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Original Article

Traumatic brachial plexopathies – Analysis of postsurgical functional and psychosocial outcome

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ABSTRACT

Introduction: Brachial plexus injuries (BPI) not only affect motor but also psychosocial aspects of patients' lives.

Aims and objectives: To evaluate results of surgery in terms of motor, functional and psychosocial recovery; and to evaluate the surgical outcome in relation to location of injury, time since injury and type of surgical procedure.

Methods: A total of 36 patients with traumatic BPI operated between Jan and Sept 2011 were prospectively analysed. Parameters analysed included demographic profile and complete injury details. Patients were evaluated in pre-op and post op (6, 9 months and then 6 monthly). Primary outcome measure was motor outcome. Secondary outcome measures included functional outcome as assessed by SF-36 score, DASH questionnaire, PVAS and psychosocial outcome assessment performed by DAQ and LH score.

Results: Mean interval between injury and surgery was 8 months (range 3–20 months). There were 15 partial and 21 panplexal injuries. Mean follow up was 13.5 months (range 9–18 months). Good motor recovery rate was 71% in partial and 23% in pan BPI. Neurotisation yielded the best motor outcome (53% patients). There was no statistical difference between motor recovery, timing of surgery and type of neurotisation. There was statistically significant improvement in all the functional outcome scores and mean PVAS score after surgery ($p < 0.05$).

Conclusions: Surgery offers a significant relief of neuropathic pain and improves the emotional well-being of the patient and should be offered to all, irrespective of delay in presentation.

Abbreviations: BPI, brachial plexus injuries; SF-36, short form 36; DASH, disability of arm, shoulder and hand; PVAS, pain visual analogue scale; DAQ, dysfunction analysis questionnaire; LH, learned helplessness.

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1. Introduction

Brachial plexus injuries are the most severe nerve injuries of upper extremity, resulting in marked functional impairment. Middle aged males are most frequently affected and road traffic accidents are most common cause.[1–3] In addition to the severe motor impairment, brachial plexus injuries take a heavy toll on the economical and psychosocial aspects rendering previous healthy individuals physically and socio-economically handicapped.[4–6]

Although surgical management of such injuries dates back to early twentieth century, it was not widely practised because of consistent poor results.[3,7,8] The advent of operating microscope and refined microneurosurgical techniques in the latter half of last century created a resurgence of interest in these injuries. A more aggressive approach towards management of these cases was popularised and maintained after good results reported by Millesi and Narakas.[9–11] Since then, various studies have documented the utility of surgery.[3,9–14]

Surgery is indicated in cases not showing any signs of regeneration even after 3 months of injury. Various surgical modalities of treatment have been described which include neurolysis, neurotisation with or without nerve grafting.[3,12–14] Although such studies have focussed on the motor outcome of these patients, very few studies have concentrated on the functional and psychosocial aspects of these injuries.[4,5,15,16]

The present study was conducted with the aim to evaluate the results of surgery in terms of motor recovery, functional recovery and psychological recovery and to evaluate the surgical outcome in relation to location of injury, time since injury and type of surgical procedure.

2. Materials and methods

This was a prospective observational study conducted at our centre involving all patients of traumatic BPI who underwent surgical treatment between January 2011 and September 2011. Ethical clearance was obtained by the Institute Ethics Committee prior to start of study. Patients with conservatively managed injuries and birth palsies were excluded from study. Complete details were recorded including demographic profile, mode of injury, type and severity of injury, associated injuries and time since injury.

Patients were studied for motor, functional and psychosocial status in pre-operative period and then followed up (OPD basis/telephonically) at 6 months, 9 months and then at half yearly intervals till last follow up.

2.1. *Outcome evaluation*

The primary outcome measure was motor outcome assessed by British MRC grading.[17] Excellent outcome was graded as motor power ≥4/5. Good outcome was motor power 3/5 or improvement of at least 2 grades on the MRC scale from the pre-op period; and poor outcome was motor power of <3/5.

The secondary outcome measures included functional and psychosocial outcome.

The functional outcome was assessed by i) DASH (Disability of the arm, hand and shoulder) questionnaire, ii) SF-36 (36 item short form health survey) questionnaire and iii) Pain Visual analogue scale (PVAS).

The psychosocial outcome was assessed by i) Dysfunction analysis questionnaire (DAQ) and ii) Learned helplessness (LH) scale.

The *DASH questionnaire*[18] has been a statistically validated scale for assessment of upper limb function. It is composed of 30 general activity, symptoms and social function items. The general activity includes questions such as the ability to open a jar and put on a sweater. The questions on symptoms evaluate severity of pain, stiffness, and general weakness of upper limb, while the social function items assess the degree of limitation in performing a variety of activities with family and friends.

SF-36 questionniare[19,20] is a generic question survey that has been statistically validated as a measure of a patient's functional health and quality of life (QOL). The results are separated into eight subscale profiles with overall 36 questions related to physical functioning, social functioning, role limitations due to physical problems, role limitations due to emotional problems, energy and vitality, mental health, bodily pain, and general perception of health. Using this questionnaire at the beginning and during the course of care, the progress of the 8 parameters mentioned can be tracked.

Pain visual analogue scale (PVAS)[21] is a standard 10 mm visual analogue scale used to assess pain, with 0 mm representing no pain and 10 mm representing severe pain.

Dysfunction analysis questionnaire (DAQ)[22] was developed to measure change in psychosocial functioning following illness/accident/operation and therapeutic intervention. It consists of 50 explicit items of daily activities in colloquial regional language (Hindi), measuring dysfunction in 5 areas namely social, vocational, family, personal and cognitive. Items are rated by patient or his significant family member on a 5 point scale i.e. better than before, same as before and deteriorated mildly, moderately or severely.

Learned helplessness (LH) scale[23–25] – Some people are unable to face new problems not because of their lack of capacity to deal with such problems, but because of acquired sense of helplessness in their early experiences. This has been named as learned helplessness. The scale contains 15 items signifying the learned helplessness.

The statistical analysis was done using SPSS software (version 16.0). Chi square test was applied to analyse motor recovery with respect to delay of presentation of the patient. To compare pre-op and post op functional and psychosocial scores (DASH, SF-36, DAQ, LH and PVAS), students paired *t* test was utilised.

3. Results

A total of 36 patients were operated during this period. The mean age was 26.9 yrs (range 11–45 yrs). Eight patients were <18 years age and rest were adults. The most common mode of injury was roadside accident (86%). The mean interval between injury and surgery was 8 months (range 3–20 months). There were 18 right sided and 18 left sided lesions. Associated injuries were present in 10 (32%) cases. Clavicle and long bone fractures were most common associated injuries.

The presentation of patients was categorised as early-15 patients (<6 months), late-18 patients (6–12 months) or delayed-3 patients (>12 months).

The injuries were divided into partial and pan subtypes, based on root involvement. There were 15 partial (41%) and 21 pan (59%) brachial plexus.

All patients underwent some kind of surgical procedure alone or in combination. In 3 cases, the procedure was abandoned due to excessive scar tissue and hence, those patients were excluded from further analysis. Neurotisation was the most common procedure performed, alone and in combination in 19 and 8 cases respectively. Neurolysis was performed in 6 cases.

Of the 27 neurotisation procedures performed, autologous nerve graft was utilised in 3 cases. Twenty-four cases had neurotisation without the use of any graft. Double neurotisation was performed in 15 cases (62.5%) while single and triple neurotisation were done in 9 (37.5%) and 3 (12.5%) cases respectively.

For shoulder abduction, spinal accessory (SAN) and phrenic (PN) nerves were the most commonly utilised donor nerves (9 and 11 cases respectively). Recipient nerves were suprascapular (SS) and axillary nerves (AN) in 18 and 2 cases respectively.

For restoration of elbow flexion, the donor nerves for musculocutaneous nerve (MC) anastomosis included intercostal nerve (ICN), ulnar nerve fascicle and medial pectoral nerve (MPN). 3rd, 4th and 5th ICN were the most commonly utilised donor nerves (12 cases) while ulnar nerve fascicle to musculocutaneous anastomosis (Oberlin transfer) was done in 10 cases. MPN to MC anastomosis was done in a single case (Table 1).

3.1. Follow up and outcome

The mean post op hospital stay was 1.6 days (range 1–4 days). Wound infection was observed in 2 cases (6%), both of which were managed conservatively with culture sensitive antibiotics. Two patients were lost to follow up. Mean duration of follow up was 13.5 months (range 9–18 months).

3.2. Motor outcome

Motor outcomes were analysed separately for type of injury (partial versus pan); type of neurotization (for shoulder abduction and elbow flexion) and timing of surgery in relation to injury.

In partial BPI, good to excellent outcomes were obtained in 64% (9/14). All of this were noted in either upper trunk (UT) or combined UT and middle trunk (MT) injuries. The single case of lower trunk injury had poor outcome. The mean follow up for partial injury was 13.9 months (range 9–18 months).

On the contrary, only 5 out of 17 cases of pan BPI had good recovery (29.5%) and the mean follow up for this subgroup was 13.4 months (range 10–18 months) (Table 2).

On comparing the various surgical procedures performed, neurotisation yielded the best outcome rates of 52.9% while a recovery rate of 50% and 25% was obtained in neurolysis and combined neurolysis-neurotisation procedures.

Separate analysis was performed noting the relation between motor recovery and type of donor nerves utilised. Overall, for shoulder abduction, utilising SAN or PN to SS anastomosis, SAN achieved 50% good to excellent recovery rates while only 40% was obtained with the use of PN. On further subgroup analysis, good to excellent recovery rate was obtained in 60% of partial injuries (3 out of 5) while that was only 38% in pan injuries (5 out of 13), with better results for SAN. In cases where double nerve transfers ($n = 4$) were performed for restoration of shoulder abduction, good to excellent recovery was obtained in 3 cases (75%).

Overall, with respect to restoration of elbow flexion, Oberlin transfer achieved the highest recovery rates (87.5% good to excellent recovery) while only 27% of those who underwent ICN to MC anastomosis achieved good recovery. This difference was again due to the fact that most of the ICN–MC anastomosis was performed in panplexal injuries. In one single case where MPN was used as the donor nerve, poor result was obtained.

On analysing the duration between injury and surgery, patients were subdivided into 3 categories – <6 months, 6–12 months and >12 months. 13 patients (42%) underwent surgery <6 months of trauma (mean interval being 5.6 months); 16 (52%) presented between 6 and 12 months (mean interval being 7.7 months) while 2 patients (6%) were operated after 12 months of injury (13 and 20 months- both being partial injuries). Overall, good to excellent recovery was achieved in the

Table 1 – Types of neurotisation according to donor and recipient nerves.

Donor nerve	Recipient nerve	No of cases
Supraclavicular		
SAN	SS	8
	AN	1
PN	SS	10
	AN	1
C6 nerve root	UT	1
Infraclavicular		
IC	MC	12
UN	MC	10
MPN	AN	3
	MC	1

Abbreviations: SAN- spinal accessory nerve; SS- suprascapular nerve; AN- axillary nerve; PN- phrenic nerve; UT- upper trunk; IC- intercostals nerve; MC- musculocutaneous nerve; MPN- medial pectoral nerve.

Table 2 – Motor outcome according to severity of BPI ($n = 31$).

	Excellent	Good	Poor	Good recovery (%)
UT ($n = 7$)	2	3	2	71.4%
UT,MT ($n = 6$)	2	2	2	67%
LT ($n = 1$)	–	–	1	0%
Pan ($n = 17$)	1	4	12	29.5%

Abbreviations: BPI- brachial plexus injury; UT- upper trunk; MT- middle trunk; LT- lower trunk.

first two categories in 46% and 37.5% patients respectively. Two patients operated after one year underwent Oberlin's transfer and both of them achieved good recovery.

3.3. *Functional and psychosocial outcome*

In all patients, there was a significant improvement between pre and post-operative functional and psychosocial scores except only in the physical aspects in SF-36 scale that was significant only in those who had motor improvement (Table 3). On comparing the functional outcome with respect to time to surgical intervention, there was no difference between those who presented within 6 months and those between 6 and 12 months.

3.4. *Pain*

Neuropathic pain is an important symptom in patients of BPI which can be sometimes severe and unrelenting not responding to usual medications. We analysed this component separately using pain visual analogue scale (PVAS) at regular intervals. Pain of any severity was present preoperatively in 20 (65%) patients. All of them, except four patients had panplexal injury. Based on PVAS score, pain was arbitrarily divided into: severe (9–10)- 8 patients, moderate (6–8)- 8 patients and mild (3–5)- 4 patients.

The mean PVAS score was 7.5 in the pre-operative period and 2.85 at last follow up ($p < 0.05$). Out of 20 patients, only 6 patients had persistent pain (mild in 4, moderate in 2 and severe in 1 case), at last follow up. Rest of the 14 (70%) patients had near complete/complete relief of pain. There was no correlation between pain relief and motor recovery. All, except 3 patients (2 with mild and 1 with severe pain), had some degree of relief within 6 months of surgery and this improvement continued thereafter, however, the rate of improvement varied. There was no statistical difference in pain relief between patients who presented early (<6 months) and late (>6 months).

Patients were then evaluated for pain outcome in relation to type of surgical procedure performed. Out of 20 patients who presented with pain, 10 patients underwent neurolysis (alone in 4 and with neurotisation in 6 cases) and further 10 only neurotisation. In both the categories, excellent pain relief was achieved in 70% patients.

Table 3 – Pre-op and post op functional and psychosocial outcome scores in relation to motor outcome.

Outcome score	Mean score in (pre-op)	Mean score (at last FU)	*p* value
DASH Score	91.9	73.6	<0.05
Improved	89.2	62.3	<0.05
Not improved	94.2	84.2	<0.05
DAQ Score	304.1	266.7	<0.05
Improved	292.6	236.3	<0.05
Not improved	310.1	289.4	<0.05
LH Scale	26.1	22.8	<0.05
Improved	25.2	21.3	<0.05
Not improved	26.3	23.9	<0.05
SF-36 component			
Physical functioning	50.8	59.9	NS
Improved	51	64.5	<0.05
Not improved	50.4	58.1	NS
Role limitations due to physical health problems	52.1	60.9	NS
Improved	51.2	67.4	<0.05
Not improved	52.4	57.2	NS
Role limitations due to emotional health problems	53.1	69.9	<0.05
Improved	52.5	72.3	<0.05
Not improved	54.1	68.2	<0.05
Energy/fatigue	35.5	49.2	<0.05
Improved	34.2	50.1	<0.05
Not improved	36.1	46.2	<0.05
Emotional well-being	37.5	55.2	<0.05
Improved	38.1	56.3	<0.05
Not improved	37.2	52.2	<0.05
Social functioning	25.4	42.3	<0.05
Improved	25.1	43.2	<0.05
Not improved	26.4	41.2	<0.05
Pain	32	55.5	<0.05
Improved	30.5	57.5	<0.05
Not improved	32.5	54.5	<0.05
General health	37.4	56.2	<0.05
Improved	37	57.5	<0.05
Not improved	36.5	55.8	<0.05

Abbreviations: DASH- disability of arm, shoulder and hand questionnaire; DAQ- dysfunction analysis questionnaire scale; LH- learned helplessness scale; SF- 36- short form 36 questionnaire.

4. Discussion

Brachial plexus injuries are the most severe nerve injuries of upper extremity, resulting in marked functional and psychosocial impairment. The history of brachial plexus injuries is as old as history of neurosurgery. The first case was reported by Flaubert[7] when he described avulsion of all roots of brachial plexus except C5 when attempting for reduction of a dislocated shoulder. The first of the nerve reconstructive surgeries was performed by William Thoburn,[8] when he resected a large neuroma below suprascapular nerve involving the entire plexus and sutured it with fine silk sutures. This created an interest in the operative management of BPI but this interest gradually waned during world war.

Although poor results were obtained in the initial days, with the advent of operating microscope, better suture materials and electrophysiological studies, multiple studies have documented consistently good results after surgery for these dismal injuries in the range of 25–85% based on whether the injury is a partial or pan BPI.[11,13,14,26]

Majority of patients affected are males in the range of 20–40 yrs and the mean age groups range from 26 to 29 yrs. Females constitute a very minor percentage of them and paediatric patients (<18 yrs) are relatively uncommonly affected.[1–3,12] In our study, the mean age was 26.9 yrs; males constituted the majority (89%), there were 4 females (11%) and 8 paediatric patients (22%) which is quite similar to other reports in the literature.[1–3,12] Road traffic accident was the most common aetiology in our study (86%) which has been echoed in other studies as well.[1,3]

With respect to the type of injuries, multiple studies have reported different incidence for partial and pan/complete subgroups and the incidence of complete variety ranges from

22% to 57%.[1,13,14,27,28] Our study had a much higher incidence of pan subgroups (61%) which might have a bearing on the motor outcome as discussed later. Various studies report time interval from injury to surgical intervention as an important aspect. In our study, it was 8 months and this was somewhat longer as compared to various other studies; although, very few studies have reported such longer intervals.[4,12,27] Our study also had a higher proportion of patients who presented between 6 and 12 months of injury (50%) as compared to within 6 months of injury (41%); however, the ratio is usually the reverse in other studies.[1,4] This delayed presentation of our patients might be multifactorial. One reason is the ignorance prevalent among patients and physicians regarding the treatment and prognosis of BPI. Also, our hospital being a tertiary care centre, delayed referral is another reason for delayed presentation to the operating surgeon.

Surgery in BPI is indicated if there are no signs of clinical/electrophysiological recovery after 3 months of injury. The surgical procedure depends upon condition of the nerves during surgery. If nerves are stimulable intra-operatively and are found to be in continuity, then a simple neurolysis would suffice while neurotisation might be required in rest of the cases.[3]

The prognosis after surgery depends largely on severity of injury, whether partial or complete. Several results have documented consistently good results in cases of partial BPI.[13,14,27] Millesi[9] reported a 70% recovery rate in motor function in at least one important area in 56 operated patients in a 5 year follow up study. Bhandari et al,[12] studied outcome rates in partial BPI in 20 patients and documented good recovery rates ranging from 45% to 75%. Venkatramani et al[29] studied 15 patients of partial BPI and documented good to excellent recovery rates in 55%–86%. Once again, these recovery rates were different for shoulder and elbow flexion. In our study, 64% of patients had good motor recovery in the partial subgroup which was comparable to other studies in literature.[11,12,30–32]

Majority of these studies are for partial BPI. An extensive search of literature showed no single study dedicated for complete BPI; however, it is usually a component of a large series of combined BPI patients. Prognosis for these complete injuries is poor as documented in various studies. Kim et al,[13] analysed over 1000 cases of BPI and reported that only 35% of the patients with C5–T1 stretch injuries gained an overall functional outcome of Grade 3 or better. Similar results for pan BPI have been documented in other reports as well.[26,30] In our study, good recovery rate was only 29.5% in pan subtype which is quite comparable to previous studies. However, our study had a mean follow up of only 13.4 months for panplexal injuries which might as well account for the low recovery rate in this patient population.

There was also significant heterogeneity in the outcome rates in relation to donor nerves used which probably could be due to the fact that number of pan and partial BPI were unequal in those donor nerve groups. With respect to restoration of shoulder abduction, spinal accessory and phrenic nerves are the most common donor nerves utilised for suprascapular nerve neurotisation, however, a few studies have suggested spinal accessory nerve as the best donor. Many studies have reported success rates ranging from 40% to 98%.[12,14,29,32,33] We obtained a good recovery rate of 50% overall (66% partial and 40% panplexal injuries) using spinal accessory nerve as the donor nerve.

The most common nerves used for achieving elbow flexion are intercostals, spinal accessory nerves and ulnar branch fascicle (only in cases of partial BPI) wherein the recipient nerve is the musculocutaneous nerve or the branch to biceps/brachialis muscles (Oberlin transfer). Recovery rates ranging from 22% to 92% have been obtained in ICN–MC neurotisation in various series in literature.[2,14,27,33,34] In our study, we achieved a recovery rate of only 27%. This might be because of the short follow up as most other studies had an FU of at least 2 yrs. This is important because both EMG and clinical signs of recovery appear late in ICN–MC neurotisation and hence long follow up is extremely essential for this anastomosis.[12,27]

Since the description of Oberlin transfer in 1994,[35] multiple studies have documented its reliability and consistency in achieving elbow flexion in cases of upper plexus injuries. Reported success rates range from 85% to 97% and the recovery rate of 87.5% obtained in our study is comparable to most other studies.[36–38] This discrepancy of poor recovery rates with respect to various neurotisers is because of differences in proximity of the anastomotic site to the neuromuscular junction. Bhandari et al documented that time duration for appearance of electromyographic re-innervation potentials for biceps muscle was as short as 2.5 months in case of Oberlin transfer while it was 10.5 months in cases of ICN–MC anastomosis. Similarly, with spinal accessory and phrenic nerves, the initial innervation potentials were recorded at average 8 and 8.5 months respectively.[12] Also, the clinical evidence of re-innervation appears as early as 2 months and 3.3 months after Oberlin transfer as shown in a few studies.[29,39]

Early surgical treatment (within 6 months) is optimal for good recovery as concluded by majority of studies. It has been said that delaying surgery for more than 6 months is not recommended[32,40,41] because prolonged denervation leads to muscular atrophy, fibrosis, and joint stiffness and even if nerve repair is successful, functional improvement may not occur. In our study, there was no statistical difference between patients operated within 6 months (mean interval was 5.5 months) or between 6 and 12 months (mean interval was 7.6 months) after injury. Overall, good recovery rates were obtained in 46% in the former and 37.5% in the latter category. This difference with the existing literature might be due to the fact that the mean FU of both the groups in our study was not significantly different.

Several investigators have stated that performing brachial plexus reconstruction in partial plexal injuries within 9 months notably improves outcome.[42,43] Some studies have noted good recovery rates after delayed surgery. Recently, Sedain et al[44] published results of delayed Oberlin transfer and found 77% gained good motor power (>/=3/5) at a mean follow up of 26.7 months. In our patient cohort, we had two patients who had a delayed presentation (>12 months), both of them being partial injuries and both achieving good recovery rates after neurotisation with Oberlin's procedure. This supports the fact that surgery should be offered to all patients with partial plexal injuries, even those with delayed presentation.

Even though there are a number of studies concerning on motor outcome of patients, studies involving the assessment of quality of life and functional outcome are very few.[4,5,15,16] After evaluation of 32 patients, Choi et al[15] concluded that there was good quality of life, despite the devastating nature of the injury. Kitajima et al[16] found no correlation between subjective satisfaction and objective joint function in 30 operated traumatic brachial plexus patients. Ahmed-Labib et al,[4] in their series of 31 patients of brachial plexus injury, assessed the post surgical quality of life and functional outcome of patients by utilising a combination of functional assessment tools namely DASH, SF-36 questionnaire and PVAS. They concluded that root avulsion injuries and delayed surgical repair correlated negatively with functional outcome. In yet another recent study, authors concluded that 87% of patients were satisfied with the results of surgery, but despite high satisfaction rate, patients remained considerably disabled.[5]

In addition to the functional outcome scales used in earlier studies,[4,5] two additional scales were utilised in our study to assess the psychosocial outcome which included learned helplessness (LH) and dysfunction analysis questionnaire (DAQ) scales in which questions were put up in a regional language (Hindi) as described earlier. Also, pain and its post op outcomes were studied in our patient cohort. On analysis of all these scales, there was a statistically significant improvement in post-op scores as compared to pre-op period (at last follow up) in all patients. The only exception to this was that there was a significant improvement in the physical aspect of life only in those who had good motor recovery. Various studies in literature have attempted to correlate the functional outcome with the time since injury. On further analysis of these functional outcome scales, we found no statistically significant difference in the functional outcome scores among patients operated within 6 months or within 6–12 months of injury. In our study, surgery offered statistically significant improvement in both these groups.

Pain after BPI is of the neuropathic variety characterised by burning sensation or painful paresthesiae in the distribution of the nerves in the region of sensory loss. Although medications such as gabapentin or carbamazepine provide some temporary relief, most of them relapse and become chronic and challenging to treat.[45,46] Although, many studies in brachial plexus literature have briefly mentioned about the pain aspect in BPI, very few have evaluated in detail the patient outcome with respect to pain improvement.[2,47,48] The main drawback of those studies were that the authors did not compare the dynamic improvement of pain between the pre-op and post op periods which, in fact, is very essential to assess the impact of surgery on pain. In a recent study by Bonilla et al,[6] the authors noted incidence of 74.5% of neuropathic pain and 57% of them had panplexal injury and there was a statistical significant reduction of pain postoperatively at 6 months and suggested that surgery is a viable option for early pain relief in patients with intractable pain postbrachial plexus avulsion injuries.

In our study, pain outcome was evaluated in detail in pre and post-operative periods at regular intervals. Pain was present preoperatively in 65% of our patients which was severe enough in 40% of cases and also noted a higher incidence of neuropathic pain in the pan subtype (80%) which is comparable to other studies.[4–6] There was a statistically significant difference in pain relief at last follow up on comparing with the pre-operative periods and overall 70% had excellent relief of pain as assessed by PVAS as comparable to other studies.[6,49]

In a recent article, Bertelli et al[48] proposed a different pathophysiological mechanism for pain generation. Also, Bonilla et al[6] concluded that neurolysis demonstrated excellent results in amelioration of pain, however, they did not compare between neurolysis and neurotisation. In our study, surgery achieved an excellent improvement of pain in 70% of patients. There was no difference between pain relief and type of procedure and in addition to neurolysis, there was excellent pain relief in patients undergoing neurotisation as well; this difference was not statistically significant. However, there was statistically significant difference between pre-op and post op PVAS scores at last FU.

Labib et al[4] showed that pain relief was better in patients operated within 6 months of injury; however, such differences were not noted in our study. Bonilla et al[6] noted a virtually immediate postoperative amelioration of pain which tends to stabilise further over a period of 6 months. They suggested that in cases in patients not responding to pain initially, be referred to secondary dorsal root entry procedure (DREZ). We however, noted an improvement of pain up to 12 months after surgery in both the neurolysis and neurotisation categories thus necessitating the need to keep such patients on long term follow up so as to avoid secondary procedures for pain. As shown by studies in the past, there was no correlation between motor outcome and pain relief in our study.[6] The improvement in the emotional well-being even in patients who had no motor recovery might have also been contributed by the pain relief which significantly adds to the agony of these patients. Even though the motor outcome cannot be reliably commented upon due to the relatively short duration of follow up, this prospective study clearly indicates a significant pain relief in addition to improvement in the functional QOL and psychosocial aspects after surgical treatment of these lesions.

5. Conclusions

Traumatic BPI renders great morbidity on patients' lives affecting both functional and psychosocial aspects. Overall, good to excellent motor outcome was achieved in 64% patients in partial and 30% in pan BPI with a mean follow up of 13.5 months. Neurotisation yielded the best motor outcome (53% patients). Spinal accessory- suprascapular nerve anastomosis (50%) and Oberlin transfer (87%) achieved best results for shoulder abduction and elbow flexion respectively. Pain relief was obtained in 70% of patients with a significant improvement in mean post op PVAS scores and this was irrespective of the time since injury, type of surgical procedure and motor recovery. Also, pain improvement was noted up to 12 months after surgery in both neurotisation and neurolysis groups.

There was significant improvement in the functional and psychosocial aspects and pain relief which was irrespective of time since injury and improvement in the motor outcome. Henceforth, surgery should be offered to all patients irrespective of duration of injury. Surgery definitely has an impact on the functional and psychosocial outcome as surgery offers a significant relief of neuropathic pain and also helps boost up the emotional well-being of the patient.

Conflicts of interest

All authors have none to declare.

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