

Communicating Branches and Terminal Branching Pattern of the Median Nerve at the Wrist: A Cadaveric Study Using the Lanz Classification**Gaurav Singh¹, Avantika Bamne²**¹Department of Anatomy, Index Medical College, Hospital & Research Centre, Malwanchal University, Indore, Madhya Pradesh, India²Professor, Department of Anatomy, Index Medical College, Hospital & Research Centre, Malwanchal University, Indore, Madhya Pradesh, India

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Conflict of interest: Nil

Abstract

Background: The median nerve's communicating branches in the forearm and its terminal branching pattern at the wrist show substantial anatomical variability with direct relevance to electrodiagnosis, forearm surgery, and the safety of carpal tunnel release. Combined, statistically compared cadaveric data addressing these two domains together remain scarce for Central India.

Methods: Thirty embalmed cadavers (60 upper limbs) were bilaterally dissected at a single institution. The presence, level, length, and width of any Martin–Gruber anastomosis; the presence and origin of the palmar cutaneous branch; and the terminal branching pattern of the median nerve, classified according to Lanz, were recorded using a standardised proforma, together with overall nerve morphometry. Findings were compared between sides and between sexes using the chi-square or Fisher's exact test (categorical variables) and the independent-samples t-test (continuous variables).

Results: A Martin–Gruber anastomosis was present in 4 of 60 limbs (6.7%) — 3 of 30 right limbs (10.0%) and 1 of 30 left limbs (3.3%) — with a mean length of 54.62 ± 3.48 mm and width of 1.75 ± 0.17 mm. The palmar cutaneous branch was identified in 55 of 60 limbs (91.7%), arising a mean of 4.66 ± 1.56 cm proximal to the wrist crease. The standard (Lanz Group I) terminal branching pattern was seen in 76.7% of limbs, with Groups II, III and IV accounting for 13.3%, 5.0%, and 5.0% respectively. Mean total nerve length was 32.38 ± 3.30 cm and mean mid-forearm diameter was 3.57 ± 0.54 mm, with no significant correlation between the two ($r = -0.005$, $p = 0.971$). No statistically significant difference between sides or sexes was found for any parameter ($p > 0.05$ throughout).

Conclusion: Communicating branches and non-standard terminal branching patterns of the median nerve, while individually uncommon, together affected close to one-third of limbs in this Central Indian cadaveric sample, with no significant side or sex difference — findings relevant to electrodiagnosis, forearm surgery, and carpal tunnel release safety.

Keywords: Median Nerve; Martin–Gruber Anastomosis; Carpal Tunnel; Lanz Classification; Cadaver; Terminal Branching.

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Introduction

The median nerve's course through the forearm and its terminal branching pattern at the wrist show substantial anatomical variability with direct surgical relevance. In the forearm, the Martin–Gruber anastomosis, a communicating branch between the median (or anterior interosseous) and ulnar nerves, has been reported in 7% to over 37% of limbs depending on population and detection method [1,2], and its presence can produce confusing electrodiagnostic findings or place anomalous motor fibres at risk during forearm surgery. At the wrist, terminal branching variation

was classified by Lanz into four groups based on the course of the thenar motor branch and the presence of accessory or high-dividing branches [3], and a subsequent meta-analysis of pooled data quantified the prevalence of each group, finding non-standard patterns in roughly one in ten hands [4]. These variations carry direct clinical consequence: carpal tunnel syndrome, the condition most closely linked to median nerve anatomy at the wrist, has an estimated global prevalence approaching one in seven individuals [5], and its surgical management via carpal tunnel release

carries a recognised, if low, risk of iatrogenic nerve injury when a variant is unanticipated. Despite this clinical importance, few cadaveric studies have documented communicating branches and terminal branching pattern together within the same sample, with formal statistical comparison between sides and sexes. This study was therefore undertaken to document the presence and morphometry of communicating branches of the median nerve, and its terminal branching pattern classified per Lanz, in a bilaterally dissected cadaveric sample from a Central Indian institution.

Materials and Methods

This cross-sectional, descriptive cadaveric study was conducted on the same 30 embalmed cadavers (60 upper limbs; 30 right, 30 left) described in our companion study of median nerve formation [6], dissected bilaterally at the Department of Anatomy of a Central Indian medical institution. Cadavers with both upper limbs available for dissection and free of documented deformity, prior surgery, or fracture in the axilla, arm, forearm, or hand were included; cadavers with a history of trauma, prior surgical intervention, congenital anomaly, gross pathology, or poor preservation in the region under study were excluded. A total enumeration sampling strategy was used until the pre-specified target of 30 cadavers was reached.

The median (or anterior interosseous) nerve was traced through the forearm to identify any communicating branch to the ulnar nerve (Martin–Gruber anastomosis); where present, its level (proximal, middle, or distal forearm), length, and width were measured with a calibrated digital vernier caliper. The palmar cutaneous branch was

identified proximal to the wrist crease, and its origin measured where present. Distal to this, the nerve was traced through the carpal tunnel into the hand, and its terminal branching pattern was classified according to the four-group system described by Lanz [3] (Group I: standard extraligamentous course of the thenar motor branch; Group II: accessory branches distal to the flexor retinaculum; Group III: high/proximal division of the nerve; Group IV: accessory branches proximal to the flexor retinaculum). Overall nerve morphometry — total length from formation to the wrist crease, diameter at the mid-forearm, and distance from the medial epicondyle — was also measured. All measurements were taken with the limb in a standardised, fully extended and supinated position, and each variation was photographed in situ with a scale reference.

Categorical variables are expressed as frequencies and percentages; continuous variables as mean $\pm$ standard deviation. The chi-square test was used for categorical comparisons where all expected cell frequencies were five or more, and Fisher's exact test otherwise, following standard guidance on statistical test selection [7]. The independent-samples t-test was used for continuous comparisons between sides and between sexes, and Pearson correlation was used to examine the association between total nerve length and mid-forearm diameter. A p-value < 0.05 was considered statistically significant.

Results

Sixty upper limbs from 30 cadavers (22 male, 8 female; mean age 54.17 ± 13.04 years) were examined.

Table 1: Martin–Gruber anastomosis (n = 60 limbs)

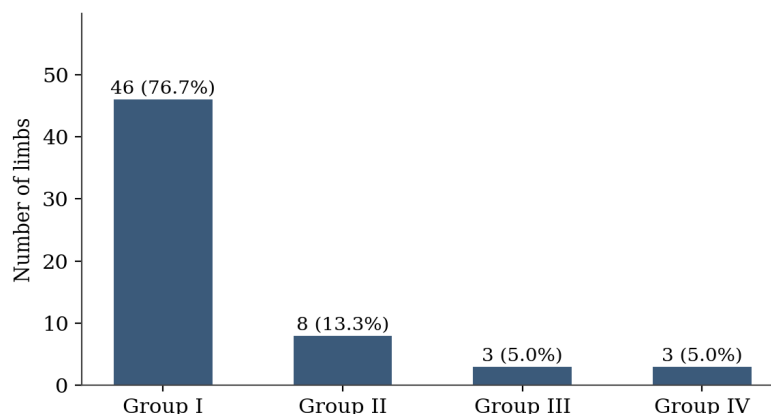
Parameter	Category	n (%) / Mean $\pm$ SD
MGA present	Yes	4 (6.7%)
	No	56 (93.3%)
MGA present, by side	Right (n = 30)	3 (10.0%)
	Left (n = 30)	1 (3.3%)
Level of anastomosis (n = 4)	Middle forearm	3 (75.0%)
	Distal forearm	1 (25.0%)
Length, mm (n = 4)	Mean $\pm$ SD (range)	54.62 ± 3.48 (50.8–58.0)
Width, mm (n = 4)	Mean $\pm$ SD (range)	1.75 ± 0.17 (1.5–1.9)

The palmar cutaneous branch was identified in 55 of 60 limbs (91.7%), arising a mean of 4.66 ± 1.56 cm proximal to the wrist crease (range 2.0–7.5 cm). Classifying the terminal branching pattern per

Lanz, Group I (the standard pattern) was seen in 46 limbs (76.7%), Group II in 8 limbs (13.3%), Group III in 3 limbs (5.0%), and Group IV in 3 limbs (5.0%) (Figure 1; Table 2).

Table 2: Palmar cutaneous branch and terminal branching pattern (n = 60 limbs)

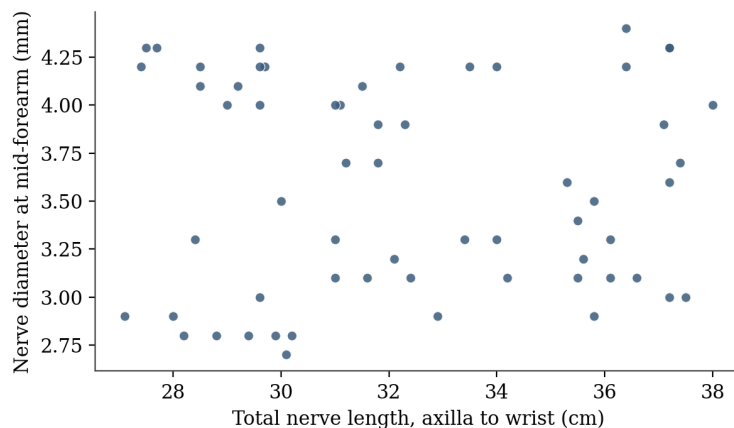
Parameter	Category	n (%) / Mean $\pm$ SD
Palmar cutaneous branch present	Yes	55 (91.7%)
	No	5 (8.3%)
Origin, cm above wrist crease (n = 55)	Mean $\pm$ SD (range)	4.66 $\pm$ 1.56 (2.0–7.5)
Terminal branching pattern (Lanz Group)	Group I	46 (76.7%)
	Group II	8 (13.3%)
	Group III	3 (5.0%)
	Group IV	3 (5.0%)

Figure 1: Terminal branching pattern of the median nerve classified per Lanz (n = 60 limbs)**Figure 1: Terminal branching pattern of the median nerve classified per Lanz (n = 60 limbs)**

The mean total length of the median nerve trunk from formation to the wrist crease was 32.38 ± 3.30 cm, its mean diameter at the mid-forearm was 3.57 ± 0.54 mm, and its mean distance from the medial epicondyle was 2.37 ± 0.52 cm (Table 3). Total nerve length was not significantly correlated with mid-forearm diameter (Pearson $r = -0.005$, $p = 0.971$; Figure 2), nor was cadaver age significantly correlated with mid-forearm diameter ($r = -0.048$, $p = 0.716$) or with total nerve length ($r = 0.082$, $p = 0.532$).

Table 3: Morphometric measurements of the median nerve (n = 60 limbs)

Parameter	Mean $\pm$ SD	Range
Total nerve length, axilla to wrist (cm)	32.38 ± 3.30	27.1 – 38.0
Nerve diameter at mid-forearm (mm)	3.57 ± 0.54	2.7 – 4.4
Distance from medial epicondyle (cm)	2.37 ± 0.52	1.5 – 3.4

Figure 2: Total nerve length vs. mid-forearm diameter (Pearson $r = -0.005$, $p = 0.971$, n = 60 limbs)**Figure 2: Total nerve length vs. mid-forearm diameter (Pearson $r = -0.005$, $p = 0.971$, n = 60 limbs)**

No statistically significant difference between right and left limbs, or between male and female cadavers, was found for any parameter examined (Table 4).

Table 4: Comparison of findings between sides and between sexes

Parameter	Right (n=30)	Left (n=30)	p (side)	Male (n=44)	Female (n=16)	p (sex)
MGA present	3 (10.0%)	1 (3.3%)	0.612*	2 (4.5%)	2 (12.5%)	0.287*
Palmar cutaneous present	28 (93.3%)	27 (90.0%)	1.000*	41 (93.2%)	14 (87.5%)	0.602*
Lanz group distribution†	—	—	0.280	—	—	0.437
Total nerve length, cm	32.58±3.08	32.18±3.55	0.646	32.27±3.14	32.67±3.80	0.682
Diameter mid-forearm, mm	3.59±0.55	3.55±0.54	0.796	3.51±0.55	3.72±0.51	0.198
Distance from epicondyle, cm	2.47±0.48	2.28±0.55	0.164	2.37±0.53	2.38±0.51	0.988

*Fisher's exact test; all other categorical comparisons by χ^2 test. †Expected cell frequency was below 5 in several cells for the Lanz-group comparison; χ^2 results (side: $\chi^2=3.833$, df=3; sex: $\chi^2=2.722$, df=3) should be interpreted with this caveat. Continuous variables compared by independent-samples t-test (df=58 throughout).

Discussion

A Martin–Gruber anastomosis was identified in 6.7% of limbs in this study, lower than the 11.6% reported by Kaur et al. in a North Indian cadaveric series [1] and considerably lower than the 37.6% reported by Tran et al. in the United States [2].

Electrodiagnostic (rather than cadaveric) series have generally reported figures within this same broad range: a Turkish study of 100 healthy volunteers found electrodiagnostic evidence of the anastomosis in 27% of subjects [8], and a comparable Indian electrophysiological study has been reported from Chhattisgarh [9].

This spread — cadaveric series from roughly one in fifteen to more than one in three limbs, and electrodiagnostic series clustering at intermediate values — is consistent with the wider literature attributing this variability to differences in population and detection technique rather than to a single explanatory factor.

Classifying terminal branching per Lanz, the standard (Group I) pattern was seen in 76.7% of limbs, somewhat lower than the 84% reported in a French cadaveric–ultrasound comparison study, which also reported a higher Group III (high-division) frequency of 13% against this study's 5.0% [10]. A recent Indian cadaveric study focusing specifically on the recurrent thenar branch similarly applied Lanz's classification and found no statistically significant difference in its distribution between sides [11], directly consistent with the present study's own non-significant side comparison for this parameter.

No statistically significant difference between sides or sexes was found for any parameter in this study, consistent with the small, recent literature applying formal statistical comparison to cadaveric median nerve data [11].

Clinically, the combination of an uncommon but real risk of a forearm communicating branch and a roughly one-in-four frequency of non-standard

terminal branching is directly relevant to the interpretation of electrodiagnostic studies and to the safe conduct of carpal tunnel release, in which iatrogenic nerve injury, while individually rare, has been documented in association with unanticipated anatomical variation [12].

This study's principal limitations are its single-institution cadaveric design; the absence of electrophysiological correlation, which is particularly relevant to the Martin–Gruber anastomosis; and a small subgroup size for the anastomosis itself ($n = 4$), which limits the precision of the associated estimates and comparisons.

Conclusion

In this Central Indian cadaveric sample, a Martin Gruber anastomosis was present in a small minority of limbs and a non-standard terminal branching pattern in close to one-quarter, with no significant difference between sides or sexes. These findings are relevant to the interpretation of electrodiagnostic studies, to forearm surgery, and to the safe conduct of carpal tunnel release in this population.

Declarations

Ethical Approval: This study was carried out on cadavers already procured and donated for anatomical dissection and teaching, and did not involve living human participants. The protocol was submitted for approval to the Institutional Ethics Committee of [institution — to be confirmed] prior to commencement. [Ethics Committee reference number and date of approval to be inserted once available.]

Author Contributions: G.S.: dissection, data acquisition, data analysis, manuscript drafting. A.B.: study conception and design, supervision, manuscript review and editing. Both authors read and approved the final manuscript.

Data Availability: The dataset analysed in this study is available from the corresponding author on reasonable request.

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