Palmar Type of Median Artery as a Source of Superficial Palmar Arch: A Cadaveric Study with Its Clinical Significance

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Abstract The superficial palmar arch (SPA) and its contributing arteries are highly variable. The palmar type of median artery (PMA) can be involved in the formation of the SPA by replacing the superficial palmar branch of the radial artery (RA) or the ulnar artery (UA). The present study was undertaken to investigate the presence of the PMA and its contribution in the formation of SPA in 42 cadavers (84 upper limbs) of Indian origin. When there was a PMA, its outer diameter was measured in the carpal tunnel. The PMA was found in 13 upper limbs (15.4%), and of these ten incidences (11.9%), the PMA took part in the formation of SPA, and in three instances (3.5%), the PMA did not make up part of the SPA. Out of the ten cases in which the PMA contributed to the formation of SPA, in six cases (7.1%), the PMA anastomosed with the UA; in three cases (3.5%), the

PMA anastomosed with both the UA and the RA, and in one incidence (1.1%), the PMA joined the arteria radialis indicis (deep branch of the RA) to complete the SPA. The outer diameters of the median arteries varied between 0.8 and 2.6 mm with the mean value of 1.7 mm. The present study concludes that the median–ulnar type of SPA was the most common type of SPA when the PMA was encountered as a source of superficial arterial arcade of the hand, followed by the radial–median–ulnar type. The vascular patterns found in this study are important to hand surgeons. The present study of PMA origin, course, and its contribution to the SPA will add to the existing knowledge of the vascular anatomy of forearm and hand.

Keywords Superficial palmar arch ·
Palmar type of median artery · Incidence ·
Carpal tunnel syndrome · Pronator syndrome ·
Indian population

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Introduction

The median artery (MA) is normally a transitory vessel, which develops from the axial artery of the upper extremity during early embryonic life. It maintains the superficial palmar arch (SPA) while the ulnar and radial arteries are developing [39]. When the ulnar and radial arteries develop, the MA usually involutes and does not persist in the post-fetal life [16]. The MA may persist in adult life in two different patterns, palmar and antebrachial, based on their vascular territory. The palmar type, which represents the embryonic pattern, is large, long, and reaches the palm. The antebrachial type, which represents a partial regression of the embryonic artery, is slender, short, and terminates before reaching the wrist [30]. The incidence and pattern of

a palmar type of MA (PMA) seem to depend on race; hence, the range given for its occurrence are extensive [7, 8, 13, 17, 29, 32, 34]. The SPA and its contributing arteries are highly variable. The MA can be involved in the construction of the SPA by replacing the SPA of the radial artery. In these cases, a MA, which is usually strongly developed than normal, accompanies the median nerve (MN) and ran through the carpal tunnel to connect itself with the SPA [6]. PMA can have a special topographical relation to the MN, carpal tunnel, and the anterior interosseous nerve. Therefore, the PMA can be involved in several clinical disorders like carpal tunnel syndrome (CTS) [4, 5, 10, 23], anterior interosseous nerve syndrome (AINS) [28], and pronator syndrome (PS) [16]. In the present study, we observed the frequency and the variable expression of the MA as a source of SPA.

Materials and Methods

Eighty-four upper limbs from 42 male embalmed human cadavers (fixed in 10% formaldehyde solution) from the western coastal region of India were studied. These limbs were previously used for routine dissection by undergraduate medical students. The forearms were carefully dissected and observed for the presence of the MA. When there was a MA observed, it was carefully dissected from its origin to its termination. The origin of MA and its relation with the MN was studied in detail. The external diameters of the MA were measured at the distal rim of the flexor retinaculum by a caliper, to a precision of 0.05 mm. The data from the left and right side were compared by the unpaired Student's *t* test. Differences were considered significant if $P < 0.05$.

Table 1 The details of palmar type of median artery.

No.	Side	Origin	Course of the median artery in relation to median nerve (forearm)	Course of the median artery in relation to median nerve (carpal tunnel)	Outer diameter of the median artery in the carpal tunnel (mm)	Type of superficial palmar arch
1	Right	UA	Lateral to the MN	Anterior to the MN	0.9	SPA was absent
2	Right	CIA	Crossed the MN from lateral to medial side. Pierced the MN	Anterior to the MN	1.7	Anastomosed with ARI (branch of RA)
3	Left	AIA	Crossed the MN from lateral to medial side	Medial to the MN	2.1	Anastomosed with both the APP (branch of RA) and the UA
4	Left	AIA	Crossed the MN from lateral to medial side. Pierced the MN	Medial to the MN	1.6	Anastomosed with the UA
5	Left	UA	Anterior to the MN.	Anterior to the MN	0.8	SPA was absent
6	Right	CIA	Lateral to the MN	Anterior to the MN	2.4	Anastomosed with both the APP (branch of RA) and the UA
7	Right	CIA	Crossed the MN from lateral to medial side. Pierced the MN	Medial to the MN	2.6	Anastomosed with the UA
8	Left	AIA	Crossed the MN from lateral to medial side. Pierced the MN	Medial to the MN	1.2	Anastomosed with the UA
9	Left	CIA	Lateral to the MN	Anterior to the MN	2.3	SPA was absent
10	Left	UA	Crossed the MN from lateral to medial side. Pierced the MN	Medial to the MN	2	Anastomosed with the UA
11	Right	UA	Crossed the MN from medial to lateral side. Pierced the MN	Anterior to the MN	1.7	Anastomosed with both the APP (branch of RA) and the UA
12	Left	CIA	Lateral to the MN	Anterior to the MN	1.4	Anastomosed with the UA
13	Left	AIA	Lateral to the MN	Anterior to the MN	2.2	Anastomosed with the UA

UA ulnar artery, RA radial artery, MN median nerve, APP arteria princeps pollicis, ARI arteria radialis indicis, CIA common interosseous artery, AIA anterior interosseous artery, SPA superficial palmar arch

Figure 1 Left upper limb exhibiting a median-ulnar type of superficial palmar arch. 1 radial artery; 2 palmar type of median artery; 3 ulnar artery; 4 median nerve; 5, 6, 7 common palmar digital arteries; 8 complete superficial palmar arch; 9 carpal tunnel. Note the palmar type of median artery piercing the median nerve (white arrow).

Results

Careful dissection of the upper extremities revealed the presence of persistent PMA in 13 of 84 upper limbs (15.4%), and its relation to MN are summarized in Table 1. We found it five times on the right and eight times on the left, respectively. The external diameters of the MA at the distal rim of the flexor retinaculum varied from 0.8 to 2.6 mm, the mean (SD) being 1.7 (0.5) mm. In ten of 13 cases, the MA made up part of the SPA, being anastomosed to the UA in six cases (7.1%; Fig. 1), with both the UA and RA in three cases (3.5%; Fig. 2) and only with the RA in a single instance (1.1%; Fig. 3). When the MA did not make up part

of the SPA ($n=3$), it supplied mainly the thumb and index finger through a common branch and the second interosseous space where it formed the common digital palmar artery ($n=1$; Fig. 4); in two cases, it supplied only the thumb and the index finger. The origin of MA was most frequent from the common interosseous artery ($n=5$). However, the MA was also seen arising from the UA and anterior interosseous artery in equal number of times ($n=4$). In six limbs (7.1%), the MA split the MN into two roots in the forearm, and the artery passed through the nerve ($n=84$; Table 1).

Discussion

The vascular anatomy of the upper limb is a complex and challenging area and has been the subject of many studies. One of the major problems involved in surgical approaches of the limbs is the occurrence of a strange anomalous arterial pattern [35]. This is due to the complicated mechanism of derivation of arteries from a simple type of axis artery of the limb. The axis artery disappears during the second embryonic month; however, it sometimes remains in the forearm as the median artery [30].

The MA as a component of the SPA has been described in the literature. Jaschtschinski [15] studied the SPA in 200 subjects and concluded that the median-ulnar and radial-median-ulnar types of SPA were observed in 3% and 0.5% of subjects, respectively [15]. Coleman and Anson ob-

Figure 2 Left upper limb exhibiting a radial-median-ulnar type of superficial palmar arch. 1 radial artery; 1a arteria radialis indicis artery; 2 palmar type of median artery; 3 ulnar artery; 4 median nerve; 5 complete superficial palmar arch; 6, 7, 8 common palmar digital arteries; 9 common interosseous artery.

Figure 3 Right upper limb exhibiting a radial–median type of superficial palmar arch. 1 ulnar artery; 2 radial artery; 3 palmar type of median artery; 4 median nerve; 5 arteria princeps pollicis; 6, 7, 8 common palmar digital arteries; 9 complete superficial palmar arch; 10 common interosseous artery; 11 anterior interosseous artery. Note the palmar type of median artery piercing the median nerve (black arrow).

served median–ulnar and radial–median–ulnar types of SPA in 3.8% and 1.2% of subjects, respectively [7]. Al-Turk and Metcalf found the same type of SPA in 4% and 2% of hands, respectively, by using the Doppler ultrasonic flow meter [2]. Ikeda et al. observed that the radial–median–ulnar type of SPA was absent in their study, and the median–ulnar type was found only in 0.9% of subjects [14]. Loukas et al. dissected 200 hands; they found the median–ulnar type (15%) and radial–median–ulnar type (6.1%) of SPA in very high percentage [22]; in contrast to this study, another study conducted by Tagil et al. showed an absence of both median–ulnar and radial–median–ulnar types [33]. Adachi (1928; quoted by Keen) reported the median–ulnar type of SPA in 9% of subjects [18], which is relatively close to the present study (7.1%). Moraes et al. reported the above occurrence in 13.3% of subjects [24]. Olave et al. observed the SPA formed by the ulnar and the median artery of the forearm without anastomosis in 6.7% subjects [25]. Moraes et al. reported the above occurrence in 3.3% subjects [14], which is similar to the present study (3.5%). Very rarely, the SPA is formed by the MA and a branch from the RA, which was termed as median–radial type of SPA by Adachi (1928; quoted by Keen [18]). Though the formation of the SPA by the MA and RA was mentioned in the literature, the occurrence in the different population is not known yet. In the present study, we observed the above rare variant of SPA in only 1.1% (one out of 84 upper limbs) subjects.

The origin of MA has previously been described as arising from the common interosseous artery, anterior interosseous artery, and ulnar arteries frequently [3, 4, 6, 8, 30, 32, 38], but it can also arise from the brachial artery, superficial brachial artery, and deep brachial artery [11, 27, 31]. Very rarely, the MA arose from the RA [1, 40]. According to Varley et al., when the MA arise from the RA, it may increase the risk of hand ischemia if the RA is sacrificed during harvesting. They also suggested that in the event of the above situation, the surgeons must be vigilant in order to ensure that its origin is not ligated during harvesting [37]. In the present study, we did not encounter

the MA taking origin from the brachial, superficial brachial, or RA, but we found the MA was taking origin from the common interosseous artery, anterior interosseous artery, and ulnar arteries with similar frequency.

The external diameter of a persistent MA is important, especially in the carpal tunnel. According to Barfred et al., the MA with an external diameter of more than 2.0 mm can cause MN compression. They operated 239 patients with CTS and found the MA of considerable caliber in 4% cases [5]. Gassner et al. found two MA with a diameter of 3.00 mm each while conducting color doppler ultrasonography on patients suffering from CTS [10]. MA is variable in size, with a diameter ranging from 0.5 to 2.7 mm [6, 26]. Libersa et al. measured the external diameter of the MA at the distal rim of the flexor retinaculum and obtained a value ranging from 0.8 to 2.5 mm [21]. In the present study, we obtained the above measurement of the MA between 0.8 and 2.6 mm, with the mean (SD) being 1.7 (0.5) mm. In six instances, the external diameter of the MA was 2.00 mm or more than the same (Table 1), which makes them potential cause for CTS. The MA can increase in the caliber due to thrombosis, aneurysm, calcification, or congenital regions, which may lead to CTS [4, 5, 20, 36, 41]

The MA may split the MN in the forearm on its way to the hand. A PS may be caused by a persistent MA that passes through the MN in the proximal forearm [9, 16]. Srivastava and Pande [32] conducted a study on 134 limbs of Indian origin and found that the MA splitted the MN into two roots in 1.5% subjects (two out of 134 limbs). In the present study, we found the above occurrence in six limbs (7.1%). According to Gutowski et al., a high bifurcation of the MN can be associated with a persistent MA [12]. Surgeons and clinicians should give emphasis on the coexistence of the MA and high bifurcation of the MN to avoid accidental injuries and also to increase effectiveness of surgical approaches [19]. Very rarely, the MA can compress the anterior interosseous nerve and cause the AINS. Proudman and Menz reported a case in which the MA pierced the anterior interosseous nerve just below the nerve and caused the paralysis of the flexor pollicis longus, the flexor

Figure 4 Right upper limb exhibiting absence of superficial palmar arch. 1 radial artery; 2 ulnar artery; 3 palmar type of median artery; 4 median nerve; 5 ulnar nerve; 6, 7, 8 common palmar digital arteries; 9 carpal tunnel.

digitorum profundus, and the pronator quadratus muscles [28]. In the present study, we did not encounter any instance in which the anterior interosseous nerve was pierced by the MA.

When we analyzed the course of the MA in relation with the MN in the present study, we observed three distinct pattern (Table 1): (a) The MA was lateral to the MN in the forearm (five out of 13), (b) the MA crossed the MN when the artery splitted the nerve in the forearm (six out of 13), and (c) the MA was anterior to the MN in the carpal tunnel (eight out of 13). The above details should be taken into consideration while approaching the forearm and hand for various surgical procedures as both the MA and the MN are in close proximity with each other throughout the forearm and hand.

Conclusion

Thus, from the above discussion, we can conclude that PMA and its clinical significance are immense, especially in respect to CTS, PS, and AINS. The PMA, when present, most of the time takes part in the formation of SPA. The present study of PMA origin, course, and its contribution to the SPA will add to the existing knowledge of the vascular anatomy of forearm and hand.

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