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Is fascicular selection by nerve stimulation techniques a necessity in selective nerve transfers targeted at restoration of elbow flexion in upper brachial plexus injuries?

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Abstract: In the restoration of elbow flexion nerve transfers have proven to be superior to muscle or tendon transfers. Biceps and brachialis muscles, the prime elbow flexors, are innervated by musculocutaneous nerve, taking its origin from the lateral cord of brachial plexus. A variety of donor nerves of both intraplexal and extraplexal sources have been used in the neurotization of this nerve. We prefer transfer of two fascicles, one each from ulnar nerve and median nerve, directly to the biceps and brachialis motor branches. Contrary to the pervious reports now we do not use nerve stimulation while selecting the ulnar and median nerve fascicles. Twenty two patients with upper plexus (C5 and C6) injuries were treated with bifascicular nerve transfer in the period between Jan 2006 and Aug 2007. All of the patients were males in the age group 18 to 35 years and motor cycle accident was the main cause of injury. The denervation period (time interval between injury and nerve surgery) averaged 5 months. Twenty one patients restored full elbow flexion (140°); one could achieve 110° of antigravity flexion. In MRC grade 16 scored M4 while 6 scored M3. Patients with good results could lift 8 kilograms of weights. In our experience, bifascicular nerve transfer using ulnar and median nerves as donor nerves is the most reliable method of restoring elbow flexion in upper brachial plexus injuries and there is no need of fascicular selection with a nerve stimulator prior to transfer.

Keywords: elbow flexion; fascicular nerve transfer; nerve stimulator

INTRODUCTION

In upper brachial plexus injury reconstructive goals are aimed at restoration of shoulder abduction, external rotation and elbow flexion, and out of these the elbow flexion takes a priority. When upper roots are avulsed or there is irreparable injury to the upper plexus, anatomical reconstruction using nerve grafts is not feasible. In such situations nerve transfers have proven to be superior to muscle or tendon transfers[1].

In the restoration of elbow flexion, a variety of donor nerves of both intraplexal [2,3] and extraplexal [4,5,6.7.8.9.10,11] sources have been used with success rates ranging between 15%[3] and 100%[12,13]. In 1994 C Oberlin introduced a new technique of nerve transfer using one or two fascicles of ulnar nerve to the biceps motor branch of musculocutaneous nerve[14]. This technique gained lot of popularity because of its simplicity and achievement of good results. In 1997 Loy et al published a report of18 patients treated with this technique[15]. Most of the cases in this series obtained good elbow flexion with MRC grade 3 to 4, but 5 patients required an additional Steindler flexorplasty to achieve satisfactory elbow flexion. Results were even less satisfactory when there was an associated C7 root injury. Hence the original Oberlin transfer was supplemented with reinnervation of brachialis muscle using a fascicle from the adjacent median nerve[15,16,]. At present, most reports are in favor of double fascicular transfer in regaining elbow flexion in C5,C6 root avulsion injuries[16,17,18]. However all studies stress on the careful selection of ulnar and median nerve fascicles prior to transfer[14,15,16,17,18]. Contrary to this we raise a fascicle from the visible surface of the donor nerve which is mobilized to the recipient motor branch without much of inter fascicular dissection. In this article we present our experience with 22 consecutive patients of upper brachial plexus injuries treated by bifascicular transfer wherein fascicular selection was independent of nerve stimulation techniques.

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PATIENTS AND METHODS

This is a prospective study of 22 consecutive cases of upper brachial plexus injuries presented at our centre in the period between Jan 2006 and Aug 2007. These patients (Figs 1 & 2) were having either C5,C6 root avulsion injuries (8 cases) or irreparable injuries with doubtful viability of the originating roots or upper trunk (14 cases). Most (15) of patients were the victims of motor cycle accidents and all of them were males in the age group 18 to 35 years (average age 24 years). The denervation period averaged 5 months. All patients were subjected to a detailed preoperative assessment which included a methodical clinical examination, electrophysiological studies and 3D MR myelography. Preoperative clinical photographs and video films were obtained as baseline in all patients.

Brachial plexus exploration was done under general anaesthesia. The technique details are mentioned in one of our article[1]. The additional nerve transfers targeted towards shoulder included, transfer of distal spinal accessory nerve to suprascapular nerve[19] and long head triceps branch of radial nerve to the anterior branch of axillary nerve[20]. For ulnar and median nerve fascicular transfer, the intermuscular course of musculocutaneous nerve was dissected through a 15 to 20 cm longitudinal incision along the anteromedial aspect of the arm. The branches to biceps and brachialis muscles were identified (Fig 3) and looped in a vascular sling. A longitudinal epineurotomy was made in the ulnar nerve. In earlier cases we used to perform electrical stimulation to isolate a fascicle carrying motor fibers to flexor carpi ulnaris. In subsequent cases any fascicle which was in close vicinity and required minimal interfascicular dissection was flipped to the recipient nerve. Similar methodology was adopted in median nerve fascicular transfer to brachialis muscle (Fig 4). With experience we found that there was no significant donor nerve related morbidity and results in elbow functions were comparable to electrically tested nerves. There was reduction in the operating time and unnecessary dissection of fascicles could be avoided.

Fig 1: Right sided upper brachial plexus palsy

Fig 2: Wasting of shoulder and arm muscles

POSTOPERATIVE PROTOCOL

Postoperatively the flexed arm was strapped to the chest at 100° flexion for 4 weeks. There after the arm was supported in a cuff-and-collar sling. Passive movements of elbow were started at 4 weeks. With the initiation of flexion movements supination exercises were begun.

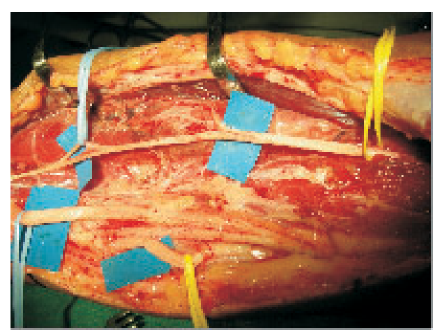

Fig 3: Target nerves (motor nerves to the biceps and brachialis muscles, and ulnar and median nerves) are depicted

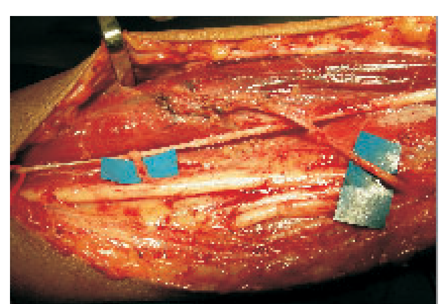

Fig 4: Oberlin transfers; no attempts made to select donor nerve fascicles by nerve stimulation

EVALUATION

Patients were initially evaluated at monthly and subsequently at 3 monthly intervals. The elbow flexion strength was measured using British Medical Research Council grading system (Table 1).

Table 1 : British Medical Research Council grading system

Observation	Muscle Grade
No contraction	0
Flicker or trace of contraction	1
Active movement, with gravity eliminated	2
Active movement against gravity	3
Active movement against gravity & resistance	4
Normal power	5

The ability of the patient to lift weights with shoulder adducted and elbow flexed at 90° were recorded. A complete neurological assessment of hand was also done. Grip strength was measured with a dynamometer.

RESULTS

The study results are depicted in Table 2. The relevant clinical results are shown in Figures 5 and 6.

The mean recovery time for biceps and brachialis muscles were 2.5 months (range 2 to 5) and 3 months (range 3 to 5) respectively. Three patients experienced transient paresthesias in the little and index fingers, which resolved in 2 to 3 months time. Patients with excellent results could lift 8 kilograms of weight with shoulder adducted and elbow flexed at 90°.

DISCUSSION

In C5 and C6 root avulsion injuries since anatomical repair is not possible, reconstructon is aimed at restoration of basic shoulder and elbow functions using nerve transfer techniques. There is a general agreement that nerve transfers offer far superior results than muscle or tendon transfers[21]. In musculocutaneous neurotization fascicular transfers of ulnar and median nerves to the target branches have consistently given good results. While describing the transfer technique most authors still stress on careful selection of donor fascicle(s), mainly with aim of avoiding sensory dominant or more important motor fascicles[14,15,16,17,18]. This evaluation is best done using a 2-mA nerve stimulator. We also adopted the same technique in initial cases but subsequently found that

Table 2 : Results of bifascicular nerve transfer

Patient	Age	Sex	Surgical delay (In months)	Follow up period (In months)	MRC grade	Elbow Flexion strength(Kg)
1.	20	M	4	24	4	8
2.	21	M	6	26	3	6
3.	33	M	3	23	4	7
4.	19	M	5	25	4	5
5.	30	M	6	24	4	5
6.	18	M	7	28	3	6
7.	35	M	4	24	4	5
8.	20	M	5	28	4	6
9.	26	M	9	26	3	3
10.	29	M	4	24	4	7
11.	30	M	5	23	4	6
12.	29	M	6	27	3	4
13.	21	M	4	24	4	6
14.	19	M	5	26	4	8
15.	23	M	7	24	3	3
16.	21	M	4	26	4	7
17.	20	M	5	24	4	5
18.	18	M	4	26	4	6
19.	27	M	6	24	3	3
20.	29	M	4	28	4	5
21.	20	M	5	24	4	5
22.	19	M	4	26	4	6

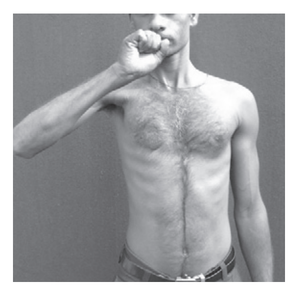

Fig 5: Full range of elbow flexion at 25 months follow up

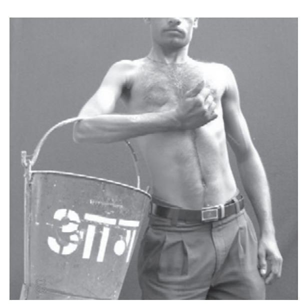

Fig 6: Elbow flexion strength of 5 kg at 25 months follow up

ultimate functional results and donor nerve related problems were not dependent on fascicular selection by electrical stimulation. Hence we have abandoned the use of nerve stimulator while performing ulnar and median nerve fascicular transfers. This has not only reduced the operating time but also made the procedure more simple. This method of fascicular transfer may be explained by the complexity of the intraneural anatomy of the brachial plexus as described in the beginning of last century by an anatomist Abraham Kerr[22]. In the arm the fascicular arrangement in relation to the ulnar and median nerves is not constant and changes at every 5mm[23,24]. Also the fascicles containing mixed motor and sensory fibers are much more common than either pure motor or pure sensory fascicles[25,26]. These anatomic findings and clinical results support our view point that it is impractical to isolate a pure motor or sensory fascicle in the arm using a hand held nerve stimulator and the functional results and donor nerve related morbidity are independent of fascicular selection.

CONCLUSION

Because of constant intertwining of motor and sensory fibers and a changing fascicular pattern over a short distances in the arm, it is impractical to isolate a pure motor or sensory fascicle(s) by nerve stimulation technique. In our experience functional results and donor nerve related morbidity have no bearing with fascicular identification by electrical stimulation. Hence we have abandoned this technique. This has made bifascicular nerve transfer further simple and a quicker procedure.

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