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Original research

CLINICAL EVALUATION OF ACCESSORY NERVE TRANSFER FOR SHOULDER FUNCTION RESTORATION IN UPPER ROOT BRACHIAL PLEXUS INJURIES

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ABSTRACT

Objective: *Upper root injuries of the brachial plexus often lead to significant impairment in shoulder motor function, drastically reducing the quality of life for affected individuals. This study systematically evaluates the clinical efficacy of nerve transfer surgery, specifically the transfer of the accessory nerve to the suprascapular nerve, aimed at restoring shoulder function.*

Methods: *This prospective study was conducted on 31 patients who sustained upper root brachial plexus injuries, treated with accessory nerve transfer to the suprascapular nerve at Hue Central Hospital from 01/2019 to 10/2022. Selection criteria included patients with complete paralysis in shoulder abduction and external rotation, with a surgery timeline of less than 12 months post-injury. Postoperative motor function recovery was monitored for at least 12 months.*

Results: *Among the 31 patients, 58.1% achieved shoulder abduction strength at M3 or higher, with an average shoulder abduction range of motion increasing by 113 degrees after surgery. Similarly, 48.3% of patients achieved external shoulder rotation strength at M3 or higher, with an average external rotation range increasing by 21 degrees. No postoperative complications were recorded during the follow-up period.*

Conclusion: *Accessory nerve transfer to the suprascapular nerve emerges as a safe and effective surgical intervention for restoring shoulder motor function in patients with upper root brachial plexus injuries. The procedure significantly enhances shoulder abduction and external rotation, thereby improving the overall quality of life for patients. However, limitations such as the relatively small sample size and limited follow-up duration should be considered when interpreting the findings.*

Keywords: *Brachial plexus injury, Nerve transfer surgery, Accessory nerve, Suprascapular nerve.*

I. INTRODUCTION

The brachial plexus is a complex system that includes the anterior branches of the spinal nerves from C4 to T1 [1]. Brachial plexus injuries are increasing, primarily due to the rise in traffic accidents, especially in the context of alcohol consumption while driving [2].

Treating brachial plexus injuries is always a substantial challenge. There are two main treatment methods: conservative treatment and surgical treatment. Surgery for brachial plexus injuries has been performed since the early 20th century, but with many limitations. However, since the advent of microsurgery techniques, some reports have shown substantially improved outcomes in treating brachial plexus injuries. The effectiveness of this method depends on various factors such as the timing of surgery, patient age, extent of injury, equipment, and the surgeon's experience. The surgical treatment of upper root brachial plexus injuries has undergone significant advancements over time. Initially, direct nerve repair and autologous nerve grafting were performed in the early 20th century. However, these procedures yielded low functional recovery rates due to limited surgical techniques and the absence of microsurgical tools. By the 1990s, the development of microsurgical techniques paved the way for the widespread application of nerve transfer procedures, particularly the transfer of the spinal accessory nerve (SAN) to the suprascapular nerve

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(SSN), first described by Mackinnon and Colbert. This technique significantly improved shoulder abduction and external rotation functions. Besides spinal accessory nerve transfer, other surgical options such as transfer of the nerve branch to the long head of the triceps to the axillary nerve, and free functional muscle transfers (e.g., latissimus dorsi or lower trapezius muscle transfers), are often considered in chronic cases or when primary nerve transfer techniques fail. However, these procedures are more complex, require longer recovery times, and do not necessarily yield superior outcomes compared to spinal accessory to suprascapular nerve transfer when performed early and appropriately

The main objective of this study is to evaluate the effectiveness of accessory nerve (AN) transfer to the suprascapular nerve (SS) in restoring motor function in patients with brachial plexus injuries. The study aims to identify the factors that determine the success of this treatment method while comparing clinical outcomes with previous studies to provide an overview and update on the effectiveness of this technique in treating complex peripheral nervous system injuries. By collecting and analyzing data from patients who underwent surgery at Hue Central Hospital, we hope to contribute valuable medical evidence not only to improve understanding of nerve surgery but also to guide more effective treatment strategies in the future.

II. MATERIALS AND METHODS

2.1. Subjects

Patients with paralysis due to upper root (C5, C6 ± C7) injuries of the brachial plexus who underwent nerve transfer surgery at Hue Central Hospital from January 2019 to October 2022.

Inclusion criteria: Patients were diagnosed with upper root injuries of the brachial plexus, paralyzed in both shoulder abduction and external shoulder rotation (shoulder abduction and external shoulder rotation strength at M0), and underwent spinal accessory nerve (SAN) transfer to the suprascapular nerve (SSN). Surgery was performed within 12 months from the time of injury. Post-surgery evaluation occurred over 12 months after surgery.

Exclusion criteria: Patients with additional injuries such as fractures involving the shoulder or elbow joints, leading to limited passive movement in these joints. Patients with fibrotic, crushed supraspinatus, infraspinatus, deltoid, biceps, and brachialis muscles. Even with nerve transfer, recovery is not possible.

2.2. Research methods

A retrospective study was conducted on 31 patients at Department of General Surgery - Plastic Surgery - Aesthetics - Hue Central Hospital.

Research process: Clinical information was recorded through patient interviews and clinical examinations, diagnostic imaging information was recorded, and follow-up evaluations were conducted to assess results.

Surgical procedure: The patient undergoes general anesthesia induction. We used the anterior approach, with the patient in the prone position. The surgical technique was performed following Mackinnon's method: The surgical incision is planned in a transverse fashion to expose both nerves and based on anatomical landmarks in Figure 1: the midline spinous process, the acromion. The location of the spinal accessory nerve is marked (SA) at a distance 40% from the dorsal midline to the acromion parallel to a line along the superior border of the scapula. The superior angle of the scapula is marked and the location of the suprascapular notch containing the suprascapular nerve is identified and marked at the midpoint between the superior angle of the scapula and the acromion along the superior border of the scapula. The nerve is confirmed to be inactive with a disposable nerve stimulator. After isolation of the suprascapular nerve, the separation of the trapezius muscle is carried medially toward the location of the spinal accessory nerve [3].

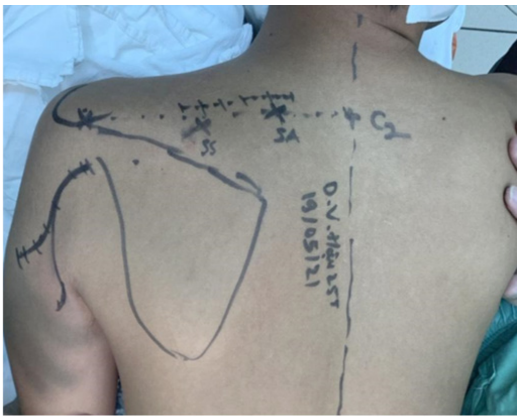

Figure 1: Design for dissecting the accessory nerve and suprascapular nerve

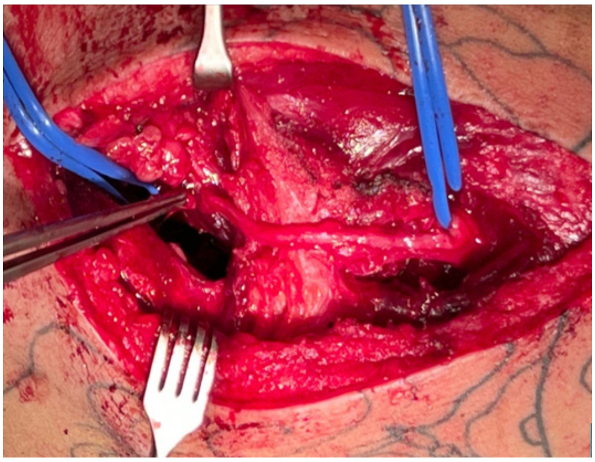

Figure 2: Transfer of the accessory nerve to the suprascapular nerve

Re-routing the accessory nerve to the suprascapular nerve (Figure 2): After confirmation of activity of the accessory and inactivity of the suprascapular nerve by nerve stimulation, the suprascapular nerve is divided first at its most proximally identified point, and then the accessory nerve divided as distal as necessary to allow a transfer without tension.

Microsurgical nerve suturing (Figure 3): The nerve ends are prepared and the proximal segment of the accessory nerve is transferred and sutured to the distal segment of the suprascapular nerve with interrupted 9 - 0 nylon under an operating microscope VITOM 3D (the Video Telescope Operating Monitor digital 3-Dimension).

Re-examination after 12 months of surgery: Assessing shoulder abduction and external rotation strength through direct clinical examination using the British Medical Research Council scale from M0 to M5. Shoulder abduction and external rotation range of motion is based on Mallet's criteria [4, 5].

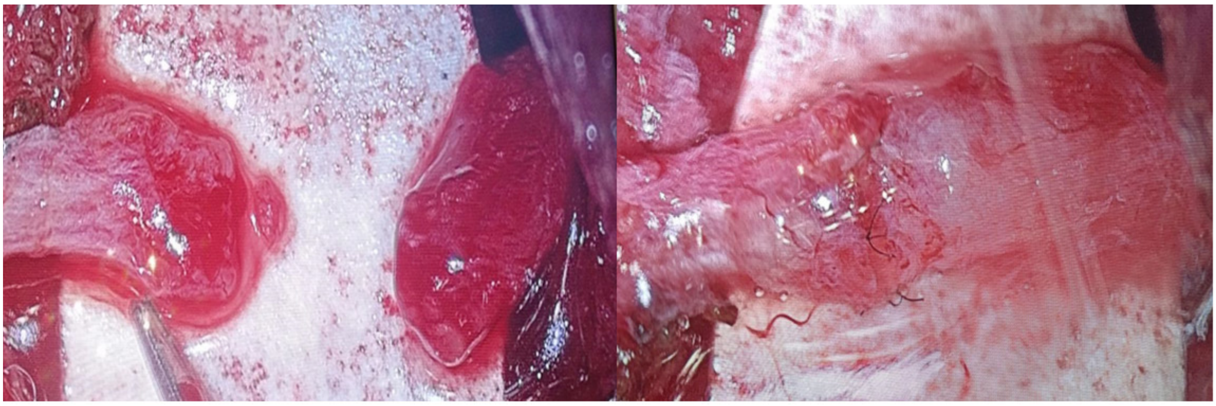

Figure 3: Microsurgical nerve suturing

Outcome evaluation (Table 1 and Table 2):

Table 1: Shoulder abduction evaluation by Mallet's criteria

Type I (Failure)	No signs of shoulder abduction
Type II (Poor)	Shoulder abduction with a range of motion ≤ 30°
Type III (Average)	Shoulder abduction with a range of motion from ≥ 30° to 90°
Type IV (Good)	Shoulder abduction with a range of motion > 90°
Type V (Very Good)	Shoulder abduction with a range of motion comparable to a normal shoulder

Table 2: External shoulder rotation evaluation by mallet's criteria

Type I (Failure)	No signs of external shoulder rotation
Type II (Poor)	External shoulder rotation at neutral position or 0°
Type III (Average)	External shoulder rotation reaching 20°
Type IV (Good)	External shoulder rotation > 20°
Type V (Very Good)	External shoulder rotation comparable to normal

III. RESULTS

The majority of patients recovered to M3 shoulder abduction strength, accounting for 58.1%. The lowest proportion of recovery was in patients who achieved M2 strength, accounting for 9.6% (Table 3). The majority of patients achieved average shoulder abduction recovery, accounting for 41.9%. The lowest proportion was in patients who achieved very good recovery, accounting for 13% (Table 4). After surgery, the majority of patients had an external shoulder rotation range > 20° to normal, accounting for 80.7% (Table 5)

Table 3: Shoulder abduction strength evaluation

Shoulder Abduction Strength	Quantity	Percentage
M0	0	0
M1	0	0
M2	3	9,6
M3	18	58,1
M4	8	25,8
M5	2	6,5
Total	31	100

Table 4: Shoulder abduction range of motion post-surgery

Abduction Range	Quantity	Percentage
Type I	0	0
Type II	5	16,1
Type III	13	41,9
Type IV	9	29
Type V	4	13
Total	31	100

Table 5: External shoulder rotation strength

External Shoulder Rotation	Quantity	Percentage
M0	0	0
M1	0	0
M2	3	9,6
M3	18	58,1
M4	8	25,8
M5	2	6,5
Total	31	100

IV. DISCUSSION

In this study, the average age of patients was 30.06 ± 1.5 years. The male/female ratio in the study group was 30/1, clearly reflecting the male dominance in brachial plexus injury cases, which may be related to the higher participation of males in traffic. Traffic accidents were the main cause, accounting for 96.77%. This is a predictable result because most patients were in the young adult and middle-aged groups, the age group with the most traffic participation and also the most vulnerable. Additionally, alcohol consumption and non-compliance with traffic regulations are contributing factors to the high accident rate [6]

Our study's results are consistent with previous studies, such as the study by Nguyen Van Phu (2013) [7], which demonstrated a higher rate of C5, C6 root injuries compared to C5, C6 and C7 injuries. C5, C6 injuries accounted for 54.83%, while C5, C6 and C7 injuries accounted for 45.17%. This may be because the C7 root is deeper and requires more force to injure all three roots compared to the first two.

The nerve transfer surgery method has shown promising results. In all cases, the donor and recipient nerves were directly sutured without the need for intermediate grafting, which enhances nerve recovery potential. This result is consistent with previous studies by Leechavengvongs et al [8] and Souza [9] demonstrated the safety and high efficacy of spinal accessory to suprascapular nerve transfer, reporting functional recovery of shoulder abduction at M3 or higher in 50 - 60% of cases, and M4 in 25 - 30% of patients. Tahir et al [10] also reported a 55% recovery rate to M3 or higher when utilizing the posterior approach.

No complications occurred during surgery. However, caution should be exercised when dissecting the recipient nerve (suprascapular nerve) because it is located deep and close to the suprascapular artery. If this artery is damaged, the surgery will be prolonged, and the risk of ischemia to the supraspinatus and infraspinatus muscles will be high, leading to reduced recovery potential. Our results also show that evaluating the recovery level of muscles in the shoulder abduction and external shoulder rotation muscle groups using the British Medical Research Council scale from M0 to M5 is very useful [11]. The group of patients recovering to M3 level accounted for the highest proportion, reflecting that the surgery had a positive outcome for the majority of patients. Compared to other studies, such as the study by Sanjay Maurya [12], our study demonstrated a higher rate of patients recovering to M5 level (6.5% compared to no patients at M5 level in Maurya's study). This difference may be due to factors such as surgical method, recovery time, and postoperative care conditions. Meanwhile, the study by Souza et al [9] also demonstrated a high rate of patients recovering to M3 level, consistent with our study.

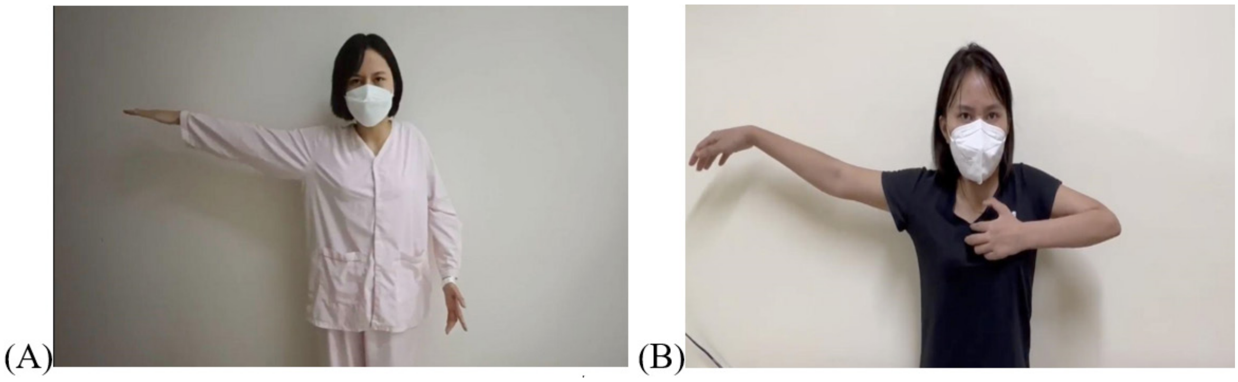

Figure 4: The patient lost shoulder abduction before surgery (A) and showed significant improvement in this movement 12 months post-surgery (B)

Additionally, the results of shoulder abduction and external shoulder rotation range of motion recovery in our study group also demonstrated substantial improvement. The maximum shoulder abduction range in our study group was 120°, with a minimum range of 20°, and an average range of 113°. This result is higher than in some previous studies, such as the study by Gao-hong Ren et al. (2012) [13], where the average shoulder abduction range was 92.5°.

Regarding external shoulder rotation range of motion, the maximum recovery result was 25°, while the minimum range was 5°, and the average range was 21°. Although this result is lower than the study by Masoud Yavari (2014) [14], it still shows substantial improvement in patients after surgery.

These results confirm that accessory nerve transfer to the suprascapular nerve is a safe and effective method for treating brachial plexus injuries and can improve patients' motor function (Figure 4).

V. CONCLUSION

Accessory to suprascapular nerve transfer surgery is an effective and safe method for restoring shoulder function in patients with brachial plexus injuries. The study results indicate that the majority of patients achieved substantial improvements in shoulder abduction and external rotation strength, with a high rate of recovery to M3 or higher. Factors such as the timing of surgery, microsurgical techniques, and the surgical approach play crucial roles in optimizing treatment outcomes. Additionally, no severe complications were observed during the surgical process, suggesting that this is a safe treatment option. However, further long-term studies with larger sample sizes are necessary to evaluate the efficacy and safety of this method more comprehensively, as well as to compare it with other treatment options. Overall, accessory to suprascapular nerve transfer surgery represents a substantial advancement in the treatment of brachial plexus injuries, contributing to the improvement of patients' quality of life.

Ethics approval

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Hue Central hospital.

Disclosure

The authors report no other conflicts of interest in this work.

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