The Serially-Operated Essex-Lopresti Injury: Long-Term Outcomes in a Retrospective Cohort

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J Hand Microsurg 2020;12:47–55

Abstract

Objective The main aim of this article is to report 10-year outcomes after Essex-Lopresti injury (ELI).

Study Design Retrospective case series. Two level I trauma centers and one associated community hospital from 2003 to 2016.

Patients Sixteen patients who sustained an ELI and were treated at one of our three regional hospitals.

Intervention Initially, 4 patients (25%) were treated nonoperatively by immobilization and 12 patients (75%) were treated operatively. Proximal surgery included radial head open reduction and internal fixation (ORIF), radial head arthroplasty, radial head excision and forearm ORIF, and wound debridement. Ten patients (63%) were acutely identified with longitudinal forearm instability. Of these, four patients had the distal radioulnar joint pinned. In the other six patients, the forearm was immobilized. Overall, 16 patients underwent a total of 32 revision surgeries.

Main Outcome Measure Performance of Patient-Reported Outcomes Measurement Information System Upper Extremity (PROMIS UE) Physical score, Numeric Rating Scale (NRS) score for pain-severity, and NRS score for satisfaction of overall outcome.

Results Follow-up for outcome evaluation was available for 10 patients, at a median of 10 (interquartile range [IQR]: 8.0–12) years after date of injury. The median PROMIS UE Physical score was 36 (IQR: 33–38). Median NRS score for pain-severity on average was 5 (IQR: 0–6). The median NRS score for satisfaction of overall outcome was 7 (IQR: 5–8).

Conclusion Patients who sustain an ELI generally have substantial deficits of upper extremity function as measured by PROMIS UE. Early radial head arthroplasty may be beneficial, but further study in a larger cohort is needed. Outcomes of nonoperative treatment and operative treatment were similar and suggest that current surgical treatments are incomplete.

Keywords
- distal radioulnar joint disruption
- Essex-Lopresti
- interosseous membrane rupture
- longitudinal forearm dissociation

Introduction

The Essex-Lopresti injury (ELI) consists of a fracture of the radial head and disruption of the soft tissue restraints between the radius and the ulna, including the interosseous ligament (IOL).[1] There is a general consensus that acute surgery is preferred, but not always feasible.[1-11] Because diagnosis is not always immediately clear and this injury involves multiple structures, multiple surgeries are common.[4,11-14]

Surgical treatment of the proximal forearm ranges from radial head fixation to replacement, and treatment of the distal forearm ranges from simple immobilization to distal

received
February 27, 2019
accepted
August 9, 2019
published online
January 16, 2020

DOI https://doi.org/10.1055/s-0039-3401380
ISSN 0974-3227.

radioulnar joint (DRUJ) stabilization with pins. Late reconstruction may involve IOL reconstruction, or may involve late salvage such as Sauvé-Kapandji or creation of a single bone forearm.[3,6-11]

We sought to describe patient, injury, and treatment characteristics and to report long-term outcomes after treatment of patients presenting with ELI at a metropolitan health system encompassing two tertiary level academic medical centers.

Materials and Methods

Patient Selection

This retrospective case series was approved by our institutional review board. International Classification of Diseases (ICD) codes for radial head fracture and subluxation/dislocation of the DRUJ were used to identify patients. Sixteen patients were treated for an ELI at one of our three regional hospitals: two level I trauma centers and one associated community hospital between January 2003 and December 2016.

All clinical, operative, and radiologist reports were assessed for (variations and misspellings of) "Essex-Lopresti"/"longitudinal forearm dissociation." Patients who had a mention of any of these terms were reviewed for inclusion and were characterized by the triad of radial head fracture, interosseous membrane (IOM) rupture, and DRUJ disruption. The diagnosis of an ELI was established by a combination of clinical signs and radiographic evidence: widening of the DRUJ, proximal migration of the radius, or dorsal subluxation of the ulna on radiographs of the wrist (►**Fig. 1**).

Outcome Evaluation

Patients were sent a letter of invitation to participate in or opt-out of the study. We approached participating patients to complete patient-rated outcomes surveys administered over the Internet or over the phone.[15,16] The level of pain on average in both the elbow and the wrist was assessed using a Numeric Rating Scale (NRS), with 0 indicating no pain and 10 indicating the worst pain imaginable. Satisfaction with the overall outcome of their treatment was also assessed using a NRS, with 0 indicating not satisfied at all and 10 indicating highly satisfied. Patients were asked to complete the Performance of Patient-Reported Outcomes Measurement Information System (PROMIS) Upper Extremity Physical Function computed tomography to evaluate physical function and upper

Fig. 1 Radiographs of the wrist ([**A**] posteroanterior, [**B**] lateral) at day of presentation, with evident widening of distal radioulnar joint and dorsal subluxation on the ulna.

extremity disability. In this questionnaire, a T-score of 50 represents the norm in the US population, and every 10 points represent a standard deviation from the norm.[17]

Statistical Analysis

We described discrete data using frequencies and percentages, and non-normally distributed continuous data through medians and interquartile ranges (IQRs). For our bivariate analysis, we used the Mann–Whitney *U*-test.

Results

Patient Characteristics

There were 14 men and 2 women with a mean age of 42 ± 10 years at the time of injury (►**Table 1**). Six patients (38%) were treated at outside facilities before presenting to us. Three of these six patients underwent surgical intervention at the radial head (one open reduction and internal fixation (ORIF) of the radial head, one radial head prosthesis, and one radial head excision). These patients presented to our institution after late complaints of wrist pain following initial treatment. The other three patients were treated conservatively initially and were diagnosed with longitudinal forearm instability after delayed development of wrist and elbow symptoms.

Injury Characteristics

Ten patients (63%) had falls from a height, four (25%) had a simple fall, one (6.3%) was injured playing sports, and one (6.3%) was injured in a motor vehicle accident (►**Table 1**). Nine (56%) patients had additional injuries to the upper limb, five (31%) had injuries in other limbs or organ systems, and four (25%) had an isolated ELI. One patient (6.3%) presented with bilateral longitudinal forearm instability. Of the five patients that underwent ORIF, in three cases there were greater than three radial head fragments present and in two cases, the operative notes did not describe the number of fragments. The type of ELI was based on the previously described classification by Edwards and Jupiter: type I—radial head fracture with a large displaced fragment amenable to ORIF; type II—comminuted radial head fracture not amenable to ORIF; and type III—irreducible proximal migration of the radius.[4] Eight patients (50%) had a type I injury, six (38%) had a type II injury, and two (13%) had a type III injury.

Treatment

Initial Treatment

The initial treatment was defined as the treatment that was chosen as initial definitive management. Four patients (25%) were treated nonoperatively by immobilization and 12 patients (75%) were treated operatively (►**Table 2**). Three patients were treated nonoperatively because the injury was not recognized initially. One patient treated nonoperatively elected not to pursue intervention. Proximal surgery included radial head ORIF (n = 5, 31%), radial head arthroplasty (n = 5, 31%), radial head excision and forearm ORIF (n = 1, 6.5%), and wound debridement (n = 1, 6.5%). Ten patients (63%) were acutely identified with longitudinal forearm instability. Of the 10 who underwent radial head ORIF or arthroplasty, 4 had the DRUJ pinned. In the other six patients, the forearm was immobilized for a period between 3 and 8 weeks. Four patients had a chronic injury (defined as older than 6 weeks) at the time of their first surgical intervention.

Table 1 Patient and injury characteristics

Patient	Age at injury	Sex	Side injury	Mechanism of injury	Type[a]	Additional injury to upper limb
1	65	F	Left	Fall	1	TFCC tear
2_right	40[b]	M	Right	Fall from height	3	Not extractable from chart
2_left	40[b]		Left	Fall from height	3	TFCC tear
3	36	M	Left	Fall from height	2	None
4	40[b]	M	Left	Fall from height	1	Unstable MCL and LCL
5	44	M	Left	Fall from height	1	None
6	24[b]	M	Left	Fall	3	Not extractable from chart
7	34	M	Right	Fall	2	Unstable LCL
8	43	M	Right	Fall from height	1	None
9	46	F	Right	Fall	1	None
10	36	M	Left	Fall	1	TFCC tear, hamate hook fracture
11	41	M	Left	Fall from height	2	Unstable LCL, index MC fracture
12	49	M	Left	Fall from height	1	Unstable LCL, scaphoid fracture
13	52	M	Left	Fall from height	2	Unstable LCL
14	45	M	Right	MVA	2	None
15	27	F	Left	Fall from height	1	Distal radius fracture
16	53	M	Left	Fall from height	2	None

Abbreviations: LCL, lateral collateral ligament; MC, metacarpal; MVA, motor vehicle accident; TFCC, triangular fibrocartilage complex.
[a]Classification by Edwards and Jupiter (1988).
[b]Based on available data in charts.

Table 2 Treatment-related characteristics

Patient	Transferred from other hospital for tertiary treatment	Treatment at other hospital	Time from injury to surgery at our hospital	Treatment at our hospital	Additional surgical procedure	Type subsequent operations at our hospital	Number of surgeries
1	No		2 wk	ORIF radial head and DRUJ pinning	Open TFCC repair	Removal of hardware and arthrotomy left elbow with capsular excision	2
2_right	Yes	ORIF forearm and radial head excision	12 y	Radial head prosthesis	Ulna shortening osteotomy and lateral epicondyle debridement	1. Hardware removal ulnar shaft, revision radial head prosthesis, capitellum prosthesis, ulnar wrist release with flexor pronator Z lengthening with submuscular transposition 2. Median nerve release, elbow arthroscopy with synovectomy and osteectomy of posterolateral olecranon 3. Wrist arthroscopy and synovectomy, DRUJ arthroplasty with Aptis prosthesis	5
2_left	Yes	ORIF forearm and radial head excision	12 y	Radial head prosthesis and DRUJ stabilization with ECU tendon graft	Wrist arthroscopy, TFCC debridement, ulnar nerve release, flexor pronator z lengthening, lunate triquetral reconstruction using extensor retinaculum, pinning lunate triquetral	1. Revision radial head prosthesis, distal ulnar resection, median and radial nerve release 2. DRUJ arthroplasty with Aptis prosthesis 3. Removal DRUJ prosth 4. esis, DRUJ fusion with iliac crest bone grafting 5. Redo DRUJ effusion with right side iliac crest bone grafting 6. Removal of hardware Left wrist arthroscopy with complete synovectomy, left elbow open arthrotomy with debridement and synovectomy 7. Left elbow and wrist arthroscopy with synovectomy and debridement	9
3	No		2 wk	Radial head prosthesis		1. Removal of radial head prosthesis and debridement of heterotopic ossification	2
4	No		1 wk	ORIF radial head	Repair LCL and MCL, ulnar nerve neurolysis	1. Radial head prosthesis 2. Ulna shortening osteotomy	3
5	Yes	Nonoperative treatment	8 mo	Debridement radial head with microfracturing	Anterior capsule release	1. Radial head excision 2. Radial head prosthesis	3

(continued)

Table 2 *(continued)*

Patient	Transferred from other hospital for tertiary treatment	Treatment at other hospital	Time from injury to surgery at our hospital	Treatment at our hospital	Additional surgical procedure	Type subsequent operations at our hospital	Number of surgeries
6	Yes	Radial head prosthesis, removal prosthesis	15 y	Debridement PRUJ		1. Radial head prosthesis 2. Removal radial head prosthesis and fusion with iliac crest bone graft 3. Removal of hardware	6
7	yes	Nonoperative treatment	6 wk	Radial head prosthesis and DRUJ pinning	Repair LCL		1
8	No		1 wk	ORIF radial head		1. Removal of hardware	2
9	No		n/a	Nonoperative treatment			0
10	No		n/a	Nonoperative treatment			0
11	No		2 wk	Radial head prosthesis and DRUJ pinning	Repair LCL, ORIF index MC fracture		1
12	No		1 d	ORIF radial head	Repair LCL		1
13	No		3 d	Radial head prosthesis and DRUJ pinning	Repair LCL	1. Removal of hardware (pins DRUJ) 2. Reconstruction DRUJ with free tendon graft 3. Sauvé-Kapandji arthrodesis	4
14	Yes	Debridement wound and repair triceps laceration	8 mo	Radial head excision	Excision heterotopic ossification PRUJ, excision distal ulna		2
15	Yes	ORIF radial head and distal radius fracture, release compartment syndrome, removal pins	8 mo	Removal of hardware	Excision heterotopic ossification, capsular release		4
16	No		2 wk	Radial head prosthesis and DRUJ pinning		1. Excision scar and heterotopic ossification elbow	2

Abbreviations: DRUJ, distal radioulnar joint; ECU, extensor carpi ulnaris; LCL, lateral collateral ligament; MC, metacarpal; MCL, medial collateral ligament; ORIF, open reduction internal fixation; PRUJ, proximal radioulnar joint; TFCC, triangular fibrocartilage complex.

Subsequent Operations

Overall, 16 patients underwent a total of 32 revision surgeries (median 1; interquartile range [IQR]: 1–3). The median time from the injury to final surgery was 8 months (IQR: 4–15).

Reoperation at the Proximal Forearm

Nine patients (56%) underwent a reoperation at the proximal forearm. Four of the five patients (80%) who underwent plate fixation of the radial head or neck underwent reoperation to remove the plates. Three patients had plates removed for hardware irritation. One patient had failure of fixation and underwent a revision to a radial head arthroplasty. Two of the five patients (40%) with radial head prostheses underwent resection arthroplasty because of pain and restricted motion of the elbow. Seven patients underwent late operative intervention at the elbow involving capsular release with joint debridement.

Reoperation at the Distal Forearm

Four patients (25%) underwent a reoperation at the distal forearm. DRUJ reconstruction was attempted in three forearms (two DRUJ replacements with implant arthroplasty, and one DRUJ reconstruction using a palmaris longus weave). Two of the three reconstructed DRUJs ultimately underwent further revision, with one of the implant arthroplasties being revised to a one-bone forearm, and the DRUJ reconstructed using a palmaris longus weave later underwent fusion through a Sauvé-Kapandji procedure. One additional patient with persistent pain and severe DRUJ arthritis also underwent creation of a one-bone forearm by DRUJ fusion with iliac crest bone graft (►**Fig. 2**). Three patients underwent ulnar shortening osteotomy. No patient underwent IOL reconstruction.

Outcomes

Follow-up for outcome evaluation was available for 10 patients, at a median of 10 (IQR: 8.0–12) years after date of injury. The median PROMIS Upper Extremity Physical score was 36 (IQR: 33–38). Median NRS score for pain-severity on average was 5 (IQR: 0–6). The median NRS score for satisfaction of overall outcome was 7 (IQR: 5–8) (►**Table 3**).

Classifying by initial treatment (nonoperative vs. operative), we found for conservative treatment a median PROMIS Upper Extremity Physical score of 41 (IQR: 32–50), a median NRS score for pain-severity on average of 2.5 (IQR: 0–5), and a median NRS score for satisfaction of overall outcome of 5.5 (IQR: 2.5–8). For operative treatment, we found a median PROMIS Upper Extremity Physical score of 33 (IQR: 33–37), a median NRS score for pain-severity on average of 5 (IQR: 2–6), and a median NRS score for satisfaction of overall outcome of 7 (IQR: 5–8) (►**Table 3**). An additional analysis was performed to compare the patients initially treated with DRUJ pinning versus those not initially treated with DRUJ pinning. With our cohort, we did not identify differences when looking at PROMIS Upper Extremity Physical score (median of 36 vs. 33; $p = 0.85$), NRS score for pain-severity (median of 3.5 vs. 5; $p = 0.85$), and NRS score for satisfaction of overall outcome (median of 7.5 vs. 6; $p = 0.39$).

Discussion

Longitudinal forearm instability arises because of structural incompetence of the radial head, IOL, and DRUJ.[1,3,4,18-20] Treatment approaches vary widely. We aimed to describe a cohort of patients including the treatment course and long-term patient-reported outcomes for this difficult injury pattern. There is a high reoperation rate at both the proximal and

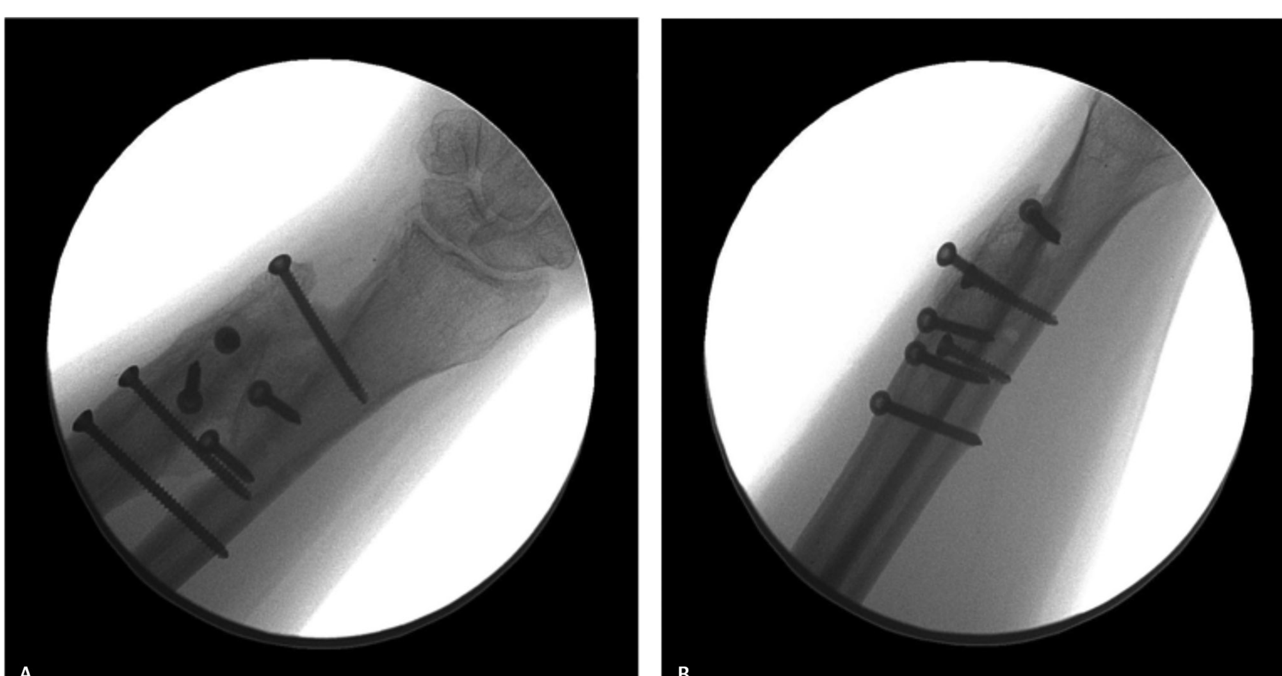

Fig. 2 Radiographs of the wrist ([**A**] posteroanterior, [**B**] lateral) after distal radioulnar joint fusion with iliac crest bone graft.

Table 3 Outcome assessment categorized by initial treatment

	Measurement				
Case number	PROMIS UE	Pain (0–10)	Satisfaction (0–10)	Number of surgeries	Follow-up (in years)
Nonoperative					
5	27.1	5	0	3	11
7	44.4	0	10	1	15
9	37.5	5	6	0	12
10	56.4	0	5	0	8.1
Operative					
Radial head ORIF					
1	30.4	6	2	2	12
15	32.9	4	5	4	2.2
Radial head excision					
2R	32.9	6	7	5	24
2L	32.9	6	7	9	24
Radial head arthroplasty					
11	36.0	0	10	1	9.8
13	37.4	5	7	4	8.0
16	36.7	2	8	2	3.8

Abbreviations: ORIF, open reduction internal fixation; PROMIS UE, performance of patient-reported outcomes measurement information system upper extremity.

distal forearm, persistent deficits in long-term physical function, and a high prevalence of residual pain. Regardless of treatment, it appears that most patients have residual upper limb disability, with a median PROMIS UE of 36 and a median NRS pain score of 5.

This study is limited in its retrospective nature. As no specific ICD code exists for ELI, we used a combination of codes for radial head fracture and subluxation/dislocation of the DRUJ, which introduces the possibility that patients were missed due to misclassification of their injury. Surveys were administered over the Internet or over the phone, so it was not possible to evaluate objective functional status such as range of motion and grip strength. Given the small sample size and the diversity of procedures used to treat these patients, limited conclusions can be drawn from this cohort. However, this report is unique in its inclusion of long-term patient-reported outcomes, with follow-up at a median of 10 years after date of injury. Further, this cohort consists of a variety of early and late diagnosed ELI patients whose treatment was based on timing and recognition of symptoms.

Research about the most optimal treatment for ELI remains inconclusive because of the complexity of the diagnosis, which is often overlooked. In a series of 20 patients, only 25% were fully recognized acutely, with 75% delayed diagnosis on an average of 7.92 years after injury.[11] Another study reported a correct diagnosis in the acute situation in 38% among 106 referral cases.[21] Often the radial head fracture is diagnosed and treated at initial presentation, but the injury of the IOM and DRUJ is missed.[4,5] Six patients (37%) in our series did not have immediate recognition of their injury.

In our series, 10 patients (63%) were acutely identified with longitudinal forearm instability and underwent DRUJ immobilization by pinning or splinting besides treatment of their elbow injury. Treatment options for reestablishing forearm stability continue to evolve, because of increasing knowledge about forearm anatomy and instability patterns.[20] A variety of augmentation techniques have been investigated for IOM reconstruction. In our cohort, there were no attempts to directly address IOM injury surgically.[2,18,22-24]

In elbow fracture dislocations, radial head fractures with three or fewer articular fragments may be amenable to ORIF, but with multiple fragments in the unstable elbow, arthroplasty is recommended.[1,12,25-27] Edwards and Jupiter found that radial excision alone led to poor results, and recommended an ulna shortening procedure with radial head arthroplasty when not immediately recognized as an ELI.[4] In our series of ELI injuries, there was a trend toward better long-term function, higher satisfaction scores, and lower pain scores when the radial head was replaced as initial treatment, suggesting that arthroplasty may be a preferred route of treatment. However, regardless of treatment technique used at the proximal forearm, our cohort demonstrated a high rate of reoperation at this location. Two out of five radial head prostheses were removed because of pain and limited motion, and all four patients undergoing ORIF with plates ultimately underwent removal of hardware or radial head excision.

Late treatment may be more problematic because the proximal migration of the radius and persistent dislocation of the DRUJ may be difficult once tissues stretch or contract permanently.[3,6,7,10,11,28] Suggested treatment for chronic or untreated ELI includes salvage procedures such as the ulna-shortening or Sauvé-Kapandji procedure, IOL reconstruction, or creation of a one-bone forearm as the ultimate salvage for a painful and unstable forearm.[2,3,6,7,10,11,19–21,28] In our cohort, 4 out of 16 patients (25%) underwent some form of salvage procedure. IOL reconstruction in our metropolitan area has not been widely utilized.

Previous studies that included patient-reported outcomes after treatment of ELI demonstrated comparable persistent deficits in upper extremity physical function, with DASH scores (Disabilities of the Arm, Shoulder and Hand Outcome Measure) ranging between 20.5 and 55 (mean 33.7; ►**Table 4**).[5,7,10,23,24,29] Similar DASH scores can be found after upper extremity amputation. A study from Pet et al reported a mean DASH score of 24.6 in replantation patients and a mean DASH score of 39.8 in patients with prosthetic rehabilitation.[30] The median PROMIS UE score in our study was 36 (IQR: 33–38). Scores for residual pain are slightly lower than shown in our study, ranging between 2 and 3.3 (mean 2.6).[3,10] Our study found a median NRS score for pain-severity on average of 5 (IQR: 0–6). We found similar outcomes for physical function and pain, when comparing nonoperative versus operative initial treatment, with the exception of one patient treated nonoperatively who had a PROMIS UE of 56. This patient had a partial articular fracture of the radial head and a DRUJ dislocation, but it is possible that this was a complete ELI. Overall, regardless of treatment course, ELI generally results in a substantial functional deficit for long term.

In conclusion, patients who sustain an ELI generally have substantial deficits of upper extremity function as measured by PROMIS UE. Early radial head arthroplasty rather than radial head ORIF or excision may be beneficial, but further study in a larger cohort is needed. Outcomes of nonoperative treatment and operative treatment were similar and suggest that current surgical treatments are incomplete.

Table 4 Overview studies that include “patient-reported outcomes” after treatment of Essex-Lopresti injury

Study	Number of patients	Mean follow-up (in months)	Initial treatment radial head	Initial treatment DRUJ	Number of patients that underwent revision surgery	Patient-reported outcome
Jungbluth et al (2006)[7]	12	29	Radial head excision (3), radial head arthroplasty (8)	Sauvé-Kapandji (3)	3	DASH = 55
Hii et al (2013)[29]	1	6	Radial head ORIF	Closed reduction	0	DASH = 44
Grassmann et al (2014)[5]	12	59	Radial head ORIF (2), radial head arthroplasty (8)	DRUJ pinning (12)	0	DASH = 20.5
Venouziou et al (2014)[3]	7	33	Radial head arthroplasty (7)	Ulna shortening osteotomy (5)	2	VAS pain = 3.3
Gaspar et al (2016)[23]	10	35	Radial head ORIF (1), radial head excision (2), radial head arthroplasty (3)	–	10 (all underwent IOM reconstruction)	DASH = 24
Schnetzke et al (2017)[10]	31	64	Nonoperative (10), radial head ORIF (13), radial head excision (1), radial head arthroplasty (7)	DRUJ pinning (16)	20	DASH = 29, VAS pain elbow = 2, VAS pain wrist = 2.4
Gaspar et al (2018)[24]	33	131	Radial head ORIF (6), radial head excision (12), radial head arthroplasty (5)	–	33 (all underwent IOM reconstruction)	DASH = 29.8

Abbreviations: ORIF, open reduction internal fixation; DASH, disability of the arm, shoulder, and hand; DRUJ, distal radioulnar joint; IOM, interosseous membrane; VAS, visual analog scale.

Ethical Approval
The Institutional Review Board of our institution approved this study under protocol no. 1999P008705.

Funding
None.

Conflict of Interest
None declared.

References

1 Essex-Lopresti P. Fractures of the radial head with distal radio-ulnar dislocation; report of two cases. J Bone Joint Surg Br 1951;33B(2):244–247
2 Dodds SD, Yeh PC, Slade JF III. Essex-Lopresti injuries. Hand Clin 2008;24(1):125–137
3 Venouziou AI, Papatheodorou LK, Weiser RW, Sotereanos DG. Chronic Essex-Lopresti injuries: an alternative treatment method. J Shoulder Elbow Surg 2014;23(6):861–866
4 Edwards GS, Jr, Jupiter JB. Radial head fractures with acute distal radioulnar dislocation. Essex-Lopresti revisited. Clin Orthop Relat Res 1988; (234):61–69
5 Grassmann JP, Hakimi M, Gehrmann SV, et al. The treatment of the acute Essex-Lopresti injury. Bone Joint J 2014;96-B(10):1385–1391
6 Heijink A, Morrey BF, van Riet RP, O'Driscoll SW, Cooney WP, III. Delayed treatment of elbow pain and dysfunction following Essex-Lopresti injury with metallic radial head replacement: a case series. J Shoulder Elbow Surg 2010;19(6):929–936
7 Jungbluth P, Frangen TM, Arens S, Muhr G, Kälicke T. The undiagnosed Essex-Lopresti injury. J Bone Joint Surg Br 2006;88(12):1629–1633
8 Marcotte AL, Osterman AL. Longitudinal radioulnar dissociation: identification and treatment of acute and chronic injuries. Hand Clin 2007;23(2):195–208
9 Matson AP, Ruch DS. Management of the Essex-Lopresti injury. J Wrist Surg 2016;5(3):172–178
10 Schnetzke M, Porschke F, Hoppe K, Studier-Fischer S, Gruetzner PA, Guehring T. Outcome of early and late diagnosed Essex-Lopresti injury. J Bone Joint Surg Am 2017;99(12):1043–1050
11 Trousdale RT, Amadio PC, Cooney WP, Morrey BF. Radio-ulnar dissociation. A review of twenty cases. J Bone Joint Surg Am 1992;74(10):1486–1497
12 Geel CW, Palmer AK. Radial head fractures and their effect on the distal radioulnar joint. A rationale for treatment. Clin Orthop Relat Res 1992; (275):79–84
13 Hotchkiss RN. Injuries to the interosseous ligament of the forearm. Hand Clin 1994;10(3):391–398
14 Rabinowitz RS, Light TR, Havey RM, et al. The role of the interosseous membrane and triangular fibrocartilage complex in forearm stability. J Hand Surg Am 1994;19(3):385–393
15 Bot AGJ, Menendez ME, Neuhaus V, Mudgal CS, Ring D. The comparison of paper- and web-based questionnaires in patients with hand and upper extremity illness. Hand (N Y) 2013;8(2):210–214
16 Bot AG, Becker SJE, Mol MF, Ring D, Vranceanu AM. Validation of phone administration of short-form disability and psychology questionnaires. J Hand Surg Am 2013;38(7):1383–1387
17 Tyser AR, Beckmann J, Franklin JD, et al. Evaluation of the PROMIS physical function computer adaptive test in the upper extremity. J Hand Surg Am 2014;39(10):2047–2051
18 Hutchinson S, Faber KJ, Gan BS. The Essex-Lopresti injury: more than just a pain in the wrist. Can J Plast Surg 2006;14(4):215–218
19 Adams JE. Forearm instability: anatomy, biomechanics, and treatment options. J Hand Surg Am 2017;42(1):47–52
20 Loeffler BJ, Green JB, Zelouf DS. Forearm instability. J Hand Surg Am 2014;39(1):156–167
21 Adams JE, Culp RW, Osterman AL. Interosseous membrane reconstruction for the Essex-Lopresti injury. J Hand Surg Am 2010;35(1):129–136
22 Pfaeffle HJ, Fischer KJ, Manson TT, Tomaino MM, Woo SL, Herndon JH. Role of the forearm interosseous ligament: is it more than just longitudinal load transfer? J Hand Surg Am 2000;25(4):683–688
23 Gaspar MP, Kane PM, Pflug EM, Jacoby SM, Osterman AL, Culp RW. Interosseous membrane reconstruction with a suture-button construct for treatment of chronic forearm instability. J Shoulder Elbow Surg 2016;25(9):1491–1500
24 Gaspar MP, Adams JE, Zohn RC, et al. Late reconstruction of the interosseous membrane with bone-patellar tendon-bone graft for chronic Essex-Lopresti injuries: outcomes with a mean follow-up of over 10 years. J Bone Joint Surg Am 2018;100(5):416–427
25 Geel CW, Palmer AK, Ruedi T, Leutenegger AF. Internal fixation of proximal radial head fractures. J Orthop Trauma 1990;4(3):270–274
26 Ring D, Quintero J, Jupiter JB. Open reduction and internal fixation of fractures of the radial head. J Bone Joint Surg Am 2002;84(10):1811–1815
27 Moro JK, Werier J, MacDermid JC, Patterson SD, King GJ. Arthroplasty with a metal radial head for unreconstructible fractures of the radial head. J Bone Joint Surg Am 2001;83(8):1201–1211
28 Jungbluth P, Frangen TM, Muhr G, Kälicke T. A primarily overlooked and incorrectly treated Essex-Lopresti injury: what can this lead to? Arch Orthop Trauma Surg 2008;128(1):89–95
29 Hii JW, Page MM, Prosser A, Bauer S. An uncommon Essex-Lopresti fracture dislocation with radial displacement in distal direction: diagnosis and surgical treatment of a rare case. BMJ Case Rep 2013;2013–2013
30 Pet MA, Morrison SD, Mack JS, et al. Comparison of patient-reported outcomes after traumatic upper extremity amputation: replantation versus prosthetic rehabilitation. Injury 2016;47(12):2783–2788