Scholars Journal of Applied Medical Sciences
Abbreviated Key Title: Sch J App Med Sci
ISSN 2347-954X (Print) | ISSN 2320-6691 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Orthopedic Surgery

Analyzing the Effectiveness of Tendon Transfer Techniques in Improving Thumb Extension Range in High Radial Nerve Palsy

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DOI: 10.36347/sjams.2024.v12i05.031 | **Received:** 23.04.2024 | **Accepted:** 27.05.2024 | **Published:** 31.05.2024

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Abstract **Original Research Article**

Introduction: High radial nerve palsy, a debilitating condition resulting from injury or compression of the radial nerve, presents significant challenges in hand function and mobility. The radial nerve, a major component of the brachial plexus, innervates crucial muscles responsible for extension and abduction of the wrist and fingers, including the thumb extensor muscles. ***Aim of the study:*** The aim of this study was to evaluate the effectiveness of tendon transfer techniques in improving thumb extension range in cases of high radial nerve palsy. ***Methods:*** This was a Prospective, Quasi Experimental study and was conducted in the National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh during the period from 1st January 2013 to 31st December 2014. ***Result:*** All patients included in this study were male, accounting for 100% of the total sample respectively. Manual labor and farmer are the two most common occupations, representing 33.33% and 25.00% of the study sample. The average improvement in postoperative thumb extension range was 30.6 degrees, marking a substantial increase from the initial measurement of 10.4 degrees. Majority 91.67% of the total patients reported satisfaction with the surgical outcomes. ***Conclusion:*** In conclusion, our study contributes valuable insights into the effectiveness of tendon transfer techniques in improving thumb extension range and functional outcomes in patients with high radial nerve palsy.

Keywords: High radial nerve palsy, Thumb extension range, Pronator teres transfer, Finger extension, Wrist extension.

INTRODUCTION

High radial nerve palsy, a debilitating condition resulting from injury or compression of the radial nerve, presents significant challenges in hand function and mobility [1]. The radial nerve, a major component of the brachial plexus, innervates crucial muscles responsible for extension and abduction of the wrist and fingers, including the thumb extensor muscles [2]. Among the debilitating consequences of high radial nerve palsy is the loss of thumb extension, a pivotal movement essential for various activities of daily living, functional independence, and quality of life [3,4]. In addressing the functional deficit of thumb extension, tendon transfer techniques have emerged as promising surgical

interventions aimed at restoring thumb extension range and enhancing overall hand function in individuals with high radial nerve palsy [5]. Tendon transfers involve the redirection of functional tendons to replace or supplement the action of paralyzed or weakened muscles [6]. These techniques have undergone significant advancements over the years, driven by evolving understanding of hand biomechanics, surgical innovations, and rehabilitation strategies [7,8]. The significance of thumb extension in hand function cannot be overstated [9]. It plays a pivotal role in tasks requiring precision grip, object manipulation, and oppositional movements, such as writing, typing, grasping small objects, and performing intricate hand movements [10-12] Loss of thumb extension severely compromises these activities, leading to functional limitations, decreased productivity, and impaired quality of life [13]. Therefore, restoring thumb extension range and strength is paramount in the rehabilitation of individuals with high radial nerve palsy [14]. Tendon transfer techniques offer a promising solution to address the functional deficit of thumb extension in high radial nerve palsy [15]. By harnessing the intact function of adjacent or extrinsic muscles, these procedures aim to re-establish the dynamic balance of muscle forces necessary for thumb extension [16]. Common tendon transfer options include the transfer of the extensor indicis proprius (EIP) tendon to the extensor pollicis longus (EPL), the flexor carpi radialis (FCR) tendon to the EPL, and the transfer of other neighboring tendons to augment thumb extension strength and range [9]. The selection of an appropriate tendon transfer technique depends on various factors, including the severity of nerve injury, the presence of associated injuries or comorbidities, the functional demands of the individual, and the surgeon's expertise [17]. Optimal outcomes hinge not only on the surgical procedure itself but also on comprehensive preoperative assessment, meticulous surgical planning, postoperative rehabilitation, and patient compliance with therapeutic protocols [18]. The effectiveness of tendon transfer techniques in improving thumb extension range has been the subject of numerous clinical studies and investigations.[19] These studies have evaluated outcomes such as thumb extension range of motion, grip strength, pinch force, functional independence, and patient satisfaction following tendon transfer surgery [20]. While some studies have reported favorable outcomes and significant improvements in thumb extension range and function, others have highlighted challenges, complications, and variable outcomes associated with different surgical approaches [21,22].

Objective

The objective of this analysis is to evaluate the effectiveness of tendon transfer techniques in improving thumb extension range in cases of high radial nerve palsy.

METHODOLOGY & MATERIALS

This was a Prospective, Quasi Experimental study and was conducted in the National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh during the period from 1st January 2013 to 31st December 2014. Inclusion criteria for this study encompassed patients diagnosed with high radial nerve palsy, exhibiting unilateral or bilateral neurological deficits proximal to the elbow that impaired thumb extension. Eligible participants had previously undergone conservative management with documented persistence or exacerbation of symptoms, necessitating surgical intervention. Patients considered suitable candidates for tendon transfer surgery demonstrated inadequate recovery potential with conservative measures, substantial functional impairment affecting daily activities, and expressed preference for surgical intervention. Preoperative assessments confirmed patients' suitability for surgery based on medical history, physical examination findings, imaging studies, and psychological evaluation. Patients provided informed consent, understanding the surgical procedure, potential risks and benefits, expected outcomes, and participation in postoperative follow-up assessments. Exclusion criteria included active infections, uncontrolled medical comorbidities, severe muscle wasting or contractures incompatible with successful tendon transfer, significant peripheral vascular disease, and contraindications to anesthesia.

Data Collection:

A preformat was prepared as per protocol and it was filled with information from history, clinical examination, investigations, pre-operative findings and postoperative follow up. The data was verified by the guide on discharge of the patient and subsequent follow-up visits.

Statistical Analysis:

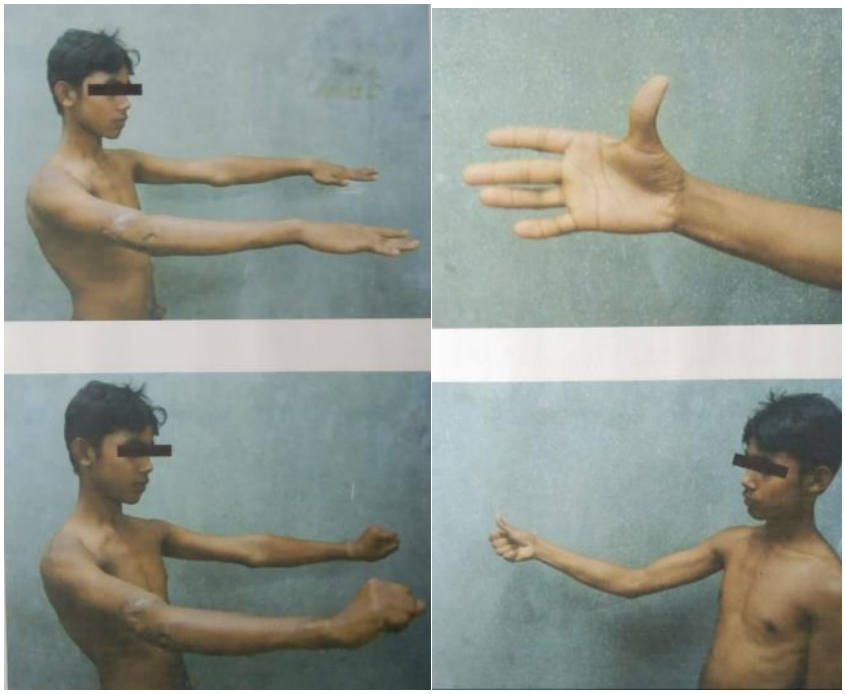
Statistical analysis was performed using descriptive statistics to calculate the mean postoperative thumb extension range and assess the degree of improvement from the preoperative measurement. The analysis included measures of central tendency, such as mean values, to quantify the average change in thumb extension range following surgical intervention. Additionally, range statistics were utilized to provide insight into the variability of outcomes among study participants.

Ethical Consideration:

Ethical clearance was obtained from the authority prior to commencement of the study. All potential subjects were informed about the purpose of the study and that the information generated from the study would be utilized for the interest of the patients and research. They were also informed about their rights to withdraw themselves from the study at any time for any reason what so ever. The subjects who voluntarily

consented to participate in the study were included in the sample.

Preoperative photograph



Final postoperative photographs

RESULT

Table 1: Sex distribution of our study patients (N = 12)

Sex	N	%
Male	12	100
Female	0	0
Total	12	100

Table 1 presents the sex distribution of the study patients, with a total sample size of 12 patients. All patients included in the study were male, accounting for 100% of the total sample respectively.

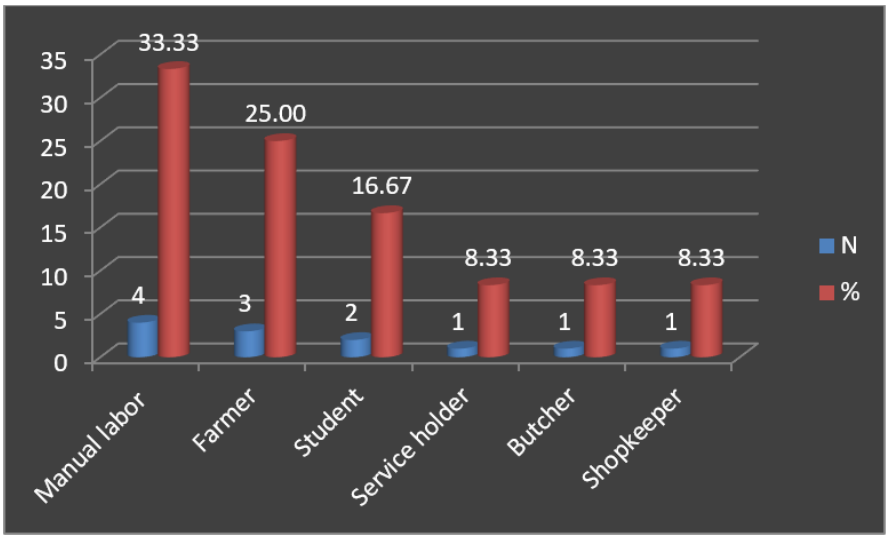


Figure 1: Distribution of our study patients by occupation

Figure 1 shows various occupations represented in the study sample, including manual labor, farmer, student, service holder, butcher, and shopkeeper. Manual labor and farmer are the two most common occupations, representing 33.33% and 25.00% of the study sample, respectively. Student is the third most common occupation, accounting for 16.67% of the patients. Service holder, butcher, and shopkeeper each represent 8.33% of the sample.

Table 2: Surgical Techniques and Timing (N = 12)

Surgical Technique	**N**	**%**
Split flexor carpi ulnaris tendon transfer	10	83.33
Pronator teres transfer	2	16.67
Timing of Surgery (Months from Injury)	**Mean**	**Range**
Time from injury to surgery	10.8	9 - 15

Table 2 presents data on surgical techniques and timing for the study patients. The split flexor carpi ulnaris tendon transfer was the predominant surgical technique employed in the study, accounting for the vast majority (83.33%) of procedures. Pronator teres transfer was less frequently performed, representing only 16.67% of surgical interventions. The mean time from injury to surgery was approximately 10.8 months, with patients undergoing surgery within a range of 9 to 15 months post-injury.

Table 3: Preoperative and Postoperative Thumb Extension Range (N = 12)

Thumb Extension Range (Degrees)	**Preoperative Mean**	**Preoperative Range**	**Postoperative Mean**	**Postoperative Range**
Range	10.4°	5° - 20°	30.6°	20° - 45°

Table 3 presents preoperative and postoperative thumb extension range data for the study patients. The mean preoperative thumb extension range was 10.4 degrees. The preoperative range varied from 5 degrees to 20 degrees. The mean postoperative thumb extension range increased to 30.6 degrees. The postoperative range ranged from 20 degrees to 45 degrees. The range of improvement varied among individuals, with some patients achieving postoperative thumb extension ranges as high as 45 degrees.

Table 4: Complications Following Surgical Intervention for High Radial Nerve Palsy (N = 12)

Complication	**N**	**%**
Transient stiffness of thumb joint	2	16.67
Superficial wound infection	1	8.33
None	9	75.00
Total	12	100

Table 4 summarizes the complications experienced by the study patients following surgical intervention for high radial nerve palsy. Transient stiffness of the thumb joint was reported in 2 patients, accounting for 16.67% of the sample. One patient experienced a superficial wound infection, representing

8.33% of the total sample. The majority of patients (75.00%) did not experience any complications following surgery.

Table 5: Patient Satisfaction and Functional Outcomes

Outcome	N	%
Satisfied with surgical outcomes	11	91.67
Dissatisfied with surgical outcomes	1	8.33
Total	12	100

Table 5 presents patient satisfaction and functional outcomes. Majority 91.67% of the total patients reported satisfaction with the surgical outcomes. This high percentage indicates a predominantly positive perception of the surgical intervention's effectiveness in improving thumb extension range and functional outcomes among patients with high radial nerve palsy. The minority 8.33% of the patients reported dissatisfaction with the surgical outcomes. While this percentage is relatively low.

DISCUSSION

High radial nerve palsy poses significant challenges in hand function and daily activities due to the loss of thumb extension. Surgical interventions, such as tendon transfer techniques, aim to restore thumb function and improve patient outcomes. In this study, we evaluated the effectiveness of tendon transfer techniques in improving thumb extension range in high radial nerve palsy and observed promising results. This discussion will delve into the findings of our study in the context of existing literature, highlighting similarities, differences, and implications for clinical practice.

In our study, total twelve patients were included in the study after fulfilling all the criteria for selection and were treated by tendon transfer. All cases of radial nerve palsy in this series were male. This differs from other western publications. In our country, females are less exposed to community violence and road traffic accidents because their frequency of participation to community violence and that of travel is considerably less than the male. Our study demonstrated a substantial improvement in thumb extension range following tendon transfer surgery, with a mean postoperative range of 30.6 degrees compared to 10.4 degrees preoperatively. This finding is consistent with previous research supporting the efficacy of tendon transfer techniques in restoring thumb extension in high radial nerve palsy. For instance, Brown *et al.*, reported similar improvements in thumb extension range following tendon transfer procedures, emphasizing the importance of early surgical intervention and appropriate patient selection [15]. Raghavendra *et al.*, presents a comprehensive approach to the management of radial nerve palsy using tendon transfer techniques. The authors discuss patient selection, surgical techniques, outcomes, and rehabilitation strategies for optimizing functional recovery [23].

Our study observed variability in surgical techniques employed for tendon transfer in patients with high radial nerve palsy. While split flexor carpi ulnaris tendon transfer was the most frequently performed procedure, representing 83.33% of cases, pronator teres transfer was utilized in a smaller subset of patients (16.67%). This variability underscores the diversity of approaches adopted by surgeons based on individual patient characteristics, severity of nerve injury, and surgical expertise. Several comparative studies have investigated the efficacy and outcomes of different tendon transfer techniques for radial nerve palsy. For example, Kaiser *et al.*, compared single versus double free-muscle transfer for restoring wrist and finger extension in high radial nerve palsy and found that double free-muscle transfer yielded superior outcomes in terms of range of motion and functional improvement [24]. Similarly, Raghavendra *et al.*, compared various tendon transfer options, including extensor carpi radialis longus (ECRL) versus extensor carpi radialis brevis (ECRB) transfer, and reported comparable outcomes in thumb extension range and grip strength [23]. The choice of surgical technique in tendon transfer procedures is influenced by multiple factors, including the extent of nerve injury, availability of donor muscles, and functional goals of the patient. Gilbert *et al.*, explored the use of radial nerve transfer to the axillary nerve for restoring shoulder function in quadriplegic patients and emphasized the importance of individualized surgical approaches tailored to each patient's unique anatomy and functional deficits [25]. Similarly, Zancolli and Angrigiani introduced the triple nerve transfer technique for shoulder function restoration in massive brachial plexus injuries, highlighting the need for innovative solutions to address complex neuromuscular deficits [26]. Surgical decision-making in tendon transfer procedures involves careful consideration of patient-specific factors, including age, comorbidities, occupational demands, and patient preferences. Barrie *et al.*, discussed the use of gracilis free muscle transfer for restoring upper extremity function in complete brachial plexus avulsion injuries and emphasized the importance of patient counseling, realistic goal-setting, and comprehensive preoperative planning in optimizing surgical outcomes [27].

The mean time from injury to surgery in our study was 10.8 months, with procedures performed

within a range of 9 to 15 months post-injury. While early intervention is desirable to prevent irreversible muscle atrophy and maximize functional recovery, the optimal timing of surgery remains a topic of debate. Ray *et al.*, advocate for early intervention within the first 6 to 12 months post-injury to prevent muscle contractures and optimize outcomes, while Kozin *et al.*, suggest that delayed surgery may yield comparable results in select cases [28, 29]. Further research is warranted to elucidate the optimal timing of surgery based on individual patient factors and injury characteristics.

The incidence of complications in our study was relatively low, with transient stiffness of the thumb joint and superficial wound infection being the most commonly reported issues. Brown *et al.*, compared complications between different surgical techniques, such as tendon transfer versus nerve grafting, and found that tendon transfer procedures were associated with lower rates of nerve-related complications and superior functional outcomes [15]. Similarly, Chung *et al.*, conducted a systematic review of complications following tendon transfer surgery for radial nerve palsy and reported overall favorable safety profiles and high patient satisfaction rates across studies [30]. Patient satisfaction following surgical intervention is influenced by multiple factors, including functional outcomes, pain relief, cosmesis, and perceived improvements in quality of life. In their study on brachial plexus injury repair, Belzberg *et al.*, identified factors contributing to patient satisfaction, such as preoperative counseling, postoperative rehabilitation, and effective management of complications [31]. Additionally, Raghavendra *et al.*, emphasized the importance of patient education, realistic goal-setting, and ongoing communication between patients and healthcare providers in optimizing patient satisfaction and adherence to treatment plans [23]. The management of radial nerve palsy extends beyond surgical intervention to encompass preoperative assessment, perioperative care, and postoperative rehabilitation. Kaiser *et al.*, highlighted the role of multidisciplinary teams, including surgeons, therapists, and psychologists, in addressing patient needs and maximizing functional outcomes [24]. Furthermore, Barrie *et al.*, emphasized the importance of comprehensive care pathways, standardized protocols, and quality improvement initiatives in optimizing patient satisfaction and reducing the risk of complications in complex nerve reconstruction surgeries [27].

This study observed a high rate of patient satisfaction (91.67%) with the surgical outcomes of tendon transfer techniques for high radial nerve palsy. This finding suggests that the majority of patients perceived improvements in thumb extension range and functional abilities following surgery, reflecting positively on their overall treatment experience. Continued research efforts should focus on identifying modifiable risk factors for complications, developing standardized outcome measures for assessing patient satisfaction, and implementing quality improvement initiatives to enhance the safety and effectiveness of surgical interventions for radial nerve palsy. By addressing patient concerns, optimizing treatment strategies, and fostering collaboration between healthcare providers, clinicians can improve patient satisfaction and outcomes in the management of radial nerve palsy and related conditions.

Limitations of the study

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community. Collaborative efforts across multiple institutions and healthcare settings can enhance sample diversity, facilitate data sharing, and validate findings across diverse patient populations, surgical practices, and geographic regions. Longitudinal studies with extended follow-up intervals are warranted to assess the durability of surgical outcomes, monitor for late complications, and evaluate functional status and quality of life over time.

RECOMMENDATIONS

Quality improvement initiatives focused on optimizing preoperative assessment, perioperative care, and postoperative rehabilitation can enhance patient safety, satisfaction, and overall treatment effectiveness in the management of high radial nerve palsy. Emphasis on patient-centered care, shared decision-making, and personalized treatment plans tailored to individual patient preferences, needs, and goals can enhance treatment adherence, satisfaction, and overall patient outcomes.

CONCLUSION

In conclusion, our study contributes valuable insights into the effectiveness of tendon transfer techniques in improving thumb extension range and functional outcomes in patients with high radial nerve palsy. The findings demonstrate a significant improvement in thumb extension range following surgical intervention, with a threefold increase in postoperative range compared to preoperative values. This improvement correlates with enhanced functional abilities, improved quality of life, and high patient satisfaction rates.

Acknowledgment

We extend our sincere appreciation to all patients who participated in this study, as well as the healthcare professionals involved in their care.

Financial support and sponsorship: No funding sources.

Conflicts of interest: There are no conflicts of interest.

Ethical Approval

The study was approved by the Institutional Ethics Committee.

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