DOI: 10.7860/IJARS/2023/65633.2941

Original Article

Anatomy Section

Morphometric Study of Martin-Gruber Anastomosis and its Surgical Implications: A Cross-sectional Cadaveric Study

D BHARATHI[1], PV VINEESH[2], BN SHRUTHI[3]

ABSTRACT

Introduction: The Martin-Gruber anastomosis is a median-ulnar nerve communication in the upper part of the forearm. This anastomosis is classified into four types.

Aim: To determine the incidence and morphometry of the Martin-Gruber anastomosis and recognise its surgical implications in the South Indian population.

Materials and Methods: This cross-sectional study was conducted on 60 cadaveric upper limb specimens obtained from the Department of Anatomy, Rajarajeswari Medical College and Hospital, Bengaluru, Karnataka, India between November 2022 and March 2023. The median and ulnar nerves were traced, and the Martin-Gruber anastomosis was identified and documented. The classification devised by Nakashima T was used in present study. The distance from the medial epicondyle of the humerus to the point of anastomosis on the ulnar nerve was measured using Vernier calipers. The data were analysed using the statistical software Stastistical Packages for the Social Sciences (SPSS) version 23.0. Categorical variables were expressed as frequency and percentage, while continuous data were expressed as mean and standard deviation.

Results: The Martin-Gruber anastomosis was observed in 11 out of 60 upper limb specimens (18.33%). Type I anastomosis was observed in 3 specimens (27.27%), Type II in 2 specimens (18.18%), and Type III in 6 specimens (54.4%). Type IV was not documented in present study. The distance from the location of the anastomosis on the ulnar nerve to the medial epicondyle of the humerus ranged from 2.2 cm to 13.2 cm, with an average of 3.5 cm.

Conclusion: The findings of present study might be useful for neurosurgeons during nerve transfer techniques for chronic ulnar neuropathy, which is seen in the general population as well as athletes.

Keywords: Chronic ulnar neuropathy, Median-ulnar nerve communication, Nerve transfer techniques

INTRODUCTION

The ulnar nerve arises as a terminal branch of the medial cord of the brachial plexus, consisting of C8 and T1. The median nerve is formed by the union of the medial root (C8, T1), which is derived from the medial cord of the brachial plexus, and the lateral root (C5, C6, C7), formed by the lateral cord of the brachial plexus. The Martin-Gruber anastomosis is the communication between the median and ulnar nerves in the upper part of the forearm. This communication was first described by Anatomist Martin R et al., [1], who considered the possibility of nerve communication in the forearm. In 1870, Gruber W demonstrated its presence in 15.2% of dissected forearms [2]. This anastomosis is classified into four types. In Type I, there is communication between the anterior interosseous nerve and ulnar nerve, while in Type II, the nerve fascicles from the median nerve descend to communicate with the ulnar nerve distally. In Type III, the muscular branches to the deep flexors of the forearm arising from the median nerve communicate with the muscular branches of the ulnar nerve. In Type IV, instead of one, two rami exist between the muscular branches from either the median nerve or the anterior interosseous nerve and the ulnar nerve [3]. Various methods are used to investigate this anastomosis, including anatomical dissection and electroneurography.

Carpal tunnel syndrome is an entrapment neuropathy caused by compression of the median nerve in the wrist's carpal tunnel. The symptoms of carpal tunnel syndrome include numbness, pain, and paresthesia [4]. On electrodiagnosis, paradoxical normal latency was observed on median nerve stimulation in five out of 65 patients with clinical carpal tunnel syndrome. It was concluded that Martin-Gruber anastomosis results in the sparing of thenar muscles from denervation in patients with carpal tunnel syndrome [5]. In addition, ulnar neuropathy, which presents with tingling and numbness in the little finger and ulnar aspect of the ring finger, is seen in the general population and athletes, and conservative treatment is usually followed [6]. However, in some cases, surgical treatment involving decompression of the ulnar nerve at the cubital tunnel is performed. The diagnosis of carpal tunnel syndrome or ulnar nerve lesions can be complicated by the presence of Median-ulnar nerve communication [7].

In addition, to decompression in ulnar neuropathy and to expedite motor recovery, nerve transfer techniques have been adopted [8]. Recently, this anastomosis has been used for restoring intrinsic function through nerve transfer techniques. To assist with this surgery, authors measured the distance between the medial epicondyle of the humerus and the Median-Ulnar nerve communication, which has not been done to date. The objective of present study was to estimate the incidence and morphometry of Martin-Gruber anastomosis and to recognise its surgical implications.

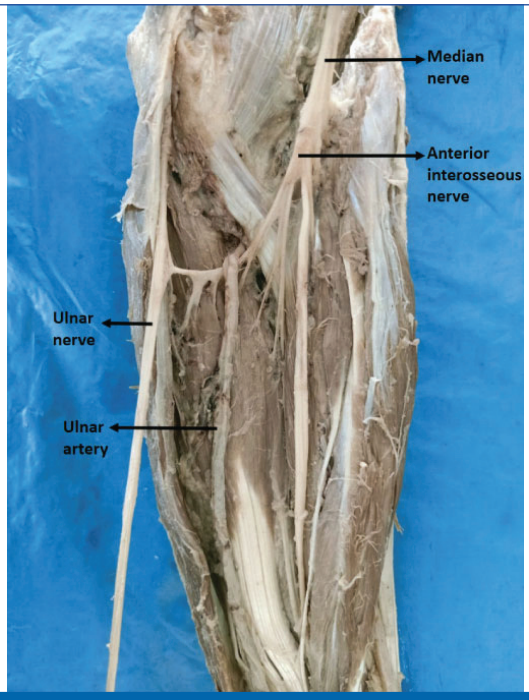
MATERIALS AND METHODS

The present cross-sectional study was conducted on sixty well-embalmed, formalin-preserved adult cadaveric upper limbs obtained from the Department of Anatomy at Rajarajeswari Medical College and Hospital, Bengaluru, Karnataka, India, from November 2022 to March 2023. Since, it was a cadaveric study, Ethical Clearance was exempted for institution.

Inclusion and Exclusion criteria: Cadavers ranging from 30 to 70 years, regardless of gender, with intact forearms were included. Forearms that were deformed due to injury or malformation were excluded from the study.

Dissection of the forearm was performed to trace the median, anterior interosseous nerve, and ulnar nerve. The deep flexors of the forearm were identified, and the muscular branches to the flexor digitorum profundus from the median nerve and ulnar nerve were

traced. Martin-Gruber anastomosis was observed on the upper part of the flexor surface of the forearm, originating from either the median nerve or anterior interosseous nerve and terminating distally onto the ulnar nerve. The ulnar artery crossed superficially to the anastomosis, as seen in [Table/Fig-1]. Over the years, researchers have devised various types of classifications of Martin-Gruber anastomosis. However, authors have followed the classification devised by Nakashima T, in which the anastomosis is classified into four types [9]. In Type I, there is communication between the anterior interosseous nerve and ulnar nerve, whereas in Type II, the nerve fascicles from the median nerve descend to communicate with the ulnar nerve distally. In Type III, muscular branches to the deep flexors of the forearm arising from the median nerve communicate with the muscular branches of the ulnar nerve. In Type IV, there is a looped anastomosis between the muscular branches of the median and ulnar nerves. Variations were recorded and photographed.



[Table/Fig-1]: In Type I, which was seen in three upper limbs, the nerve fascicles originated from the anterior interosseus nerve and communicated with the ulnar nerve distally.

Additionally, the distance from the medial epicondyle of the humerus to the point of anastomosis at the ulnar nerve was measured using digital vernier calipers (accuracy 0.1 mm).

STATISTICAL ANALYSIS

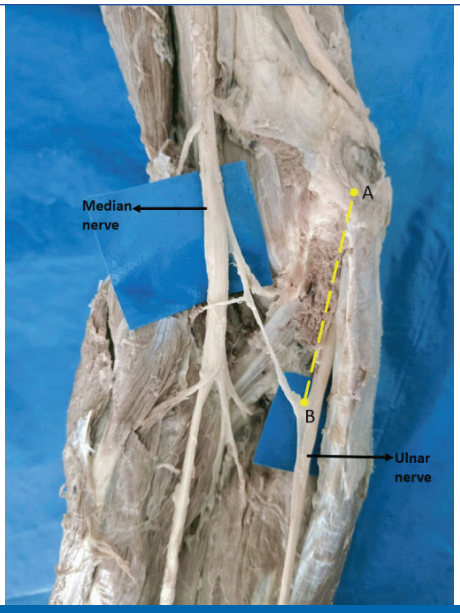
The data were analysed using the statistical software SPSS version 23.0. Descriptive statistics were used to express categorical variables as frequency and percentage, while continuous data were expressed as mean and standard deviation.

RESULTS

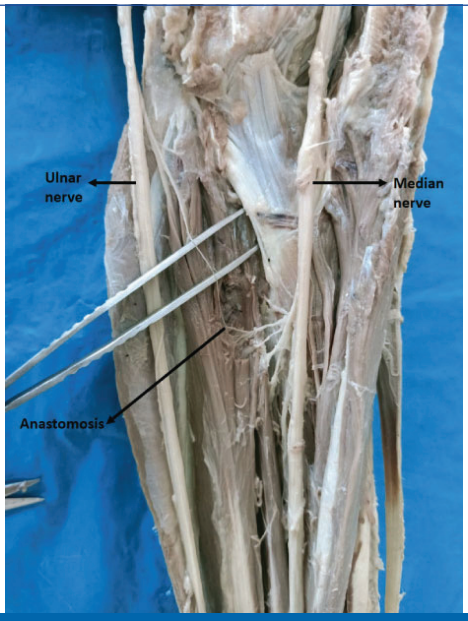
The Martin-Gruber anastomosis was observed in 11 out of 60 upper limb specimens (18.33%). Type I communication was recorded in three specimens, as seen in [Table/Fig-1]. Type II was observed in two specimens [Table/Fig-2]. Type III was found in six specimens [Table/Fig-3]. Type IV was not observed in any of the specimens. Morphometrically, the distance of the location of the anastomosis at the ulnar nerve from the medial epicondyle of the humerus ranged from 2.2 cm to 13.2 cm, with a mean of 3.5 cm±1.2 cm, as depicted in [Table/Fig-4].

DISCUSSION

Several studies have demonstrated the incidence of Martin-Gruber anastomosis. Our findings are consistent with the study done by Roy J et al., in which the prevalence was 19.5% [10]. The study



[Table/Fig-2]: In Type II, which was observed in two limbs, the nerve fascicles originated from the median nerve at the level of medial epicondyle and communicated with the ulnar nerve distally. Point A: Medial epicondyle; Point B: Point of anastomosis with the Ulnar nerve. Dotted line AB (Yellow colour)- Measurement taken from medial epicondyle to the point of anastomosis on the Ulnar nerve.



[Table/Fig-3]: Type III was recorded in six limbs in which the muscular branches to the deep flexors of forearm arising from the median nerve communicated with the muscular branches of Ulnar nerve.

Types	Incidence of anastomosis	Range
Type I	3 (5%)	3.5 to 5.2 cm
Type II	2 (3.33%)	1.6 to 4.2 cm
Type III	6 (10%)	2.2 to 5.4 cm
Overall	11 (18.33%)	3.5±1.2 cm

[Table/Fig-4]: Incidence range, and mean distance of the location of Martin-Gruber anastomosis at the ulnar nerve from the medial epicondyle of humerus.

done by Srinivasan R and Rhodes J found that the median-ulnar anastomosis of the forearm was seen in 15% of the normal dissected foetuses [11]. Nakashima T observed the anastomosis in 23 out of 108 cadaveric arms and classified the anastomosis into four types. Type 1a, characterised by communication between the anterior interosseous and ulnar nerve, was seen in 13 specimens. Type 1b, with communication between the median and ulnar nerve, was found in one specimen. Type II, involving the muscular branches of the flexor digitorum profundus, was seen in eight specimens. Type III, a combination of Type 1a or 1b and Type II, was observed in one specimen [9]. For several years, researchers have been focusing on

the median-ulnar nerve communication to understand its incidence across various ethnic groups and its various types. The Martin-Gruber anastomosis was found in 25 (21.2%) out of 118 cadavers in the study conducted by Rodriguez-Niedenführ M et al., [12].

A systematic review of the literature has highlighted the necessity of knowledge of forearm nerve anatomy for nerve transfer techniques. Davidge KM et al., conducted a study in which they evaluated 55 patients preoperatively and postoperatively following a nerve transfer technique. They concluded that supercharge end-to-side anterior interosseous-to-ulnar nerve transfer may be a useful technique for augmenting intrinsic muscle function for severe ulnar neuropathy. Recently, surgical treatment for patients with rapidly progressive ulnar neuropathy has shown promising results with supercharged end-to-side nerve transfer between the anterior interosseous nerve and the ulnar nerve [13]. Jarvie G et al., performed nerve transfer on two patients with severe cubital tunnel syndrome and demonstrated postoperative improvement in their electrodiagnostic studies, clinical outcomes, and patient-reported outcome scores [14].

The findings in the present study might be useful for neurosurgeons during nerve transfer techniques. Nerve defects are an indication for nerve transfer surgery, which involves not only anatomical reconstruction but also functional re-innervation. The goal of surgery is to reinnervate specific muscles. While sural nerve was previously used as an interposition nerve graft, now coaptation is done end-to-end for intrinsic muscle of hand defects. In supercharged end-to-side techniques, coaptation is done between the donor nerve distally and the injured nerve to rapidly innervate the specific muscle. Baron A and Strohl A have documented that the ideal candidates for supercharged anterior interosseous nerve to ulnar motor nerve transfer are those with severe ulnar neuropathy based on nerve conduction and electromyographic studies, showing reduced compound action potential and fibrillations at rest [15]. [Table/Fig-5] compares the incidence of Martin-Gruber anastomosis with published studies [2,9,16-19].

Author's name	Year	Sample size	Incidence of anastomosis (%)
Gruber W [2]	1870	250	15.2
Nakashima T [9]	1993	108	21.3
Prates LC et al., [16]	2003	64	7.8
Kaur N et al., [17]	2015	60	11.6
Cavalheiro CS et al., [18]	2015	100	27
Felippe MM et al., [19]	2017	30	10
Present study	2023	60	18.3

[Table/Fig-5]: Literature review of cadaveric studies showing the incidence of anastomosis between the median and ulnar nerves (Martin-Gruber anastomosis) [2,9,16-19].

Limitation(s)

The limitations of present study include its relatively small size and data collection from a single centre. Therefore, the findings cannot be generalised. In the future, a multicenter study with a larger sample should be conducted to assess the incidence of anastomosis.

CONCLUSION(S)

This cadaveric dissection comprehensively enumerates the various types of Martin-Gruber anastomosis, with emphasis on its morphometry. It is imperative for neurovascular surgeons to recognise and understand the possibility of using it in nerve transfer techniques, particularly in cases of chronic ulnar neuropathy. An easy method to predict the location of the Martin-Gruber anastomosis is described, providing valuable insight for nerve transfer techniques. Further studies are required to precisely understand the morphometry of the Martin-Gruber anastomosis.

REFERENCES

[1] Martin R. Tal om Nervus allmanna Egenskaper I Maniskans Kropp. Stockholm: Las Salvius; 1763.
[2] Gruber W. Ueber die Verbindung des Nervus medianus mit dem Nervus ulnaris am Unterame des Menschen um der Saugethiere. Arch Physiol. 1870;37:501-22.
[3] Lee KS, Oh CS, Chung IH, Sunwoo IN. An anatomic study of the Martin-Gruber anastomosis: Electrodiagnostic implications. Muscle Nerve. 2005;31(1):95-97.
[4] Sevy JO, Varacallo M. Carpal Tunnel Syndrome. [Updated 2022 Sep 5]. In: StatPearls [Internet]. Treasure Island (FL): Stat Pearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448179/.
[5] Iyer V, Fenichel GM. Normal median nerve proximal latency in carpal tunnel syndrome: A clue to coexisting Martin-Gruber anastomosis. J Neurol Neurosurg Psychiatry. 1976;39(5):449-52.
[6] Lleva JMC, Munakomi S, Chang KV. Ulnar Neuropathy. [Updated 2023 Feb 12]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK534226/.
[7] Di Stefano V, Gagliardo A, Barbone F, Vitale M, Ferri L, Lupica A, et al. Median-to-ulnar nerve communication in carpal tunnel syndrome: An electrophysiological study. Neurol Int. 2021;13(3):304-14.
[8] Dy CJ, Mackinnon SE. Ulnar neuropathy: Evaluation and management. Curr Rev Musculoskelet Med. 2016;9(2):178-84.
[9] Nakashima T. An anatomic study on the Martin-Gruber anastomosis. Surg Radiol Anat. 1993;15(3):193-95.
[10] Roy J, Henry BM, Pekala PA, Vikse J, Saganiak K, Walocha JA, Tomaszewski KA. Median and ulnar nerve anastomoses in the upper limb: A meta-analysis. Muscle Nerve. 2015;54(1):36-47.
[11] Srinivasan R, Rhodes J. The Median-Ulnar anastomosis (Martin-Gruber) in normal and congenitally abnormal fetuses. Arch Neurol. 1981;38(7):418-19.
[12] Rodriguez-Niedenführ M, Vazquez T, Parkin I, Logan B, Sañudo JR. Martin-Gruber anastomosis revisited. Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists. 2002;15(2):129-34.
[13] Davidge KM, Yee A, Moore AM, Mackinnon SE. The supercharge end-to side anterior interosseous-to-ulnar nerve transfer for restoring intrinsic function: clinical experience. Plast Reconstr Surg. 2015;136:344e-52e.
[14] Jarvie G, Hupin-Debeurme M, Glaris Z, Daneshvar P. Supercharge end-to-side anterior interosseous nerve to ulnar motor nerve transfer for severe ulnar neuropathy: Two cases suggesting recovery secondary to nerve transfer. J Orthop Case Rep. 2018;8(5):25-28.
[15] Baron A, Strohl A. Severe cubital tunnel syndrome: Considerations for nerve transfer surgery. Curr Rev Musculoskelet Med. 2020;13(6):708-16.
[16] Prates LC, de Carvalho VC, Prates JC, Langone F, Esquisatto MA. The Martin-Gruber anastomosis in Brazilians: An anatomical study. Journal of Morphological Sciences. 2017;20(3):177-180.
[17] Kaur N, Singla RK, Kullar JS. Martin-Gruber anastomosis- A cadaveric study in north Indian population. J Clin Diagn Res. 2016;10(2):AC09-11. Doi: 10.7860/JCDR/2016/16447.7247. Epub 2016 Feb 1. PMID: 27042438; PMCID: PMC4800503.
[18] Cavalheiro CS, Filho MR, Pedro G, Caetano MF, Vieira LA, Caetano EB. Clinical repercussions of Martin Gruber anastomosis: Anatomical study. Rev Bras Ortop. 2016;51(2):214-23. Doi: 10.1016/j.rboe.2016.02.003. PMID: 27069892; PMCID: PMC4812040.
[19] Felippe MM, Telles FL, Soares AC, Felippe FM. Anastomosis between median nerve and ulnar nerve in the forearm. J Morphol Sci. 2012;29(01):23-26.

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Anatomy, Rajarajeswari Medical College and Hospital, Bengaluru, Karnataka, India.
2. Assistant Professor, Department of Anatomy, Rajarajeswari Medical College and Hospital, Bengaluru, Karnataka, India.
3. Professor, Department of Anatomy, Rajarajeswari Medical College and Hospital, Bengaluru, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
D Bharathi,
Flat No-009, Ground Floor, Someshwara Arcade, Tent Road, Mooddalpalya, Bengaluru-560072, Karnataka, India.
E-mail: bharathidhananjaya@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: May 26, 2023
- Manual Googling: Aug 18, 2023
- iThenticate Software: Aug 22, 2023 (21%)

ETYMOLOGY: Author Origin

EMENDATIONS: 5

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? No
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **May 26, 2023**
Date of Peer Review: **Jul 31, 2023**
Date of Acceptance: **Aug 23, 2023**
Date of Publishing: **Nov 01, 2023**