j.jhsa.2007.09.008
19. Sabo MT, Watts AC (2012) Reconstructing the interosseous membrane: a technique using synthetic graft and endobuttons. Tech Hand Upper Extrem Surg 16(4):187–193. https://doi.org/10.1097/BTH.0b013e3182634ce4
20. Daecke W, Martini AK (2004) Secondary treatment for undetected Essex-Lopresti lesion. Z Orthop Grenzgeb 142(2):235–240. https://doi.org/10.1055/s-2004-823087
21. Gaspar MP, Kane PM, Pflug EM, Jacoby SM, Osterman AL, Culp RW (2016) Interosseous membrane reconstruction with a suture-button construct for treatment of chronic forearm instability. J Shoulder Elbow Surg 25(9):1491–1500. https://doi.org/10.1016/j.jse.2016.04.018
22. Dumontier C, Soubeyrand M (2014) The forearm joint. In: Bentley G (ed) European surgical Orthopaedics and traumatology: the EFORT textbook. Springer, Berlin, pp 1509–1524. https://doi.org/10.1007/978-3-642-34746-7_209
23. Soubeyrand M, Oberlin C, Dumontier C, Belkheyar Z, Lafont C, Degeorges R (2006) Ligamentoplasty of the forearm interosseous membrane using the semitendinosus tendon: anatomical study and surgical procedure. Surg Radiol Anat 28(3):300–307. https://doi.org/10.1007/s00276-006-0086-z
24. Marcotte AL, Osterman AL (2007) Longitudinal radioulnar dissociation: identification and treatment of acute and chronic injuries. Hand Clin 23(2):195–208, **vi**. https://doi.org/10.1016/j.hcl.2007.01.005
25. Werner FW, LeVasseur MR, Harley BJ, Anderson A (2017) Role of the Interosseous membrane in preventing distal radioulnar gapping. J Wrist Surg 6(2):97–101. https://doi.org/10.1055/s-0036-1584545
26. Adams JE, Culp RW, Osterman AL (2016) Central band Interosseous membrane reconstruction for forearm longitudinal instability. J Wrist Surg 5(3):184–187. https://doi.org/10.1055/s-0036-1585070
27. Soubeyrand M, Ciais G, Wassermann V, Kalouche I, Biau D, Dumontier C, Gagey O (2011) The intra-operative radius joystick test to diagnose complete disruption of the interosseous membrane. J Bone Joint Surg Brit Vol 93(10):1389–1394. https://doi.org/10.1302/0301-620x.93b10.26590
28. Brin YS, Palmanovich E, Bivas A, Sagiv P, Kotz E, Nyska M, Kish BJ (2014) Treating acute Essex-Lopresti injury with the TightRope device: a case study. Tech Hand Up Extrem Surg 18(1):51–55. https://doi.org/10.1097/bth.0000000000000036
29. Matson AP, Ruch DS (2016) Management of the Essex-Lopresti injury. J Wrist Surg 5(3):172–178. https://doi.org/10.1055/s-0036-1584544
30. Ruch DS, Chang DS, Koman LA (1999) Reconstruction of longitudinal stability of the forearm after disruption of interosseous ligament and radial head excision (Essex-Lopresti lesion). J South Orthop Assoc 8(1):47–52