Chirurgia (2012) 107: 442-446
No. 4, July - August
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Median to Ulnar Nerve Anastomosis: A Review of the Literature

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Rezumat

Anastomoza nervului median cu nervul ulnar – recenzia literaturii

Anastomoza nervului median cu nervul ulnar la nivelul antebrațului a fost dovedit a fi de importanță clinică conducând la inervare "anormală" şi este corelată cu diagnosticarea greşită în timpul evaluării leziunilor nervoase, traumatimelor şi sindromului de tunel carpian. În 1763, Martin a descris pentru prima dată anastomoza şi Gruber a menționat-o ulterior, astfel în anul 1870 fiind citată ca anastomoză Martin - Gruber. În ciuda istoriei sale lungi, natura sa rămâne neclară. Multe studii anatomice, histologice, electrofiziologice şi genetice au fost publicate, raportând frecvența anastomozei, invocând importanța ei clinică şi clasificând-o în diferite clase şi tipuri. Diagnosticul se face în cea mai mare parte cu studii electrofiziologice, prin care cercetătorii au arătat anumite indicii, luând în considerare natura asimptomatica a anastomozei. Literatura actuală privind anastomoza nervului median cu nervul ulnar este revizuită, subliniind frecvența şi semnificația ei clinică, fiind un excelent instrument pentru mulți clinicieni în diagnosticarea corectă a afecțiunii.

Cuvinte cheie: nervul median, nervul ulnar, anastomoza nervoasă

Abstract

Median to Ulnar nerve anastomosis in the forearm has been shown to be of clinical significance leading to "anomalous" innervation and is correlated with misdiagnosis during the assessment of nerve lesions, injuries and Carpal Tunnel Syndrome (CTS). In 1763, Martin first described the anastomosis and Gruber next mentioning it, in 1870 thus referred to as Martin – Gruber anastomosis. Despite its long history, its nature remains unclear. Many anatomical, electrophysiological, histological and genetic studies have been published, reporting the anastomosis' frequency, citing its clinical importance and classifying it into various classes and types. Diagnosis is made mostly with electrophysiological studies whereby researchers have cited certain clues taking into consideration the asymptomatic nature of the anastomosis. The current literature on median to ulnar nerve anastomosis is reviewed, highlighting its frequency and clinical significance making an excellent tool for correct diagnosis in many clinicians.

Key words: median nerve; ulnar nerve; nerve anastomosis

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No benefits or funds were received in support of this study

Introduction

Anastomoses between the median (MN) and ulnar nerves (UN) are the commonest forms of "anomalous" innervation, in various levels at the upper limb [upper part, distal forearm and palm (between the recurrent branch of the MN and deep branch of the UN)] but are most common in the upper part (1). Anatomical, electrophysiological and histological studies have proven that the anastomoses contribute to variable innervation of the intrinsic hand muscles and lead to severe clinical and surgical implications (2). Various communication forms between MN and UN are observed. In the forearm, communication branches may rise from the MN and join the UN (Martin-Gruber anastomosis, MGA); from the UN and join the MN (reversed MGA- Marinacci communication). In the palm, communication branches join the MN recurrent branch and the UN deep branch (Riche – Cannieu anastomosis) *(Fig. 1)* and common digital nerves arising from the UN and MN (Berretini anastomosis) are reported less frequently in the literature.

Martin was the first to describe the MN to UN anastomosis and Gruber next mentioning it, thus the anastomosis later referred as MGA. MGA is a neural connection which involves axons leaving either the main trunk of the MN or the anterior interosseous nerve (AIN), crossing through the forearm to join the main trunk of the UN and ultimately innervating the intrinsic hand muscles (3,4). MGA has been considered as carrying motor or sensory fibers between the MN and UN (5).

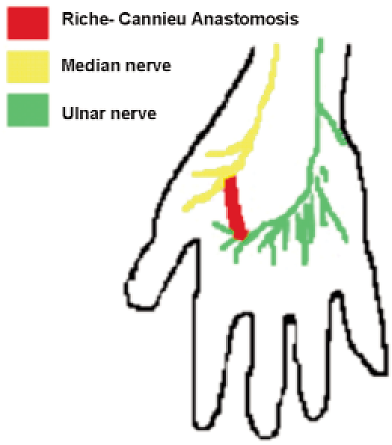

Figure 1. *The Riche- Cannieu anastomosis*

Median to ulnar nerve anastomosis

There are various anatomical, histological and electrophysiological studies reporting the frequency of the MN to UN anastomosis, studies claiming the hereditary/genetic background of the anastomosis (6) and others citing its clinical importance (7, 8,9,10,11,12,13) *(Table 1)*. Furthermore, numerous classifica-

Table 1. *Summary of literature involving documented occurrence of MN to UN anastomosis according to author*

Year	Authors	Study	Cases/ Subjects	MN to UN communication (%)
1870	Gruber (14)	Anatomical	250	15.2
1893	Thomson (15)	Anatomical	406	15.5
1931	Hirasawa (16)	Anatomical	no data	10.5
1966	Mannerfelt (17)	Electrophysiological	41	15
1976	Kimura et al. (8)	Electrophysiological	328	17
1977	Vasickova (18)	Anatomical	106	39.6
1980	Crutchfield and Gutmann (6)	Genetic	50	28
1981	Srinivasan and Rhodes (19)	Anatomical, genetic	200	15
1987	Kayamori (20)	Electrophysiological	600	14
1992	Uchida and Sugioka (13)	Electrophysiological	47 (Cubital syndrome) 87 (Normal)	17 16
1992	Amoiridis (7)	Electrophysiological	100	32
1993	Nakashima (9)	Anatomical	108	21.3
1997	Taams (21)	Anatomical	112	23
1999	Budak and Gonenc (22)	Electrophysiological	108	17.5
1999	Shu et al. (12)	Anatomical histological	72	23.6
2001	Simonetti (23)	Electrophysiological	42	57
2002	Rodriguez- Niedenfuhr et al. (10,11)	Anatomical	140 236	13.6 13.1
2002	Erdem et al. (24)	Electrophysiological	100	27
2003	Sarikcioglu et al. (25)	Anatomical electrophysiological	30 (Anatomical) 60 (Electrophysiological)	6.6 3.3
2003	Prates et al. (26)	Anatomical	64	7.8
2003	Amoiridis and Vlachonikolis (3)	Electrophysiological	50 (potential comparison method) 50 (collision technique)	54 46
2004	Kawashima et al. (27)	Anatomical	32	15.6
2005	Lee et al. (15)	Anatomical electrophysiological	102 (Anatomical) 224 (Electrophysiological)	39.2 23.2
2005	Kazakos et al. (28)	Anatomical	100	10

Table 2. *Summary of literature involving classification of anastomosis between the MN and UN*
(MN: median nerve, UN: ulnar nerve, AIN: anterior interosseous nerve, TM: thenar muscles, HM: hypothenar muscles, FDP: flexor digitorum profundus muscle, FDI: first dorsal interosseous)

Year	Authors	Classification proposed; anastomosis between
1893	Thomson (15)	Class I; AIN and UN Class II; MN and UN Class III; Muscular branch to FDP
1931	Hirasawa (16)	Oblique anastomosis; AIN and UN MN and UN Looped anastomosis; Muscular branch to FDP Combined anastomosis; Combination or other
1976	Kimura et al. (8)	Type I: MN and UN innervating HM Type II: MN and UN innervating the FDI Type III: MN and UN innervating TM
1981	Srinivasan and Rhodes (19)	Type I, II ,VI: AIN and UN Type III: MN and UN Type IV, V: Combination or other
1992	Uchida and Sugioka (13)	Type I: MN and UN innervating HM Type II: MN and UN innervating the FDI Type III: MN and UN innervating TM
1993	Nakashima (9)	Type Ia: AIN and UN Type Ib: MN and UN Type III: Combination of Type Ia, Ib and II
1995	Oh et al. (29)	Type I: MN and UN innervating HM Type II: MN and UN innervating the FDI Type III: MN and UN innervating TM
1999	Shu et al. (12)	Type I: AIN and UN Type II: MN and UN Type III: Muscular branch to FDP Type IV: AIN and UN, muscular branches FDP muscle originated from the connection Type V: Two anastomotic branches
2002	Rodriguez-Niedenfuhr et al. (10,11)	Pattern I: One anastomotic branch Pattern II: Two anastomotic branches Type a: anastomotic branch originating from the branch of the MN to the superficial forearm flexor muscles Type b: anastomotic branch originating from the MN Type c: anastomotic branch originating from the AIN
2005	Lee et al. (15)	Type I: AIN and UN Type II: MN and UN Type III: Muscular branch to FDP Type IV: Two anastomotic branches MN or AIN and UN

tions have been proposed, but there is no consensus about the anastomosis classification *(Table 2, Fig. 2)*. The incidence of MN to UN anastomosis differs between the studies. In the forearm, it has been described as occurring in 5-40% (6,15,17, 25,30,31) whereas anatomic studies report an incidence between 10% and 30.6% (9,10,11,12,14,15,16,19,21,27). Unilateral anastomosis occurs more often in the right than in the left side. Tountas and Bergman (32) reported that 90% of the population had MN –UN anastomoses, more frequently on the right side; 10% were bilateral. No differences were reported between sexes (21). MN to UN anastomosis seems to be inherited in autosomal dominant mode (6).

Martin (1763) described a branch between MN and UN, a neural connection in the palm and a communicating branch distal to the Flexor Digitorum Profundus (FDP) but made no comment of the content of the communicating branches (motor or sensory branches) *(Fig. 3)*. Then, Gruber (1870) found a connection between MN and UN in 15.2% (38/250 forearms). In 1966, Mannerfelt (17) detected the communicating branch in 41 patients (15%) using electrodiagnostic techniques and Rosen (45) has shown the anomalous distribution of the MN and UN in 20% of a normal population. Crutchfield and Gutmann (6) found MN to UN communication in the family members of persons with the anomalous connection, and suggested the familiar (autosomal dominant) inheritance. Srinivasan and Rhodes (19) reported an incidence 15% on human fetuses and found that abnormal fetuses with trisomy 21 had an MGA in both forearms. Uchida and Sugioka (13) found 16% incidence in normal Japanese population and 17% in the

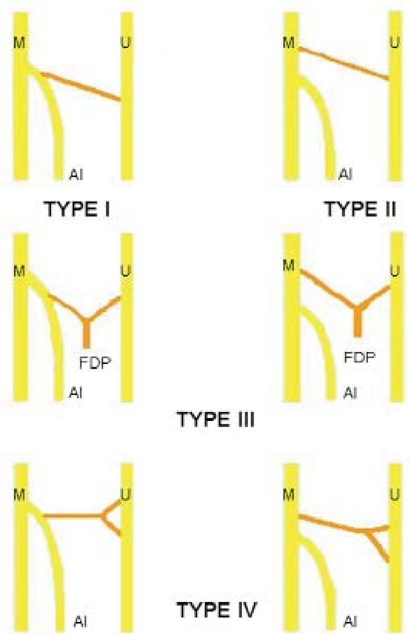

Figure 2. *Types of communications observed between the median and ulnar nerves. M, median nerve; U, ulnar nerve; AI, anterior interosseous nerve; FDP, flexor digitorum profundus. With the orange colour the Martin-Gruber communicating branch (Lee et al., 2005- modified)*

Cubital Tunnel Syndrome (CTS) group. No sensory communication was demonstrated. Amoiridis (7) examining 100 left

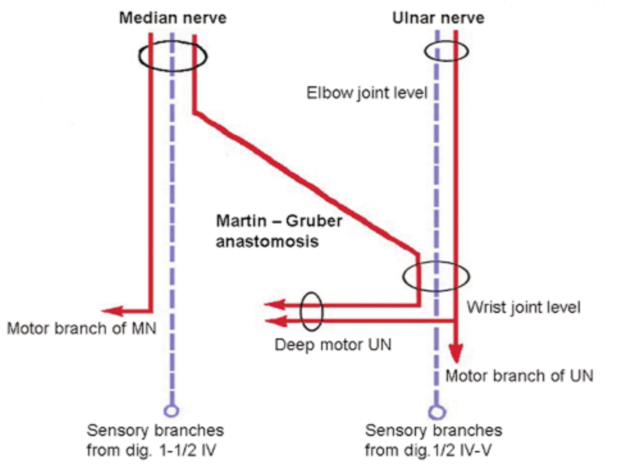

Figure 3. *Schematic drawing to demonstrate the entrance of the Martin- Gruber anastomosis in the distal ulnar nerve. With the red and blue colors indicated the content of nerve fibers (motor and sensory respectively)*

forearms, found a motor MN to UN communicating branch in 32% of the cases, which innervated the muscles normally supplied by the UN. Nakashima (9) found a communicating branch in 21.3% (23/108 cadaveric arms) and Shu et al. (12) in 23.6% (17/72 upper limbs). In their histological examination, Shu and colleagues state that the different number of nerve fibers innervate different amounts of the intrinsic muscles in the hand. Several authors reported an incidence 17.5% (19/108 subjects) and 27% (27/100 subjects) respectively, in Anatolian population (22,24) and 7.8% (5/64 upper limbs) in Brazilian population (26). The incidence was greater in males than in females. Kazakos et al. (28) found the anastomosis in 8.6% (14/163 forearms) of the Greek population and Dogan et al. (33) in 7.5% of the Turkish human fetuses. Other morphological details reported, are the course of the anastomosis, its relationships to the ulnar artery (UA) and its anastomoses with the UN. The course of the anastomosis has been more frequently described as transverse or oblique than arched. The anastomosis most frequently passes behind the UA and terminates either as a single branch or two branches, one with an oblique course and the other with a recurrent course (10, 11,14,16,21). Finally Isakovic et al. (34) found an invisible anastomosis of the main stem of the MN with UN through CTS followed by a superficial ulnar artery.

Clinical Significance and Diagnosis

The diagnosis of the anastomosis is made with electrophysiological studies, using various proposal neurologic diagnostic criteria (35,36,37). Gutmann (38) stated that when the anastomosis occurs in association with the Carpal Tunnel Syndrome (CTS) additional changes may occur in evoked muscle potentials (EMP). Iyer and Fenichel (35) reported that although this anomaly is asymptomatic and often goes undetected, its presence is revealed by the unusual distribution of the motor and/or sensory deficit. Prerequisite for the diagnosis is the simultaneous presence of pathological conditions of the MN and UN, such as the CTS. Otherwise, the anastomosis is difficult to be suspected. The MN to UN anastomosis is clinically important and has resulted in misdiagnosis during the assessment of nerve lesions, injuries (39), leprosy and entrapment neuropathies (carpal and cubital tunnel syndrome) (13,34,40,41,42,43). Clinically, the coexistence of anastomoses in the forearm and hand has been related with anomalous innervation of muscle or skin, and anomalous nerve conduction observed in electrophysiological studies (7,30,31,40). The connections between the MN and UN are often proposed as causes of unusual motor losses from peripheral lesions (12). There are also reports considering the anastomosis as the main factor causing/inducing complications during surgical procedures (44). In traumatic or entrapment nerve lesions, the functional loss differs if the anastomosis between the MN and UN is present. In such cases, the loss of motor function exceeds normal expectations in the proximal MN lesion, and is of much more limited extent in the distal lesion (7). Moreover the intrinsic hand muscles were completely unaffected by MN lesions, situated proximal to the communicating branch and affected the median thenar muscles, whereas a lesion below that level would not affect (9).

The presence of the anastomosis in patients with coexisting CTS results in a partial or total sparing of thenar muscles from denervation and produces a characteristic change in motor conduction studies. The MN is intentionally stimulated at the wrist (distally) and the elbow (proximally), and as a result the distal latency of the MN will be prolonged, but on stimulation at the elbow the latency will be normal as the stimulus can travel along the non-compressed fibers by the flexor retinaculum (35,38).

The anatomical studies showed different anastomotic branches of MN to UN communication which will probably be difficult to detect through electrodiagnostic studies. These branches include branch innervating the flexor digitorum profundus and not crossing over to the UN, thin anastomotic branch between the MN and UN and branch arising proximally to the elbow joint (15).

Conclusion

The MN to UN anastomosis has great significance due to its numerous patterns and clinical results, as in electrophysiological studies it may be manifest as anomalous nerve conduction in CTS and persistence of muscle innervation in spite of UN section. It is important to note that the MN to UN anastomosis is not always followed by symptoms and is often misinterpreted by clinicians when diagnosing peripheral nerve lesions or compression neuropathies in the forearm. By recognizing the existence of different types of the anastomosis and the resulting clinical correlations when performing emergency electromyographies, mistakes can be avoided. This review consists an excellent diagnosis tool for hand surgeons, neurosurgeons and orthopaedic surgeons who must have a high index of suspicion for this clinical entity.

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