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OPTIONS FOR RESTORATION OF ELBOW FLEXION IN CASES OF PAN BRACHIAL PLEXUS INJURY

Masooma Amber*[1], Abu-ul-Ala Nafees[2], Saba Aziz[3]

*[1,3](MBBS), Registrar Plastic Surgery, Department of Plastic Surgery, CMH Lahore.
[2](MBBS, FCPS, FRCS Plastic Surgery), Consultant Plastic Surgery, Department of Plastic Surgery, CMH Lahore.

*[1]ambermasooma@yahoo.com, [2]abuulala@gmail.com, [3]inosbas@gmail.com

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Corresponding Author: *
Masooma Amber

Abstract

Background: *Pan brachial plexus injury is a devastating injury leading to permanent functional deficit and psychological scarring. The most common cause of traumatic adult pan-brachial plexus injury in motorbike accidents. The timing of presentation of these patients play a vital role in choosing the surgical intervention for the deficits. Other factors that determine the overall outcome of treatment include level and pattern of injury.*

Objective: *To describe the various surgical techniques to restore the elbow flexion post pan brachial plexus injury according to the time of presentation, pattern and level of injury.*

Study design: *Prospective observational study*

Place and duration of study: *Combined Military Hospital, Lahore Pakistan, from 1st July 2022 to 31st July 2023.*

Methodology: *After providing informed consent, a total of 26 patients with mean age of 29 years were included. Depending on when the injuries occurred, the study included a variety of surgical procedures, including as proximal explorations, distal nerve transfers and free functional muscle transfers.*

Results: *The study's surgical procedures differed according to the period of the injury, with a mean participant age of 29 ± 7.14 years and a male preponderance (73.1%). Proximal exploration done in 8 patients, distal nerve transfers in 9 patients and functional muscle transfers in 9.*

Conclusion: *When surgical interventions for elbow flexion restoration are timed according to the injury phase, patients with pan-brachial plexus injuries see significant increases in their muscular strength. The effectiveness of proximal exploration, distal nerve transfers, pedicled or functional muscle transfers cannot be over emphasized. These operations emphasize how important it is to use timely, appropriate surgical techniques that are tailored to the damage stage.*

INTRODUCTION

Pan brachial plexus injury is a devastating injury mostly caused by motorcycle accidents leading to permanent damage and partial functional restoration. The intricate nature of pan brachial plexus injury (PBPI) and its substantial influence on upper limb function makes it a considerable challenge in reconstructive surgery. Elbow flexion is one of the essential functions which is compromised.[1] To restore elbow flexion, a number of surgical procedures have been described; each has a set of

indications based on the type of nerve injury and the patient's general health. The type of procedure to be done depends upon multiple factors including timing of presentation, level, severity of injury, available donor options and recovery at the time of presentation. In this article time of presentation will be considered for deciding the procedure to be done for elbow flexion.

The best surgical strategy for regaining elbow flexion is proximal exploration if the patient presents within three months of the injury.[2]After this time, between three and nine months following the injury, nerve transfer becomes the method of choice. In order to successfully reanimate the biceps muscle, which is necessary for elbow flexion, this usually entails the direct transfer of fascicles from either the intercostal nerve (ICN), targeting the musculocutaneous nerve, or the spinal accessory nerve (SAN) utilizing sural nerve grafts.[3]

Free Functional muscle transfer (FFMT) is considered the appropriate option in situations where nerve transfer is either not possible or the patient presents later than nine months of injury.[4] The function of biceps muscle is frequently replaced with the free gracilis muscle transfer.[5] Even though it involves prolonged surgery with microsurgical equipment and expertise, still this option is the workhorse for the patients who have presented late or in whom the previous reconstructive procedures were unsuccessful.[4,6]

Every surgical option has unique advantages and disadvantages. While FFMT may be taken into consideration in situations when nerve transfers are not appropriate or have not worked. Otherwise, nerve transfers provide a less extensive procedure with a quicker recovery of elbow flexion.[7] In clinical practice, decision-making frequently entails evaluating each patient's state, the precise deficits and the timing of operation.[8]

Restoring elbow flexion in patients with PBPI requires a customized strategy that takes into account the degree of damage, the patient's general condition, and the timing of surgical intervention.[8]The possibility of nerve regeneration and the particular requirements and goal of the patient are among the criteria that influence the decision between nerve transfer and FFMT. Ongoing research and case studies further contribute to our understanding and improvement of these intricate surgical operations as the techniques evolve.

The goal of this study is to close a significant gap in the local literature because not much research has been done on this subject in Pakistan. The aim of this study is to show the effectiveness of different surgical techniques for restoring elbow flexion in patients from Pakistan who have had pan-brachial plexus injury. This research aims to advance surgical techniques and rehabilitation methods, addressing the critical requirement for increased functional independence in affected individuals. This input is essential for developing evidence-based, locally tailored surgical methods that take into account Pakistan's unique healthcare environment.

MATERIAL AND METHODS

A prospective observational study was carried out at the Combined Military Hospital in Lahore over the course of one year, from 1st-July-2022 to 31st-july-2023. Non-probability random sampling was done. A total of 26 patients were recruited in accordance with the subsequent inclusion criteria: both genders, 16 years of age and older, no history of brachial plexus injury treatment, and no concomitant life-threatening injuries.

Ethical approval is obtained from the Institutional Review Board with a reference number of 541/2024.

Techniques

Proximal Exploration:

Proximal explorations were conducted on patients presented within three months' of injury, involving surgical examination of the brachial plexus's proximal nerve trunks and roots. This critical assessment of nerve root avulsions or ruptures included a supraclavicular incision, with subsequent interventions like laceration repair, nerve grafting for gaps, and neurolysis for neuroma treatment (Figure 1. A,b and c) show proximal exploration and (fig 1 d and e) show nerve grafting.

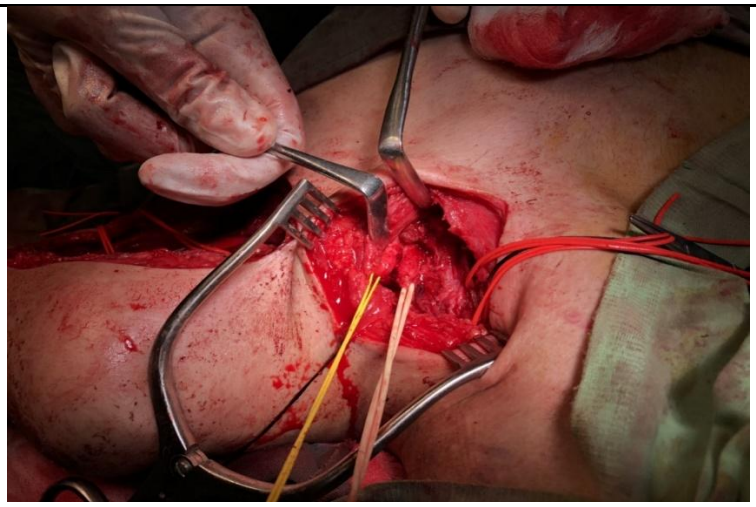


Fig 1 a

Fig 1 b

Fig.1(c) proximal exploration.

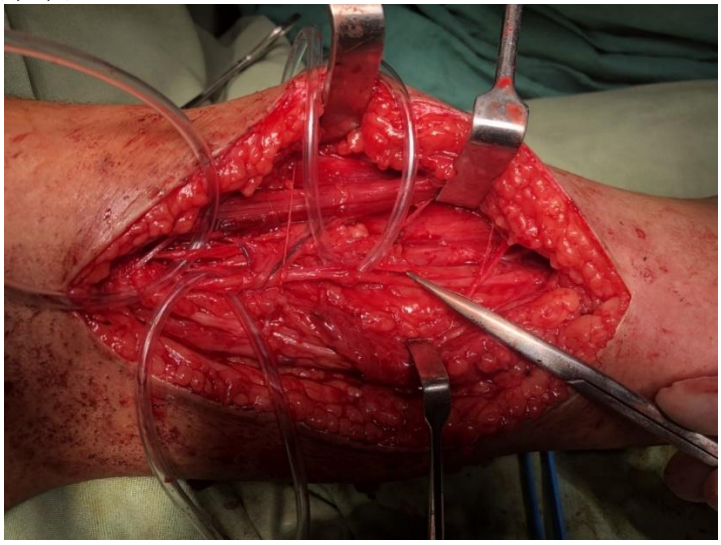
Fig 1 d

Fig 1 d

Distal Nerve Transfer:

Patients who came between three and nine months after injury had distal nerve transfers. Key muscles involved in elbow flexion are re-innervated by means of distal nerve transfers. Often, the biceps and brachialis muscle branches of the musculocutaneous nerve receive the fascicles as we use extaplexal options like intercostal nerves in these patients where intraplexal options are not available (Figure 2). Compared to proximal nerve repairs, this approach may result in a quicker recovery by restoring muscle function based upon slightly delayed presentation.

Fig 2(a,b ,c) nerve transfer from intercostal nerve to musculocutaneous.



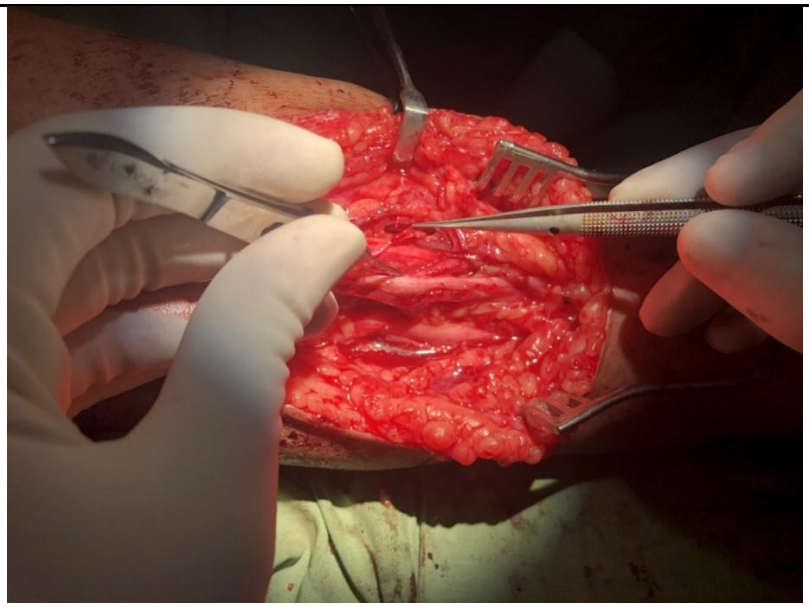


Fig 2(d,e and f) Oberlin's transfer

Free Functional Muscle Transfer:

Patients who presented nine months after injury undergo free functional muscle transfer. Gracilis free functional muscle transfer is the most frequent choice in situations when nerve transfers are not feasible. The gracilis muscle is transferred from the thigh to the arm during this treatment, and is neurotized by a functioning donor nerve (often the intercostal or spinal accessory nerve). The muscle restores elbow flexion by acting as a substitute and imitating the biceps muscle's activity (Figure 3).

Figure 3. Gracilis muscle transfer.

RESULTS

The mean age of the participants was approximately 29 years with a standard deviation of 7.14035. The gender distribution was skewed towards males, who made up about 73.1% of the participants (Table II).

Table II. Descriptive Characteristics of study participants. (n = 26)

Study Parameters	**n** (%)
Age (years)	
Mean + SD	29.2308± 7.14035
Range	17 years – 43 years
Gender	
Male	19 (73.1 %)
Female	7 (26.9 %)

The timing of presentation after injury varied among the participants: 30.8% presented within 3 months, 34.6% between 3 to 9 months, and another 34.6% after 9 months. The most common pattern of injury was observed at the C5-T1 spinal level, followed by injuries at the C5-C7 and C5-C6 levels. The study also categorized injuries into different levels: 53.8% of cases were postganglionic supraclavicular injuries, followed by mixed injuries. Various surgical procedures were conducted, including proximal exploration, distal nerve transfer, and functional muscle transfer, each performed on roughly one-third of the participants (Table III).

Table III. Patients' parameters preoperatively. (n=26)

Timing of Presentation	**Number**	**Percentage** (%)
Within 3 months of injury	8	30.8
3 to 9 months of injury	9	34.6
After 9 months of injury	9	34.6
Pattern of Injury		
C5-C6	4	15.4
C5-C7	9	34.6
C5-T1	13	50
Level of Injury		
Postganglionic Supraclavicular	14	53.8
Root Avulsion	4	15.4
Mixed	8	30.8
Procedures		
Proximal Exploration	8	30.8
Distal Nerve Transfer	9	34.6
Functional Muscle Transfer	9	34.6

DISCUSSION

The demographics of our sample, which included 26 patients with an average age of 29 years and a preponderance of males (73.1%), are typical of those reported in the literature. Due to the high frequency of motorcycle accidents and other traumatic injuries in this population group, Silva et al. studied a similar demographic with an average age of 30 years and a predominance of male patients. This demographic is consistent with the typical profile of patients with brachial plexus injuries.[9] The demographic stability observed across studies supports the generalizability of our results and emphasizes how widely applicable the surgical methods under review are.

In order to restore elbow flexion in patients with pan-brachial plexus injuries, we examined a variety of nerve transfer strategies in our study. This analysis allowed us to get insight into how different procedures affect the healing of muscles. Proximal exploration performed within three months after the injury, distal nerve transfers performed between three and nine months, and functional muscle transfers free functional muscle transfer performed nine months after the damage were all shown to be

beneficial. This analysis confirms the results of studies by Ochiai et al. and Lee et al. that looked at various nerve transfer methods.[10,11]Ochiai et al. found that dual nerve transfers, namely those involving the ulnar and median nerve fascicles, significantly increased muscle strength.[10] Lee saw notable benefits when using less common donor nerves, like intercostal.[11] To improve surgical outcomes and recovery trajectories, our study builds on these findings by emphasizing the significance of early intervention and the thoughtful selection of nerve transfer techniques depending on damage characteristics and patient health. This focus on individualized strategies is consistent with previous research and emphasizes the need for specialized surgical planning to attain the best possible functional recovery.

The results of our investigation support a study by Brazilian authors that found that gracilis muscle transfer can successfully restore muscular strength of M3 or higher in 65 percent of cases, demonstrating the procedure's efficacy for long-term brachial plexus injuries.[9] This finding highlights the usefulness of functional muscle transfers in situations when conventional nerve repairs would be unfeasible. In a similar way, our results concur with a study by Pakistani researchers and another by American researchers that examined the effectiveness of nerve transfers involving the phrenic and intercostal nerves.[1,12] When phrenic nerves were employed, the percentage of patients who attained at least MRC Grade 3 at 12 months improved to 80% at 18 months following surgery, according to Pakistani authors. Conversely, an astounding 86% of patients who had intercostal nerve transfers achieved MRC Grade 3 at 12 months, and 100% of them did so at 18 months.[12] Similar successes with these nerve transfers was reported by American writers, who praised the intercostal nerve in particular for its combined advantages of efficacy and little invasiveness, which make it a great option in some therapeutic situations.[1,13] The outcomes of our investigation corroborate these conclusions; our own use of intercostal nerve transfer produced similar increases in muscular strength. We found that intercostal nerve transfers provided a less invasive surgical option with a possible lower risk profile and faster recovery timeframes, in addition to matching the recovery outcomes of more invasive treatments. This highlights how important it is to choose a nerve transfer method that strikes a balance between patient burden and efficacy, especially for patients who report with complicated or chronic injuries.

Pengked et al. and Mitchel and colleagues have demonstrated the importance of surgical therapies for brachial plexus injuries being successful over the long term. These studies found that the interventions significantly improved muscular strength over long durations of follow-up. While Mitchel saw ongoing progress in over 80% of patients reaching functional muscle strength two years after surgery, Pengked et al. reported that 78% of patients maintained at least an MRC grade of M3 up to five years' post-surgery.[14,15] Our results support these observations by demonstrating that long-term surgical improvements are preserved. We build on the comparative analysis of two studies, one by American authors and one by Chinese authors, that looked at various surgical procedures. The authors from China discovered that patients who underwent dual nerve transfers often had better results, with almost 75% of them obtaining M4 strength.[16] The success of intercostal nerve transfers was also highlighted by American writers, who noted that 82% of patients achieved M3 or better for elbow flexion.[3] Our research provides comprehensive evaluations of different surgical approaches throughout time, allowing for direct comparisons and the identification of the best circumstances for each procedure. For patients with brachial plexus injuries, this method helps more successfully customize therapy regimens, assuring long-term healing and functional independence.

For the best results in cases with pan-brachial plexus injuries, our research recommends early surgical procedures. It is advised to do distal nerve transfers up to nine months and proximal explorations within three months. Next, think aboutfree functional muscle transfers. Tailored rehabilitation and ongoing monitoring are essential for long-term recovery.

LIMITATIONS OF STUDY

Some of the shortcomings of this study include the small sample size that may limit generalizability, the lack of a control group to confirm causal

relationships, and the brief follow-up period that may miss long-term results.

CONCLUSION

When surgical interventions for elbow flexion restoration are timed according to the injury phase, patients with pan-brachial plexus injuries see significant increases in their muscular strength. The effectiveness of proximal exploration, distal nerve transfers, pedicled or functional muscle transfers cannot be over emphasized. These operations emphasize how important it is to use timely, appropriate surgical techniques that are tailored to the damage stage.

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