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ORIGINAL ARTICLE

Outcome of Tendon Transfer to Restore Wrist, Fingers and Thumb Extension in Adult Brachial Plexus Injuries

Durga Karki[1], Bhojani Jatin[2]

Abstract This study reviewed outcomes of tendon transfer in ten patients following adult brachial plexus injury presenting with loss of extension at wrist, fingers and thumb. All patients had previously undergone primary reconstruction of brachial plexus. Seven of them had sustained C5, C6, C7 root avulsion injury while three had posterior cord injury. Restoration of wrist extension in C5, C6, C7 root injury was done by transferring pronator teres (PT) or flexor carpi radialis (FCR) to extensor carpi radialis brevis (ECRB). Finger extension was achieved with transfer of flexor carpi radialis (FCR) or flexor digitorum superficialis to ring finger (FDS III) to extensor digitorum communis (EDC) tendon. Palmaris longus (PL) tendon was transferred to extensor pollicis longus (EPL) tendon to restore thumb extension. In posterior cord injury, wrist extension was achieved with transfer of PT to ECRB, finger extension by transfer of FCR to EDC and thumb extension by transfer of PL to EPL. All transfers were successful.

The mean extension of wrist achieved with PT to ECRB was 42 degrees (range, 30 - 60 degrees) and 40 degrees (range, 24 to 50 degrees) when FCR was used as a donor. The mean extension of fingers achieved with FCR to EDC was 8 degrees (range,5-12 degrees) with wrist in extension, and 12 degrees (range, 8 - 15 degrees) with wrist in neutral position. The mean extension of fingers with FDS III to EDC transfer was 6 degrees (range, 5-10 degrees) with wrist in extension and 12 degrees (range, 8 - 14 degrees) with wrist in neutral position. The mean extension and abduction of thumb as assessed by measuring first web space was 60 degrees (range, 40 to70 degrees). The functional results were evaluated according to scoring system of Bincaz. Out of 10, 6 patients scored excellent, 3 good and 1 fair result.

Tendon transfer is a good option even after microsurgical repair of brachial plexus injury for restoration of hand function. To perform successful transfers, muscles units need to have sufficient reinnervation or sparing from injury. Careful selection of available muscle units is valuable in achieving maximum hand function.

Keywords: Brachial plexus, tendon transfer, wrist extensors, radial nerve palsy

Introduction

Brachial plexus, a complex network of nerves, is responsible for the innervation of an upper extremity. Due to an increase in the number of motor vehicle accident survivors, there is a global increase in the incidence of brachial plexus injuries.[1-4] The usual sufferers are young boys in the age group 15 to 25 years.[3,5]

Restoration of hand function in brachial plexus injury remains a challenge.[6] Several procedures have been described in restoration of function in an upper extremity. These are nerve repair, nerve transfer, free muscle transfer, tendon transfer and arthrodesis. Usually a combination of procedures is required. It is important to assess functional deficit and the reconstructive options prior to a particular procedure.[7,8]

Tendon transfer is a reliable option to restore hand function usually as a secondary procedure and best described as a means to restore a lost function rather than a means to substitute a specific muscle.[9]

Prior to a tendon transfer surgery, it is important to ensure that adequate muscle units have been spared or sufficiently re-innervated. Poorly functioning motor muscles are not suitable for tendon transfer. Commonly described transfers may not be possible in each and

✉ Durga Karki
+91 9910649386
dkarki10@yahoo.co.in

[1] Professor, Department of Burns, Plastic & Maxillofacial Surgery, VM Medical College & Safdarjung Hospital, Delhi, India

[2] Senior Resident, Department of Burns, Plastic & Maxillofacial Surgery, VM Medical College & Safdarjung Hospital, Delhi, India

every case and operator should modify procedure according to the availability of motor units.[10]

C5, C6, C7 nerve root and posterior cord injuries present with inability to extend wrist, fingers, and thumb. These patients possess a poor grip strength from inability to stabilize hand in neutral position or in extension. Tendon transfers are aimed to reanimate extensions at wrist, finger and thumb and for this the techniques described by Brand, Jones and Boyes are commonly followed.[11-16] As there may be mixed pattern of injury and re-innervation, a specific set of transfer may not be possible in every case so there is a need to modify the procedure according to the available functional donor motor units.

We present a report of 10 brachial plexus injury patients who were managed with tendon transfer in the restoration of wrist, finger and thumb extension. The aim of this study is to assess clinical and functional outcomes of tendon transfer.

Patients and Methods

Between May 2014 to May 2017, ten patients were included with C5, C6, C7 roots avulsion and posterior cord injury of the brachial plexus. Seven patients had C5, C6, C7 root avulsion while 3 had injured the posterior cord. All of them had previously undergone primary nerve reconstruction. These patients presented with loss of wrist, finger and thumb extension from incomplete recovery or residual deficit. All patients possessed supple radiocarpal and metacarpophayngeal joints.

Out of seven patients with C5, C6, C7 injury, pronator teres (PT) was preserved in six but paralysed in one. Hence restoration of wrist extension was done by pronator teres in six patients and flexor carpi radialis(FCR) in one patient. In all patients recipient tendon for wrist extension was extensor carpi radialis brevis (ECRB).Finger extension in five patients was achieved with transfer of flexor carpi radialis to extensor digitorum communis and in two patients with transfer of flexor digitorum superficialis (FDS) of ring finger to extensor digitorum communis (EDC) tendon. Thumb extension restored by transfer of palmaris longus (PL) to extensor pollicis longus (EPL) in all seven patients.

In posterior cord injury wrist extension was achieved by transfer of pronator teres to extensor carpi radialis brevis (ECRB) while finger extension by transfer of flexor carpi radialis to extensor digitorum communis tendon. Palmaris longus tendon was transferred to extensor pollicis longus to restore thumb extension.

Surgical Technique

A curved incision was made over the volar-radial aspect of the middle third of the forearm, extending dorso-ulnar along the radial border of forearm, through which the tendon of PT was elevated along with periosteum from the radius (Fig 1&2). The PT was rerouted along the radial border of the forearm, superficial to the brachioradialis and ECRL, in a straight direction and sutured to the ECRB by pulvertaft method with wrist in 40° extension.

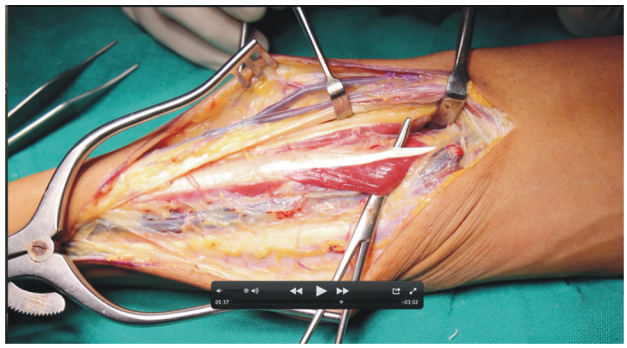

Fig. 1 Through a curved incision on volar- radial aspect of middle and distal third of forearm, pronator teres musculotendinous unit is dissected and showing its insertion on radial bone.

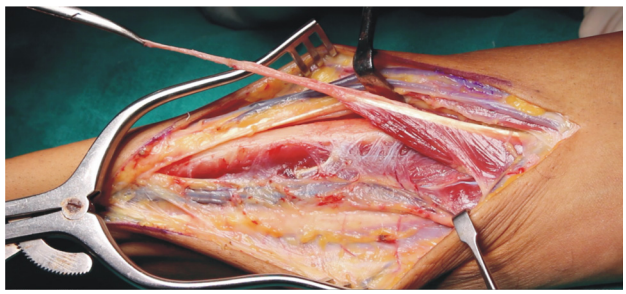

Fig. 2 Pronator teres tendon is detached along with a portion of periosteum.

The tendon of flexor carpi radialis (FCR) was divided at distal wrist crease, mobilized to the level of mid forearm, and then re-routed dorsally along the radial border of the forearm and woven into extensor digitorum communis (EDC) tendon with wrist in neutral position and metacarpo-phalangeal joint in full extension (Fig 3&4).

Flexor digitorum superficialis (FDS) tendon of ring finger was divided through a small distal wrist crease incision. This tendon was delivered into the forearm through volar incision used for PT. FDS was rerouted

dorsally and woven into EDC tendon under maximum tension with wrist and metacarpo-phalangeal joint in neutral position.

Extensor pollicis longus (EPL) is identified in the dorsal incision and divided at its musculotendinous junction. EPL was passed through a subcutaneous tunnel towards volar aspect of wrist in the direction of first metacarpal (Fig 5).

Palmaris longus (PL) tendon was divided at distal wrist crease, rerouted towards thumb, and woven into EPL with thumb in full extension and abduction. Wrist was placed in 40° extension (Fig 6).

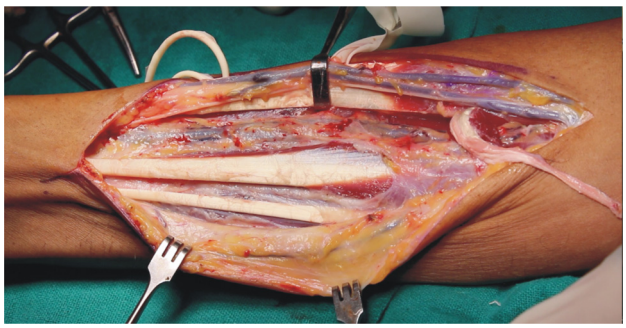

Fig. 3 Tendons of flexor carpi radialis and palmaris longus are dissected on volar aspect of forearm.

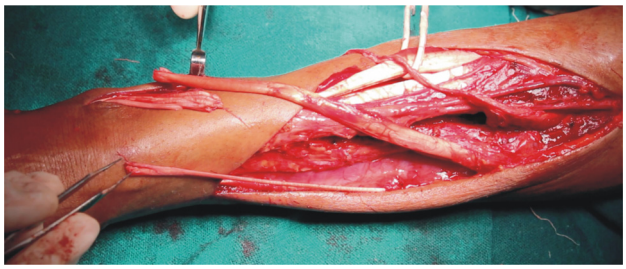

Fig. 4 Tendons of pronator teres (PT), flexor carpi radialis (FCR) and palmaris longus (PL) are transected distally and showing line of transfer to tendons of extensor carpi radialis brevis, (ECRB), extensor digitorum communis (EDC) and extensor pollicislongus (EPL)

Fig. 5 Subcutaneous tunnel is made to re-route extensor pollicis longus tendon.

Fig. 6 All tendons sutured and wrist in 40 degrees extension.

Post-Operative Care

Immobilization achieved with elbow pronated and flexed at 90^0, wrist kept at 40 degree of extension and metacarpo-phalangeal joints and thumb in full extension. This immobilization was maintained for 4 weeks after which a new splint was applied to keep the wrist in 30° of extension, the thumb and fingers were kept free and encouraged for active range of motion (ROM). At 5 weeks postoperatively active ROM of the wrist started. Strengthening exercises were introduced 8 weeks onwards postoperatively.

Assessment

Patients were followed up at 4 weekly intervals. During follow up, active range of movements at the wrist and metacarpo-phalangeal joints were measured. Extension of thumb was assessed by measuring first web space. Opposition of thumb was assessed using the Kapandji scale.[17] The functional results were assessed using scale described by Bincaz (Table1).[18] Patient satisfaction, their return to work and to normal activities were also evaluated.

Table 1: Scale for assessment of tendon transfer

Score	3	2	1	0
Wrist extension		$>29^0$	0 to 29^0	$<0^0$
Metacarpo-phalangeal (MCP) joint extension		Full (no extension loss)	Extension loss$<10^0$	Extension loss$>10^0$
First web space opening		$>39^0$	Between 30 and 39^0	$<30^0$
Patient satisfaction	Excellent	Good	Fair	Bad

Excellent: Score above or equals to 8

Good: 6 or 7

Fair: 4 or 5

Bad: 3 or less

Results

The mean postoperative follow-up was 14 months (12 to 24 months). The mean extension of wrist (PT to ECRB) was 42 degrees (30 - 60 degrees) and where FCR used was 40 degrees (24 to 50 degrees). The mean extension of fingers with wrist in extension (FCR to EDC) was 8 degrees (5-12 degrees) and in wrist neutral position was12 degrees (8 - 15 degrees). The mean extension of fingers with wrist in extension (FDS III to EDC) was 6 degrees (5-10 degrees) and in wrist neutral position was 12 degrees (8 - 14 degrees). Finger flexion was normal in all cases. The extension and abduction of thumb as assessed by measuring first web space was 60 degrees (range,40 to70^0). Mean opposition of thumb according to Kalpandji scale was8 (range,7-10). The functional results were evaluated according to scoring system by the Bincaz. Out of 10 patients, 6 scored excellent, 3 good and 1 fair result (Fig 7 & 8).

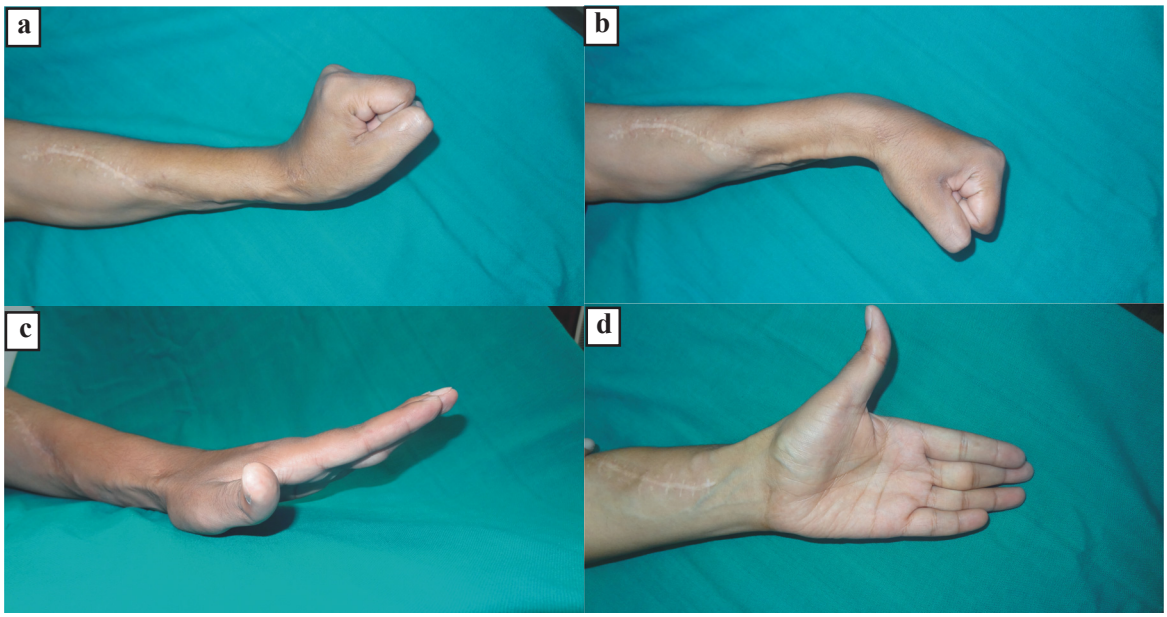

Fig. 7 (a & b) Excellent wrist extension and flexion **(c)** Full finger extension **(d)** Excellent thumb extension and abduction

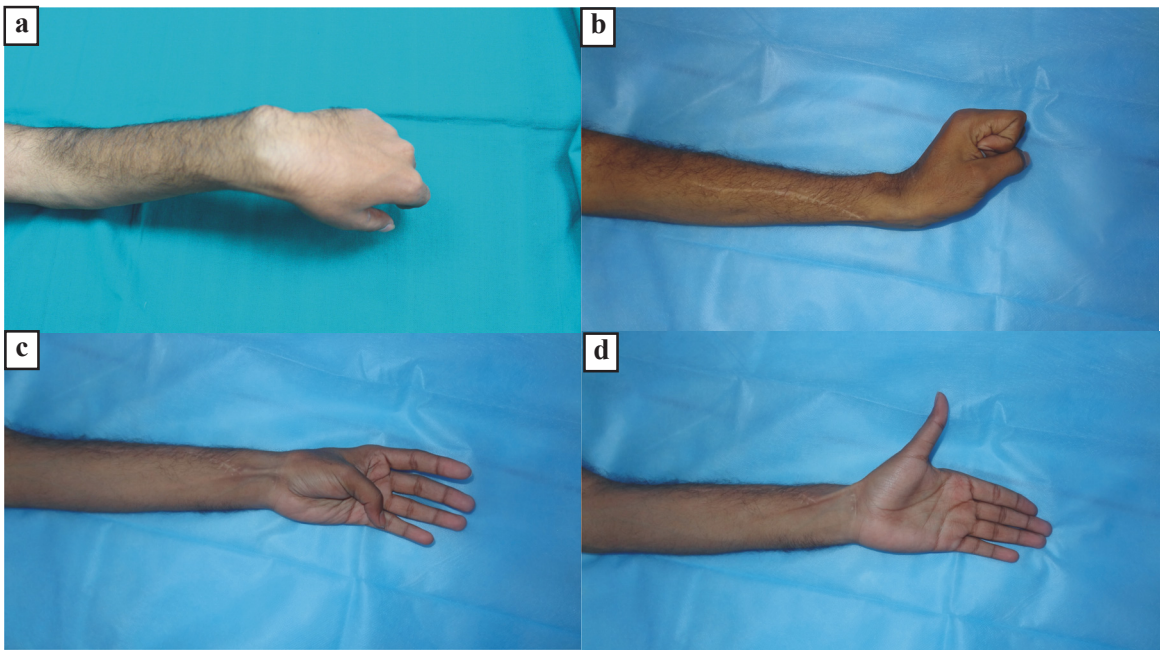

Fig. 8 (a) Pre-op view with loss of wrist, finger and thumb extension in patient with C5, C6, C7 root avulsion injury **(b)** 2yrs 6 months post-op with excellent wrist extension (PT to ECRB, FDS to EDC & PL to EPL) **(c & d)** Full thumb opposition & extension

Discussion

Brachial plexus injury involving C5, C6, C7 root injury and posterior cord are treated with nerve transfer for functional recovery of shoulder and elbow. However for restoration of wrist, fingers and thumb extension tendon transfers are preferred.

Several sets of tendon transfer have been described for isolated radial nerve palsy. In brachial plexus injury there is inadequate recovery, residual deficit and donor muscle-tendon unit paucity, classic sets of transfers are always not possible. So different combinations of tendon transfers are required in order to get maximum restoration of functions.

Several donors including PT, FCR, FCU, PL and FDS have been used in brachial plexus injury.[19]

In our study, patients with C5, C6, C7 root avulsion, restoration of wrist extension was done by transferring pronator teres (PT) in six patients and flexor carpi radialis (FCR) in one patient, where PT was absent. Finger extension in five patients was done with transfer of FCR and two patients where FCR was absent, FDS III was transferred to EDC. Thumb extension restoration by transfer of PL in all seven patients. In all patients with posterior cord injury, wrist extension was achieved with transfer of pronator teres and finger extension by transfer of FCR and thumb extension restoration by transfer of PL. The functional result was evaluated according to scoring system by the Bincaz. Out of 10 patients, 6 patients had excellent, 3 good and 1 fair result.

Bincaz described a study of ten with brachial plexus injury who underwent transfer of PT to ECRB, FCU to EDC+EPL and PL to APL+ EPB. Results were excellent in five cases and good in other five. The wrist extension of 32 degrees was obtained, as well as MP extension deficit of 16 degrees with wrist straightened and opening of first commissure of 38 degrees. The functional results were satisfactory.

Ruchelsman DE et al assessed the clinical results in children with brachial plexus birth injury with involvement of C5, C6, C7 in eight patients and global palsy in thirteen patients. Tendon transfer to reconstruct active wrist extension was done in 21 patients over 10 year interval. Fourteen (66%) children demonstrated active wrist extension >30 degrees. Within the global injury subcohart, three patients demonstrated static extension of wrist. Four failure occurred in the global palsy group.

Oberlin[20] published a series in 2013 on combined nerve and tendon transfer on nine patients, presenting with palsy secondary to a lesion in the posterior cord of the brachial plexus. Clinically, they all suffered from a paralysis of the deltoid muscle and triceps muscle. Eight patients suffered from paralysis of the extension of the wrist, thumb and fingers. To restore deltoid function, they used intercostal nerve in four patients, ulnar nerve in one patient and shoulder arthrodesis in one patient. For restoration of elbow extension, they used motor branch of the ulnar nerve which was sutured directly onto the branch to the triceps brachii. In patients with ulnar nerve palsy, they used a motor branch from the median nerve. The tendon transfer used for ECRB was PT in eight patients. Mean extension achieved was 40^0. Wrist extension strength scored M4. Restoration of finger extension was obtained with the transfer of FCU in six patients and that of FCR in two patients, who also presented with a partial ulnar nerve palsy. The result in all patients was complete extension (PIP joint 0^0 and DIP joint 0^0) with the wrist in neutral position or in slight extension. PL tendon was used for thumb extension in all patients except for one, in whom PL was absent and tendon of the flexor digitorum superficialis to little finger was subsequently harvested.

Conclusion

In brachial plexus injury, usually due to a mixed pattern of involvement and partial recovery of motor units, it is important to modify tendon transfer according to available motor units. Classic set of transfer as described for isolated radial nerve palsy may not be possible in this subset of patients. These patients can be suitability rehabilitated by a careful selection of available donor muscles.

References

1. Azze RJ, Mattar R, Jr., Ferreira MC, Starck R, Canedo AC. Extraplexual neurotization of brachial plexus. Microsurgery.1994;15(1):28–32
2. Brandt KE, Mackinnon SE. A technique for maximizing biceps recovery in brachial plexus reconstruction.J Hand Surg Am. 1993 Jul;18(4):726-733
3. Doi K, Muramatsu K, Hattori Y, Otsuka K, Tan SH, Nanda V, et al. Restoration of prehension with the double free muscle technique following complete avulsion of the brachial plexus. Indications and long-term results. J Bone Joint Surg Am.2000 May;82(5): 652-666
4. Doi K, Kuwata N, Muramatsu K, Hottori Y, Kawai S. Double muscle transfer for upper extremity

reconstruction following complete avulsion of the brachial plexus. Hand Clin. 1999 Nov;15(4):757-767

5. Dubuisson AS, Kline DG. Brachial plexus injury: a survey of 100 consecutive cases from a single service.Neurosurgery. 2002 Sep;51(3):673-682
6. Allieu Y. Evolution of our indications for neurotization. Our concept of functional restoration of the upper limb after brachial plexus injuries. Chir Main .1999;18(2): 165-166
7. Cheah AE, Etcheson J, Yao J. Radial nerve tendon transfers. Hand Clin. 2016 Aug; 32:323-338
8. Richards RR. Tendon Transfers for Failed Nerve Reconstruction. Clin Plast Surg. 2003; 30: 223–246
9. Bonnard C, Narakas A. Restoration of hand function after brachial plexus injury. Hand Clin. 1995;11:647-656
10. Ruchelsman DE, Ramos LE, Price AE, Grossman, Valencia H, Grossman JA. Outcome after tendon transfers to restore wrist extension in children with brachial plexus injuries. J Pediatr Orthop. 2011;31:455-457
11. Green DP. Radial nerve palsy. In: Green DP, Hotchkiss RN, Pederson WC, Wolfe SW. Editors. Green's operative hand surgery. 6th ed, Philadelphia, Pensylvania Churchil Livingston; 2011;1:1080-1081
12. Seiler JG 3rd, Desai MJ, Payne SH. Tendon transfers for radial, median and ulnar nerve palsy. J Am Acad Ortop Surg. 2013; 21:675-684
13. Korteweg SF, van de Graaf RC, Werker PM. Who was the first in history to treat radial nerve palsy by tendon transfer? Plast Reconstr Surg 2010;125:756-757
14. Brand PW: Clinical mechanics of the hand. St. Louis (MO): CV Mosby Co; 1985
15. Jones A. Tendon fixation in unrecoverable musculo-spinal paralysis. J Orthop Surg 1919;1:135-140
16. Boyes JH. Tendon transfers for radial palsy. Bull Hosp Jt Dis 1960;21:97-105
17. Kalpandji A. Clinical test of apposition and counter apposition of the thumb. Annales de Chirurgie de la Main. 1986;5:67-73
18. Bincaz LE, Cherifi H, Alnot JY. Palliative tendon transfer for reanimation of the wrist and finger extension lag. Report of 14 transfers for radial nerve palsies and ten transfers for brachial plexus lesions. Chir Main 2002; 21: 13-22 (in French)
19. Al-Qattan MM. Tendon transfer to reconstruct wrist extension in children with obstetric brachial plexus palsy. J Hand Surg Br.2003; 28:153-157
20. Oberlin C, Chino J, Belkheyar Z. Surgical treatment of brachial plexus posterior cord lesion: A combination of nerve and tendon transfers, about nine patients. Chir Main. 2013;32:141-146