Spectrum of Brachial Plexus Injuries: Our 10 Years' Experience

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Abstract

Introduction Traumatic brachial plexus (TBP) injuries are disabling injuries with profound functional deficits. Patients often suffer from debilitating pain, substantial psychological trauma, and variegated socioeconomic disabilities. The aim of this study was to analyze the outcome of patients with TBP injuries operated in our center.

Material and Methods In this retrospective study, demographic details, mode of injury, various surgical interventions, and the neurological outcomes of the TBP injury patients operated at our center in the past 10 years (2011–2023) were analyzed.

Results There were 227 patients with TBP injury (114 patients with pan-brachial plexus injury and 113 patients with partial brachial plexus injury). The majority of them were males (96.48%). Around 75% of the patients were aged between 21 and 40 years. Mode of injury was road traffic accidents in 94.71% cases. In all, 31.28% of cases underwent surgery within 6 months after the injury, while around 47% cases were operated on 6 months after the injury. One hundred and eighty-five patients (81.50%) underwent neurotization and in 37 patients (16.30%) only neurolysis was done without neurotization. Neurological improvement was seen in 70% of the patients who underwent surgery within 3 months after injury, while patients who underwent surgery at 4 to 6 and 7 to 12 months after injury had 42.25 and 47.17% improvement, respectively, but as the time interval increased, improvement drastically fell to 26.09 and 14.29%, respectively, in patients who underwent surgery between 13 and 24 and greater than 24 months after injury.

Conclusion Both neurotization and neurolysis are beneficial for TBP injury patients. Patients who underwent surgery within a 1 year of injury had a far better outcome than

Keywords
- brachial plexus injury
- neurolysis
- neurotization

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patients who were operated on after a 1-year period. Nevertheless, our study shows that surgical repair should be offered to all patients of TBPI, even after 24 months of injury as at least 15% will have good recovery of motor power following surgery.

Introduction

Traumatic brachial plexus injury is one of the most devastating injuries that cripples the life of the affected individual. Typically, the patient suffers traction injury between the neck and shoulder, after a road traffic accident while riding a two wheeler, damaging his plexus to varying degrees. This causes significant loss of function in one or very rarely two upper limbs often leading to unemployment, economic losses, depression, and even suicidal tendencies in the affected individuals. In the early days of the 20th century, results of brachial plexus surgeries were very bad and many authors including Sir Herbert Seddon were in favor of conservative treatment, even amputation of the affected limb.[1] The popularity of surgery for brachial plexus reconstruction was started in the 1970s by Millesi and Narakas.[2] But in later decades, technological advancements in the operating microscope, use of intraoperative electrophysiological monitoring, and use of biological tissue glue significantly improved the surgical outcomes in patients suffering from brachial plexus injury. The aim of our study was to analyze the outcome of patients with TBP injury undergoing surgery at our center.

Material and Methods

In this study, we retrospectively collected data of the TBP injury patients operated on at our center in the past 12 years (2011–2023). However, as the center was converted to a COVID center for 2 years (2020–2021), data of only 10 years are available. Demographic details, mode of the injury, surgery performed, and outcomes were analyzed. The types of operative procedures were categorized into neurolysis only, supraclavicular neurotization, infraclavicular neurotization, and both supra- and infraclavicular neurotization. Analysis of outcome was taken in terms of improvement in the motor power using Medical Research Council (MRC) grading.

Results

In total, 227 patients were diagnosed with brachial plexus injury. Of these, 114 patients had a pan-brachial plexus injury and 114 had a partial brachial plexus injury. ►**Table 1** demonstrates the demographic profile of the patients. The mean age at the time of injury was 32.81 years and the majority of them (96.48%) were males.

The mode of injury (►**Table 2**) was road traffic accident in 94.71% cases. In all, 31.28% of the patients underwent surgery within 6 months after injury, while around 47% patients were operated on 6 months after the injury.

Surgery was abandoned in 5 patients, 37 (16.30%) patients underwent neurolysis only, supraclavicular exploration with neurotization was done in 21 (9.25%) patients, and 29 (12.78%) patients underwent infraclavicular exploration with neurotization. In 21 (9.25%) patients, supraclavicular neurolysis and infraclavicular neurotization were done and 114 (50.22%) patients underwent supraclavicular as well as infraclavicular neurotization (►**Table 3**).

Out of 37 patients who underwent **neurolysis only**, 13 (35.14%) patients were lost to follow-up, 15 (40.54%) patients had improvement in neurological status, while 9 (24.32%) patients had no improvement. Out of 24 patients who were on regular follow-up, 1 patient suffered severe brachialgia for which dorsal root entry zone (DREZ) lesioning was done with excellent pain relief.

Out of 21 patients who underwent **supraclavicular exploration with neurotization**, 1 patient was lost to follow-up, 7 (33.33%) patients had improvement in neurological status, while 13 (61.91%) patients showed no improvement. Out of 20 patients who were on regular follow-up, 4 patients underwent DREZ lesioning for severe brachialgia.

Out of 29 patients who underwent **infraclavicular exploration with neurotization**, 5 (17.24%) patients were lost to follow-up, 13 (44.83%) patients had neurological improvement, while 11 (37.93%) patients had no improvement.

Table 1 Age and gender of patients of patients with brachial plexus injury in our study

Age (y)	Frequency	Percent
1 (1–10)	3	1.32
2 (11–20)	17	7.49
3 (21–30)	84	37
4 (31–40)	86	37.89
5 (41–50)	21	9.25
6 (51–60)	13	5.73
7 (61–70)	1	0.44
8 (71–80)	2	0.88
9 (81–90)	0	0
10 (91–100)	0	0
Total	227	100
Gender	**Frequency**	**Percent**
Male	219	96.48
Female	8	3.52
Total	227	100

Table 2 Mode of injury in brachial plexus injury patients in our study

Mode of injury	Frequency	Percent
RTA	215	94.71
FFH	5	2.21
MI	2	0.88
BI	4	1.76
GS	1	0.44
Total	227	100

Abbreviations: FFH, fall from height; RTA, road traffic accident.

Out of 24 patients who were on regular follow-up, 2 patients underwent DREZ lesioning for severe brachialgia.

Out of 21 patients who underwent **supraclavicular neurolysis and infraclavicular neurotization**, 4 (19.05%) patients were lost to follow-up, 7 (33.33%) patients had neurological improvement, while 10 (47.62%) cases had no improvement. Out of 17 patients who were followed up, only 1 (5.88%) patient had intractable pain for which he underwent DREZ lesioning.

Out of 114 patients who underwent **supraclavicular as well as infraclavicular neurotization**, 10 (8.77%) patients were lost to follow-up, 58 (50.88%) patients had neurological improvement, while 46 (40.35%) patients had no improvement. Out of 104 patients who were on regular follow-up, 14 (13.46%) patients developed intractable pain; however, only 6 (42.86%) patients underwent DREZ lesioning and achieved excellent results in 5 (83.33%) patients.

We also analyzed patients' outcomes according to the time interval between their injury and surgical exploration. We found that most patients (70%) who underwent surgery within 3 months after injury showed neurological improvement, while patients who underwent surgery at 4 to 6 and 7 to 12 months after injury had 42.25 and 47.17% neurological improvement, respectively. But as the time interval increased, improvement drastically fell to 26.09 and 14.29%, respectively, in patients who underwent surgery between 13 and 24 and greater than 24 months after injury (►**Table 4**).

Discussion

In the early part of the 20th century, surgery for brachial plexus injuries was pioneered by Kennedy,[3] Sever,[4] and Wyeth and Sharpe.[5] Initially results were very poor and development of brachial plexus surgeries was a setback till Seddon reported good results during World War II. This work laid the foundation for the subsequent important contributions by Gilbert and Tassin,[6] and Narakas.[7–9] Refinement in the microsurgical techniques, introduction of fine microsutures, and improved understanding of the pathophysiology of nerve repair and regeneration further led to enhanced surgical outcomes.

Epidemiological data about the traumatic brachial plexus injury vary in different parts of the world. Jain et al observed that in 304 consecutive patients operated on for traumatic brachial plexus injury, 94% injuries were due to road traffic accidents and 94% injuries were associated with two wheeler accidents.[9] Similar results were observed in our study.[10–12] Also, similar to other studies, the majority of brachial plexus injury patients were young males in our study.[10]

The surgical approach in the brachial plexus surgery may be supraclavicular, infraclavicular, or a combination of the supra- and infraclavicular approach depending on the extent of injury. There are four major surgical techniques commonly performed in brachial plexus injury patients.

- Direct end-to-end repair.
- Neurolysis can be external neurolysis (where the nerve is dissected from the circumferential scar tissue by sharp dissection) or internal neurolysis (fibrous scar tissue is dissected from nerve fascicles).
- Neurotization means nerve transfer (when a less important but functional nerve is being transferred to a distal but more important denervated nerve) to improve its function.[13]
- Nerve grafting is done when resection of the nerve segment is required in cases of a nonconducting neuroma, or in postganglionic injury. The sural nerve is most commonly used and can yield a length of as much as 40 cm from one side.[10–12]

Table 3 Results of various surgical interventions

	Surgical interventions					
	Neurolysis alone	Supraclavicular exploration with neurotization	Infraclavicular exploration with neurotization	Supraclavicular neurolysis and infraclavicular neurotization	Supraclavicular as well as infraclavicular neurotization	Total
Improvement	15 (40.54%)	7 (33.33%)	13 (44.83%)	7 (33.33%)	58 (50.88%)	100 (45.04%)
No Improvement	9 (24.32%)	13 (61.91%)	11 (37.93%)	10 (47.62%)	46 (40.35%)	89 (40.00%)
Lost to follow-up	13 (35.14%)	1 (4.76%)	5 (17.24%)	4 (19.05%)	10 (8.77%)	33 (14.86%)
Mortality	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0(0%)
Total	37	21	29	21	114	222

Table 4 Timing of surgical intervention and functional outcomes

Time interval (mo)	No improvement	Improvement	Lost to follow-up
<3	20	70	10
4–6	43.66	42.25	14.09
7–12	38.68	47.17	14.15
13–24	56.52	26.09	17.39
>24	57.14	14.29	28.57

In a review by Martin et al,[11] multiple factors affect the outcome after brachial plexus surgery, which can be conveniently grouped as the following:

- *Age of the patient:* In multiple series, age has shown to affect neurological outcome.[10–12,14] Patients older than 40 years have poor outcomes as compared with patients younger than 30 years. Similar findings were observed in our study with younger patients doing better. This can be related to higher cortical plasticity in younger individuals.
- *Level of the brachial plexus injury:* Upper brachial plexus lesions (C5–C7) have the best results, while C8 and T1 lesions have comparably less favorable outcomes. Complete lesions have the worst outcomes.[11,12,14] Similar results were obtained in our study, with good results seen in patients with upper brachial plexus injury.
- *Type of nerve grafts and transfers:* Intraplexal donors generally give better results, due to the large number of axons in the donor. In a systematic review, Ali et al concluded that there is a significant difference in the outcomes comparing nerve transfer technique to nerve graft techniques, with transfer techniques having better results.[15] Also, the length of the graft affects the outcomes, with longer grafts yielding worse results. In our study, all patients underwent nerve transfers with satisfactory results.
- *Timing of the surgical intervention:* To date, no randomized control trial or prospective cohort studies have been conducted to assess the optimal timing of surgery after brachial plexus injury.[11,12,14–17] Terzis et al recommended delays of less than 3 months, but failed to demonstrate a statistically significant difference with delays between 3 and 6 months.[16] Results of the systematic review by Martin et al indicated that the best surgical outcomes are observed when operative delays are less than 6 months after injury.[11] Similar results are observed in our study. Another reason for delayed surgical intervention in our series was late referrals to our center.[18–28]

The presence of posttraumatic brachialgia has shown a wide range of incidence in various studies. In a study by Jain et al, 24% of the patients had pain at the time of presentation. Eleven percent had complete relief of pain after surgery and 6.9% continued to have intractable pain.[10] In our series also, patients suffering from intractable pain got excellent pain relief with DREZ lesioning.

Limitations

This is a large cohort of patients presenting at different intervals (after injury). Hence, generalization is difficult.

Future Directions

This study shows that even if surgical repair is offered after 2 years of injury, there is more than 15% chances of recovery in motor power. Hence, larger studies should be planned on such patients. Also, quality-of-life (QOL) assessments were done on these patients to see for actual benefits of surgical repair.

Conclusion

From our study, we can conclude that neurotization should be done as early as possible. Patients who underwent surgery within a 1 year of injury had a far better outcome than patients who got operated on after a period of 1 year. Our study shows that surgical repair should be offered to all patients of TBPI even after 24 months of injury as at least 15% will have good recovery of motor power following surgery.

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Conflict of Interest
None declared.

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