



Case report

A case report of surgical treatment of traumatic drop hand by quadruple tendons transfer

Abdullah Noufal

AUHD (Al-Assad University Hospital Damascus), Syria

ARTICLE INFO

Keywords:

Drop hand
Tendon transfer
Radial nerve palsy
Wrist dorsiflexion

ABSTRACT

Introduction: Drop hand is the case of inability to dorsiflexion of the hand and fingers according to radial nerve palsy (complete syndrome) or PIN (Posterior Interosseous Nerve) palsy (partial syndrome). Therefore, the patient loses part of the normal function of his/her hand causing life problems especially if it is the dominant hand. Tendon transfer is the main surgical treatment.

Case report: We present a case of a young male who sustained multiple traumatic war injuries especially in the left upper limb; open humerus fracture, open ulna fracture, open radius fracture with a clear drop hand syndrome. After quadruple tendons transfer, he got a very good result especially in thumb movements with good ROM (Range Of Motions) in the wrist.

Discussion: Since it is difficult to restore full ROM and full muscular strength in the wrist and fingers of a drop hand with triple tendon transfer routinely, especially in the case of multiple injury to the upper extremity with the pronator teres being nonfunctional, we decided to perform quadruple tendon transfer depending on the tendons; FCR, PL, 3rdFDS, 4thFDS for stronger extension of the wrist, thumb, and other fingers.

Conclusion: Our aim here is to confirm that the drop hand does not have standard findings in all cases. It may be a challenge, and may have atypical findings especially in the case of ipsilateral multiple traumatic limb, which in turn may have weakness or restriction in some important movements, so, it is important to keep in mind alternatives of tendon transfer.

1. Introduction

Wrist drop is a disorder caused by radial nerve palsy. Because of the radial nerve's innervation of the extensor muscles of the wrist and digits, those whose radial nerve function has been compromised cannot actively extend them. As such, the hand hangs flaccidly in a position of flexion when the patient attempts to bring the arm to a horizontal position. Causes of wrist drop include a stab wound to the shoulder area just below the clavicle, as this is the area where the radial nerve is the terminal branch of the posterior cord of the brachial plexus. A knife wound, for example, may easily transect the cord. Traumatic contusions caused by crush or twisting injuries of the wrist or forearm can cause such a neuropathy. Entrapments are rare. Compressive lesions can be secondary to repetitive occupational pronation-supination movements, wristwatch bands, casts, or even handcuffs. Similar to "Saturday night palsy," many patients with handcuff neuropathies are inebriated, Lead poisoning and thiamin deficiency (beriberi) may also result in wrist drop [1].

It is well known that wars present different kinds of injuries that can

lead to permanent injury, disability or limb loss. The radial nerve is one of the most common war-related injury sites due to penetrating cutting tool injuries or gunshot wounds, resulting in drop-hand syndrome [2]. Although surgical treatment for this wound pattern is controversial among surgeons of the upper extremity, certain management principles are valid in all cases.

The most common indication for upper extremity tendon transfer procedures is a peripheral nerve injury that has no potential to improve [3]. This includes nerve injuries that are physically irreparable such as root avulsions, nerve injuries that do not recover after direct nerve repair or grafting, or failed nerve transfers. In addition, tendon transfer procedures are often indicated when peripheral nerve injuries present so late that muscle re-innervation is impossible due to motor end-plate fibrosis. Other common indications include loss of muscle or tendon following trauma, central neurologic deficits such as spinal cord injuries and cerebral palsy [4], and tendon ruptures in patients with rheumatoid arthritis. Other rarer disorders, including poliomyelitis and leprosy, can result in disability that may benefit from a tendon transfer procedure.

Tendon transfer is applied following peripheral nerve injuries that

E-mail address: abdullahanoufal@gmail.com.

<https://doi.org/10.1016/j.ijscr.2022.106880>

Received 9 January 2022; Received in revised form 20 February 2022; Accepted 22 February 2022

Available online 26 February 2022

2210-2612/© 2022 The Author. Published by Elsevier Ltd on behalf of IJS Publishing Group Ltd. This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

present with delayed re-innervation of the related muscle, with a lack of function due to motor fibrosis [5]. In such cases, transferring tendons is the only chance for the patient to regain wrist or finger extension. Although different tendon options are available, surgeons prefer the use of specific tendon groups [6]. As a general reference, wrist extension restoration is employed with the transfer of the pronator teres (PNT) to the Extensor Carpi Radialis Brevis (ECRB) [7]. Palmaris Longus (PL) is the best choice for restoration of thumb extension and thumb radial abduction [8]. The repair approach for finger extension can be employed using the Flexor Digitorum Superficialis (FDS), Flexor Carpi Ulnaris (FCU), or Flexor Carpi Radialis (FCR) [9].

The principles of successful tendon transfer procedures have been identified and refined over the last century. They are 1) supple joints prior to transfer, 2) soft tissue equilibrium, 3) donor of adequate excursion, 4) donor of adequate strength, 5) expendable donor, 6) straight line of pull, 7) synergy, and 8) single function per transfer [10,11].

This case report has been reported in line with the SCARE 2020 criteria [12]

2. Case report

A 19 years old male patient presented to the orthopedic clinic of Al-Andalus private hospital in Damascus. He was a right-handed auto mechanic, and his weight was 73 kg. He walked into the clinic. He was nonsmoker and had no family, personal or medical history. His main complaint was drop hand with restricted supination and pronation movements in the left forearm and wrist after multiple previous injuries caused by an explosion in Damascus. The previous surgical treatments were as follow; 1- urgent closed reduction and external fixation of the left humerus, removal of some shrapnel with K-Wires fixation of left radius and ulna [Figs. 1A&B and 2A&B]. 2- Intra medullary (IM) nailing of the left humerus with bone grafting [Figs. 3 A&B, 4A&B] and open surgical bone grafting with locked plate fixation of the non- united proximal third of the left radius [Figs. 5 A&B and 6A&B]. Clinical examination discovered a complete drop hand syndrome with inability to dorsiflexion of the left wrist and fingers and restricted supination and pronation of the forearm [Video No1]. X-ray imaging discovered good union of the humerus, ulna and radius fractures without any clear

synthesis between the two forearm bones with mild palmar angulation of the proximal third of the left ulna, which may explain the restricted supination and pronation [Fig. 7A&B].

A new electromyography showed a severe injury and absent connectivity of the left radial nerve at the level of the proximal third of the humerus, and a complete drop hand syndrome, with normal connectivity in the ulnar and median nerves. The clinical examination confirmed the absence of the pronator teres muscle (PT) function, which may be injured with shrapnel or the open wound, and -as we know- this muscle is an important part of classic tendon transfer as a surgical treatment for drop hand. Therefore, we decided to do quadruple tendon transfer to get the best result.

After thirteen months of the explosion, surgical treatment of drop hand syndrome was done as follow; with the patient in supine position, and through an eight cm exposure in the shape of C on the dorsal part of the distal third of the left forearm, the dorsal extensors of the thumb,

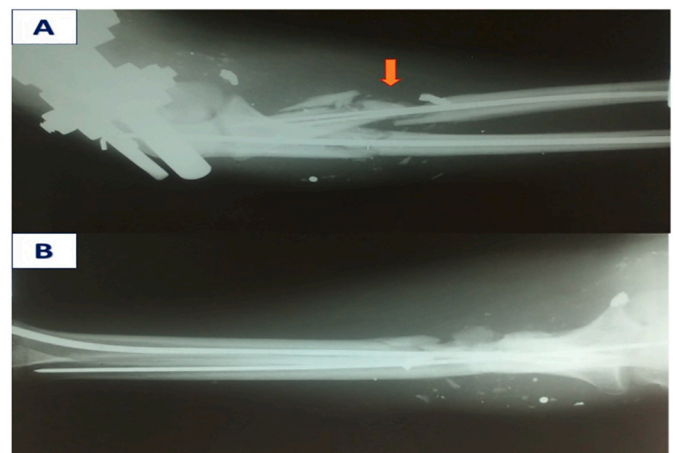


Fig. 2. A&B show urgent fixation of radius and ulna with intra medullary K-Wires with a clear gap and fragmentation in the proximal third of the radius (red arrow). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



Fig. 1. A&B show the primary urgent surgical treatment after the multiple traumatic injuries in the left arm and forearm. Here we can see the external fixator and the mid-shaft humerus fracture, a shrapnel in the posterior thoracic wall (blue arrow), and K-wires in radius and ulna. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

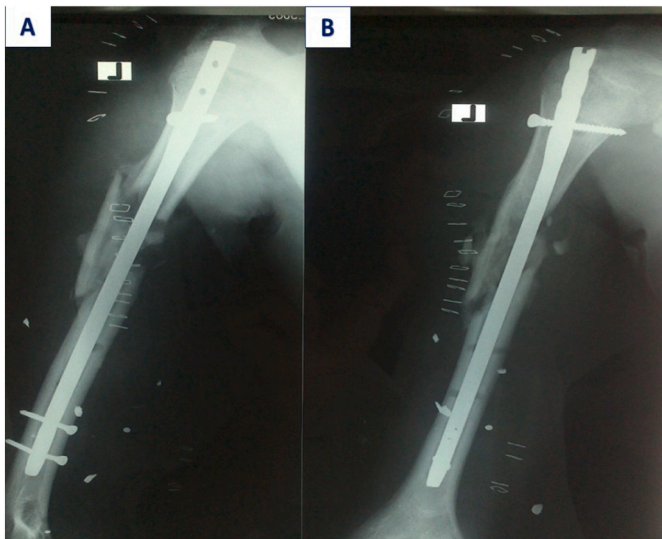


Fig. 3. A&B IM (intra Medullary) nailing with open bone grafting for the non-united fracture of the proximal third of the left humerus.



Fig. 4. A&B Left humerus after IM nail removal 2 years after open bone grafting.

fingers and the wrist were exposed as follow: ECRL, ECRB, EPL, AbPL, and EDC (Extensor Carpi Radialis Longus, Extensor Carpi Radialis Brevis, Extensor Pollicis Longus, Abductor Pollicis Longus, and Extensor Digitorum Communis). And through three separate palmar exposures, the tendons of the donor muscles which are; PL (palmaris Longus), FCR

(Flexor Carpi Radialis) in addition to the 3rd and 4th tendons of FDS (Flexor Digitorum Superficialis) were harvested. Then, the harvested tendons were passed through the interosseous membrane towards the dorsal exposure to be reinserted (end to side) into their final sites as follow: 1- PL (Palmaris Longus) into the EPL (Extensor Pollicis Longus) to restore thumb extension 2- FCR (Flexor Carpi Radialis) into the EDC (Extensor Digitorum Communis) to restore the extension of the wrist and fingers. 3- the 3rd tendon of FDS (Flexor Digitorum Superficialis) into the tendons of ECRL & ECRB (Extensor Carpi Radialis Longus & Extensor Carpi Radialis Brevis) to restore wrist extension 4- the 4th tendon of FDS (Flexor Digitorum Superficialis) into AbPL (Abductor Pollicis Longus) to restore thumb abduction [Figs. 7 Aa,Ab,Ba,Bb & 8 Aa,Ab,Ba,Bb & 9A,B, C].

After surgery, an infra-elbow palmar slab was used for two weeks in position of 20° dorsiflexion of the wrist, 15° of palmar flexion at the level of the MP joints, and full extension in DIP and PIP joints. Then, an excessive gradual rehabilitation program was applied for two months to restore wrist and fingers extension and muscles strength [Video No2], and then he admitted another program to strengthen the muscles of the arm and the forearm bilaterally for about 6 months [Video No3] (this video is 3 years after the surgery).

3. Discussion

The radial nerve is the most frequently injured major nerve in the upper limb and etiology of its injury is quite varied, As result of its proximity to humeral shaft, as well as its long and tortuous course [13].

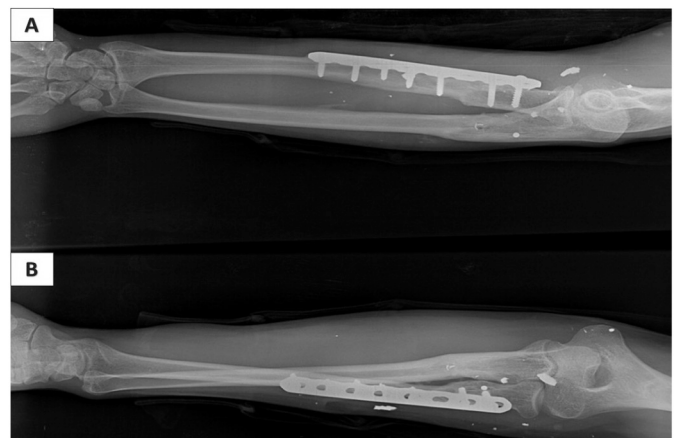


Fig. 6. A&B good union of the left radius and ulna with lucked plate fixation of the radius (2 years after bone grafting surgery).

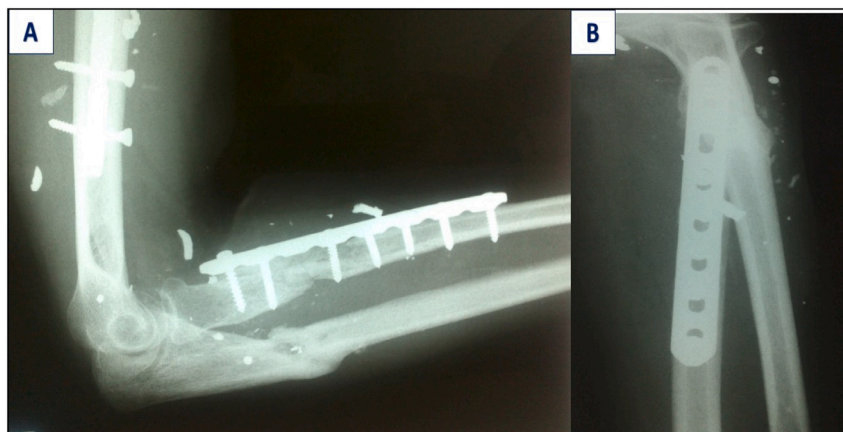


Fig. 5. A&B lucked plate fixation with open bone grafting for the non-united fracture of the proximal third of the left radius.

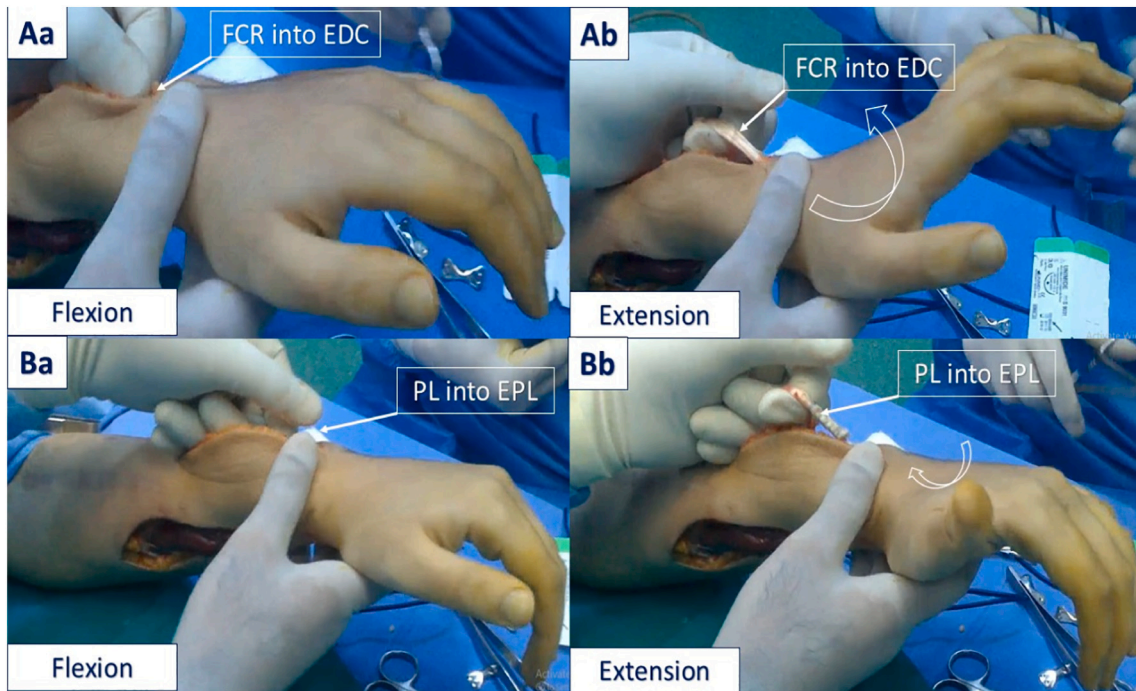


Fig. 7. A a&b show the effect of the EDC, B a&b show the effect of EPL and the new insertion of PL.

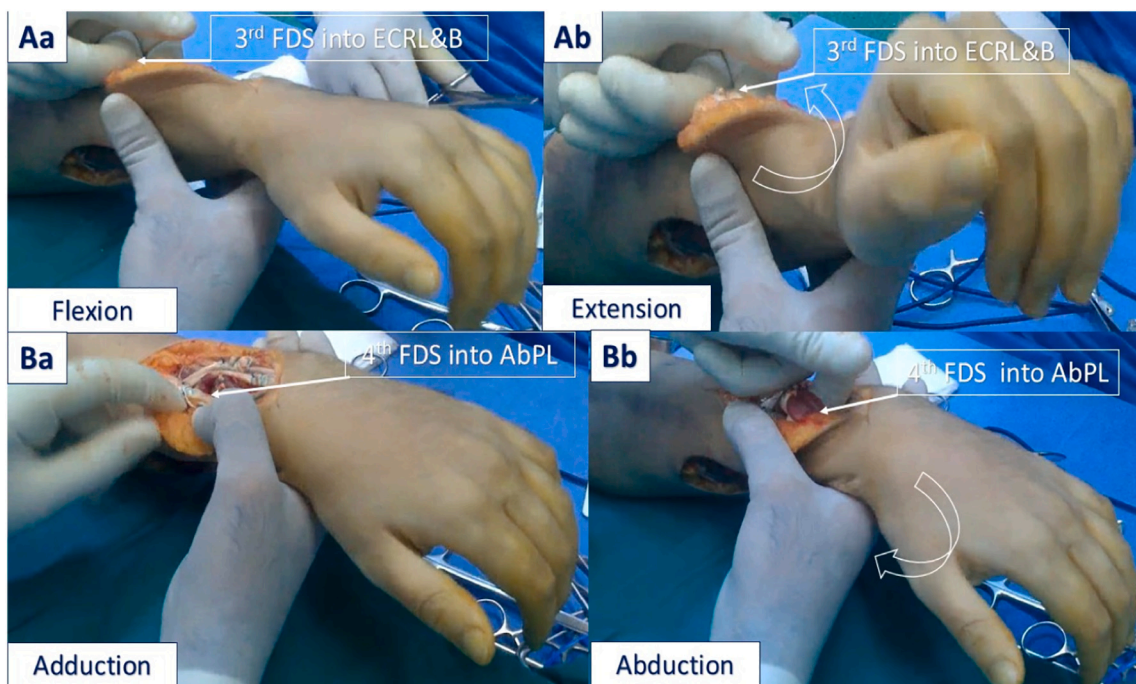


Fig. 8. A a&b show the effect of ECRL&B, B a&b show the effect of AbPL.

Most authors believe that tendon transfers will result in good outcomes in cases of radial nerve palsy with irreparable damage or reconstruction failure [14].

- 1- Sunderland recommended that one year is enough to go on tendon transfer if nerve recovery has not happened in this time [15].
- 2- Burkhalter believed that the greatest functional loss in patient with radial nerve injury is weakness in grip and recommended early transfer to eliminate the need for external splint and reduce the period of disability after injury [16].

So, there is no consensus on the best method for tendon transfer in patients with radial nerve palsy [17]. Classically, surgeons use different combinations of tendon transfers in order to achieve three major goals in treatment of radial nerve palsy including restoration of finger extension, restoration of thumb and wrist extension in cases of severe radial nerve palsy [18]. In early transfer, this was intended as substitute for internal splint during regeneration of the nerve after repair and there are quite acceptable functional results in first weeks after removing plaster splint and patients were able to return to work early than expected before nerve healing and regeneration had happened [19].

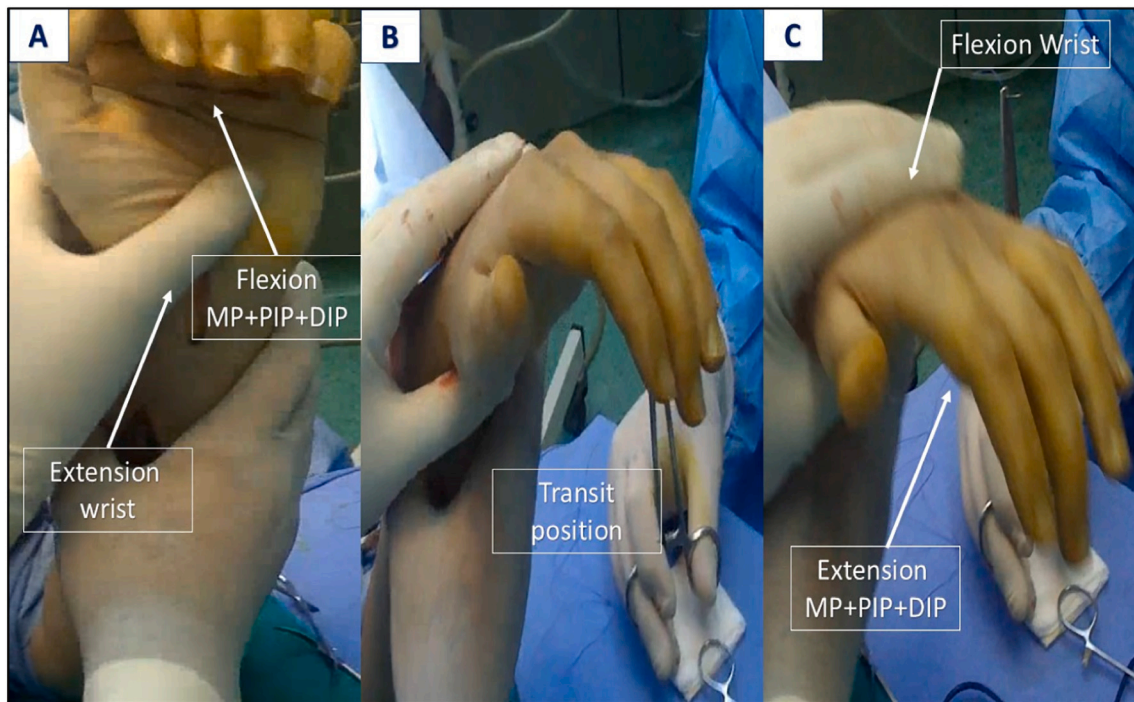


Fig. 9. A, B and C show the documentary movement (Accompany of wrist flexion and fingers extension against the wrist extension and finger flexion)

The rationale for Jones transfer (FCU to EDC) was a matter of surgeon's preference and some patients have ulnar deviation of the wrist pre-operatively while Brands (FCR to EDC) transfer was advocated instead of FCU to restore finger extension to preserve FCU which is more important wrist flexor than FCR because normal axis of wrist motion is from dorsal-radial to volar-ulnar [20].

Boyes then Chuinard et al.; suggested that Flexor Digitorum Superficialis (FDS) tendons, with their greater excursion, would be better motors for finger and wrist extensors. Their major proof was the fact that amplitude of action and power of wrist flexors is too small to allow simultaneous extension of wrist and fingers [21].

The FDS transfer was primarily employed as it provides thumb extension independent from wrist and fingers extension, because the FDS control each finger is independent from other fingers. The FDS of the middle finger was preferred as motor for EPL because it provides 7 cm of excursion, while FCR provides only 3 cm; therefore, the FDS is more efficient, noting that EPL normally provides 5 cm excursion [22].

In this case report, we introduced a rare case of multiple traumatic left upper limb contained a full drop hand syndrome with injured Pronator teres muscle. Therefore, and according to the studies that suggest the wrist and fingers flexors as a better donor for wrist and fingers extension, we decided to use alternatives like the third and fourth tendons of the FDS (Flexor Digitorum Superficialis). Moreover, we added the thumb abduction to the group of the restored movements along with the extension of the wrist, fingers and thumb to get a powerful extension and a functional hand that abduction gives the thumb a full ROM, and additional maneuvers to catch and fix then release grasped things.

The good results were clear after 12 weeks as the patient got good active flexion and extension in the affected wrist and started again his routine works. Nevertheless, as we know, it is very weak to rely on only one case to give a final judgment on this method and the extent of its usefulness in managing hand drop. Therefore, we suggest conducting in-depth and specialized studies dealing with a comparison between the flexor muscles of the forearm in terms of muscle strength and thus their ability to give the strongest extension after tendon transfer, taking into account the comparison with the pronator teres muscle, to get dependable results.

4. Conclusion

Drop hand should be suspected in any case of absent dorsiflexion and extension of the wrist and fingers after cutting wounds, displaced fractures of the humerus or war accidents that may affect the radial nerve. Careful clinical examination that concentrate on the functional muscles and deep reading of electromyography are essential to get enough information about the type of the injury, the predicted plans for treatments, and the presence of accompanying injuries like fractures, muscular destruction or de-innervation that may require alternatives in physiotherapy or surgical plan. In the medical practice, orthopedists tend to deal with classic drop hand that caused by radial nerve injuries with normal flexors and pronator teres function. Therefore, the most popular tendon transfer contains transferring the tendon of PT into FCR (Flexor Carpi Radialis) to restore wrist extension. In the case of absent or nonfunctional Pronator Teres, we suggest quadruple tendons transfer by using the third and fourth tendons of the FDC (Flexor Digitorum Communis), and adding the thumb abduction to the restored movements, to get a powerful extension and a functional thumb. It is important to use a perfect length of tendons and suitable suturing type to get firm ways to transfer power into new effect points. In addition, the follow up and physiotherapy for suitable periods are essential to get the best results.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijscr.2022.106880>.

Funding

This research did not receive any specific grant from any funding agencies in the public, commercial, or not-for-profit sectors.

Ethical approval

This study is exempt from ethical approval in our institution.

Consent

Written informed consent was obtained from the patient for

publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Registration of research studies

Not applicable.

Guarantor

Abdullah Noufal PhD, MD.

Provenance and peer review

Not commissioned externally peer-review.

CRedit authorship contribution statement

Abdullah Noufal PhD, MD: conceptualization, investigation, data curation, writing, editing and reviewing.

Declaration of competing interest

The author has no conflicts to disclose.

References

- [1] A.C. Grant, A.A. Cook, A prospective study of handcuff neuropathies, *Muscle Nerve* 23 (2000) 933–938.
- [2] D.C. Riordan, Radial nerve paralysis, *Orthop. Clin. N.Am.* 5 (2008) 283–287.
- [3] R.R. Richards, Tendon transfers for failed nerve reconstruction, in: S.E. Mackinnon (Ed.), *Clinics in Plastic Surgery: Peripheral Nerve Surgery* Vol. 30, W.B. Saunders Company, Philadelphia, 2003, pp. 223–246 [PubMed] [Google Scholar].
- [4] A.E. Van Heest, J.H. House, C. Cariello, Upper extremity surgical treatment of cerebral palsy, *J. Hand Surg. [Am]* 24 (2) (1999 Mar) 323–330 [PubMed] [Google Scholar].
- [5] M. Al-Qattan, The, "double wrist flexor" tendon transfer for radial nerve palsy, *Ann. Plast. Surg.* 71 (2013) 34–36.
- [6] A.E. Cheah, J. Etcheson, J. Yao, Radial nerve tendon transfers, *Hand Clin.* 32 (2016) 323–338.
- [7] M.A. Pet, A.B. Lipira, J.H. Ko, Nerve transfers for the restoration of wrist, finger, and thumb extension after high radial nerve injury, *Hand Clin.* 32 (2016) 191–207.
- [8] M. Bumbasirevic, T. Palibrk, A. Lesic, H. Atkinson, Radial nerve palsy, *EFORT Open Rev.* 1 (2016) 286–294.
- [9] I. Sajid, Understanding of tendon transfer in radial nerve palsy in leprosy, *Indian J. Lepr.* 86 (2014) 171–177.
- [10] J.H. Boyes, Tendon transfers in the hand; paper presented at: Medicine of Japan in 1959, in: *Proc 15th Gen Assembly Japan Med Cong, 1959* [Google Scholar].
- [11] J.H. Boyes, Selection of a donor muscle for tendon transfer, *Bull. Hosp. Joint Dis.* 23 (1962 Apr) 1–4 [PubMed] [Google Scholar].
- [12] R.A. Agha, T. Franchi, C. Sohrabi, G. Mathew, for the SCARE Group, The SCARE 2020 guideline: updating consensus Surgical Case REport (SCARE) guidelines, *Int. J. Surg.* 84 (2020) 226–230.
- [13] M.T. Jobe, S.F. Martiney, Peripheral nerve injuries, in: *Campbell's Operative Orthopaedics*, 12th ed., Elsevier Mosby, Philadelphia, 2013, pp. 3063–3123. P.
- [14] J. Lowe, B. Sen, K. Subhro, S.E. Mackinnon, Current approach to radial nerve paralysis, *Plast. Reconstr. Surg.* 110 (2002) 1099–1113. P.
- [15] S. Sunderland, Decision making in clinical management of nerve injury and repair, in: S. Sunderland (Ed.), *Nerve Injuries And Their Repair*, Churchill Livingstone, Edinburgh, 1991, pp. 413–431. P.
- [16] W.E. Burkhalter, Early tendon transfer in upper extremity peripheral nerve injury, *Clin. Orthop. Relat. Res.* 104 (1974) 68–79. P.
- [17] M. Yavari, H.A. Abdolrazaghi, A. Riahi, Comparative study on tendon transfer surgery in patients with radial nerve palsy, *World J. Plast. Surg.* 3 (1) (2014) 47–51. P.
- [18] K.G. Krishnan, G. Schackert, An analysis of results after selective tendon transfers through the interosseous membrane to provide selective finger and thumb extension in chronic irreparable radial nerve lesions, *Am. J. Hand Surg.* 33 (2008) 223–231. P.
- [19] J. Gousheh, E. Arasteh, Transfer of a single flexor carpi ulnaris tendon for treatment of radial nerve palsy, *Br. J. Hand Surg.* 31 (2006) 542–546. P.
- [20] W.J. Dunnet, P.L. Housden, R. Birch, Flexor to extensor tendon transfers in the hand, *Br. J. Hand Surg.* 20 (1995) 26–28. P.
- [21] R.G. Chuinard, J.H. Boyes, H.H. Stark, C.R. Ashworth, Tendon transfers for radial nerve palsy: use of superficialis tendons for digital extension, *Am. J. Hand Surg.* 3 (1978) 560–570. P.
- [22] N.F. Jones, K.T. Khiabani, Tendon transfers in the upper limb, in: S.T. Mathes, V. R. Hentz (Eds.), *Plastic Surgery*, 2nd ed. Vol. 8, Saunders, Philadelphia, 2006, pp. 453–487. P.