

Outcome of End to Side Nerve Modified Double Oberlin Procedure and End to End Dorsal Approach Spinal Accessory to Suprascapular Nerve in Partial Postganglionic BPI: A Case Report

I Kadek Riyandi Pranadiva Mardana¹, Made Bramantya Karna²,
AA. Gde Yuda Asmara², Stedi Adnyana Christian²,
I Gusti Ngurah Paramartha Wijaya Putra²

¹Resident of Orthopaedics and Traumatology Department, ²Consultant of Orthopaedics and Traumatology Department, Faculty of Medicine, Udayana University, Prof. Dr. I.G.N.G. Ngoerah General Hospital, Denpasar, Indonesia

Corresponding Author: I Kadek Riyandi Pranadiyva Mardana

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ABSTRACT

Introduction: Brachial plexus injury (BPI) is a devastating peripheral nerve injury that mostly affecting young men, often due to motor vehicle accidents. BPIs can be classified into preganglionic and postganglionic lesions, with postganglionic injuries allowing potential nerve regeneration. The Oberlin method, aimed at reinnervating the biceps, and the Mackinnon technique, targeting both biceps and brachialis muscles, have shown promising outcomes in BPI management.

Case report: A 45-year-old man presented with right hand weakness and occasional tingling in the upper arm and fingers two months after a motorcycle accident. Motor examination revealed muscle strength of 0/5 in the right trapezius, rhomboids, serratus anterior (positive winging scapula), pectoralis minor and major, latissimus dorsi, deltoid, biceps, and elbow flexion. Wrist and finger functions remained intact. Diagnosed with post-ganglionic BPI, the patient underwent two nerve transfer surgeries: the Mackinnon technique, transferring the spinal accessory nerve to the suprascapular nerve to reinnervate shoulder

muscles, and the Double Oberlin procedure, transferring fascicles from the median and ulnar nerves to the musculocutaneous nerve for reinnervation of the biceps and brachialis muscles. Post-surgery, the patient engaged in an aggressive rehabilitation program focusing on strength, range of motion, and sensory re-education. Over nine months, the patient showed significant improvement in elbow flexion (MRC grade 3), wrist extension (MRC grade 5), hand grip strength (MRC grade 3) with improved sensation across the affected limb. He returned to work and daily activities with mild residual weakness and sensory deficits.

Discussion: This case illustrates the effectiveness of the Mackinnon and Double Oberlin nerve transfer techniques in restoring function in a patient with total post-ganglionic BPI. The Mackinnon technique enabled shoulder muscle reinnervation, essential for abduction and stabilization, while the Double Oberlin procedure enhanced elbow flexion by reinnervating both the biceps and brachialis muscles. The combined surgical and intensive rehabilitation approach facilitated significant functional recovery.

Conclusion: The successful application of the Double Oberlin and Mackinnon techniques in this case demonstrates their potential in managing total post-ganglionic BPI. Early surgical intervention and consistent rehabilitation are crucial for optimizing recovery outcomes. This case highlights the importance of a multidisciplinary approach in treating complex peripheral nerve injuries.

Keywords: Double Oberlin, Mackinnon, Brachial Plexus Injury

INTRODUCTION

Brachial plexus injury (BPI) is a devastating damage to the peripheral nerves that impacts the upper limbs, resulting in substantial loss of function and physical handicap.¹ Predominantly, young men between the ages of 15 and 25 are affected by BPIs, with a substantial majority of these injuries resulting from motor vehicle accidents. Narakas, in his extensive experience with over 1000 BPI patients over nearly two decades, noted that 70% of traumatic BPIs are due to motor vehicle accidents.^{1,2}

Lesions of the brachial plexus can be classified into preganglionic, postganglionic, or mixed categories depending on their position in relation to the dorsal root ganglion (DRG).³ Infraganglionic injuries occur distal to the dorsal root ganglion (DRG), whereas supraganglionic lesions emerge proximal to the DRG. Postganglionic injuries are distinguished by nerve ruptures or discontinuations distal to the sensory ganglion, which preserve the connection to the central nervous system and enable the nerve to function as a source of axons for possible regeneration, hence resulting in muscle function loss.^{2,4}

The Oberlin method is a reliable technique for BPI treatment, primarily targeting the reinnervation of the biceps muscle, which acts more as an elbow supinator than a flexor. However, the brachialis muscle is primarily responsible for elbow flexion, and

its reinnervation is crucial for better functional recovery of elbow flexion. Susan MacKinnon pioneered the double nerve transfer procedure with the express goal of concurrently reinnervating both the biceps and brachialis muscles. This technique entails the use of different donor nerves, including the medial pectoral nerve, intercostal nerve, thoracodorsal nerve, and the triceps branch of the radial nerve, to restore nerve supply to the brachialis muscle, with or without the use of nerve transplants. Reports from both the Mackinnon and Oberlin groups indicate a 100% success rate in achieving M4 elbow flexion recovery, with no donor site morbidity. The double nerve transfer technique thus offers a higher success rate for restoring elbow flexion without compromising donor nerve function in the hand.^{5,6,7}

Despite promising results, there is a lack of literature comparing the long-term functional outcomes of these two techniques, particularly in cases of delayed surgical intervention beyond 12 months after injury. More research is needed to understand the factors that contribute to the success of these procedures and to identify the best candidates for surgery.

CASE REPORT

A 45-year-old man presented with weakness in his right hand that began 2 months ago after falling from a motorcycle 2 months prior to hospital admission (June 2023). Additionally, the patient occasionally complained of tingling and numbness along the upper arm through first, second, and third fingers. The patient had been referred to the Neurology Division and was diagnosed with right BPI. The patient had a history of surgery (+) ORIF-Miniplate for an orbital rim fracture at Graha Medika Hospital (June 2023). He did not have a history of systemic diseases or medication. Motor examination comparing the right and left sides revealed the following muscle strength: trapezius (0/5), rhomboids (0/5),

serratus anterior (winging scapula positive/winging scapula negative), pectoralis minor (0/5), pectoralis major (0/5), latissimus dorsi (0/5), deltoid (0/5), biceps (0/5), triceps-extensor pollicis longus-extensor carpi radialis longus (5-5-0/5-5-5), flexor carpi radialis-flexor digitorum profundus (5-5/5-5), flexor carpi

ulnaris-flexor digitorum profundus (5-5/5-5).

Local status examination of the upper extremities, comparing the right and left sides, showed shoulder abduction (0/5), elbow flexion (0/5), wrist extension (5/5), elbow extension (0/5), wrist flexion (5/5), finger flexion (5/5), finger abduction (5/5), and finger adduction (5/5).

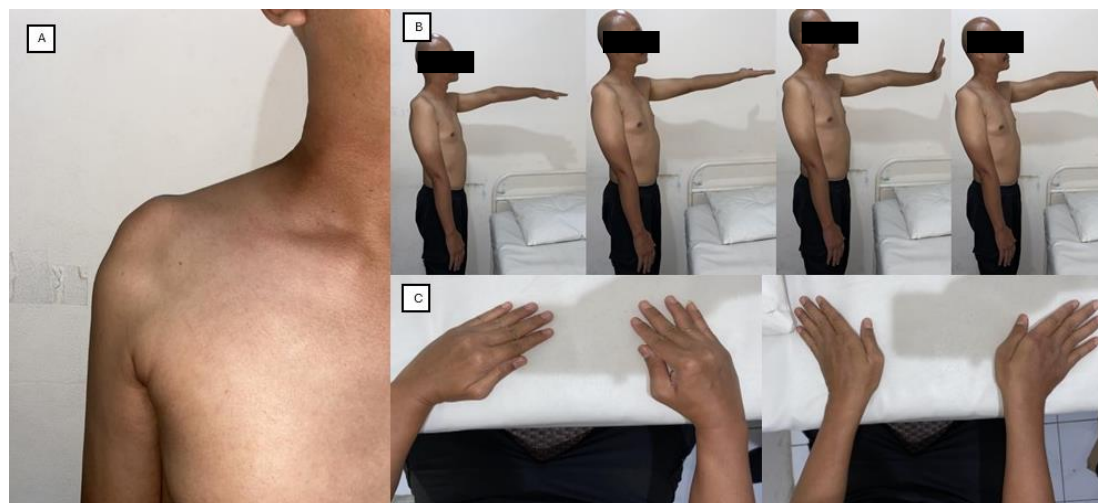


Figure 1. (A) Physical examination of the right shoulder, (B) Atrophy and motor function loss of pectoralis minor, pectoralis major, latissimus dorsi, deltoid, and biceps muscle, (C) Motor function loss of wrist eversion and inversion.

Surgical Approach

Mackinnon Procedure

The patient was positioned prone and a posterior approach incision. Exploration of the accessory nerve (N. Accessorius) at the medial border of the scapula and the suprascapular nerve (N. Suprascapularis) at the suprascapular notch was performed. Nerve stimulation revealed good activity in the spinal accessory nerve (N. Spinal Accessorius) and no activity in the suprascapular nerve (N. Suprascapula). A nerve transfer was conducted from the spinal accessory nerve to the suprascapular nerve using the end-to-end method with 8-0 Prolene sutures. Hemostasis was achieved and the incision was closed.

Double Oberlin Procedure

Next, the patient was positioned supine, and a medial approach incision was made on the right arm. Exploration and identification of

the musculocutaneous nerve (N. Musculocutaneous), median nerve (N. Medianus), ulnar nerve (N. Ulnaris), and brachial artery were performed. Neurostimulation was employed to ascertain the precise activity of each individual nerve. The median and ulnar nerves had robust activity, whereas the musculocutaneous nerve displayed no activity in either the biceps or brachialis branches. A partial division was made between the median and ulnar nerves, resulting in the transfer of the most robust fascicle of the median nerve to the biceps branch of the musculocutaneous nerve, and a fascicle of the ulnar nerve to the brachialis branch of the musculocutaneous nerve. The suturing was performed using the conventional end-to-end technique using 8-0 Prolene. Successful hemostasis was attained and the incision was thus sealed.

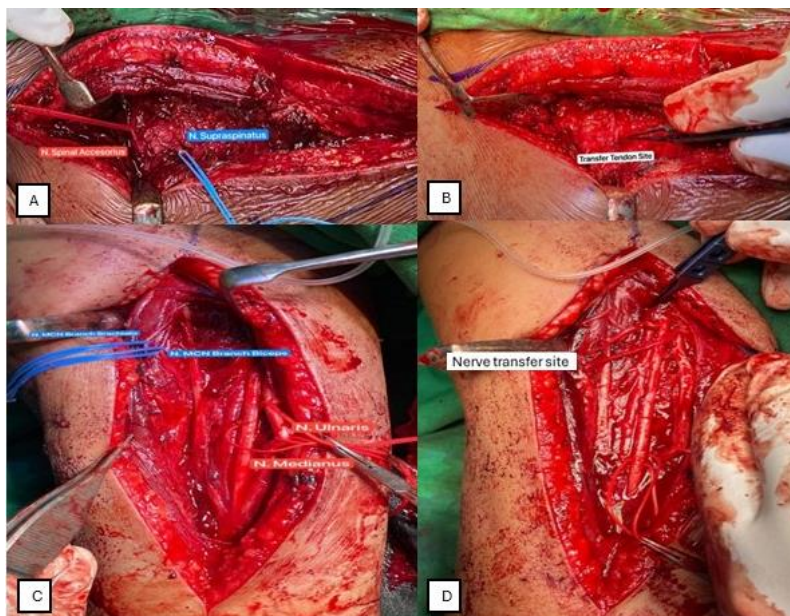


Figure 2. Step by step of Oberlin and Mackinnon procedures which show the process of transferring fasciculus ulnar nerve to the brachialis branch of musculocutaneous nerve and accessory spinal nerve to the suprascapular nerve.

Post-Operative and Rehabilitation

Postoperatively, the patient was enrolled in an aggressive rehabilitation program focusing on strengthening exercises, range of motion activities, and sensory re-education. Over the course of the rehabilitation, the patient demonstrated marked improvement in elbow flexion (MRC grade 3) and wrist extension (MRC grade 5). Hand grip strength also improved

(MRC grade 3), and the patient reported subjective improvement in sensation across the affected limb. By nine months post-surgery, the patient was able to return to work and resume most of his daily activities, with only mild residual weakness and sensory deficits. Nowadays, this patient still underwent rehabilitation program in our hospital.



Figure 3. Follow up clinical condition after 19 months after post operative treatment

DISCUSSION

This case report highlights the successful application of nerve transfer using the Double Oberlin and Mackinnon techniques in a 45-year-old male patient with total post-ganglionic brachial plexus injury (BPI). The patient initially presented with significant motor and sensory deficits following a motorcycle accident, characterized by near-complete paralysis of the right upper limb. Given the severity of his injuries, nerve transfer procedures were deemed the most viable option for functional recovery.^{1,3,4}

The Mackinnon technique involves transferring a functioning nerve to a non-functioning target nerve. Based on the literature, this procedure was crucial for re-innervating the supraspinatus and infraspinatus muscles, which play essential roles in shoulder abduction and stabilization.^{6,8} The choice of the spinal accessory nerve, known for its robust axonal count and proximity to the suprascapular nerve, facilitated a successful transfer.^{9,10,11} Research indicates that the Mackinnon technique is a safe and effective approach for treating acute C5-8 injuries and partial T1 acute BPIs, particularly when combined with thorough preoperative assessment, prompt intervention, precise intraoperative selection of functional fascicles, and intensive postoperative rehabilitation. In our patient's case, the spinal accessory nerve, which retained good activity, was transferred to the suprascapular nerve using an end-to-end method procedure led to improved wrist and finger movements and reduced muscle atrophy.⁴

The aim of the Double Oberlin operation was to restore elbow flexion by transplanting fascicles from the median and ulnar nerves to the musculocutaneous nerve. Utilising two donor nerves was chosen to maximise the re-innervation of both the biceps and brachialis muscles, hence improving elbow flexion strength.^{4,6} By splitting the median and ulnar nerves and identifying the strongest fascicles, the surgical team maximized the potential for

functional recovery. The double nerve transfer technique thus offers a higher success rate for restoring elbow flexion without compromising donor nerve function in the hand. Research has shown that patients often experience excellent functional and clinical results, with 94-100% achieving at least M3 biceps strength and 75-94% reaching M4 strength. In our patient's case, significant improvement in elbow flexion was observed at three and six months after surgery, with the patient attaining M3 strength by the final follow-up.^{5,7}

Postoperative rehabilitation played a pivotal role in the patient's recovery. An aggressive rehabilitation program focusing on strengthening exercises, range of motion activities, and sensory re-education facilitated significant improvements.^{11,12} Our rehabilitation program emphasized range of motion exercises, strength training, and functional task training to aid the patient in regaining fine motor skills in the affected limb. This case showed at nine months post-surgery, the patient achieved notable recovery milestones include elbow flexion improved to MRC grade 3, wrist extension maintained at MRC grade 5, and hand grip strength also reached MRC grade 3. Additionally, the patient reported subjective improvements in sensation, highlighting the importance of a comprehensive rehabilitation approach. The patient's ability to return to work and resume daily activities, despite mild residual weakness and sensory deficits, underscores the efficacy of the combined surgical and rehabilitative interventions.^{1,11,12}

The outcomes of this case are consistent with previous studies demonstrating the efficacy of nerve transfer techniques in BPI. The Mackinnon and Double Oberlin procedures have been documented to yield significant functional recovery in patients with severe brachial plexus injuries. The patient's positive outcome in this case adds to the growing body of evidence supporting these techniques as viable options for

restoring function in cases of total post-ganglionic BPI.^{4,6,12}

However, it is important to note that individual outcomes can vary based on factors such as the timing of surgery, extent of nerve damage, and patient adherence to rehabilitation protocols. Early intervention, as seen in this case, likely contributed to the favorable outcome. Additionally, the patient's consistent participation in rehabilitation was crucial for maximizing functional recovery.

CONCLUSION

This case report demonstrates the favorable use of the Double Oberlin and Mackinnon nerve transfer techniques in a patient with total post-ganglionic BPI. The significant functional improvements observed underscore the potential of these surgical interventions when combined with an intensive rehabilitation program. Continued follow-up and long-term rehabilitation remain essential for maintaining and further enhancing the patient's functional outcomes. This case reinforces the importance of a multidisciplinary approach in managing complex peripheral nerve injuries, highlighting the critical roles of both surgical innovation and comprehensive postoperative care.

Declaration by Authors

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