Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 26s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Comparative Study between Topographic and Anatomical Motor Branch Localization of the Ulnar Nerve during Supercharged Ulnar Nerve Repair by Anterior Interosseous Nerve Transfer

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Cite this paper as: Yasser Ahmed Abdalraheem, Wael Mohamed Nazim; Mostafa Mahmoud Samy Ahmed, Mostafa Mahmoud Ahmed Hassanein, Mohamed Ahmed Hewedy, (2025) Comparative Study between Topographic and Anatomical Motor Branch Localization of the Ulnar Nerve during Supercharged Ulnar Nerve Repair by Anterior Interosseous Nerve Transfer. *Journal of Neonatal Surgery*, 14 (26s), 551-557.

ABSTRACT

Background: The research aims to determine if anatomical localization is more effective than topographic localization in supercharged nerve repair for claw hand deformity correction & intrinsic muscle power recovery.

Methods: We performed comparative randomized prospective research on 26 cases with ulnar nerve injury who presented to Beni-Suef University Hospitals and Cairo University Hospitals in the period from March 2021 to March 2024. Thirteen patients were managed with ulnar nerve repair+ supercharged end-to-side nerve transfer (UR+SETS), where a motor branch of the nerve is anatomically localized, and 13 cases have been treated by UR+SETS, where a motor branch of the ulnar nerve has topographically been localized.

Results: The age group of topographic localization consisted of 33.23± 10.07 years, with the majority of the participants being male (76.9%). Additionally, the anatomical localization group's mean age was 37.92± 7.66 years, with the majority of the participants being male (69.2%). The two groups did not exhibit any statistically significant variances in terms of gender or age (p above 0.05). We observed very good to excellent outcomes in both groups according to the recovery of reduction of deformity & intrinsic muscle function, as evidenced by the earlier enhancement in the score of Raji &Birch & Brand's principles.

Conclusion: A study found no significant variance in motor & functional outcomes among the 2 groups regarding the localization of the ulnar nerve motor branch, suggesting that prioritizing this location is crucial for restoring nerve function in severe cases.

Keywords: *supercharge end-to-side, Ulnar nerve, Anterior Interosseous Nerve transfer*

1. INTRODUCTION

The injury of the Ulnar nerve outcomes in severe pinch & weak grip strength with claw hand. Despite microsurgical advances in microsurgical techniques for treating proximal ulnar nerve injury through graft or direct repair, the restoration of motor functions remains poor, even with early surgery (1,2). Nerve transfer from the terminal branch of the anterior interosseous nerve to the deep motor branch of the ulnar nerve has been proposed as an alternative due to the inadequate outcomes of direct UR nerve (3). This procedure the 1st that has been conducted in 1997 by Wang and Zhu (4) in an end-to-end fashion, leading to the innervation of the aim muscles solely by the transferred nerve rather than the ulnar nerve itself. These factors led to unfinished functional recovery (5). Consequently, it is advisable to develop a supercharged repair technique that

involves an end-to-end co-optation. This approach enables the rapid establishment of axon end plate connections by the donor nerve sprouting through an epineurial window of the injured recipient nerve. Furthermore, this approach ensures that the target organs receive double innervation from both the donor & the original nerves, as demonstrated by the findings from animal models (6,7). It was initially introduced in clinical practice by Barbour et al. (8). Following the remarkable outcomes of UR+SETS regarding motor & functional improvement in proximal ulnar nerve pathology, we managed preliminary research to compare the two ways of localization of the motor branch of the ulnar nerve. In addition, we aimed to determine whether there are any variances in the functional result findings regarding the claw hand deformity correction & ulnar intrinsic muscle power recovery.

2. METHODS

This prospective comparative randomized study was conducted on 26 patients at the Neurosurgery Department, Faculty of Medicine, Beni-Suef University hospitals, & Cairo University hospitals in the period from March 2021 to March 2024.

The patients underwent UR+SETS transfer to the motor part of the ulnar nerve. The cases were then randomly determined to one of two groups based on the method of motor branch identification.

Group (A): Topographic Localization (thirteen patients)

Group (B): Anatomical Localization (thirteen patients)

Inclusion criteria:

1. **Type of injury:** post-traumatic injury or entrapment neuropathy
2. **Site of injury:** at or above the elbow level or 10 cm below the medial epicondyle.
3. **Age:** any age.
4. **Sex:** both males and females.
5. **Time:** within 6 months of injury

Exclusion criteria:

1. Any distal forearm injury.
2. Any patient with injury, either inflammatory or tumor-caused palsy or idiopathic.
3. Brachial plexus affection
4. Delayed presentation more than six months after injury.
5. Any other concomitant distal injury in the wrist or fractures.

Preoperative evaluation

The patients had preoperative clinical documentation of ulnar nerve affection verified by muscle wasting, paralysis, clawing deformity, & +ve Froment sign.

Surgical technique

The cases have been detected in a supine position. The arm has been prolonged using a sideboard, & a tourniquet was subsequently applied. In cases of traumatic ulnar nerve injury or entrapment, a tension-free repair was carried out utilizing monofilament, 8-0 synthetic, nylon or nonabsorbable polypropylene sutures under microscope magnification.

In the anatomical localization class, an incision has been performed overlying the hypothenar eminence with a Bruner extension across the wrist. The deep motor branch has been localized, and the ulnar nerve has been decompressed in the Guyon canal. Subsequently, intraneural dissection has been conducted to divide the ulnar nerve into motor & sensory fascicles as much as eight to ten centimeters from the wrist crease. Subsequently, the PQ muscle was subsequently recognized by radially retracting the long flexor tendons. The AIN has been recognized upon entering the PQ muscle & subsequently dissected within the muscle. It has been separated just proximal to its 1st branch. The SETS repair procedure has been made possible by opening the perineurium of the motor fascicular group of the ulnar nerve. The AIN was repositioned to the perineural window within the ulnar motor fascicles & coapted in an end-to-side manner, six to eight centimeters proximal to the wrist crease. Finally, a tension-free repair has been conducted under magnification and using 8-0 or 9-0 synthetic or nylon, nonabsorbable polypropylene, monofilament sutures. An above-elbow slab has been applied for three weeks. following immobilization has been discontinued, all cases contributed to functional rehabilitation sessions.

In the topographic localization group, the skin incision was ten centimeters over the wrist crease & extended distally until the distal border of the pronator quadratus muscle. FCU has been reflected medially to recognize the ulnar nerve & artery. Subsequently, we searched for the dorsal cutaneous branch of the ulnar nerve, which is located almost ten centimeters above the wrist crease. The topography of the nerve becomes motor fascicles medial & sensory fascicles lateral following the

branching of the dorsal cutaneous branch from the ulnar nerve. The cleavage involving these fascicles has been identified using a microscope. We started to identify the AIN in Group A after retrieving the motor branch using a vessel loop. Subsequently, we performed an ETS anastomosis.

Cases' monitoring was conducted at three, six, nine, and twelve months, along with clinical examination of intrinsic muscles and functional response. We used for assessing the strength of the hand muscles the standard Medical Research Council (MRC) grading:

Grade 0: No range of motion & no felt muscle contraction.

Grade 1: No active range & palpable muscle contraction

Grade 2: Decreased active range & no muscle resistance.

Grade 3: complete active range & no muscle resistance.

Grade 4: complete motion active range & reduced muscle resistance.

Grade 5: complete motion active range & normal muscle resistance.

The classification of grades is as follows: Grade 2 or less is considered a bad result, Grade 3 is considered a good result, Grade 4 indicates a very good result, in addition Grade 5 is considered excellent.

The assessment of ulnar function was conducted using Birch's grading for ulnar recovery.

Evaluation of hand strength was done using a dynamometer. Pinch strength was evaluated based on the grading of the adductor pollicis muscle. Evaluation of clawing was done based on clinical observation and patient satisfaction. The forearm pronation was evaluated to assess the donor site's morbidity. Follow-up photography and videography were done in all cases.

3. RESULTS

This study was conducted on 26 cases of ulnar affection presented to the neurosurgery departments at Beni-Suef University Hospitals and Cairo University Hospitals. The interval between pathology and surgery was 3.25±1.48 months, with a minimum of 2 months & a maximum of 6 months. The final analysis included 13 patients per group, as illustrated in the flow chart. No patients were excluded during the follow-up period.

The patients had UR+SETS transferred to the motor branch. Subsequently, the cases were randomized into two groups depending on the method of identifying the motor branch of the ulnar nerve.

Group (A) (N=13): Topographic localization was used

Group (B) (N=13): Anatomical localization was used

Table 2 shows that the topographic localization group had an average age of 33.23± 10.07 years. The majority (76.9%) of the group were males, and three cases were smokers. The anatomical localization group had a mean age of 37.92± 7.66 years. The majority of participants (69.2%) were male, and four cases were smokers. In the topographic localization group, 76.9% of cases reported entrapment neuropathy, 23.1% of them had a history of trauma, 76.9% were right hanged, and the affected hand was in 62.5% of cases. In the anatomical localization group, 69.2% of cases reported entrapment neuropathy, 30.8% had a history of trauma, 84.6% were right hanged, and the affected hand was present in 69.2% of cases.

The level of injury/entrapment is compared between the two studied groups in Table 3. The level elbow was the site of injury or entrapment in most cases in the topographic localization group (76.9%) and anatomical localization group (69.2%).

With regard to postoperative complications, none of the cases in the topographic and anatomical localization groups had donor site injury, wound infection, or weakness of muscles supplied by AIN (Table 4).

Sensory improvement was observed in approximately 77% of cases in group (A) as assessed by the SW Tool, whereas only 53% of cases in group (B) demonstrated sensory improvement.

Table 5 depicts a comparison of the motor skills of the 2 examined groups at various monitoring intervals. At VI months, lX months, and 12 months, a statistically insignificant variance has been observed among the topographic & anatomical localization groups in terms of motor improvement (p above 0.05). Furthermore, the topographic localization group (p below 0.001) and anatomical localization group (p below 0.001) demonstrated more significant improvement at 12 months than at 9 months and 6 months (p below 0.001).

Functional outcome:

Both groups showed significant improvement in hand deformity correction, lateral pinch grip improvement, and grip improvement.

Table 1: Birch's grading

Grade	Motor	Equivalent to Seddon's grading
Excellent	Power MRC5 No wasting or deformity, trophic changes	Good M5
Good	Power MRC4 to MRC5 Abolition of paralytic deformity, Minimal pulp wasting	Good M5
Fair	MRC3 or more Some sweating Pulp wasting	Fair M3
Bad	MRC3 or less No sweating Trophic changes	Bad M0, 1 or 2

Table 2: Comparative analysis between the 2 examined groups according to baseline characteristics

		Group (A) Topographic localization group (N= 13)		**Group (B) Anatomical localization group (N= 13)**		**Test value**	**P-value**
		N	**%**	**N**	**%**		
Gender	**Male**	10	76.9%	9	69.2%	X^2= 0.195	>0.99 FET
	Female	3	23.1%	4	30.8%		
Age (years)	**Mean± SD**	33.23± 10.07		37.92± 7.66		T= 1.288	0.210
	Range	11.0 - 48.0		26.0 - 55.0			
Smoking	**No**	10	76.9%	9	69.2%	X^2= 0.195	>0.99 FET
	Yes	3	23.1%	4	30.8%		
Occupation	**Client**	0	0.0%	2	15.4%	X^2= 7.200	0.408
	Driver	2	15.4%	2	15.4%		
	Engineer	1	7.7%	0	0.0%		
	Farmer	2	15.4%	3	23.1%		
	Housewife	3	23.1%	3	23.1%		
	Manual Worker	0	0.0%	1	7.7%		
	Student	3	23.1%	0	0.0%		
	Teacher	2	15.4%	2	15.4%		

T: Student T-test, SD: standard deviation, X^2: Chi-Square test, FET: Fischer Exact Test

Table 3: Level of injury/entrapment among the examined groups

		Group (A) Topographic localization group (N= 13)		Group (B) Anatomical localization group (N= 13)		Test value	P-value
		N	%	N	%		
Level of injury/entrapment	**Above elbow**	0	0.0%	3	23.1%	X^2= 4.053	0.132
	Below elbow	3	23.1%	1	7.7%		
	Elbow	10	76.9%	9	69.2%		

Table 4: Postoperative complications among the examined groups

		Group (A) Topographic localization group (Num.= 13)		Group (B) Anatomical localization group (Num.= 13)		Test value	P-value
		N	%	N	%		
donor site injury	**Negative**	13	100.0%	13	100.0%	-	-
	Positive	0	0.0%	0	0.0%		
wound infection	**Negative**	13	100.0%	13	100.0%	-	-
	Positive	0	0.0%	0	0.0%		
Weakness of muscles supplied by AIN	**Negative**	13	100.0%	13	100.0%	-	-
	Positive	0	0.0%	0	0.0%	-	-

Table 5: Motor power among the studied groups

Motor		Group (A) Topographic localization group (N= 13)		Group (B) Anatomical localization group (N= 13)		Test value	P-value
		N	%	N	%		
At 6 months	**Bad**	3	23.1%	4	30.8%	X^2= 0.195	0.658
	Fair	10	76.9%	9	69.2%		
At 9 months	**Bad**	1	7.7%	0	0.0%	X^2= 2.25	0.325
	Fair	3	23.1%	6	46.2%		
	Good	9	69.2%	7	53.8%		
12 months	**Bad**	1	7.7%	0	0.0%	X^2= 4.00	0.261
	Fair	2	15.4%	0	0.0%		
	Good	3	23.1%	6	46.2%		

	Excellent	7	53.8%	7	53.8%
Test value		21.81		24.53	
P-value		<0.001*		<0.001*	

**: statistically non-significant at p>0.01*

4. DISCUSSION

Surgical management of proximal nerve injuries yields less good outcomes than that for distal lesions (9-11). Axons pass longer distances to end-organs. Multiple irreversible changes may occur during this period, which could have a detrimental impact on the result. The time of reinnervation for proximal injuries at the elbow degree may go over one year (12). The majority of published series indicate that just twenty percent of cases recover grade IV muscle strength (9,10).

Our study was done at Beni-Suef University Hospitals and Cairo University Hospitals, and it included 26 patients with ulnar injuries. The patients had UR+SETS transfer to the motor fasciculus of the ulnar nerve. The cases were then randomized into two groups depending on a method of identifying the motor branch of the ulnar nerve: group A: anatomical localization (13 patients) and group B: topographic localization (13 patients).

Regarding Group A, good motor recovery (G3 or G4) has been performed in 70 % of cases after 9 months of monitoring with regular physiotherapy. The Adductor pollicis longus muscle recovered (G3) in three cases & (G4) in the other 6 cases. This led to good grip strength & lateral pinch following surgery.

Furthermore, 13 patients achieved satisfactory motor recovery in the dorsal interossei muscles (9 patients in G4, 3 cases in G3, and 1 case in G2). Regarding the abductor of fingers, 10 cases showed improvement in the first & second palmar interossei (G3), while 3 cases had poor outcomes (G2). In terms of hypothenar muscle recovery, eight cases achieved good recovery (G4).

Regarding Group B, good motor recovery (G3 or G4) was observed in 53 % of cases after 9 months of follow-up. Furthermore, good results were observed in nearly all patients after 12 months of motoring.

After a 12-month follow-up, we observed excellent outcomes in both groups concerning the improvement of deformity and the return of intrinsic function. We hypothesize that the UR+SETS will exhibit superior functional outcomes over extended periods due to the increased fascicular density of the ulnar nerve & the terminal AIN.

Our research limitations involve the short monitoring period, which is inadequate to fully assess intrinsic muscle reinnervation, measurement bias, and the limited number of cases.

5. CONCLUSION

A statistically insignificant variance has been observed among the 2 groups in terms of the improvement of motor & functional outcomes concerning motor branch localization. However, anatomical localization of the nerve motor branch is preferred. In the event of severe nerve lesions, the procedure offers a viable alternative for recovering ulnar function. The procedure is straightforward and does not result in any significant donor-site morbidity.

6. ABBREVIATIONS

AIN Anterior interosseus nerve

UR Ulnar repair

SETS Supercharged end-to-side

FCU Flexor carpi ulnaris

ETS End to side

MRC Medical Research Council

SW Semmes Weinstein

PQ pronator quadratus

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