Original Article

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Outcome of Oberlin II versus Intercostal Nerve to Musculocutaneous Nerve Transfer Procedure for Elbow Flexion in Adult Brachial Plexus Injury

Surgery Section

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ABSTRACT

Introduction: In the management of brachial plexus injury restoration of elbow flexion has been prioritised over shoulder abduction in pan plexus injury due to scarcity of suitable donor nerve for nerve transfer procedure. Literature has shown promising result in restoring elbow flexion both in upper type as well as pan plexus injury by early intervention.

Aim: To assess the outcomes of Oberlin II and intercostal nerve to musculocutaneous nerve transfer procedures to restore elbow flexion, in upper type and pan plexus type adult brachial plexus injury respectively.

Materials and Methods: A prospective cohort study was conducted from November 2015 to October 2018 at tertiary care hospital at Cuttack, Odisha, India. Oberlin II procedure in 20 cases of upper type and intercostal nerve to musculocutaneous nerve transfer procedure in 20 cases of pan plexus type adult brachial plexus injury to restore elbow flexion, were included. In both the groups elbow flexion was assessed by British Medical Research Council (MRC) motor grading scale. Statistical analysis was made using IBM Statistical Package for the Social Sciences (SPSS) version 21.0, Pearson's Chi-square test was used for the data analysis and p-value <0.05 was considered as significant.

Results: The study had a total of 40 cases with age range from 19 to 58 years with mean age of 31.78±11.07 years. Full range of elbow flexion against gravity i.e., M3 power was achieved in 17 out of 19 (89.5%) of cases in less than six months of denervation, seven out of eight (87.5%) of cases in six to nine months of denervation and five out of 13 (38.5%) of cases in more than nine to 12 months of denervation (p-value <0.006). In case of Oberlin II procedure full range of elbow flexion against gravity i.e., M3 power or more was achieved in 100% of cases, whereas in case of intercostal nerve transfer full range of elbow flexion against gravity i.e., M3 power only was achieved in 45% of cases and M0 power in 55% of cases (p-value <0.001).

Conclusion: The study has concluded that in adult brachial plexus injury early intervention by Oberlin II nerve transfer procedures results in full range of elbow flexion against gravity i.e., M3 power or more was achieved in 100% of cases. In cases of pan plexus type injury full range of elbow flexion against gravity i.e., M3 power only was achieved in 45% of cases.

Keywords: Abduction, Brachial plexus neuropathies, Hand, Nerve transfer

INTRODUCTION

Brachial plexus injury is devastating in nature, mostly in case of pan brachial plexus injury, which is most debilitating. In the recent two decades, after the advent of nerve transfer procedure like Oberlin's [1,2] technique in 1994, has changed the scenario of brachial plexus injury management in upper type injury. Similarly, intercostal nerve to musculocutaneous nerve [3,4] transfer for elbow flexion in pan plexus injury also has infused some hope in the patient as well as the treating surgeon, so as to have some degree of productive function in the elbow joint. In the management of brachial plexus injury restoration of elbow flexion has been prioritised over shoulder abduction in pan plexus injury due to scarcity of suitable donor nerve for nerve transfer procedure. Literature has shown promising result in restoring elbow flexion both in upper type as well as pan plexus injury by early intervention [5-9]. In this study, the aim was to assess the outcome of Oberlin II [2] and intercostal to musculocutaneous nerve [8] transfer procedures to restore elbow flexion, in upper type and pan plexus adult brachial plexus injury respectively in the upper limb.

MATERIALS AND METHODS

The prospective cohort study was conducted at a tertiary care Government Medical College at Cuttack, Odisha, India, and the Department of Plastic Surgery catering to brachial plexus injury patient in the state. The time period of study was from November 2015 to October 2018. All the consecutive patients of brachial plexus injury admitted to the department, meeting the inclusion criteria were selected for the study. Informed consent was obtained from all the patients and the study was approved by the Institutional Ethics Committee (IEC/IRB No:625/26.02.2018).

Inclusion criteria: All the adult brachial plexus injury patient, aged between 18 years to 60 years of age and duration of denervation between 3 months to 12 months were included.

Exclusion criteria: Brachial plexus injury with associated head injury and compound fractures of upper limb bones with soft tissue injury, obstetric brachial plexus palsy patient were excluded from the study.

A total 40 patients of adult brachial plexus injury, consisting of 20 patients each of upper type injury and pan plexus injury. Oberlin II procedure in upper type injury and Intercostal Nerve to Musculocutaneous Nerve (ICN to MCN) transfer in pan plexus type injury were undertaken to restore elbow flexion. Postoperatively patients were put under physiotherapy in the supervision of experienced physiotherapist in Adult Brachial Plexus Injury (ABPI) management. Outcome was assessed on 3, 6, 12 and 18 months follow-up by British Medical Research Council (MRC) motor grading scale [3].

Thorough history regarding mode of injury, duration of denearvation, sides affected and associated injury was collected. Clinical examination

of the side affected, range of motion and power of muscles across different joint was elicited by British MRC scale of motor grading [3].

Magnetic Resonance Imaging (MRI) of the bilateral brachial plexus was asked for evaluation by Department of Radiodiagnosis. The nature of injury, whether preganglionic or postganglionic injury, root avulsion, root rupture or shear type of injury and the number of roots involved was ascertained. Nerve conduction velocity study of the nerves of the bilateral upper limb was carried out to find out the affected nerve. The electro diagnostic studies i.e., the Compound Motor Action Potential (CMAP) amplitude, Sensory Nerve Action Potential (SNAP) amplitude, distal latency, duration, nerve conduction velocity was assessed. Non recordable electro diagnostic studies of the nerves like suprascapular nerve, axillary nerve, musculocutaneous nerve were found in C5 and C6 injury and along with this finding when non recordable electro diagnostic study are found in radial nerve then C5, C6 and C7 injury was diagnosed and grouped in upper type injury. Along with this when non recordable electro diagnostic studies were found in median nerve and ulnar nerve then C5, C6, C7, C8 and T1 injury was diagnosed and grouped in pan plexus type injury.

The clinical diagnosis of upper type or pan plexus type was made based on the clinical examinations, nerve conduction velocity study and MRI findings.

In case of preganglionic injury, intervention was made around 3 months and in the postganglionic injury early intervention was preferably made around 5 to 6 month if presented early.

In cases of upper type of injury, Oberlin II procedure and pan plexus type injury intercostal nerve to musculocutaneous nerve (ICN to MCN) transfer procedure was undertaken and postoperatively the limb was kept in described position for 4 weeks.

Nerve transfer procedures both in the upper type and pan plexus palsy cases, restoration of elbow flexion was given priority over other affected joint, but for managing the patient of brachial plexus injury in its entirety other procedures were done on due time to restore the function of other joints like neurotisation of suprascapular nerve with spinal accessory nerve to restore shoulder abduction which was carried out one month after the primary procedure. Authors staged the procedure to focus in Oberlin II methods and limit the surgery time.

Oberlin II Procedure

The patient was placed in supine position and the upper limb was abducted to about 90°. An incision of approximately 10 to 12 cm was put in the medical aspect of arm just lateral to the brachial neurovascular bundle by appreciating the brachial artery pulse in upper and middle half of arm. The biceps brachi muscle was approached and the elbow joint was flexed to identify the musculocutaneous nerve in the interval between biceps brachi and brachialis muscles, motor branches to the biceps brachi and brachialis were identified and safeguarded.

The brachial neurovascular bundle was dissected and the median nerve, the ulnar nerves were identified and confirmed with nerve stimulation (Stimuplex, B Braun). Adjacent to the motor branches of the MCN the epineurium of the ulnar nerve and median nerve were incised and the internal neurolysis of the ulnar and median nerve were carried out. Then the ventromedial fascicle of the ulnar nerve and lateral fascicles of the median nerve were stimulated with the nerve stimulator 3 to 5 mA current and the wrist flexor preferable Flexor Carpi Ulnaris (FCU) and Flexor Carpi Radialis (FCR) stimulation confirmed respectively. Then the fascicle is divided 2 to 2.5 cm distally. Corresponding motor fascicle of biceps brachi and brachialis were divided 2 to 2.5 cm proximally and tension free coaptation of the ulnar nerve fascicle with the biceps motor branch and median nerve fascicle with the brachilis motor branch were coapted with maximum three sutures of 10-0 nylon and fibrin glue [Table/Fig-1].

Postoperatively the limb was placed in 90° elbow flexion with shoulder immobiliser for 2 weeks and after that on arm sling for another two weeks. After four weeks physiotherapy was began under the supervision of a physiotherapist.

Intercostal Nerve to Musculocutaneous Nerve Transfer

The patient was placed in supine position an infra mammary incision was made from the mid axillary line to the lateral border of the sternum. The pectoralis major muscle was reflected medially along with the skin and the intercostal nerves were approached in the 3rd, 4th and 5th intercostal space. The nerves were isolated from costochondral function to the midaxillary line. The distal end of the nerves close to the costochondral junction was divided.

After that the intercostal nerves 3rd, 4th and 5th were tunneled to the arm subcutaneously through the axillary fold and coapted directly to musculocutaneous nerve with 10-0 nylon suture and fibrin glue [Table/Fig-2].

[Table/Fig-1]: Intraoperative photograph showing Oberlin II procedure.
[Table/Fig-2]: Intraoperative photograph showing intercostal nerve to musculocutaneous nerve transfer. (Images from left to right)

Postoperative protocol of rest to the part by keeping elbow joint in 90° flexion, limb being kept in an arm sling. Physiotherapy was began two months after surgery by the physiotherapist experienced in managing brachial plexus injury in postoperative period. The patient followed-up at one month, three months, six months and 18 months. Nerve transfer procedure for shoulder abduction was carried out one month after the priority procedure.

STATISTICAL ANALYSIS

The data was analysed using IBM Statistical Package for the Social Sciences (SPSS) version 21.0, and relation between duration of the denervation and outcome of surgery were analysed by Pearson's Chi-square test. The p-value <0.05 was considered as statistically significant.

RESULTS

The present study had total of 40 cases with age range from 19 years to 58 years with mean age of 31.78 years with standard deviation of 11.07 years. The demography and clinical parameters were enumerated in [Table/Fig-3].

Full range of elbow flexion against gravity i.e., M3 power was achieved in 17 out of 19 (89.5%) of cases in less than 6 months of denervation, 7 out of 8 (87.5%) of cases in 6 to 9 months of denervation and 5 out of 13 (38.5%) of cases in more than 9 to 12 months of denervation (p-value=0.006) [Table/Fig-4].

The relation between distribution of age group and outcomes of nerve transfer procedure was enumerated in [Table/Fig-5], shows no significant difference in outcomes of nerve transfer in younger age groups and older age group below sixty years (p-value=0.347).

In case of Oberlin II procedure full range of elbow flexion against gravity i.e., M3 power or more was achieved in 100% of cases whereas in case of intercostal nerve transfer full range of elbow flexion against gravity i.e., M3 power only was achieved in 45% of cases and M0 power in 55% of cases (p-value <0.001) [Table/Fig-6]. The representative cases of the present study series were shown in [Table/Fig-7-9].

Variables	n (%)
Age (years)	
Mean±SD	31.78±11.07
Minimum	19
Maximum	58
Age groups (years)	
18 to 30	26 (65%)
31 to 40	8 (20%)
41 to 50	4 (10%)
51 to 60	2 (5%)
Duration of denervation in months	
Mean±SD	6.7±3.16
Minimum	3
Maximum	12
Gender	
Male	39
Female	1
Cause of injury	
Motorcycle accident	34 (85%)
Pedestrian	3 (7.5%)
Fall from height	1 (2.5%)
Gun shot	1 (2.5%)
Assault	1 (2.5%)
Side of injury	
Left side	12 (30%)
Right side	28 (70%)
MRI findings	
C5, C6 root injury	9 (22.5%)
Pan brachial injury	20 (50%)
C5, C6 root avulsion	3 (7.5%)
C5, C6, C7 root avulsion	2 (5%)
C5, C6, C7 nerve shear	6 (15%)
Associated injury	
No associated injury	19 (47.5%)
Fracture clavicle	3 (7.5%)
Fracture ribs	1 (2.5%)
Fracture upper limb bones	5 (12.5%)
Fracture facial bones	2 (5%)
Fracture lower limb bones	10 (25%)

[Table/Fig-3]: Table showing demography and clinical parameters.

Duration of denervation in months	Postoperative BMRC grading of elbow flexion at 18 months follow-up				
	Grade-0	Grade-3	Grade-4	Grade-5	Total
<6 months	2 (10.5%)	6 (31.6%)	9 (47.4%)	2 (10.5%)	19 (100%)
6 to 9 months	1 (12.5%)	5 (62.5%)	2 (25.0%)	0 (0%)	8 (100%)
>9 months	8 (61.5%)	5 (38.5%)	0 (0%)	0 (0%)	13 (100%)

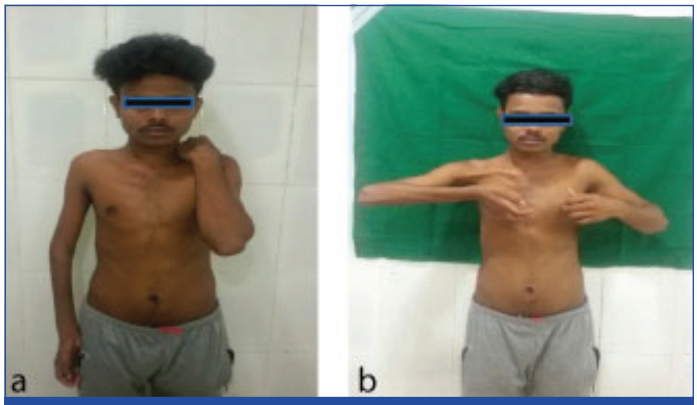
[Table/Fig-4]: Shows relation between duration of denervation in months and postoperative BMRC grading of elbow flexion at 18 months follow-up cross tabulation (Degree of freedom 6).
Pearson's Chi-square value: 18.01; p-value=0.006; BMRC: British medical research council

Age groups	Postoperative BMRC grading of elbow flexion at 18 months follow-up				
	Grade-0	Grade-3	Grade-4	Grade-5	Total
18-30 years	8 (30.8%)	12 (46.2%)	4 (15.4%)	2 (7.7%)	26 (100%)
31-40 years	2 (25.0%)	2 (25.0%)	4 (50.0%)	0 (0%)	8 (100%)
41-50 years	1 (25.0%)	2 (50.0%)	1 (25.0%)	0 (0%)	4 (100%)
51-60 years	0 (0%)	0 (0%)	2 (100%)	0 (0%)	2 (100%)

[Table/Fig-5]: Shows relation between age groups and postoperative British Medical Research Council (BMRC) grading of elbow flexion at 18 months follow-up cross tabulation.
Pearson's Chi-square value: 10.044; degree of freedom: 9, p-value=0.347

Procedure done for elbow flexion	BMRC grading of elbow flexion			
	Grade 0	Grade 3	Grade 4	Grade 5
Oberlin II	0 (0%)	7 (35.0%)	11 (55.0%)	2 (10.0%)
ICN to MCN	11 (55.0%)	9 (45.0%)	0 (0%)	0 (0%)
Total	11 (27.5%)	16 (40.0%)	11 (27.5%)	2 (5.0%)

[Table/Fig-6]: Procedure done for restoration of elbow flexion in adult brachial plexus injury vs British Medical Research Council (BMRC) grading of elbow flexion at 18 months follow-up.
Chi-square value: 24.250; Degree of freedom: 3; p-value <0.001



[Table/Fig-7]: a) Preoperative photograph of upper type brachial plexus injury in right upper limb; b) Postoperative photograph of the patient following Oberlin II procedure showing more than M3 power elbow flexion at 18 months follow-up.
*This patient also shows shoulder abduction M3 and more power with 50 degree shoulder abduction that authors have not included in this study

[Table/Fig-8]: a) Preoperative photograph of upper type brachial plexus injury in right upper limb; b) Postoperative photograph of upper type brachial plexus injury right upper limb, showing M3 and more elbow flexion at 18 months follow-up after Oberlin II procedures.

[Table/Fig-9]: a) Preoperative photograph of upper type brachial plexus injury in right upper limb; b) Postoperative photograph of upper type brachial plexus injury right upper limb, showing M3 and more elbow flexion at 18 months follow-up after Oberlin II procedures.

DISCUSSION

In the present study, males were most commonly affected than female in 39 out of 40 cases (97.5%) similar to study by Jain DA et al., and Dubuisson AS and Kline DG, [10,11]. Males were most commonly involved in outdoor work than females. In this study most commonly affected age group was 21-30 years which accounted for

26 out of 40 cases (65%) similarly to study by Jain DA et al., where 45.72% of patients were in age group of 21-30 years of age [10].

Most common cause of injury was road traffic accident in 37 out of 40 cases (92.5%) and most common by motorcycle accident in 34 out of 37 cases (85%) and pedestrian sustaining injury in 3 cases (7.5%) which was similar to study by Jain DA et al., where 94.4% of cases by road traffic accident and 90.24% were by two wheeler accident [10]. Songcharoen P, had similar result in their study where 91% of brachial plexus injury was due to road traffic accident and 82% was due to two wheeler accident [12].

Most common associated fracture was lower limb bone fracture in 10 out of 40 cases (25%), next common was upper limb bone fracture in 5 out of 40 cases (12.5%). Other fracture associated were clavicle fracture in 3 cases (7.5%) of cases, Jain DA et al., in their study got similar result where lower limb bone fracture in 19.4% of cases, upper limb bone fracture in 16.77% of cases, clavicle fracture in 10.19% cases, facial bone fracture 6.5% of cases, spine fracture in 4.9% of cases, rib fracture in 2.63% and pelvis fracture 0.65% of cases is found [10].

In the literature, many studies have reported that in the younger age group the outcomes of nerve transfer procedures are better than the older age group but in present series authors have obtained good result both in younger as well as older age group (p-value=0.347) [9-14]. Average duration of denervation in the present study was 3-6 months in 19 out of 40 cases (47.5%) of cases similar to study by Bhandari PS et al., where most commonly surgery was done between 3-6 months [13]. Jain DA et al., also found similar result where average duration of denervation before surgery was 127 days [10].

Right upper limb was more commonly involved in 28 out of 40 cases (70%) of cases similar to study by Jain DA et al., where 69.73% was right sided injury [10]. Bhandari PS et al., also obtain right sided injury in 65.91% of cases [13]. Right arm is dominant in most people than left hand drive and hence this arm is used for protection of body during road traffic accident and most likely to be involved in injury.

The present study showed that in adult brachial plexus injury early Oberlin II nerve transfer procedures resulted full range of elbow flexion against gravity M3 power and more in 100% of cases, this finding is similar to other authors [1,2,10-13,15-21]. In cases of pan brachial plexus injury full range of elbow flexion against gravity M3 power only was achieved in 45% of cases, this is similar to other study [7]. So, this showed that Oberlin II procedure has better learning curve than intercostal to musculocutaneous nerve transfer in beginner's hand.

Chuang DC et al., during their initial time obtained grade 3 or more muscle power of elbow flexion in 66% of cases of intercostal nerve to musculocutaneous nerve transfer [4]. Marrel GA et al., obtained grade 3 or muscle power of elbow flexion in 72% of cases of intercostal nerve to musculocutaneous nerve transfer [15]. Chuang DC, after two decades of experience obtained grade 3 or more muscle power for elbow flexion in 80% of cases of intercostal nerve to musculocutaneous nerve transfer [16]. De Mendonca CM et al., has obtained M3 and more power in 50% of cases of pan plexus injury with intercostal to musculocutaneous nerve transfer [7]. He has reported complication like pneumothorax, haemothorax, infection and pleural laceration without intercostal chest drain. But authors have not encountered any such complications in the present study.

Xiao C et al., has found effective elbow flexion in 85.7% of cases in upper type and 66.7% case in pan plexus type adult brachial plexus injury following intercostal nerve to musculocutaneous nerve transfer, the result of 66.7% in pan plexus injury is superior to the present study result [8]. Due to the inferior result, our study needs further research to find out the cause. Authors also found that no statically significant difference in outcome of elbow flexion in different types of brachial plexus injury but in the present study series there was a significant difference in the outcomes of nerve transfer procedure between upper type and pan plexus injury (p-value<0.001) due to poor result in pan plexus type of injury.

Verdins K and Kapickis M reported M4 and more elbow flexion in 100% of cases in upper type injury even in cases of delayed presentation beyond 12 months of injury in some of his cases [9]. In the present study, authors have also obtained M3 and more elbow flexion around 9 months of denervation following upper type injury. Most authors reported that morbidity of donor site have not resulted following nerve transfer procedures if the donor nerve is chosen carefully [13-16]. Authors have encountered temporary weakness both motor and sensory in the ulnar and median nerve distribution that normalised spontaneously within 3 months.

In intercostal nerve to musculocutaneous nerve group, the present study result was 45% because the procedure demands a long learning curve, and as the nerve transfer was done to a mixed recipient nerve by a mixed donor nerve, in which the nerve regeneration is unpredictable due to chances of misdirection of axons leading to axonal loss. Authors proposed further study to exactly locate the motor fascicle of both recipient and donor nerve ends before coaptation of the nerve ends by fascicular repair and to practice this principle sincerely to achieve predictable results in ICN to MCN transfer procedures. However, Chuang DC obtained useful elbow flexion of M3 power or more in 80% of cases [16].

Oberlin C et al., obtained grade 3 or more muscle power in 75 to 100% of patients for elbow flexion by Oberlin I procedure [1]. Other study by Sungpet A et al., and Leechavengvong S et al., obtained grade 4 or more muscle power in 75 to 94% of cases [17,20]. Double neurotisation has improved outcome in comparison to single nerve transfer in restoration of elbow flexion also shown by other authors [18-20]. Venkatramani H et al., also have shown good to excellent result in all his cases of nerve transfer procedure between 2 to 6 months of incident of injury to brachial plexus [21].

Limitation(s)

The limitation of study included its lack of quantitative assessment of the strength of elbow flexion, lack of intraoperative frozen section and immune histochemistry to identify motor fascicle in mixed nerve before coaptation of nerve ends, small number of cases and short follow-up period of 18 months.

CONCLUSION(S)

The present study showed that Oberlin II procedure result predictable outcomes not only in cases of early intervention within 6 months of denervation but also in cases of delayed presentation within 12 months of denervation in upper type injury. But ICN to MCN transfer procedure result unpredictable outcomes even in cases of early presentation and younger age groups.

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