

Original Research Article

Unipolar pedicled latissimus dorsi transfer for elbow reanimation in traumatic brachial plexus injuries

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ABSTRACT

Background: Brachial plexus injuries are troubling for the patients socially, economically and emotionally. Elbow joint being a large and vital joint needs to be reanimated so that the patient can carry out his routine work and bring the hand to the mouth. Number of procedures have been defined but latissimus dorsi being a large muscle is the muscle of choice for transfer in cases who present late. Bipolar latissimus dorsi transfers have often been reported but unipolar latissimus dorsi transfer has also been described. Authors have studied the unipolar muscle transfer, its surgical technique and results.

Methods: In this study 18 patients were studied for demographic data, pre- and post-operative flexion of the elbow and the MRC grade of the corresponding movements. Diagnostic work up in the form of nerve conduction velocity, electromyography and magnetic resonance imaging were carried out and evaluated for their significance in traumatic brachial plexus injuries.

Results: In this study 13 patients had avulsion of the C5-6 roots on magnetic resonance imaging. The patients presented after a period of 128.83 ± 56.76 days. Substantial time elapsed and ruled out primary brachial plexus reconstruction or nerve transfers. The average elbow flexion improved from 6.67 ± 5.69 degrees (range: 0-20 degrees) to 86.94 ± 12.38 degrees (range: 65-110 degrees) following unipolar latissimus dorsi transfer. 12 patients (66.67%) developed M4 or M4+ power.

Conclusions: Unipolar latissimus dorsi muscle transfer is a reliable method and most of the patients develop adequate strength and satisfactory function at the elbow joint.

Keywords: Bipolar latissimus dorsi transfer, Brachial plexus injuries, Elbow flexion, Magnetic resonance imaging and reliability, Unipolar latissimus dorsi transfer, Upper trunk injuries

INTRODUCTION

Brachial plexus trauma results in a variable loss of upper extremity function. The restoration of this function requires elbow flexion of adequate strength and range of motion.¹ Restoration of elbow flexion is one of the priorities in brachial plexus palsy, as this function brings the hand to the mouth.² Elbow stability is also critical in the preservation of distal functions.³ The upper extremity consists of a linked system between the shoulder, elbow, wrist, and hand. The elbow positions the hand in space

acting as a fulcrum for the forearm, thus facilitating powerful grasping and fine motions of the hand and wrist.³ The long term implications of reduced hand function may have adverse impact on the individual's ability to return to work, resulting in a short term loss of income or even unemployment.

Reconstruction of elbow function in severe or late brachial plexus injuries may be managed by the current sophisticated techniques of nerve reconstruction, in combination with secondary local or free functional

muscle transfers, which may offer satisfactory outcome.⁴ However, in older injuries, nerve repair surgeries are not recommended, as there is definite atrophy and classic muscle transfers are possible in partial lesions.⁵ Various muscle transfers have been evaluated, performed and recommended like transfer of triceps to biceps or pectoralis major-minor to biceps and Steindler's flexorplasty alone or combined with wrist arthrodesis.⁶⁻⁹ These procedures have been used sporadically and none has been propagated as the procedure of choice.

Latissimus dorsi is a useful alternative and it can be transferred as a unipolar or bipolar pedicled or free muscle to restore elbow function. The latissimus was initially transferred to achieve elbow extension in 1949 and modified for flexion in 1955.¹⁰ The powerful latissimus dorsi muscle can provide more lift strength than a flexorplasty.¹¹ Eggers et al, found that latissimus dorsi transfer provides more powerful elbow flexion and a greater range of movement.¹²

Unipolar latissimus dorsi transfer produces results similar to bipolar transfer. In fact, in a study of 362 patients over a period of 12 years, a unipolar latissimus dorsi transfer was shown to lift 10-15 kg, while a bipolar latissimus dorsi transfer produced a maximal strength of 5-8 kg.¹¹

The article is intended to share the experiences of the authors regarding unipolar latissimus dorsi transfer for traumatic brachial plexus injuries in adults. The finer details of the surgery, their indications, prerequisites, postoperative results and the limitations of the technique are also discussed.

METHODS

This study was conducted in Department of Plastic Surgery, Institute of Medical Sciences, Banaras Hindu University, Varanasi, India from 1 September 2016 to 31 August 2018.

33 patients of clinically proven traumatic brachial plexus injury with loss of shoulder abduction and elbow flexion were evaluated. 7 patients improved on conservative management. 8 patients who presented within 3 months improved on neurolysis or primary brachial plexus reconstruction. 18 patients who had failed primary surgery or who presented late were included in the study for muscle transfers. Patients with M4+ power of latissimus dorsi and triceps, supple elbow joint and unscarred elbow were included in the study.

Patients who required MRI and had a magnetic implant in the associated region of the body were excluded from the study. Other exclusion criteria were weak adductors (Pectoralis major and latissimus dorsi), concomitant bony injury and limited elbow movements and psychiatric patients or children who were not likely to follow the physiotherapy regime.

Procedure of the study was thoroughly explained to each patient and informed consent was obtained for inclusion in the study. Notification, Cost and Compensation details were explained to each patient. Potential benefits for participation in the study were explained to patients with assurance of confidentiality of patient's information. Ethical clearance was also received.

Information regarding mechanism of trauma with relevant past and medical history were recorded. Thorough clinical examination was performed and the nature of the injuries, whether closed or open, traction or penetrating, supraclavicular and/or infraclavicular were noted. Other parameters evaluated were laterality of injury (right or left upper limb), associated vascular injuries, associated fractures of bones like cervical spine, clavicle, humerus, scapula, sternum, ribs and joint involvement like sternoclavicular joint, acromioclavicular joint, glenohumeral joint, head, chest and abdominal injuries. Detailed sensory and motor examination of the affected limb, as compared to the normal upper limb, were performed. Ipsilateral latissimus dorsi muscle was evaluated clinically and using electromyography to ensure suitability for transfer. Magnetic resonance imaging of brachial plexus was done to assess the nature and extent of injury to brachial plexus. The unipolar latissimus dorsi transfer was performed by positioning the patient in lateral decubitus position. The incision was made parallel to the lateral border of the latissimus dorsi muscle extending from the posterior border of the axilla to the iliac crest (Figure 1). Initial dissection elevated the posterior and anterior skin flaps from the underlying fascia and muscle. Lateral border of latissimus dorsi identified and dissection performed deep to the muscle from distal to proximal. The lumbar fascial and posterior pelvic origins of the muscle are divided (Figure 2) and the muscle is lifted off the chest wall with meticulous dissection as the vascular hilum was approached. Neurovascular pedicle identified about 3 inches proximal to the tip of the scapula and 1 inch medial to the free border of the muscle (Figure 3). The pedicle was sufficiently mobilized to avoid kinking. This invariably required ligation of the branch to serratus anterior and multiple (four to six) more proximal perforating branches. All the fascia surrounding the pedicle was completely released to maximize muscle mobility and minimize the potential for kinking of the pedicle. Dissection was then performed towards the axilla taking due care does not damage the pedicle. The muscle dimension was 38-40 cm in length and 15-20 cm wide. The muscle harvested was tubed (Figure 4) for easy retrieval at the elbow and provide strength to flexors of the elbow joint.

A 5-7 cm long transverse incision is made along the posteromedial surface of the midarm and a generous tunnel made up to the axilla proximally and the elbow distally. The origin of the latissimus dorsi was passed under the axillary skin bridge into the incision while protecting its neurovascular pedicle from kinking or

tension. The latissimus dorsi muscle was then retrieved through a stay suture (Figure 5).

completely expose the muscle belly and distal tendon (Fig 6).



Figure 1: incision for latissimus dorsi muscle exposure.



Figure 4: Tubing of the harvested muscle before transfer to elbow.



Figure 2: Detachment of lumbar origin and latissimus dorsi.



Figure 5: Latissimus dorsi passed through the posteromedial incision of the mid arm using a stay suture, after passing under axillary skin bridge.

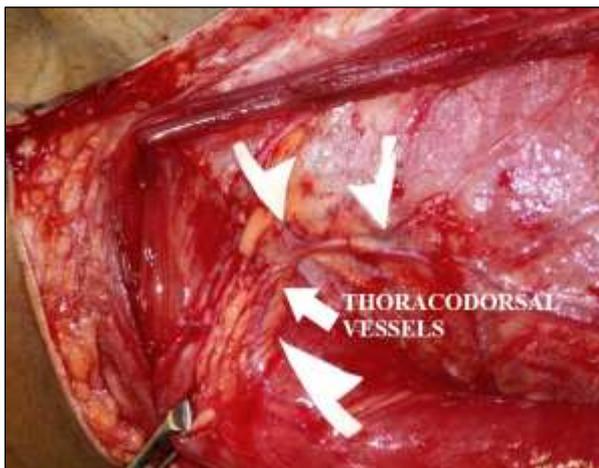


Figure 3: Identification and meticulous dissection of thoracodorsal neurovascular pedicle.

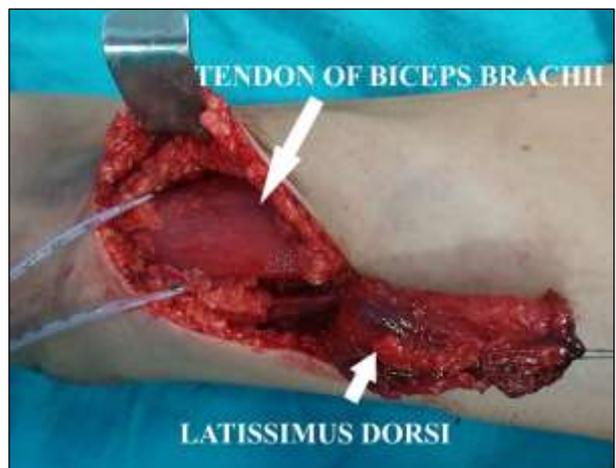


Figure 6: Z shaped incision given in the antecubital fossa for exposure of biceps tendon and latissimus dorsi delivered.

The position of the patient is changed to the supine position. Incision in the form of a Z was made along the distal biceps muscle at the level of the antecubital fossa to

The elbow was passively flexed to 100° and four mattress sutures were placed in the biceps tendon, medial and lateral at the musculotendinous junction and medial and lateral more distally at the tendinous portion of the biceps

in preparation for securing the latissimus dorsi to the distal biceps tendon (Fig 7). The limb was adjusted to maintain the elbow in approximately 100 degrees of flexion with full supination. Two deep drains were placed in the donor site until output is less than 5 mL in 24 hours to prevent seroma formation. Wounds were closed in layers.

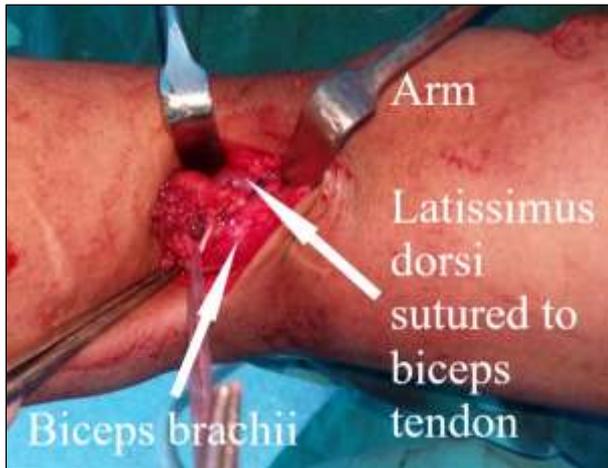


Figure 7: Latissimus dorsi fixed to biceps tendon using mattress sutures.

The arm was kept immobilized in a sling with an abduction pillow for 8 to 9 weeks. At 4 weeks, the patient was advised to start isometric contraction of the transferred muscle while at the shoulder was still in 90 degrees. After 8 weeks, the patients were asked to begin

working on slowly regaining extension at a rate of 10 to 20 degrees per week. Reeducation of the transferred latissimus dorsi muscle was accomplished initially by simultaneous shoulder extension and elbow flexion. Patients were followed up for 1 year and after initiation of active mobilization, range of motion of flexion at elbow joint with MRC grading were evaluated with goniometry and noted at regular intervals.

Results reported in the study were those noted after 1 year of follow up and physiotherapy.

RESULTS

The 18 patients studied had a mean age of 36.33±13.63 years with the range of 18-60 years and median age 34 years. 11 patients (61.11%) were in the age group of 21-40 years. 16 patients (88.89%) sustained injury due to high velocity road traffic accidents. Other modes of trauma were gunshot injury and fall from height in 1 patient each (Table 1). Right upper limb was most commonly injured, in 13 patients (72.22%), while the left upper limb was affected in the remaining 5 patients. 16 patients (88.89%) had closed type injury with swelling and bruises over neck, supraclavicular, shoulder or arm region. Only 2 patients presented with open brachial plexus injuries. All the patients presented with preganglionic supraclavicular injury and with Horner’s Syndrome in only 1 patient. The affected motor nerves as found on Nerve Conduction Velocity were only axillary and musculocutaneous nerve in 6 patients (33.33%) but in addition median, ulnar, radial nerves were also affected in 12 patients (66.67%).

Table 1: Demography of patients with particular reference to preoperative and postoperative elbow flexion.

Age (yrs)	Mode o trauma	Day of presentation (days)	Day of surgery (days)	Preoperative flexion power	Preoperative flexion (degrees)	Postoperative flexion power	Postoperative flexion (degrees)	Improvement in flexion (degrees)
23	RTA ^A	90	102	M1	15	M4	85	70
47	RTA	115	190	M2	20	M4	75	55
31	RTA	95	170	M2	5	M4	95	90
34	RTA	120	140	M0	5	M4	80	75
34	RTA	136	178	M0	5	M3	65	60
44	RTA	121	153	M0	5	M4+	95	90
1	GSI ^B	102	137	M2	10	M3	90	80
55	RTA	300	305	M1	10	M3	60	50
52	RTA	91	120	M2	5	M3	95	90
25	RTA	88	100	M1	5	M4+	100	95
8	FFH ^C	240	300	M1	0	M4	90	90
22	RTA	101	240	M1	5	M4	120	115
40	RTA	110	260	M1	0	M4+	110	110
34	RTA	120	124	M2	15	M3	80	65
20	RTA	180	200	M0	0	M4+	100	100
60	RTA	91	145	M1	0	M4	85	85
57	RTA	121	180	M2	10	M4	90	80
37	RTA	98	194	M0	0	M3	80	80

Table 2: Investigative and diagnostic workup of the patients.

MNCV	SNCV	EMG	MRI
Axillary, musculocutaneous, median, ulnar, radial	Normal	Upper trunk plexopathy with evidence of chronic denervation	Root avulsion of c5 with pseudo meningocele formation with neuritis
Axillary, musculocutaneous	Normal	Upper trunk plexopathy with evidence of chronic denervation	Neuropraxia with neuritis involving c5-6 nerve roots
Axillary, musculocutaneous	Normal	Upper trunk plexopathy with evidence of chronic denervation	Neuropraxia with neuritis involving c5-6 nerve roots with root avulsion injury of c5
Axillary, musculocutaneous, median, ulnar, radial	Increased latency, decreased snap in media and ulnar nerves	Pan-plexopathy with evidence of chronic denervation	Not done due to orthopaedic implant
Axillary, musculocutaneous, median, ulnar, radial	Normal	Pan-plexopathy with evidence of chronic denervation	Neuropraxia with neuritis c4-5, c5-6, c6-7 roots, superior and middle trunks and division
Axillary, musculocutaneous, median, ulnar, radial	Normal	Pan-plexopathy with evidence of chronic denervation	Root avulsion c5 and c6 with pseudo meningocele
Axillary, musculocutaneous	Normal	Upper trunk plexopathy with evidence of chronic denervation	Root avulsion c5 with pseudo meningocele
Axillary, musculocutaneous, median, ulnar, radial	Normal	Pan-plexopathy with evidence of chronic denervation	Root avulsion of c5 with pseudo meningocele with neuritis over upper trunk
Axillary, musculocutaneous	Normal	Upper trunk plexopathy with evidence of chronic denervation	Root avulsion c5 with pseudo meningocele with neuritis
Axillary, musculocutaneous, median, ulnar, radial	Increased latency, decreased snap in media and ulnar nerves	Upper trunk plexopathy with evidence of chronic denervation	Root avulsion c5 with pseudo meningocele formation with neuritis
Axillary, musculocutaneous, median, ulnar, radial	Normal	Upper trunk plexopathy with evidence of chronic denervation	Ill-defined brachial plexus with distortion of surrounding fat with pseudo meningoceles at the level of c5-6
Axillary, musculocutaneous, median, ulnar, radial	Normal	Upper trunk plexopathy with evidence of chronic denervation	Root avulsion with pseudo meningoceles at c5-6
Axillary, musculocutaneous, median, ulnar, radial	Normal	Pan-plexopathy with evidence of chronic denervation	Root avulsion with pseudo meningoceles at c5-6 with no signs of atrophy or edema of adjacent muscles with supraspinatus tear
Axillary, musculocutaneous	Normal	Upper trunk plexopathy with evidence of chronic denervation	Root avulsion with pseudo meningoceles at the level of c5-6
Axillary, musculocutaneous, median, ulnar, radial	Normal	Pan-plexopathy with evidence of chronic denervation	Root avulsion c5 with pseudo meningocele formation with neuritis
Axillary, musculocutaneous, median, ulnar, radial	Normal	Pan-plexopathy with evidence of chronic denervation	Root avulsion injury with posttraumatic pseudo meningocele at c5-6
Axillary, musculocutaneous	Normal	Upper trunk plexopathy with evidence of chronic denervation	Root avulsion injury of c5 with pseudo meningocele formation with neuritis
Axillary, musculocutaneous, median, ulnar, radial	Increased latency, decreased snap in median and ulnar nerves	Pan-plexopathy with evidence of chronic denervation	Pan-plexopathy with evidence of chronic denervation

EMG suggested upper trunk plexopathy with evidence of chronic denervation in 10 patients (55.56%) and panplexopathy in 8 patients (44.44%). However, Magnetic Resonance Imaging of the brachial plexus

showed root avulsion of C5 or C5,6 in 13 patients (72.22%), 2 had neuropraxia with neuritis and 1 patient had neuropraxia with root avulsion (Table 2). 13 patients had pseudomeningocele formation. Mean time that elapsed

between injury and presentation was 128.83 ± 56.76 days, median time being 112.5 days. Mean time that elapsed from injury to surgery was 179.89 ± 62.04 days, median time being 174 days. Average flexion in patients who were subjected to unipolar latissimus dorsi muscle transfer was $6.38 \pm 5.89^\circ$ (range $0-20^\circ$) preoperatively which improved after surgery to $88.61 \pm 14.63^\circ$ (Figures 8-11) with median of 90° (range $65-120^\circ$).

The mean time taken to perform unipolar latissimus dorsi muscle transfer was 3.30 ± 0.66 hours with a median of 3 hours (range 2 hours 45 min- 4 hours 30 minutes). On the MRC scale 5 patients had no elbow flexion preoperatively, 7 had M1 grade and 6 patients had M2 power of elbow flexion. 6 months postoperatively 6 patients (33.33%) reached only M3 power, 8 patients had M4 (44.44%) power and 4 patients developed M4+ muscle power (22.22%).



Figure 8: Preoperative elbow flexion of 5° in a 22 years young male who was operated 8 months after left brachial plexus injury.



Figure 10: Preoperative elbow flexion of 0° in a 40 years old male operated 9 months after right brachial plexus injury.



Figure 9: Postoperative elbow flexion of 120° in the same patient 9 months after unipolar latissimus dorsi muscle transfer to biceps brachii tendon.

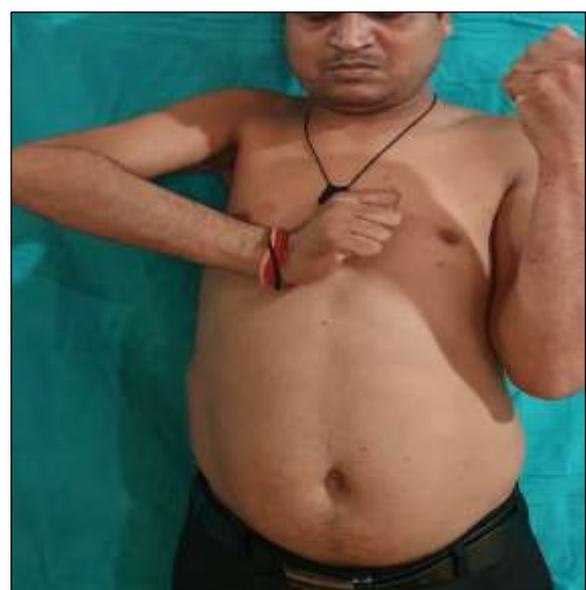


Figure 11: Postoperative elbow flexion of 110° in the same patient after latissimus dorsi.

DISCUSSION

A number of patients with traumatic brachial plexus injuries may benefit by neurolysis, primary plexus reconstruction or neurotization procedures. Although a direct approach to the neurological lesion has given some encouraging results, these can be incomplete and for this reason muscle or tendon transfers still have an important role.⁹ Elbow function is the most important function to regain in a flail arm as the loss of such an important function can be crippling. Defining an adequate elbow flexion has been a matter of great debate. Bengston et al considered adequate elbow as the one with strength \geq M3, ideally \geq M4 and with more than 80° of active flexion.¹³ Other studies suggested restoration of grade M4 or M4+ elbow flexion with a range of motion, will allow the hand to reach the face. 90-100° of elbow flexion are needed to provide useful function.¹ Ever since Schottstaedt et al, first described latissimus dorsi muscle transfer for restoration of upper-extremity function, the functional LD muscle transfer has become a “workhorse” flap in upper-extremity salvage specially closed brachial plexus injury.¹⁰ The latissimus dorsi known for its power, large size, long and consistent vascular pedicle, easily contoured shape and a straighter line of pull. These favorable characteristics have led to its use for other reconstructions including triceps, trapezius, and deltoid, and most commonly irreparable rotator cuff tears.¹⁴⁻¹⁷ Various other pedicled muscle transfers have been described like flexor-pronator mass, pectoralis major, pectoralis minor, triceps, and sternocleidomastoid.^{8,9,18-20} Most of the studies use a bipolar pedicled latissimus dorsi transfer whereas in this study authors used a unipolar transfer i.e. keeping the humeral insertion intact. However, either technique may be used depending on the surgeon’s preference and comfort. Kawamura et al, in their series could not differentiate between the two types of transfer and the outcomes were not significant.²¹

Patients who sustained brachial plexus injury and present later than 6 months and with significant biceps atrophy, elbow flexion was best achieved by a muscle transfer, for the reason that nerve transfer procedures are unlikely to provide useful function.¹ Latissimus dorsi can provide a stronger elbow flexion than a flexorplasty.

The authors found in this study that 66.67% of patients who underwent unipolar latissimus dorsi transfer developed M4 or M4+ muscle power with active flexion of 88° and postoperative improvement of 82°. In a retrospective analysis of 7 patients, 5 patients (71.43%) recovered M4 elbow flexion strength (0.5 to 8kg) while 1 patient recovered M3 strength. The mean active elbow flexion was 91° (range 45 to 130°).²² Similarly Zancolli and Mitre reported eight patients who underwent transplantation of the latissimus dorsi.²³ Total arc of active flexion ranged from 105 to 140 degrees. Flexion contractures of 10 degrees and 15 degrees occurred in two, and active supination of 20 to 50 degrees was achieved in six. Moneim and Omer achieved satisfactory

flexion (100 degrees or more) in three of five patients. The other two initially had paralysis of the latissimus dorsi and achieved only 65 to 70 degrees of flexion. Two of 5 patients could lift 4 lb, while two others could lift 1 and 1.5 lb, respectively. They stressed that the procedure should not be done unless the latissimus dorsi muscle is normal.²⁴ Hirayama et al, had 2 of 6 patients who could raise their hands to their mouths.²⁵ Botte and Wood studied 16 patients with mean age of 31.6 years and noted satisfactory function in four of five patients treated by unipolar latissimus dorsi transfer, flexion averaged 87° (range 35 to 130°).²⁶ In this study the average age was 36.33 years and the average flexion was also 88°.

The technique of unipolar latissimus dorsi necessitated adequate rather generous mobilization of the muscle based on humeral insertion lest the pedicle kinked to result in flap failure.²⁷ Tubing the muscle pedicle was preferable as it eased the pedicle transfer through the subcutaneous tunnel created on the posteromedial aspect of the arm. The tubed latissimus dorsi when sewn to the biceps brachii provided greater strength to the repair and stronger elbow flexion. The tension of muscle transfer was of paramount importance. Prior to transfer, it was important to determine the resting length of the latissimus dorsi.²⁸ Two methods were described, one was placement of sutures every 5 cm or so to mark the resting length and the other was putting the elbow in 90° to 100° flexion and full supination to determine the appropriate resting length.^{23,29} Authors, however, raised the muscle generously well beyond the vascular pedicle and sutured the latissimus to the biceps with the elbow in 100-120° of passive flexion and forearm in supination. The assessment was purely subjective driven by experience and encouraging results.

Diagnostic methods to determine the patterns of brachial plexus injuries have always been intriguing as there is no consensus regarding which tool is the best. Physical examination, Magnetic Resonance Imaging (MRI) and Nerve Conduction studies (NCV) have widespread use and feasibility for everyday assessment. It has been found in studies that physical examination and nerve conduction studies are any day better than Magnetic Resonance Imaging with high sensitivity of about 97-98%.³⁰ The accuracy of MRI to diagnose root avulsion was 73% for C5 and 64% for C6.³¹

Preoperative EMG was studied by Stern et al who reported success in functional LD muscle transfer regardless of the evidence of denervation on electromyography and thus believed it was unnecessary.³²

Although several options exist for reconstruction of elbow flexion, latissimus dorsi muscle transfer is a reliable method, unipolar giving as good results as bipolar. Almost all the patients undergoing functional muscle transfer regain at least motion against gravity whereas a large proportion regain motion against resistance. Preoperative muscle strength assessment,

meticulous surgical technique and an appropriate postoperative management is vital to obtain a better outcome.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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