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ORIGINAL STUDY

Central band reconstruction for the treatment of Essex-Lopresti injury : A novel technique using the brachioradialis tendon

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Longitudinal stability of the forearm is mainly provided by three structures: the radiocapitellar contact, which acts as the primary stabilizer, the central band of the interosseous ligamentous complex (IOLC) and the intact triangular fibrocartilage complex (TFCC). In an Essex-Lopresti lesion the forearm becomes fully destabilized, since all of these three components are injured. Fixation or replacement of the radial head with a metallic prosthesis along with repair of the TFCC and stabilization of the distal radioulnar joint (DRUJ) are well-established treatment goals. However the reconstruction of the central band of the IOLC remains to some extent controversial. The authors believe that the reconstruction of the central band, particularly in active patients, is crucial in order to restore normal load distribution through the forearm, thus ensuring both transverse and longitudinal stability. In this article, we present a case with an Essex-Lopresti lesion, which was effectively treated acutely with restoration of all three components of the injury (radial head prosthesis, DRUJ repair and reconstruction of the central band of the IOLC). A novel technique by rerouting the brachioradialis tendon is described in detail.

Keywords : Essex-Lopresti ; brachioradialis tendon ; interosseous membrane ; central band reconstruction ; longitudinal radioulnar dissociation.

INTRODUCTION

Essex-Lopresti lesion or longitudinal radioulnar dissociation (LRUD) occurs when a high-energy force is axially applied on the forearm. It is characterized by fracture of the radial head, dislocation of the distal radioulnar joint (DRUJ) and rupture of the interosseous ligamentous complex (IOLC) *(7)*. A high level of clinical suspicion is required in order to recognize the true extent of the injury since 75% of injuries can be missed on first presentation *(34)*. Careful clinical and radiological examination of elbow and wrist should always be performed: Bilateral x-rays of the elbow, forearm and wrist are indicated and any DRUJ length discrepancies as well as shortening of the distance between radial tubercle and coronoid process must

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be evaluated. MRI and ultrasound can aid to the diagnosis by detecting IOLC tears *(25)*. Finally, radius pull test *(29)* and the radius joystick test *(30)* can help to evaluate the integrity of IOLC intraoperatively.

The treatment of Essex-Lopresti lesion depends on time of diagnosis, extent of injury of IOLC and functional demands of the patient. Although reconstruction of the central band (CB) has been supported by many authors as an essential part of the treatment, there is no widely accepted technique. We present a novel technique for the reconstruction of the IOLC by rerouting the tendon of brachioradialis (BR).

CASE PRESENTATION

A 50-year old school teacher fell from a height of 10 ft (3 m) onto his outstretched left non-dominant hand. Initially, he was admitted in a district hospital with pain, swelling and limitation of elbow movement. Radiographic examination showed a comminuted radial head fracture (Fig. 1a). An above elbow backslab was applied and he was referred to our unit.

On presentation to our hospital, two days later, the limb was neurovascularly intact; elbow and wrist movements and DRUJ examination were painful. Radiographs of the whole forearm revealed proximal migration of the radius (Fig. 1b) and DRUJ subluxation (Fig. 1c). MRI of the forearm identified rupture of the IOLC (Fig. 1d). Hence, the diagnosis of an Essex-Lopresti injury was established.

Fig. 1a.— Anteroposterior radiograph demonstrating the comminution of the radial head fracture

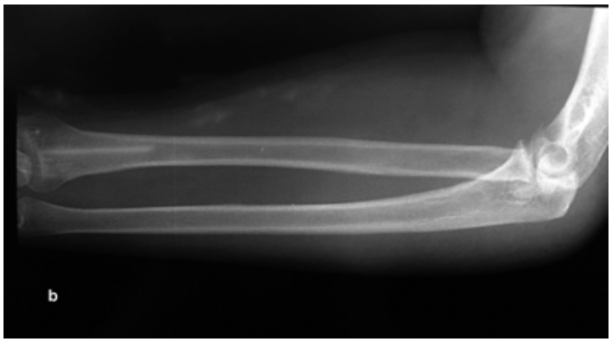

Fig. 1b. —Posteroanterior view of the wrist demonstrating the radioulnar discrepancy

Restoration of all three components of the injury was proposed to the patient. On the fifth day from injury, under general anesthesia, the patient was positioned supine with the hand on an arm table. The difference in ulnar-variance was measured radiographically, using the radius pull test and was found +5 mm. A tourniquet (250 mmHg) was used and the procedure evolved in three stages:

a) The radial head was exposed through the posterolateral approach (Kocher). The comminution of the radial head precluded any attempt for ORIF; hence radial head replacement was performed in a standard manner (Bi-polar, SBI, rHead™ Recon). Post replacement, radioulnar length was restored and leveling of distal radioulnar joint was confirmed radiographically.

b) Dorso-ulnar approach to the DRUJ. Rupture of dorsal capsule was identified with avulsion of dorsal and volar distal radioulnar ligaments from their ulnar insertion. TFC was trapped between

Fig. 1c. — Lateral view of the forearm revealing the proximal radial migration

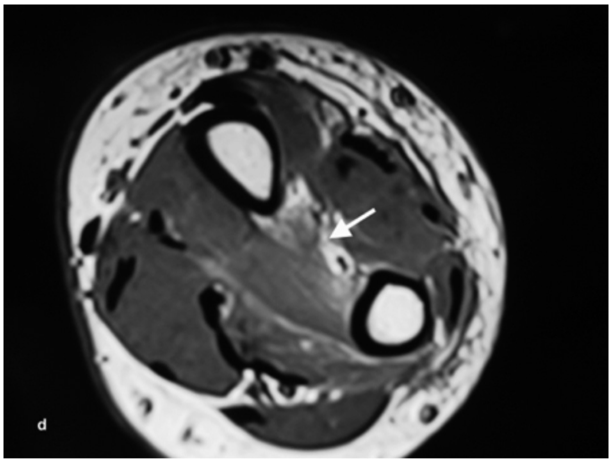

Fig. 1d. — MRI imaging showing the loss of fiber continuity in the central region of the forearm (arrow)

the seat of the ulnar head and the sigmoid notch (Fig.2a). Release and reinsertion of TFC to the fovea using a bone anchor was performed. Then the dorsal capsule of the DRUJ was sutured.

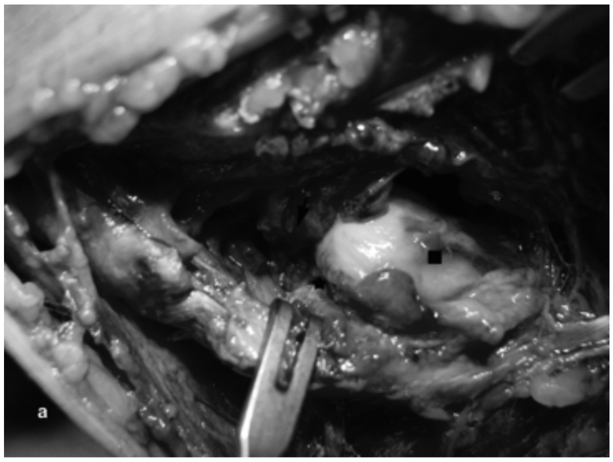

Fig. 2a. — DRUJ dorsal approach; The ulnar head (square), the avulsed TFC (arrow) and the fovea (star) were indicated

c) Using a 10 cm longitudinal incision along the lateral forearm compartment the first dorsal compartment was released and the wide insertion of brachioradialis tendon was identified and detached with a bone block using a fine osteotome from its insertion on radial styloid. The tendon was freed-up from distal to proximal up to its musculotendinous junction, while taking care not to injure the superficial radial nerve (Fig. 2b). Radius was approached through the interval between the dorsal border of BR and ECRL muscle and subperiosteal dissection was carried out. At approximately 60% of the radius length, as measured from the radial

Fig. 2b. — The brachioradialis tendon was detached from its insertion with a bone block (white arrow) while black arrow indicates the superficial radial nerve

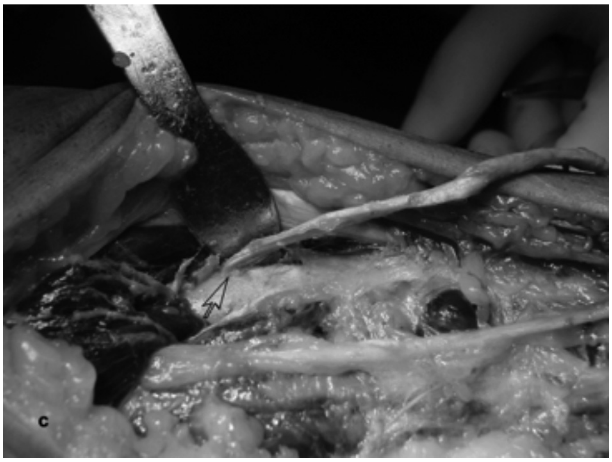

Fig. 2c. — The brachioradialis tendon graft passing through the oblique bone tunnel created to the radius, from an ulnovolar to radiodorsal direction (arrow).

Fig. 2d. — Through a 2 cm ulnar incision the tendon graft embedded into the osseous hole created to the radial border of the ulna and sutured over two small holes created to the ulnar border of the ulna

styloid, a bone tunnel was created in an oblique fashion from radiodorsal to ulnovolar using drills with gradually increasing diameters (from 3.2 to 4.5 mm) (Fig. 2c). An additional 2cm skin incision was made on the ulnar side at a point near the junction of the middle and distal thirds of the ulna. A unicortical oblique osseous hole was created on the radial border of the ulna using a 4.5 mm drill, and two separate smaller holes (2.8 mm) were created on the ulnar border of the ulna. The BR tendon was then rerouted in a distal oblique direction at an angle of approximately 21° to the long axis of the ulna. It was passed through the radius entering dorsal to IOLC and beneath extensor tendons. A Kelly hemostat was passed from distal ulna to proximal radius, grasped the incorporated bone block to the BR tendon and pulled back to the ulnar incision. Only the distal end of the BR tendon was fixed with a Bunnell stitch using a No 2 nonabsorbable suture: the bone block was readjusted and embedded into the osseous hole of the radial border of the ulna. Sutures were threaded through the two holes, tied over the bone bridge of the ulnar border of the ulna and tensioned with the forearm in neutral rotation (Fig. 2d). Pronosupination was assessed and the incisions were closed. At the end of the procedure, the DRUJ was transfixed with the forearm in neutral rotation with a 2 mm smooth K-wire (Fig. 3) (Fig. 4 a, b).

Postoperatively, the patient was placed in a sugar-tongue splint in neutral forearm rotation for

Fig. 3. — X-ray of the forearm at the end of the procedure

5 weeks after which the splint and the K-wire were removed and forearm and wrist motion initiated. Weight bearing activities were restricted for 6 additional weeks.

Pearls and Pitfalls

- It is crucial to re-establish the length of the radius before starting the CB reconstruction. If needed, an ulnar shortening osteotomy may precede.
- When mobilizing the BR tendon, it is important to recognize and protect the superficial branch of the radial nerve by retracting it medially. It becomes subcutaneous at a mean of 8,5 cm proximal to the radial styloid, emerging in dorsal

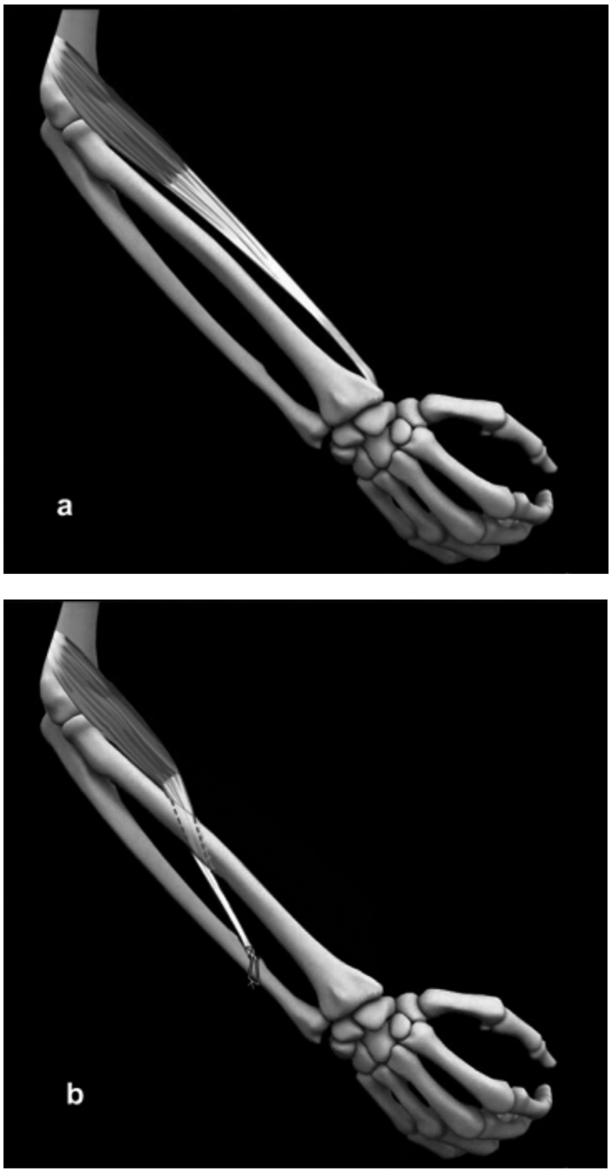

Fig. 4. — Schematic drawing demonstrating the reconstruction using brachioradialis tendon rerouting technique

direction between the BR and extensor carpi radialis muscles *(24)*.

- Fluoroscopy can aid to mark precisely the appropriate location for bone tunnels creation in order to attain the required orientation of the graft.
- In order to avoid iatrogenic fracture during ulnar tunnel creation, drill bits for the opposite cortex should not exceed 2.8 mm in diameter and diverge as much as possible. Prophylactic plating, although proposed by some surgeons, is not routinely recommended *(20)*.
- The wider proximal aspect of the tendon could be trimmed or folded with stiches to produce a uniform tendon graft.
- The graft should be placed in (20°-24°) angle with respect to the long axis of the ulna replicating the anatomy of the native CB, while a more horizontal orientation may have an adverse effect on the range of rotational movements. Slight inaccuracy in the proximal - distal direction may be less significant *(1,4,16,17)*.

RESULTS

A close clinical follow-up examination was carried out in the first months (1, 3 and 6 months) and then annually until 44.9 months (3.68 years). ROM and grip strength were electronically measured with E-link (Biometrics, Gwent, UK), using the other hand as control. The patient was already pain-free 3 months after the operation with no DRUJ instability. He had a functional ROM of 8°-125° degrees flexion/extension of the elbow and 150° pronosupination, which improved further to 0 to 133° flexion/extension, 85° supination and 80° pronation at 9 months. Wrist flexion was 68° and extension 81°. Grip strength was measured in kilograms with the dynamometer set at five positions of which the mean value was based on three trials for each grip strength position. At final follow-up, average grip strength was 32 kg, reaching 96.3% of the contralateral side.

Upper limb function was measured using the Disability of Arm, Shoulder and Hand (DASH) outcome questionnaire *(13)* and was found 18.3. Elbow function was evaluated using the Mayo Elbow Performance Score (MEPS) *(18)* and was found 100. Wrist function was 100 and was measured using the modified Mayo wrist score *(2)*.

All of the above measurements indicate a good to excellent function. Radiographic examination of the elbow at the final follow-up showed a well-fixed distal stem and bone resorption (stress shielding) immediately beneath the implant collar (Fig. 5 a,b).

Assessment of sequential postoperative x-rays revealed that bone resorption beneath the implant collar started at 5 months post-surgery and was

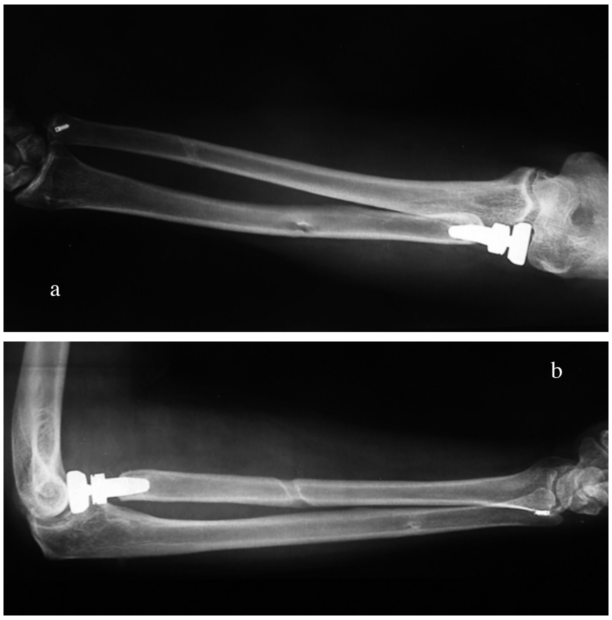

Fig. 5. — Antero-posterior (a) and lateral (b) radiographic images of the forearm 3.68 years postoperatively

completed in one year. Since then it remained unchanged. The ulnar variance measured -2 mm, did not change with clenched fist views and was equal to the contralateral healthy wrist.

DISCUSSION

When treating an Essex-Lopresti lesion, it is paramount to address all the injured components in order to restore both the longitudinal stability and the transverse stability of the forearm bones: The radial head should be preserved if amenable to repair; otherwise a metallic prosthesis is indicated. Open reduction of the DRUJ, in conjunction with direct TFCC repair and DRUJ pinning are also well-established procedures *(1,5)*. Finally, the central band has to be reconstructed so that normal load distribution is re-established. Otherwise excess force transmission through the radiocapitellar joint will eventually lead to implant instability, arthritis and pain *(36)*. When treating delayed cases, it is crucial to evaluate whether the proximal radial migration is reducible or fixed. If it's reducible, then radial head replacement and DRUJ reconstruction and pinning, constitute the usual practice. If it's fixed, leveling of the radioulnar joint must precede, either with an ulnar shortening osteotomy or by using a distraction device as a one or two stage procedure *(1,4)*.

While chronic instability is clearly the absolute indication for CB reconstruction, the procedure can also be used for active patients in the acute phase. There is strong evidence suggesting the low healing potential of the CB *(1,12,16)*. Reasons being: interposition of forearm musculature and high ratio of collagen to elastin content *(19)*. Although suture repair of the CB has been described *(23,26)* there is no data to suggest that this is any better than allowing the IOLC to scar once a normal radioulnar relationship has been restored *(32)*. As a result, a reconstruction procedure must be considered.

Sellman et al. *(28)* were the first to investigate the biomechanical effect of replacing the radial head and reconstructing the IOLC with a polyester cord in a cadaveric study in 1995. They demonstrated that reconstruction of IOLC alone could restore forearm stiffness by 94%. Many procedures have been described since then for the reconstruction of the IOLC.

We can classify them into one of three types depending on the graft used:

a. Local graft from the injured forearm: single or double band flexor carpi radialis (FCR) tendon (22,33), pronator teres *(4,17)*, palmaris longus *(33)*.

b. Graft harvested from a healthy region: bone-patellar-bone (BPB) tendon *(1,16)*, or hamstrings/semitendinosus tendon *(31)*.

c. Synthetic materials or allografts: Mini Tight Rope and suture-button constructs *(6,11,14)*, Achilles tendon allograft *(32)* and anterior tibialis allograft *(20)*.

Teiwani et al. *(33)* compared three tendon autografts for the reconstruction of the CB in radial head deficient cadaveric forearms: palmaris longus (PL), FCR and BPB tendon. They concluded that that the BPB tendon could prevent proximal migration of the radial head more effectively than the other grafts, while none was capable to restore normal mechanics of the forearm. Marcotte and Ostermann reported good functional outcomes in a clinical series of 16 patients using BPB tendon for the treatment of an Essex-Lopresti lesion, but they underlined donor site morbidity as a major concern. 25% of the patients complained about knee pain and the authors suggested the use of a BPB allograft. *(1,16)*. Promising results have been reported using synthetic materials, such as Tight-Rope device, but the long term outcomes of their clinical application have yet to be evaluated. As they may experience fatigue over time, there are concerns over their long-term stability given the low healing capacity of the CB *(6,14).* Finally, allografts (Achilles and anterior tibialis) *(20,32)* have also been suggested, but potential risks of disease transmission, limited availability and additional costs may prevent their widespread use.

While none of the existing techniques has met general acceptance, the reconstruction of the IOLC is crucial in order to restore normal load distribution through the forearm thus creating a biomechanically favorable environment for the radiocapitellar joint. In our method a local graft is harvested and to our knowledge BR has never been used before for the reconstruction of the IOLC.

The selection of BR tendon was based on its unique anatomical and structural features. Although there is no biomechanical study in the literature comparing directly the stiffness of BR tendon to the native CB and to other commonly used grafts, the anatomy and the biomechanical properties of the BR have been thoroughly described by experimental studies on tendon transfers *(9,10,15)*. The muscle fibers of the BR converge to the tendon at the junction of the proximal and middle third of the forearm *(15)*, which facilitates its rerouting through the radius tunnel at this point. Being 13.4 cm (SD, 1.6 cm) in length and 11mm in width, it has a quite long and stout tendon *(15)*, which meets the criteria of the required graft (112±14 mm long) *(3)*. The BR muscle is strongly tethered to other surrounding structures of the forearm with multiple intermuscular connections accounting for the limited excursion of this muscle *(9,15)*. This fact explains the relatively stable tension of BR tendon during elbow flexion *(10)* obliterating the need for proximal securing of the graft to the radius. Finally, the expendability of the BR as an elbow flexor reduces substantially donor site morbidity *(9,35)*. Tirrel et al showed that releasing the tendon up to the musculotendinous junction decreases BR-induced elbow flexion torque by less than 20%, which corresponds only to 4-5% of overall elbow flexion torque *(35)*.

Micromotion of the BR tendon through the osseous tunnel of the radius during elbow flexion allows the graft to act as a dynamic stabilizer, more than a static one, at least in the early postoperative phase. This may protect the graft from excessive loads, until a biological incorporation has occurred. In the late post-op period, no motion of the graft through the radius tunnel is anticipated, thus providing a rigid construct. Yet, the transformation of the tendon graft into ligament and the integration of the tendon graft into the osseous tunnels have to be further investigated by biomechanical studies *(27)*.

Advantages of our technique merit to be mentioned are: BR tendon is an autograft and the results rely on biological incorporation of the graft, ensuring long-term stability as opposed to synthetic constructs. When compared to the BPB tendon, the use of a local graft with an insignificant functional impact on elbow movements minimizes donor site morbidity. Morevover, the fixed length of BPB tendon and the difficulty in appropriate tensioning are additional limitations *(20)*. The rerouting of the pronator teres tendon is an attractive alternative, but its technical difficulties and the proximity of the median nerve have reduced its reproducibility *(4,20)*. Finally, our technique pioneers dynamic stability with only one fixation point of the graft required.

Regardless of the graft type, the reconstruction of the CB is technically demanding and requires careful preoperative planning and surgical expertise. Appropriate graft orientation and tensioning are the keys to having a favorable outcome. The optimal position of the forearm, in which the graft should be tightened, remains to some extent controversial: While some authors claim that the CB is significantly shorter in supination *(8)*, Moritomo et al have shown, that the CB demonstrates isometric properties during forearm rotation *(21)* suggesting a neutral position to tighten the graft. Most surgeons prefer to tension it in neutral rotation or slight supination *(4,11,16,17)*.

Our technique has shown that the BR tendon can safely be used as a local graft for IOLC reconstruction. Further clinical and biomechanical studies are necessary to evaluate the efficacy of the technique.

REFERENCES

1. **Adams JE, Steinmann SP, Osterman AL.** Management of injuries to the interosseous membrane. *Hand clinics.* 2010 ; 26 : 543-8.
2. **Amadio PC, Berquist TH, Smith DK, Ilstrup DM, Cooney WP, 3rd, Linscheid RL.** Scaphoid malunion. *J Hand Surg.* 1989 ; 14 : 679-87.
3. **Chandler JW, Stabile KJ, Pfaeffle HJ, Li ZM, Woo SL, Tomaino MM.** Anatomic Parameters for planning of interosseous ligament reconstruction using computer-assisted techniques. *J Hand Surg Am.* 2003 ; 28 : 111-6.
4. **Chloros GD, Wiesler ER, Stabile KJ, Papadonikolakis A, Ruch DS, Kuzma GR.** Reconstruction of essex-lopresti injury of the forearm: technical note. *J Hand Surg.* 2008 ; 33 : 124-30.
5. **Dodds SD, Yeh PC, Slade JF, 3rd.** Essex-lopresti injuries. *Hand clinics.* 2008 ; 24 :125-37.
6. **Drake ML, Farber GL, White KL, Parks BG, Segalman KA.** Restoration of longitudinal forearm stability using a suture button construct. *J Hand Surg.* 2010 ; 35 : 1981-5.
7. **Essex-Lopresti P.** Fractures of the radial head with distal radio-ulnar dislocation: report of two cases. *J Bone Joint Surg* 1951 ; 33B : 244–247.
8. **Farr LD, Werner FW, McGrattan ML, Zwerling SR, Harley BJ.** Anatomy and biomechanics of the forearm interosseous membrane. *The Journal of hand surgery.* 2015 Jun ; 40(6) : 1145-51.
9. **Fridén J, Albrecht D, Lieber RL.** Biomechanical analysis of the brachioradialis as a donor in tendon transfer. *Clin Orthop Relat Res.* 2001 ; 152-61.
10. **Fridén J, Shillito MC, Chehab EF, Finneran JJ, Ward SR, Lieber RL.** Mechanical feasibility of immediate mobilization of the brachioradialis muscle after tendon transfer. *J Hand Surg Am.* 2010 ; 35 : 1473-8.
11. **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 : 1491-500.
12. **Gong HS, Chung MS, Oh JH, Lee YH, Kim SH, Baek GH.** Failure of the interosseous membrane to heal with immobilization, pinning of the distal radioulnar joint, and bipolar radial head replacement in a case of Essex-Lopresti injury: case report. *J Hand Surg.* 2010 ; 35 : 976-80.
13. **Hudak PL, Amadio PC, Bombardier C.** Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). *American journal of industrial medicine.* 1996 ; 29 : 602-8.
14. **Kam CC, Jones CM, Fennema JL, Latta LL, Ouellette EA, Evans PJ.** Suture-button construct for interosseous ligament reconstruction in longitudinal radioulnar dissociations: a biomechanical study. *J Hand Surg* 2010 ; 35 : 1626-32.
15. **Koh S, Andersen CR, Buford WL Jr, Patterson RM, Viegas SF.** Anatomy of the distal brachioradialis and its potential relationship to distal radius fracture. *J Hand Surg Am.* 2006 ; 31 : 2-8.
16. **Marcotte AL, Osterman AL.** Longitudinal radioulnar dissociation: identification and treatment of acute and chronic injuries. *Hand clinics.* 2007 ; 23 : 195-208.
17. **Matson AP, Ruch DS.** Management of the Essex-Lopresti Injury. *J Wrist Surg.* 2016 ; 5 : 172-8.
18. **Mayo Elbow Performance Score.** *J Orthop trauma.* 2006 ; 20 : S127.
19. **McGinley JC, Kozin SH.** Interosseous membrane anatomy and functional mechanics. *Clinical orthopaedics and related research.* 2001 : 108-22.
20. **Miller AJ, Naik TU, Seigerman DA, Ilyas AM.** Anatomic Interosseus Membrane Reconstruction Utilizing the Biceps Button and Screw Tenodesis for Essex-Lopresti Injuries. *Tech Hand Up Extrem Surg.* 2016 ; 20 : 6-13.
21. **Moritomo H, Noda K, Goto A, Murase T, Yoshikawa H, Sugamoto K.** Interosseous membrane of the forearm: length change of ligaments during forearm rotation. *J Hand Surg* 2009 ; 34 : 685-91.
22. **Pfaeffle HJ, Stabile KJ, Li ZM, Tomaino MM.** Reconstruction of the interosseous ligament restores normal forearm compressive load transfer in cadavers. *J Hand Surg.* 2005 ; 30 : 319-25.
23. **Poitevin LA.** Anatomy and biomechanics of the interosseous membrane: its importance in the longitudinal stability of the forearm. *Hand clinics.* 2001 ; 17 : 97-110, vii.
24. **Robson AJ, See MS, Ellis H.** Applied anatomy of the superficial branch of the radial nerve. *Clin Anat.* 2008 ; 21 : 38-45.
25. **Rodriguez-Martin J, Pretell-Mazzini J.** The role of ultrasound and magnetic resonance imaging in the evaluation of the forearm interosseous membrane. A review. *Skeletal radiology.* 2011 ; 40 : 1515-22.
26. **Ruch DS, Chang DS, Koman LA.** Reconstruction of longitudinal stability of the forearm after disruption of interosseous ligament and radial head excision (Essex-Lopresti lesion). *J Southern Orthopaedic Association.* 1999 ; 8 : 47-52.
27. **Sanchez Hidalgo R, Forriol F.** Bone-tendon integration of autologous grafts using different diameter tunnels. An experimental study on sheep. *Rev Esp Cir Ortop Traumatol.* 2012 ; 56 : 216-23.
28. **Sellman DC, Seitz WH, Jr., Postak PD, Greenwald AS.** Reconstructive strategies for radioulnar dissociation: a biomechanical study. *J Orthop Trauma.* 1995 ; 9 : 516-22.
29. **Smith AM, Urbanosky LR, Castle JA, Rushing JT, Ruch DS.** Radius pull test: predictor of longitudinal forearm instability. *J Bone Joint Surg* (Br). 2002 ; 84-A : 1970-6.
30. **Soubeyrand M, Ciais G, Wassermann V, Kalouche I, Biau D, Dumontier C,** *et al.* The intra-operative radius joystick test to diagnose complete disruption of the interosseous membrane. *J Bone Joint Surg* (Br). 2011 ; 93 : 1389-94.
31. **Soubeyrand M, Oberlin C, Dumontier C, Belkheyar Z, Lafont C, Degeorges R.** Ligamentoplasty of the forearm

interosseous membrane using the semitendinosus tendon: anatomical study and surgical procedure. *Surgical and radiologic anatomy*. 2006 ; 28 : 300-7.

32. **Stabile KJ, Pfaeffle J, Saris I, Li ZM, Tomaino MM.** Structural properties of reconstruction constructs for the interosseous ligament of the forearm. *J HandSurg Am*. 2005 ; 30 : 312-8.
33. **Tejwani SG, Markolf KL, Benhaim P.** Reconstruction of the interosseous membrane of the forearm with a graft substitute: a cadaveric study. *J Hand Surg*. 2005 ; 30 : 326-34.
34. **Thomason K, Burkhart KJ, Wegmann K, Muller LP.** The sequelae of a missed Essex-Lopresti lesion. *Strategies in trauma and limb reconstruction* (Online). 2013 ; 8 : 57-61.
35. **Tirrell TF, Franko OI, Bhola S, Hentzen ER, Abrams RA, Lieber RL.** Functional consequence of distal brachioradialis tendon release: a biomechanical study. *J Hand Surg* 2013 ; 38 : 920-6.
36. **Tomaino MM, Pfaeffle J, Stabile K, Li ZM.** Reconstruction of the interosseous ligament of the forearm reduces load on the radial head in cadavers. *J Hand Surg*. 2003 ; 28 : 267-70.