

The communications between the ulnar and median nerves in upper limb

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ABSTRACT

The basic anatomy of the median and ulnar nerves in the upper limb is well described in textbooks. Besides detailed anatomy of the communications between median and ulnar nerves was designed to help hand surgeons understand both anatomic variations and paradoxical complaints of sensory and motor loss of patients. Reports in the literature describe the four communicating branches between median and ulnar nerves in the upper limb.

We would like to summarize previous studies in order to be understood properly and make general comments on this complex relationship between structure and innervation. © Neuroanatomy. 2009; 8: 15-19.

Key words [median nerve] [ulnar nerve] [Martin-Gruber anastomosis] [Marinacci communication]

Introduction

The median nerve has two roots from the lateral (C5,6,7) and medial cords (C8,T1), which embrace the third part of the axillary artery, and unite anterior or lateral to axillary artery [1]. It runs distally in the arm on the lateral side of the brachial artery until it reaches the middle of the arm, where it crosses to the median side and contacts the brachialis. The median nerve has no branches in the axilla or the arm, but it does supply articular branches to the elbow joint [2]. Enters cubital fossa medial to brachial artery; exits by passing between heads of pronator teres; descends in fascial plane between flexors digitorum superficialis and profundus; runs deep to palmaris longus tendon as it approaches flexor retinaculum to reverse carpal tunnel [2].

The ulnar nerve arises from the medial cord (C8, T1) but often receives fibres from the ventral ramus of C7. It runs distally through the axilla medial to the axillary artery, between it and the vein. Continuing distally medial to the brachial artery as far as the midarm. Here it pierces the medial intermuscular septum [1]. Like the median nerve, the ulnar nerve has no branches in the arm, but it also supplies articular branches to the elbow joint [2]. It enters the forearm between two heads of flexor carpi ulnaris superficial to the posterior and oblique parts of the ulnar collateral ligament [1]. The ulnar nerve leaves the forearm by emerging from deep to the tendon of the flexor carpi ulnaris. It continues distally to the wrist via the ulnar canal [2].

Reports in the literature describe the four communicating branches between median and ulnar nerve in the upper limb. In the forearm, communicating branch may rise from the median nerve and join to the ulnar nerve, so-called Martin-Gruber anastomosis (MGA) [3-7], it may rise from the ulnar nerve and join to the median nerve, so-called reversed Martin-Gruber anastomosis, ulnar-to-median nerve communication or Marinacci communication [6-8]. The Riche-Cannieu anastomosis occurs in the palm between the recurrent branch of the median nerve and the deep branch of the ulnar nerve [9,10]. And the communicating branch between common digital nerves that arise from the ulnar and median nerves in the palmar surface of hand is called 'Berretini Anastomosis, ramus communicans or superficial communicating branch' [11-15]. Illustrations of these communications showed in Figures 1,2 (for forearms) and Figures 3,4 (for hands).

Martin-Gruber anastomosis (median-to-ulnar anastomosis in the forearm)

In the forearm, median and ulnar communication was first described by the Swedish anatomist Martin (in 1763) and later by Gruber (in 1870) and thus referred to as the Martin-Gruber Anastomosis (MGA). Various forms and connections were found in Martin's cadaver dissections [16]. This anastomosis involves axons leaving either the main trunk of median nerve or the anterior interosseous nerve, crossing through the forearm to join the main trunk of the ulnar nerve and ultimately innervating the intrinsic hand muscles [17].

Its reported incidence differs between physiologic and anatomic studies. In the former it has been described as occurring in 5-40% of cases [6,18,19] whereas anatomic studies report a narrower range of 10-30.6% [3,4,15,20,21]. In the literature, on human fetuses (normal and congenitally abnormal fetuses) there was only one study [5] which reported the incidence of MGA [15%]. Sarikcioglu et al. [6] studied on 30 cadaver arms and 60 patient arms by dissection and electrophysiological technique respectively and they found MGA less [3.3% ve 6.6% of arms] frequently than reported in the available literature. They suggested that these differing frequencies in the Anatolian population should be corrected by studies with larger samples.

The MGA suggested that unilateral MGA occurs more often in the right side than the left [4,6,20]. But no differences were reported with respect to the frequencies of MGA or MGA types for the sexes [17]. This anomaly seems to be inherited in autosomal dominant mode [18].

In the literature, there are several studies on MGA classification; by different techniques [anatomical [4,5,21], histological [20] and electrophysiological [19]]. In these studies, 4-6 subtypes of MGA reported regarding the origin and connection of communication the nerves (between interosseus nerve, proximal or distal part of median and ulnar nerves). But, Lee et al. [19] reported that three morphologic features of MGA that could not be detected by an electrodiagnostic method: Firstly; a branch innervating the flexor digitorum profundus and not crossing over to the ulnar nerve, secondly; a very thin anastomotic branch between the median and ulnar nerves, thirdly; a branch arising proximally to the elbow joint.

In the literature, some researchers cited the clinical importance of MGA [3,20-24]. The intrinsic muscles of the hand were completely unaffected by median lesions. A lesion of the median nerve situated proximal to the departure of the communicating branch would affect the median thenar muscles, whereas a lesion below that

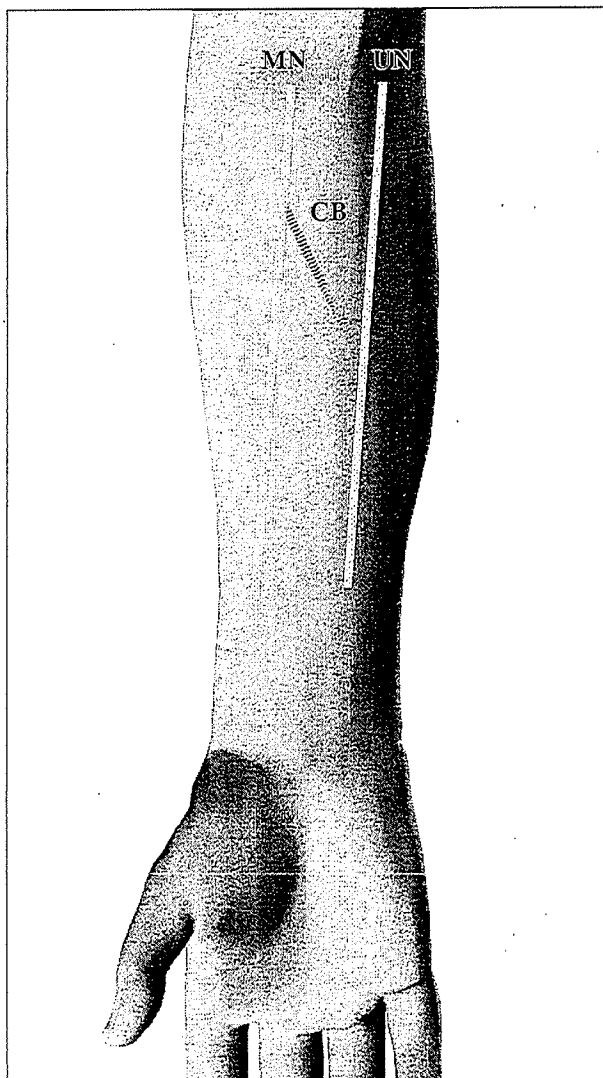


Figure 1. Schematic illustration of Martin-Grüber anastomosis. (MN: median nerve; UN: ulnar nerve; CB: communicating branch)

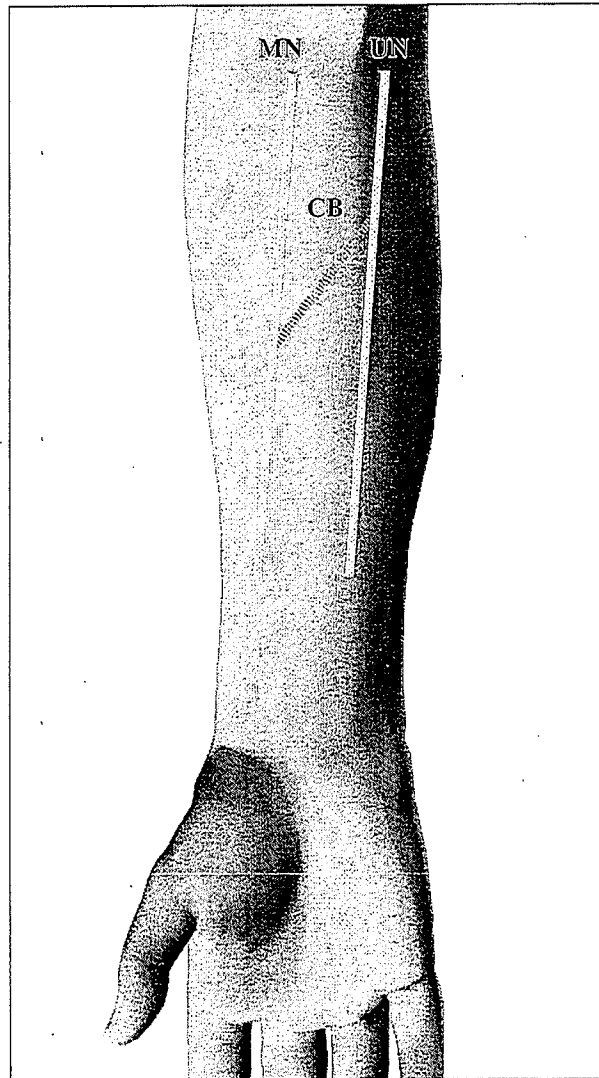


Figure 2. Schematic illustration of Marinacci communication. (MN: median nerve; UN: ulnar nerve; CB: communicating branch)

level would not [3]. Brandsma et al. [24] reported that the clinical importance of this anastomosis is that an isolated ulnar nerve lesion at the elbow may produce an unusual pattern of intrinsic muscle paralysis. The MGA has clinical significance for understanding median nerve lesion and the carpal tunnel syndrome. In addition, Niedenfuhr et al. [25] cited that the intramuscular MGA because the intramuscular course of a nerve is a potential compression site, the cases presented in this study may have an additional clinic implication.

Marinacci communication (ulnar-to-median anastomosis in the forearm)

Prevalence of MGA, an anomalous median-to-ulnar forearm communication, is well reported in literature while Marinacci communication, the reverse of Martin-Gruber with forearm ulnar-to-median communication is underrecognized [8]. Marinacci (in 1964) first reported patient who, following trauma to the median nerve at the forearm, had preservation of median nerve innervated hand muscles despite denervation of forearm flexors [16].

Marinacci communication involving only sensory nerve fibers rise from the median nerve distally to ulnar nerve proximally has been reported [26]. In the patient, reported by Hopf [26], that the nerve action potentials evoked by stimulation of the middle finger (ulnar side) and the ring finger (radial side) digital nerves were propagated with the median nerve at the wrist and the ulnar nerve at the elbow.

Occurrence frequency for Marinacci communication was reported as 1.3% by Kimura et al. [27], 4% by Sundaram et al. [8], 16.7% by Golovchinsky [28]. But in many studies, they did not find any ulnar-to-median communication [6,7]. Golovchinsky [28] suggested that, when an ulnar-to-median anastomosis is suspected, special care should be exerted in evaluation of motor distal latency of the median nerve with a gradual and slow increase of the

stimulus voltage. Use of high voltage from the beginning can simultaneously activate both the median nerve and a collateral branch of the ulnar nerve, the later bypassing the carpal tunnel and evoking a short latency response in the thenar muscles, with the simultaneous long latency response to the stimulation of the median nerve being masked by this fast response. Furthermore, Amoridis and Vlachonikolis [7] said that cases of false positive criteria for ulnar-to-median nerve anastomosis in this study have shown that stimulus spread to the median nerve on supramaximal stimulation of the ulnar nerve about 1 cm above the *epicondylus medialis humeri* is possible.

Marinacci communication, although not as frequent as MGA, is not uncommon in electrophysiological practise. So far, there is no any report from cadaver studies related with Marinacci communication.

According to Sundaram et al. [8], the importance of recognizing such anomalous anastomosis cannot be overemphasized. First, the changes noted over the median nerve may be interpreted as neuropraxia if one does not pay attention to the amplitude difference between the compound muscle action potential obtained on distal and proximal stimulation of the ulnar nerve. Second, ulnar nerve injuries at the elbow may be accompanied by denervation changes over median innervated thenar muscles such as the abductor pollicis brevis, which may receive these fibers through such a communication. Third, median nerve injuries at the elbow may not result in clinically significant effects on the thenar muscles, more importantly the abductor pollicis brevis.

Riche-Cannieu anastomosis (ulnar-to-median anastomosis in the hand)

In the hand, Riche (1897) and Cannieu (1897) described a neural connection between the deep branch of the ulnar nerve and the recurrent branch of the median nerve at the thenar eminence [27].

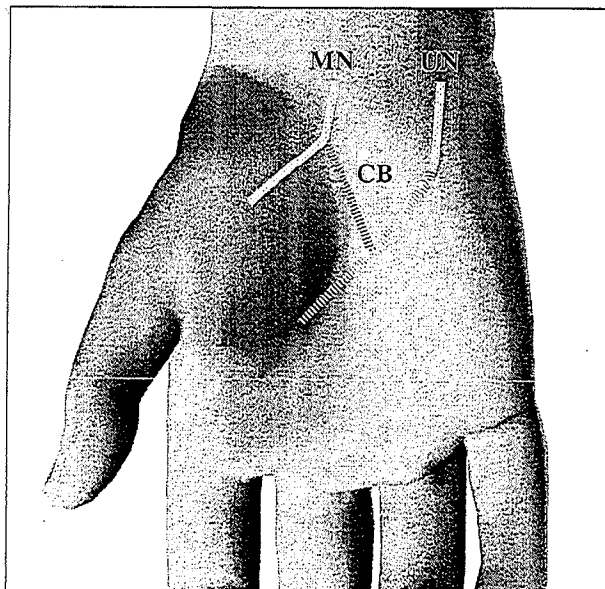


Figure 3. Schematic illustration of Riche-Cannieu anastomosis. (MN: median nerve; UN: ulnar nerve deep branch; CB: communicating branch)

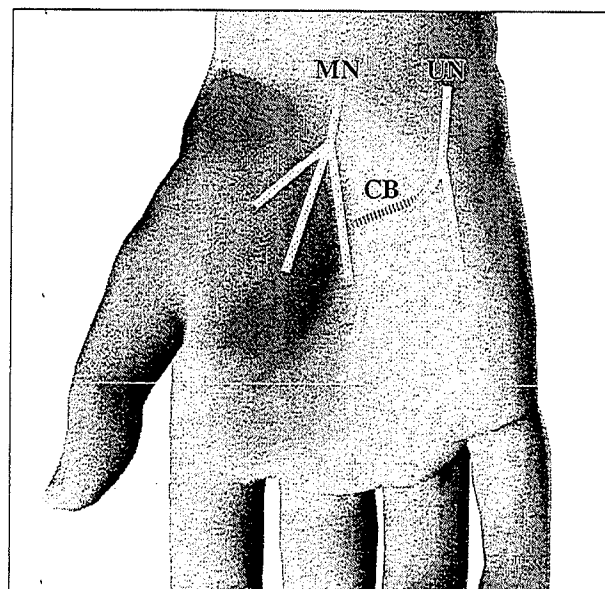


Figure 4. Schematic illustration of Berretini anastomosis. (MN: median nerve; UN: ulnar nerve; CB: communicating branch)

Ulnar to median nerve anastomosis, in the forearm, is generally known as a rare condition although its frequency for Riche-Cannieu anastomosis (RCA) was reported as 83.3%, 77% [27,29].

According to Boland et al. [9] these findings infer an hereditary basis for RCA, consistent with an autosomal dominant pattern of inheritance. In the American black population, this neural communication was detected statistically less frequently when compared with the other populations ($p < 0.05$). There was no significant difference in this percentage between the Caucasian and Hispanic populations [27].

Clinical presentations of RCA may vary, resulting in a hand that: 1) is completely supplied by the ulnar nerve [30]; 2) has motor innervation solely supplied by the ulnar nerve [31], as reported in a patient with a sensory presentation of cubital tunnel syndrome, but with weakness of abductor pollicis brevis [32]; or 3) has ulnar innervation for a proportion of typically median innervated muscles [33, 34].

Saperstein and King [35] reported that a patient with a deep branch ulnar neuropathy complicated by a RCA. His clinical presentation led to an initial diagnosis of motor neuron disease. Extensive electrophysiologic studies clarified the extent of the RCA and the ulnar neuropathy. This anastomosis in the setting of an ulnar or median nerve lesion can produce confusing clinical and electrodiagnostic findings [35].

Refaeian et al. [34] reported that this observed preservation of function and electrophysiologic responses are best explained by the presence of a RCA innervating the thenar eminence through branches from ulnar nerve.

Berretini anastomosis

The communications between common digital nerves that arise from the ulnar and median nerves in the palmar surface of hand is called 'ramus communicans cum nervi ulnari' in Terminologia Anatomica [36]. Overlap and variations of this division exist and communicating branch between the ulnar fourth common digital nerve and the median third common digital nerve can explain further variations in digital sensory patterns. Berretini's anatomic drawings from 1741 are the earliest illustrations of communicating branch [11].

The incidence of Berretini anastomosis reported in these studies [11-14] varied significantly (4-94%). Because, many investigators [11,13] found its incidence to be over 80%, the Berretini anastomosis should be considered a normal structure rather than an anatomic variation.

According to literature, the first report was published by Meals and Shaner [37] on definition of the Berretini anastomosis and than their classification was modified by other authors [11,13,15]. In the literature some researchers cited the clinical importance of Berretini anastomosis [13,38]. Rollins and Meals [38] described the sensory losses caused by traumatic laceration of the Berretini anastomosis. In that case, the patient lost sensation in the area between the middle and ring fingers. Loukas et al. [13] reported that the localization of Berretini anastomosis is important on the side effect of the injury of nerves. They mentioned that the extent of losses suffered from such injuries depends on the individual topography of the Berretini anastomosis within the affected patient.

A specific region was described as a 'danger zone' by Ferrari and Gilbert and defined this area extends as far as the middle half of the hypothenar eminence and is limited distally by the proximal transverse crease of the palm and on the radial side by the longitudinal crease between thenar and hypothenar eminence [12]. Don Griot [11] et al. described slightly different (more ulnar and radially and less distally) danger zone localization from Ferrari and Gilbert. Regarding the course of the Berretini anastomosis, Ferrari and Gilbert triangular danger zone extend than Don Griot rectangular one and it does not correspond with Don Griot observations.

Loukas et al. [13] reported that 'no differences were observed in morphometric or topographic parameters of Berretini anastomosis regarding age, race or sex, or between the specimens'.

The Berretini anastomosis is important to emphasize that because of the location in which the anastomosis occurs, iatrogenic injury is unlikely, and this is certainly what is observed clinically. This stems largely from the fact that neurosurgeons treating carpal tunnel syndrome are working superficially to the area of the Berretini anastomosis [13].

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