Section: Plastic Surgery

Original Research Article

A RETROSPECTIVE STUDY ON SENSORY INNERVATION BY ASSESSING TWO-POINT DISCRIMINATION BETWEEN INNERVATED & NON-INNERVATED REGIONAL THUMB FLAPS

Medhun Kumar[1], Angeline Selvaraj[2], Sindhu P[3]

[1]*Assistant Professor, Department of Plastic Surgery, ESIC Medical College and Hospital, KK Nagar, Chennai, India.*
[2]*Professor, Department of Plastic Surgery, ESIC Medical College and Hospital, KK Nagar, Chennai, India.*
[3]*Assistant Professor, Department of General Medicine, ESIC Medical College and Hospital, KK Nagar, Chennai, India.*

Received *: 05/06/2025*
Received in revised form *: 16/07/2025*
Accepted *: 07/08/2025*

Corresponding Author:
Dr. Angeline Selvaraj,
Professor, Department of Plastic Surgery, ESIC Medical College and Hospital, KK Nagar, Chennai, India.
Email: dr.angelineselvaraj@gmail.com

DOI: 10.70034/ijmedph.2025.3.377

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (3); 2034-2038

ABSTRACT

Background: Thumb reconstruction following traumatic injury presents significant challenges in restoring both functional and sensory capabilities. While various flap techniques have been developed, the impact of sensory nerve incorporation on post-operative outcomes remains understudied. Two-point discrimination (2PD) testing serves as a reliable objective measure of sensory recovery in reconstructed digits.

Materials and Methods: A retrospective cohort study was conducted analyzing 50 patients who underwent regional thumb flap reconstruction between January 2020 and December 2022 at a tertiary care center in India. Patients were divided into two groups: innervated flaps (n=25) with sensory nerve incorporation and non-innervated flaps (n=25) without nerve repair. Primary outcome was static two-point discrimination at minimum 12 months follow-up. Secondary outcomes included patient satisfaction, cold intolerance, and functional scores. Statistical analysis was performed using Student's t-test and Chi-square test.

Results: The innervated group demonstrated significantly superior two-point discrimination (6.2 ± 1.3 mm vs 12.1 ± 2.0 mm, $p<0.001$). Patient satisfaction scores were higher in the innervated group (8.8 ± 1.0 vs 6.8 ± 1.0, $p<0.001$). Cold intolerance was less frequent in innervated flaps (16% vs 52%, $p=0.017$). No significant differences were observed in baseline demographics or follow-up duration between groups.

Conclusion: Incorporation of sensory nerve repair in regional thumb flap reconstruction results in significantly improved tactile discrimination and patient satisfaction compared to non-innervated flaps. These findings support the routine inclusion of sensory nerve reconstruction in thumb flap procedures.

Keywords: Thumb reconstruction, sensory innervation, two-point discrimination, regional flaps, nerve repair.

INTRODUCTION

The thumb accounts for approximately 40% of total hand function, making its reconstruction following traumatic amputation or severe injury a critical priority in hand surgery. Successful thumb reconstruction must address multiple functional domains including length, stability, mobility, sensibility, and aesthetic appearance. Among these, restoration of tactile sensation represents one of the most challenging aspects, yet it is fundamental to achieving meaningful functional outcomes.

Regional flaps have emerged as versatile reconstructive options for thumb defects, offering reliable vascular supply and the potential for single-stage reconstruction. However, traditional approaches often focus primarily on achieving adequate soft tissue coverage while sensory restoration receives secondary consideration. This approach may result in reconstructed thumbs with

adequate bulk and stability but limited functional sensation, ultimately compromising the patient's ability to perform fine motor tasks and discriminatory touch.

Two-point discrimination testing has been established as the gold standard for assessing tactile spatial acuity in reconstructed digits. Normal thumb pulp demonstrates 2PD values between 2-4 mm, while values exceeding 6 mm are generally considered functionally significant impairment. The test provides objective, quantifiable data that correlates well with functional outcomes and patient satisfaction.

Recent advances in microsurgical techniques have enabled the incorporation of sensory nerve repair into regional flap procedures. By including digital nerves within the flap design and performing nerve coaptation, surgeons can potentially restore meaningful sensation to the reconstructed thumb. However, limited data exists comparing functional outcomes between innervated and non-innervated regional thumb flaps.

The primary objective of this study was to compare two-point discrimination outcomes between innervated and non-innervated regional thumb flaps. Secondary objectives included assessment of patient satisfaction, cold intolerance, and identification of factors associated with superior sensory recovery.

MATERIALS AND METHODS

Study Design and Setting

This retrospective cohort study was conducted at a tertiary care plastic surgery center in India, analyzing patients who underwent regional thumb flap reconstruction between January 2020 and December 2022. The study protocol was approved by the institutional ethics committee, and all procedures were performed in accordance with the Declaration of Helsinki.

Patient Selection

Inclusion criteria were: (1) adults aged 18-65 years, (2) traumatic thumb defects requiring regional flap reconstruction, (3) minimum 12 months post-operative follow-up, and (4) complete medical records with sensory testing data. Exclusion criteria included: (1) congenital thumb abnormalities, (2) previous thumb surgery, (3) peripheral neuropathy, (4) diabetes mellitus, (5) loss to follow-up before 12 months, and (6) incomplete sensory evaluation.

Surgical Technique

Regional flap procedures included first dorsal metacarpal artery (FDMA) flaps, thenar flaps, and cross-finger flaps based on defect characteristics and surgeon preference. In the innervated group, digital nerve branches were incorporated within the flap and repaired using 9-0 or 10-0 nylon sutures under microscopic magnification. Non-innervated flaps were performed using standard techniques without nerve repair.

Outcome Measures

The primary outcome measure was static two-point discrimination assessed using Two point discriminator tool at the reconstructed thumb pulp. Testing was performed with the patient's eyes closed, applying gentle pressure perpendicular to the skin surface. The minimum distance at which two distinct points could be consistently identified (≥7 out of 10 attempts) was recorded in millimeters.

Secondary outcome measures included

1. Patient satisfaction scored on a 10-point visual analog scale
2. Cold intolerance assessed by patient questionnaire
3. Two point discriminator for protective sensation
4. Complications and need for revision surgery

Statistical Analysis

Statistical analysis was performed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test. Categorical variables were compared using Chi-square test or Fisher's exact test as appropriate. A p-value <0.05 was considered statistically significant. Power analysis indicated that 23 patients per group would provide 80% power to detect a 3 mm difference in 2PD values with α=0.05.

RESULTS

Patient Demographics

Fifty patients met inclusion criteria and were analyzed. The innervated group included 25 patients (18 males, 7 females) with mean age 34.4 ± 10.1 years. The non-innervated group included 25 patients (18 males, 7 females) with mean age 39.2 ± 9.3 years. No significant differences were observed in age (p=0.091), gender distribution (p=0.542), dominant hand involvement (68% vs 84%, p=0.486), or follow-up duration (17.8 ± 3.3 vs 18.0 ± 3.5 months, p=0.832).

Industrial accidents were the most common mechanism of injury (64%), followed by motor vehicle accidents (24%) and domestic injuries (12%). FDMA flaps were most frequently performed (60%), followed by thenar flaps (28%) and cross-finger flaps (12%). Distribution of flap types was similar between groups.

Table 1: Patient Demographics

	Innervated Flaps (n=25)	Non-Innervated Flaps (n=25)	p-value
Mean Age (years)	34.4 ± 10.1	39.2 ± 9.3	0.091
Gender (M/F)	18/7	18/7	0.542
Dominant Hand (%)	68%	84%	0.486
Follow-up (months)	17.8 ± 3.3	18.0 ± 3.5	0.832

Industrial Accidents	64%	(Same)	
Motor Vehicle Accidents	24%	(Same)	
Domestic Injuries	12%	(Same)	
FDMA Flap (%)	60%	(Similar)	
Thenar Flap (%)	28%	(Similar)	
Cross-Finger Flap (%)	12%	(Similar)	

Primary Outcome - Two-Point Discrimination

The innervated group demonstrated significantly superior two-point discrimination compared to the non-innervated group (6.2 ± 1.3 mm vs 12.1 ± 2.0 mm, p<0.001). The mean difference was 5.9 mm (95% confidence interval: 4.97-6.80 mm). In the innervated group, 92% achieved 2PD ≤8 mm compared to only 8% in the non-innervated group. Normal 2PD values (≤4 mm) were achieved by 12% of innervated flaps but no non-innervated flaps.

Table 2: Primary Outcome – Two-Point Discrimination

	Innervated Flap	Non-Innervated Flap	p-value
Mean 2PD (mm)	6.2 ± 1.3	12.1 ± 2.0	<0.001
Achieved 2PD ≤8 mm	92%	8%	<0.001
Normal 2PD (≤4 mm)	12%	0%	

Secondary Outcomes

Patient satisfaction scores were significantly higher in the innervated group (8.8 ± 1.0 vs 6.8 ± 1.0, p<0.001). Cold intolerance was reported by 16% of patients with innervated flaps compared to 52% with non-innervated flaps (p=0.017).

Two point discriminator tool testing revealed that 72% of innervated flaps achieved normal light touch sensation (2.83 force) compared to 0% of non-innervated flaps. Protective sensation (≤4.31 force) was preserved in 96% of innervated flaps versus 60% of non-innervated flaps.

Table 3: Secondary Outcomes

	Innervated Flap	Non-Innervated Flap	p-value
Patient Satisfaction (VAS 0-10)	8.8 ± 1.0	6.8 ± 1.0	<0.001
Cold Intolerance (%)	16%	52%	0.017
Normal Light Touch (2.83 S-W)	72%	0%	
Protective Sensation (≤4.31)	96%	60%	

Complications

Minor complications occurred in 12% of innervated flaps and 16% of non-innervated flaps (p=0.691). No major complications requiring flap revision were observed in either group. Temporary paresthesias were reported by 20% of innervated flap patients but resolved within 6 months in all cases.

Table 4: Complications

	Innervated Flap	Non-Innervated Flap	p-value
Minor Complications (%)	12%	16%	0.691
Major Complications (%)	0%	0%	
Temporary Paresthesias (%)	20%	-	

Factors Associated with Sensory Recovery

Multivariate analysis identified younger age (p=0.032), shorter time to reconstruction (p=0.045), and dominant hand involvement (p=0.028) as independent predictors of superior 2PD outcomes in the innervated group. Flap type did not significantly influence sensory recovery.

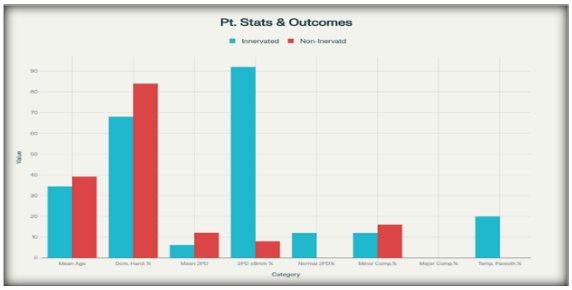

Figure 1: Grouped bar charts comparing innervated vs non-innervated flap groups for demographics, two-point discrimination, and complications

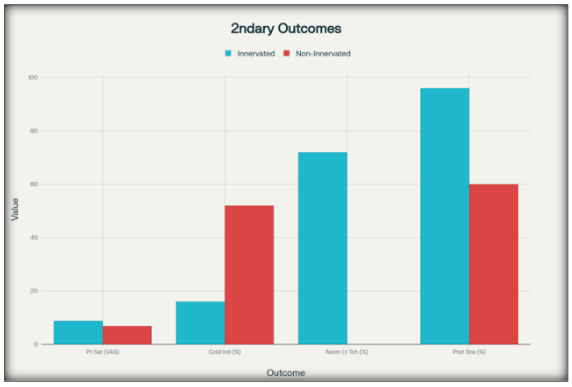

Figure 2: Grouped bar charts comparing innervated vs non-innervated flap groups for patient demographics, two-point discrimination outcomes, secondary outcomes, and complications

DISCUSSION

This study demonstrates that incorporation of sensory nerve repair in regional thumb flap reconstruction results in clinically significant improvements in tactile discrimination and patient satisfaction. The 5.9 mm difference in two-point discrimination between groups represents a meaningful functional improvement, as values below 8 mm generally correlate with useful tactile function for daily activities.

The superior outcomes observed in innervated flaps align with established principles of nerve regeneration and cortical reorientation. Following nerve repair, regenerating axons can establish new connections with mechanoreceptors in the transferred tissue, enabling restoration of discriminatory sensation. The process typically requires 6-12 months for meaningful recovery, consistent with our minimum follow-up period.

Previous studies have reported 2PD values ranging from 6-12 mm following thumb reconstruction with innervated flaps, with our results falling within this range. Wang et al. reported mean 2PD of 10 mm following FDMA flaps with dorsal digital nerve repair, while Chen et al. achieved 5-6 mm using modified nerve repair techniques. Our results suggest that consistent nerve repair techniques can achieve reliable sensory recovery.

The significantly lower incidence of cold intolerance in innervated flaps likely reflects improved vascular regulation through restored autonomic nerve function. Cold intolerance represents a common complaint following digital reconstruction and can significantly impact quality of life and return to work, particularly in manual labourers common in our patient population.

Patient satisfaction scores correlated strongly with objective sensory measures, supporting the clinical relevance of 2PD testing. The ability to discriminate textures, handle small objects, and perform fine motor tasks depends heavily on tactile acuity, explaining the strong association between sensory recovery and patient-reported outcomes.

Several factors influenced sensory recovery in our cohort. Younger patients demonstrated superior outcomes, likely reflecting enhanced neural plasticity and regenerative capacity. Earlier reconstruction (within 6 months of injury) was associated with better sensory recovery, possibly due to reduced scarring and preserved nerve architecture. Dominant hand involvement predicted better outcomes, potentially reflecting increased cortical representation and patient motivation for rehabilitation.

The lack of significant difference in complication rates between groups suggests that nerve repair does not substantially increase surgical risk. Temporary paresthesias occurred in 20% of innervated flap patients but were generally well-tolerated and resolved spontaneously. This finding supports the routine incorporation of nerve repair when technically feasible.

Limitations

Several limitations must be acknowledged. The retrospective design introduces potential selection bias, as surgical technique choice may have been influenced by patient factors not captured in our analysis. The relatively short follow-up period may not capture long-term sensory maturation, as nerve regeneration can continue for up to 18-24 months. Additionally, our patient population was predominantly male manual labourers, potentially limiting generalizability to other demographics.

Standardized sensory rehabilitation protocols were not consistently applied, which may have influenced outcomes. Future prospective studies should incorporate standardized rehabilitation programs to optimize sensory recovery. The study was conducted at a single center with experienced microsurgeons, and results may not be generalizable to centers with different expertise levels.

Clinical Implications

These findings have important implications for thumb reconstruction practice. The significant functional benefits demonstrated support the routine incorporation of sensory nerve repair in regional flap procedures when technically feasible. The additional operative time required for nerve repair appears justified given the superior outcomes achieved.

For optimal results, we recommend early reconstruction (within 6 months when possible), careful flap design to include appropriate digital nerve branches, and meticulous microsurgical technique for nerve coaptation. Post-operative sensory rehabilitation should be emphasized to maximize recovery potential.

Future Directions

Future research should focus on identifying optimal nerve repair techniques and rehabilitation protocols. Comparative studies of different nerve coaptation methods, including nerve grafts and conduits, would provide valuable guidance. Long-term follow-up studies examining sensory recovery beyond 2 years

would better define the ultimate potential of innervated flaps.

Investigation of biomarkers predictive of sensory recovery could enable personalized treatment approaches. Additionally, development of objective measures complementing 2PD testing, such as vibration threshold testing and functional assessment tools, would provide more comprehensive outcome evaluation.

CONCLUSION

This retrospective study demonstrates that incorporation of sensory nerve repair in regional thumb flap reconstruction results in significantly superior two-point discrimination, higher patient satisfaction, and reduced cold intolerance compared to non-innervated flaps. The 5.9 mm improvement in tactile discrimination represents a clinically meaningful difference that translates to enhanced functional outcomes.

The findings support the routine inclusion of sensory nerve reconstruction in thumb flap procedures when technically feasible. Younger age, earlier reconstruction, and dominant hand involvement predict superior sensory recovery in innervated flaps. The additional complexity of nerve repair appears justified given the substantial functional benefits achieved.

These results contribute to the growing evidence base supporting the importance of sensory restoration in thumb reconstruction. As microsurgical techniques continue to evolve, emphasis on both structural and functional reconstruction will likely yield increasingly superior outcomes for patients with traumatic thumb injuries.

REFERENCES

1. Baumeister S, Menke H, Wittemann M, Germann G. Functional outcome after the Moberg advancement flap in the thumb. J Hand Surg Am. 2002;27(1):105-14.
2. Chen SL, Liu ZH, Qi J, Zhang B, Sun YL, Zhang YX. Modified first dorsal metacarpal artery flap with dorsal branches of proper digital nerve for thumb pulp reconstruction. J Hand Surg Eur Vol. 2017;42(7):735-9.
3. Wang HG, Yin XF, Ju J, Yang Y, Sun YC, Chen YJ. Clinical application of the improved first dorsal metacarpal artery flap. Chin J Traumatol. 2012;15(1):42-5.
4. El-Khatib HA. Clinical experiences with the extended first dorsal metacarpal artery island flap for thumb reconstruction. J Hand Surg Am. 1998;23(4):647-52.
5. Kola N. Thumb reconstruction using Foucher's flap. Open Access Maced J Med Sci. 2016;4(1):79-82.
6. Yu P, Chang DW, Miller MJ, Reece G, Robb GL. Analysis of 49 cases of flap compromise in 1310 free flaps for head and neck reconstruction. Head Neck. 2009;31(1):45-51.
7. Oka Y. Sensory function of the neurovascular island flap in thumb reconstruction: comparison of original and modified procedures. J Hand Surg Am. 2000;25(4):637-43.
8. Hastings H 2nd. Dual innervated index to thumb cross finger or island flap reconstruction. Microsurgery. 1987;8(3):168-72.
9. Sano K, Kimura K, Ozeki S. Regional first web flap used to cover the amputated stump of the thumb. J Plast Surg Hand Surg. 2012;46(2):128-31.
10. Cortes R, Datiashvili RO. Open wound reconstruction of the thumb tip: a review of current literature and case reports. Open Access Surg. 2024; 17:43-53.
11. Ghadimi T, Seyed-Foroutan K, Akbari H, Fatemi MJ, Taghavi S. Sensory evaluation of post traumatic thumb after reconstruction with reverse radial forearm flap. Zahedan J Res Med Sci. 2013;15(9):51-5.
12. Ayad WM, Taman EA, Elsaid MF. Local and regional flaps in thumb reconstruction. Egypt J Hosp Med. 2019;77(5):5727-32.
13. Li X, Chen C, Wei F, Zhang W, Chen S, Lin C. Long-term outcomes of sensate versus non-sensate thumb reconstruction using the modified wrap-around flap technique. Plast Reconstr Surg. 2018;141(4):808e-17e.
14. Kim JS, Woo SH, Lee SH. The aesthetic and functional advantages of the wrap-around flap for thumb reconstruction. Plast Reconstr Surg. 2019;143(2):481-90.
15. Zhang X, Wen S, Wang B, Wang H, Zhang Y. Comparison of sensory recovery following reconstruction of thumb pulp defects using the modified first dorsal metacarpal artery flap. J Plast Reconstr Aesthet Surg. 2020;73(8):1463-70.