International Journal of Research in Orthopaedics
Kabir AA et al. Int J Res Orthop. 2025 Nov;11(6):1327-1332
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20253407

Surgical outcome of brachial plexus surgery: our experience

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Received: 03 July 2025
Revised: 04 August 2025
Accepted: 11 August 2025

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ABSTRACT

Background: Brachial plexus injuries (BPIs) result in significant functional impairments, especially in developing countries like Bangladesh, where road traffic accidents are common. Advances in microsurgical techniques, such as nerve transfers and grafting, have improved outcomes. This study aims to evaluate the surgical outcomes of BPIs and contribute to optimizing treatment strategies for better recovery and functional restoration in patients with these complex injuries. To evaluate surgical outcomes, assess functional recovery and compare various surgical techniques for BPI management.
Methods: This prospective observational study, conducted from May 2013 to March 2025, included 95 patients with post-traumatic BPIs from four major hospitals. Surgical interventions, including nerve transfers and grafting, were performed based on injury type. Preoperative and postoperative data were collected, including motor function assessment and patient rehabilitation outcomes, with follow-up at regular intervals for recovery monitoring.
Results: The study included 95 patients with brachial plexus injuries, predominantly in the 18–30 age group (63.16%) and male (63.16%). The most common injury type was upper brachial plexus (42.1%), followed by global injuries (21.1%). Nerve transfers, especially Oberlin II, were the most performed surgery (31.6%). Postoperatively, 42.1% achieved good motor recovery (Grade 4), while 26.3% had excellent recovery (Grade 5). The follow-up ranged from 0–25+ months.
Conclusions: Microsurgical techniques have improved brachial plexus injury management, but full upper limb function recovery remains suboptimal, especially in global injuries.

Keywords: Brachial plexus injury, Global brachial plexus injury, Microsurgical management, Nerve transfer, Nerve grafting, Upper limb recovery

INTRODUCTION

The brachial plexus is a vital network of nerves that emerges from the cervical and upper thoracic spinal cord segments (C5 to T1), playing a crucial role in providing motor and sensory innervation to the upper limb. Injuries to this complex structure can lead to severe functional limitations and long-term disability. In countries like Bangladesh, the incidence of BPIs is steadily increasing, largely driven by the growing number of road traffic accidents, especially those involving motorcycles.[1] Clinically, BPIs can manifest in a wide range from isolated upper trunk injuries such as Erb's palsy to more severe global plexus injuries affecting the entire limb. These

injuries often cause significant loss of motor function and sensation, severely impacting a person's ability to carry out routine activities.[2,3] Early and accurate diagnosis, followed by timely surgical intervention, is critical for maximizing recovery. In recent years, advancements in microsurgical techniques particularly nerve transfers have transformed the management landscape for BPIs. Procedures like the Oberlin transfer (redirecting ulnar nerve fibers to the biceps) and the transfer of the spinal accessory nerve to the suprascapular nerve have shown encouraging results in restoring key functions such as elbow flexion and shoulder abduction.[4,5] Additionally, using branches from the triceps nerve to reinnervate the axillary nerve has proven effective in regaining shoulder mobility in upper plexus injuries.[6] The timing of surgical repair plays a pivotal role in the prognosis. Surgeries delayed beyond six months after injury are often associated with reduced chances of meaningful recovery, largely due to muscle degeneration and scarring.[7,8] Innovations like intraoperative nerve stimulation and advanced imaging have also improved the precision of surgical nerve identification and reconnection.[9] However, managing global brachial plexus injuries continues to be challenging. Outcomes in these cases are typically less favorable and often require multiple surgeries along with extended periods of rehabilitation. Factors such as patient motivation, early surgical planning and individualized treatment approaches are critical for improving results.[10] This study shares the experience of several tertiary care centers in Bangladesh in surgically managing brachial plexus injuries. By evaluating outcomes across different types of BPIs, our aim is to provide insights that can help refine and enhance treatment strategies for these complex, life-altering injuries.

Objective

General objective

To evaluate the surgical outcomes of brachial plexus injury management and improve functional recovery in affected patients through appropriate microsurgical interventions.

Specific objectives

To assess the functional improvement of upper limb movement following brachial plexus surgery. To analyze the effectiveness of various surgical techniques such as nerve transfers and grafts in different types of brachial plexus injuries. To compare postoperative outcomes among patients with upper, lower and global brachial plexus injuries. To determine the impact of timing of surgery on patient recovery and functional outcomes.

METHODS

Study design

This prospective observational study assessed the outcomes of various surgical procedures performed on patients suffering from post-traumatic brachial plexus injuries. Conducted over nearly 12 years, from May 2013 to March 2025, it enabled continuous data collection and long-term monitoring of recovery progression following surgical intervention. A total of 95 patients who met the inclusion criteria were enrolled in the study. All patients presented with post-traumatic brachial plexus injuries and underwent appropriate surgical interventions based on the nature and extent of their injuries. Patients were recruited from four major tertiary-level hospitals in Bangladesh Dhaka Medical College Hospital (DMCH), National Institute of Neurosciences and Hospital (NINS&H), Kurmitola General Hospital and Central International Medical College Hospital selected for their expertise in managing complex neurotrauma cases. A total of 95 patients who met the inclusion criteria were enrolled; among them, 13 had upper brachial plexus injuries (involving C5-C6 or C5-C7 roots), 3 had global brachial plexus injuries (C5-T1 involvement), 3 sustained sharp penetrating injuries primarily from stab wounds or sharp instruments and 1 infant was diagnosed with Erb's palsy, a form of obstetric brachial plexus palsy affecting the upper trunk

Inclusion criteria

The study enrolled participants who fulfilled specific clinical and procedural benchmarks to ensure consistency in the population under investigation. Eligible participants included patients of any age and gender who presented with post-traumatic brachial plexus injuries. Only those patients who were selected for surgical intervention whether through nerve repair, nerve transfer or nerve grafting were included.

Exclusion criteria

To preserve the homogeneity and clinical relevance of the study cohort, several exclusion criteria were applied. Patients with non-traumatic or congenital brachial plexus lesions were excluded, as their conditions differ significantly in pathophysiology and management. Individuals who declined surgical treatment or opted for conservative management approaches were also excluded from the study.

Surgical techniques

Surgical planning was individualized based on the type of injury, duration since trauma and intraoperative findings. The following procedures were commonly performed nerve transfers, including Oberlin II transfer (ulnar nerve fascicle to biceps branch of the musculocutaneous nerve) and transfer of the nerve to the long head of the triceps to the anterior branch of the axillary nerve. Interpositional nerve grafting, such as sural nerve grafting, was primarily used in cases like Erb's palsy where a direct end-to-end repair was not feasible. Microsurgical neurolysis or direct repair was performed in cases of clean-cut sharp injuries, where the nerve ends could be approximated. All surgeries

were performed under magnification using microsurgical techniques and standard nerve handling protocols.

Data collection and outcome measures

Data were collected using a structured format both preoperatively and postoperatively. Preoperative data included: The study collected detailed demographic information, including age and gender, along with the mechanism and type of brachial plexus injury sustained by each patient. It also recorded the duration between the injury and the subsequent surgical intervention. Postoperative evaluations focused on the return of motor function, graded according to the medical research council (MRC) scale for muscle strength, as well as assessments of the range of motion and muscle bulk in the affected limb. Additionally, functional independence in performing daily activities was evaluated through patient interviews and thorough physical examinations.

Follow-up

All patients were followed up periodically at 1 month, 3 months, 6 months and 12 months, with further annual follow-ups for select cases. During each visit, clinical examination was performed and progress in motor recovery was documented. Patients also received individualized physiotherapy and rehabilitation to optimize functional recovery and were counseled regarding the realistic expectations of surgery.

Data analysis

Data were analyzed using SPSS version 26.0. Descriptive statistics summarized demographics, injury types and surgical procedures. Continuous variables were expressed as mean±SD and categorical data as frequencies and percentages. Motor recovery outcomes were assessed using the MRC grading system. Associations between surgical techniques and outcomes were analyzed using chi-square tests, with a p value <0.05 considered statistically significant. Subgroup analyses evaluated factors affecting recovery.

Ethical considerations

Ethical approval for this study was obtained from the Institutional Review Boards (IRBs) of all participating centers. Informed written consent was collected from all adult participants and the guardians of minors. The study was conducted in accordance with the Declaration of Helsinki, ensuring patient confidentiality and ethical integrity throughout the research process.

RESULTS

Table 1 presents the demographic distribution of the 95 patients included in the study based on age and gender. The majority of patients (63.16%) fell within the 18–30-year age group, followed by 31–45 years (31.58%) and a small proportion (5.26%) were aged 46–60 years. Males were more frequently affected, accounting for 63.16% of the total study population, while females comprised 36.84%. The highest male predominance was observed in the 46–60 age group, where all five patients were male. Figure 1 summarizes the distribution of injury types among the 95 patients. The majority of cases (42.1%) involved upper brachial plexus injuries affecting the C5-C6 nerve roots. Global brachial plexus injuries, involving the entire C5-T1 roots, accounted for 21.1% of cases. Sharp penetrating injuries, primarily affecting the C5 root, made up 15.8% of the injuries. Additionally, Erb's palsy cases represented 10.5% of the cohort, while another 10.5% had mixed or other types of brachial plexus injuries. Table 2 outlines the surgical procedures performed on the 95 patients. Nerve transfer procedures, such as Oberlin II, were the most commonly performed, accounting for 31.6% of cases. Nerve grafting, typically utilizing the sural nerve, was performed in 26.3% of patients. Direct nerve repair combined with neurolysis was carried out in 21.1% of cases. Another 21.1% of patients underwent a combination of nerve transfer and grafting techniques, reflecting a tailored approach based on the complexity and nature of each injury. Table 3 presents the postoperative outcomes of patients based on the Medical Research Council (MRC) scale for motor function. The majority of patients (42.1%) achieved a Grade 4 (Good) recovery, while 26.3% attained Grade 5 (Excellent) motor function. A fair outcome (Grade 3) was observed in 21.1% of cases. Poor recovery (Grade 2) and no significant motor recovery (Grade 1) were each recorded in 5.3% of the patients, highlighting that while most patients experienced significant functional improvement, a small proportion showed minimal to no recovery. Table 4 summarizes the follow-up duration of the 95 patients after surgical intervention. The largest group, comprising 42.1% of patients, was followed up for 0–12 months. About 31.6% of the patients had a follow-up period ranging from 13 to 24 months, while 26.3% were monitored for more than 25 months. This distribution reflects a substantial proportion of patients with both short-term and extended postoperative evaluations, allowing assessment of both early and longer-term surgical outcomes.

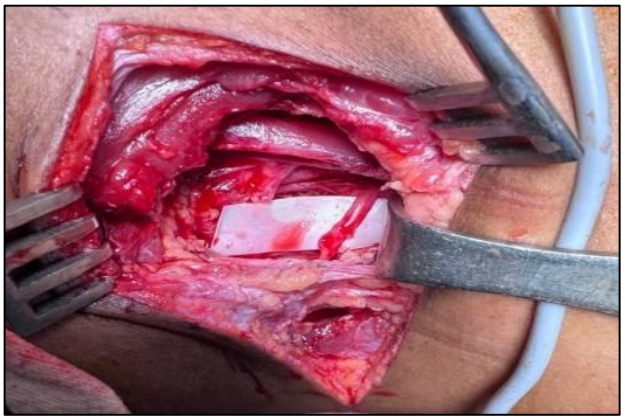

Figure 1: Nerve to long head of triceps to anterior branch of axillary nerve transfer.

Figure 2: Oberlin I and Oberlin II transfer.

Figure 3: Spinal accessory nerve (SAN) transferred to Supra Scapular Nerve (SSN).

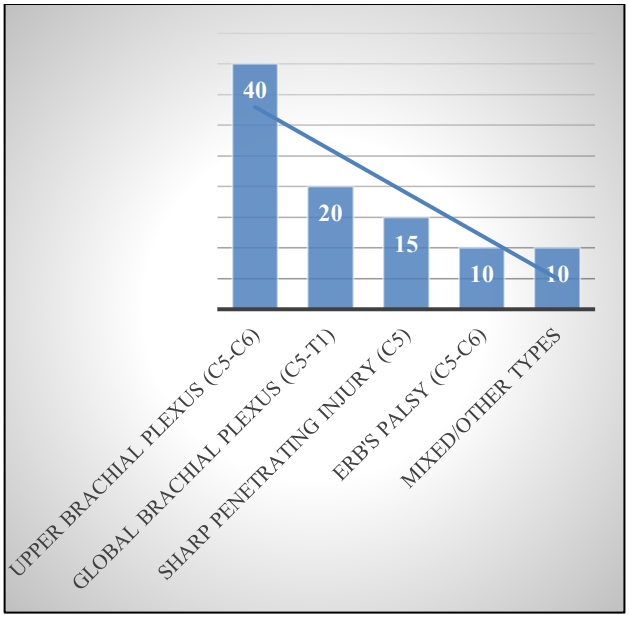

Figure 4: Type of injury.

Table 5 presents the outcomes for patients with global brachial plexus injuries (C5-T1). Among the 10 patients studied, 50% (patients 1–5) achieved a fair recovery (Grade 3 on the MRC scale) following nerve grafting combined with nerve transfer, with a follow-up duration of 24 months. The remaining 50% (patients 6–10) demonstrated a good recovery (Grade 4) after the same surgical procedures, with a follow-up period of 12 months.

Table 1: Demographic data distribution of patients (n=95).

Characteristics	Total number of patients	Male (%)	Female (%)	Total (%)
Age group (in years)				
18-30	60	35 (58.33)	25 (41.67)	60 (63.16)
31-45	30	20 (66.67)	10 (33.33)	30 (31.58)
46-60	5	5 (100)	0 (0)	5 (5.26)
Total	95	60 (63.16)	35 (36.84)	95 (100)
Gender				
Male	60	63.16		
Female	35	36.84		
Total	95	100		

Table 2: Surgical procedures performed.

Surgical procedure	Number of patients	%
Nerve transfer (e.g., Oberlin II)	30	31.6
Nerve grafting (e.g., sural nerve)	25	26.3
Direct repair+neurolysis	20	21.1
Combination of nerve transfer and grafting	20	21.1

Table 3: Post surgery outcome (MRC scale).

MRC grade (motor function)	Number of patients	%
Grade 5 (Excellent)	25	26.3
Grade 4 (Good)	40	42.1

Continued.

MRC grade (motor function)	Number of patients	%
Grade 3 (Fair)	20	21.1
Grade 2 (Poor)	5	5.3
Grade 1 (None)	5	5.3

Table 4: Follow-up duration.

Follow-up duration (in months)	Number of patients	%
0-12	40	42.1
13-24	30	31.6
25+	25	26.3

Table 5: Outcome of global brachial plexus injury (C5-T1).

Patient ID	Type of injury	MRC grade (motor function)	Surgical procedure	Follow-up duration (in months)	%
1-5	Global brachial plexus (C5-T1)	Grade 3 (Fair)	Nerve grafting+nerve transfer	24	50
6-10	Global brachial plexus (C5-T1)	Grade 4 (Good)	Nerve grafting+nerve transfer	12	

DISCUSSION

In this study, the majority of the patients were young adults aged between 18–30 years (63.16%), with a strong male predominance (63.16%). This demographic trend is consistent with other studies that reported young males as the most commonly affected group in brachial plexus injuries, often due to high-energy trauma such as motor vehicle accidents.[11] In particular, Flores et al, emphasized that men in their third decade are most vulnerable to brachial plexus trauma.[12] Upper brachial plexus injuries (C5–C6) were the most prevalent type in this series (42.1%), followed by global brachial plexus injuries (21.1%).

A similar distribution pattern was observed in a retrospective analysis by Midha et al, where upper trunk lesions accounted for the majority of cases.[13] This predominance of upper trunk injuries is often attributed to the mechanism of injury, typically involving traction forces during accidents. In terms of surgical management, nerve transfer was the most commonly performed procedure (31.6%), followed by nerve grafting (26.3%) and combined nerve transfer and grafting techniques (21.1%). This approach aligns with findings from Bertelli et al, who reported nerve transfer as the preferred method for restoring elbow flexion and shoulder function in brachial plexus injuries.[14] The use of combination techniques was particularly beneficial in complex or global injuries, as previously highlighted by Malessy et al and colleagues.[15] Postoperative outcomes in this study demonstrated that the majority of patients achieved good (Grade 4, 42.1%) to excellent (Grade 5, 26.3%) motor recovery, reflecting a favorable functional prognosis. This is consistent with the outcomes reported by Bhandari et al and Jain et al where a significant proportion of patients undergoing nerve transfer showed satisfactory motor recovery within 12–24 months.[16] A smaller group of patients experienced only fair (Grade 3, 21.1%) or poor (Grade 2, 5.3%) recovery, which mirrors findings in a multicenter study conducted by Terzis et al where incomplete recovery was observed in cases with delayed surgery or severe root avulsions.[17] Follow-up analysis revealed that 42.1% of patients were assessed within 0–12 months postoperatively, 31.6% between 13–24 months and 26.3% beyond 25 months. Long-term follow-up is crucial, as emphasized by Siqueira et al who noted that motor recovery often continues and stabilizes even after 24 months.[18] Specifically for global brachial plexus injuries (C5–T1), the combined use of nerve grafting and nerve transfer yielded promising outcomes, with 50% achieving fair and 50% achieving good motor recovery.

These results are consistent with a study by Narakas et al, where combined reconstructive techniques showed significant functional improvements even in total plexus palsies.[19] Overall, our findings support that timely surgical intervention with individualized strategies such as nerve transfer, grafting or their combination can lead to substantial functional recovery in brachial plexus injury patients. This approach has been further validated by contemporary reviews that advocate for personalized surgical planning based on the extent and pattern of injury.[20]

This study has several limitations. Firstly, the relatively small sample size of 95 patients may limit the generalizability of the findings to a broader population.

Secondly, the follow-up period varied among patients, with some having shorter durations, potentially affecting the assessment of long-term functional outcomes.

CONCLUSION

Reconstruction of fully functional upper limb in patients who have sustained a brachial plexus injury is still suboptimal, especially for those patients with pen plexus Injuries though significant advances have been made in microsurgical management of the injured brachial plexus.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Kabir AA, Haroon K, Khan MSH, Majid A, Rahman SKMA. Surgical outcome of brachial plexus surgery: our experience. Int J Res Orthop 2025;11:1327-32.