

# Morphological variants of the *human* superficial palmar arch and their clinical implications

Madhyastha, S., Murlimanju, BV.\*, Jiji, PJ., Saralaya, VV., Rai, A. and Vadgaonkar, R.

Department of Anatomy, Manipal University, Centre for Basic Sciences, Kasturba Medical College,  
575004, Bejai, Mangalore, India  
\*E-mail: flutesnowmm@gmail.com

## Abstract

**Introduction:** The traditional definition of superficial palmar arch consists of linkage between the superficial palmar branches of the radial and ulnar arteries. But it is interesting to know that this is not always the most commonly observed morphology. In the present study, the objective was to study the morphological variants of the superficial palmar arch in humans and to discuss their clinical implications. **Material and methods:** The study included 48 hands from the adult human cadavers. All the cadavers were available at the department of anatomy and fixed with 10% formalin solution. The morphology of the superficial palmar arch was studied in all the hands and the variations were noted. **Results:** Among our specimens, 45 (93.75%) hands had the usual morphology of the superficial palmar arch and the variant morphological patterns were observed in only 3 (6.25%) hands. In one of the hands, there was absence of formation of the arch; the other hand had the arch which was formed only by the ulnar artery. The third case though the arch was formed by the anastomosis between ulnar and radial arteries, showed the variation in its branching pattern. **Conclusion:** The present study had provided details about some of the morphological variants of superficial palmar arch in humans which will be enlightening for the operating hand surgeons and orthopedicians. Recent advances in the microsurgical techniques for reconstructive hand surgeries have necessitated the understanding of variant arterial arches, the comprehensive knowledge of which is important for the surgical interventions and successful outcome.

**Keywords:** morphology, radial artery, superficial palmar arch, ulnar artery, variation.

## 1 Introduction

The ulnar and radial arteries provide most of the blood supply to the hand (RUENGSAKULRACH, EIZENBERG, FAHRER et al., 2001). The superficial palmar arch (SPA) is a direct continuation of the ulnar artery. On entering the palm, it curves laterally deep to the palmar aponeurosis and superficial to the long flexor tendons. The arch is contributed on the lateral side by one of the branches of the radial artery (SNELL, 2004). It gives four palmar digital arteries, the medial most supplies the medial side of little finger and is termed as the proper palmar digital artery. The other three are common palmar digital arteries which pass to the medial three interdigital clefts (ROMANES, 2005). The classic morphology of SPA is defined as direct continuity between the ulnar artery and superficial palmar branch of the radial artery (RUENGSAKULRACH, EIZENBERG, FAHRER et al., 2001). Keen (1961) reported that, according to Adachi, there exist three types of SPAs, the type 1 (ulnar type), in which the arch is formed by the ulnar artery alone, type 2 (radio-ulnar type), which is considered as the classical type and the type 3 (median-ulnar or median-radial type), in which the median artery forms part of the arch.

Since the SPA is the main source of arterial supply to the palm, the details about its possible variations is important for the reconstructive hand surgeons. The knowledge is important while performing the superficial dissections and to the radiologists while performing the angiographic procedures (LATIFF, OTHMAN, SUHAIMI et al., 2008). Their variations being one of the challenging anatomical

areas have long intrigued clinicians and radiologists (DHAR and LALL, 2008). Though there are few cases reported in the literature (CAMBRON, FERRADA, WALCOTT et al., 2006; DHAR and LALL, 2008; VOLLALA, NAGABHOOSHANA, BHAT et al., 2008; NAYAK, KRISHNAMURTHY, RAMANATHAN et al., 2008; RAO, VOLLALA, PAMIDI et al., 2010) which describe the variations of SPA, the detailed anatomical studies about this subject are scarce. In the present investigation, the objective was to study the morphological variants of the SPA in adult humans. The clinical implications of these variant palmar arches are emphasized with relevant review of literature.

## 2 Materials and methods

The present study included 48 human cadaveric hands (24 right hand and 24 left hand) which were belonged to the gross anatomy laboratory of our department. Among them, 21 were male adult and 3 were female adult cadavers. They were fixed in 10% formalin solution. The hands were devoid of any external trauma and pathologies. The dissections of hands were performed as per the Cunningham's manual of practical anatomy (ROMANES, 2005). The course and branches of the radial and ulnar arteries in the hand were meticulously dissected, the morphology of SPA was studied and the variations were noted. The arches were observed and discussed by the two investigators of the present study in order to avoid the observer errors.

### 3 Results

Among our series, the SPA was observed to be classic in 93.75% (45) of specimens. In all these cases, the arch was formed by the anastomosis between superficial palmar branches of the ulnar and radial arteries. It was only three (6.25%) hands exhibited the variant morphological pattern of the SPA. In all the cases, the SPA was single and the double SPA was not found in any of the specimens. Among the variant patterns observed, one of the hands (2.08%) had the arch which was exclusively formed by the ulnar artery (Figure 1) without any contribution from the radial or median artery. In that right hand, the superficial branch of the ulnar artery gave five branches, one of which was the proper digital branch which passed to the medial side of little finger and the other four branches supplied the four web spaces.

Whereas in the other specimen, the SPA was not observed (Figure 2), in that left hand, the superficial branch of the ulnar artery after crossing superficial to the flexor retinaculum, gave two palmar digital arteries which entered the third and fourth web space. The palmar digital arteries to the first and second web spaces were found arising from the superficial branch of the radial artery, which entered the hand through the substance of abductor pollicis brevis muscle.

In the third variant (Figure 3) of our study, though the SPA was complete and formed by the superficial branches of radial and ulnar arteries, it exhibited the variation in branching pattern. In this SPA, in addition to the three common palmar digital arteries and one proper digital artery, the arch gave an additional palmar digital branch to the first web space (Figure 3) which divided into two branches. One of them followed the radial side of the index finger, representing the *arteria radialis indicis* and the other branch passed to medial side of the thumb representing the *arteria princeps pollicis*. In the usual morphology, the *arteria princeps pollicis* and *arteria radialis indicis* are supposed to arise from the radial artery. Here they were found arising from the branch of SPA. It was also observed that there was a transverse artery which connected the superficial branches of radial and ulnar arteries just proximal to the arch formation.

### 4 Discussion

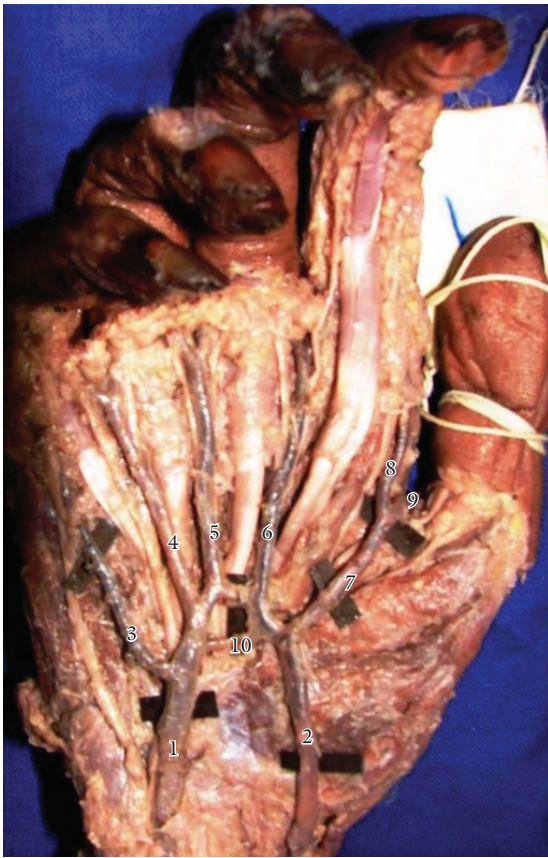
It is interesting to know that the SPA which is formed by the linkage between superficial palmar branches of the radial and ulnar arteries is not always the most commonly observed morphology (LOUKAS, HOLDMAN and HOLDMAN, 2005). The incomplete SPA was observed earlier by Loukas, Holdman and Holdman (2005) in 10% of their cases, 16% cases by Patnaik, Kalsey and Singla (2002) and Al-turk and Metcalf (1984) and 21.47% cases by Coleman and Anson (1961). The complete SPA was observed in 90% cases by Loukas, Holdman and Holdman (2005), 78% cases by Patnaik, Kalsey and Singla (2002), 84% of the cases by Al-turk and Metcalf (1984) and 78.46% cases by Coleman and Anson (1961). Among the complete arches, Loukas, Holdman and Holdman (2005) observed that 40% were formed by anastomosis of superficial palmar branch of radial artery with the ulnar artery (type 1), 35% were formed entirely by the ulnar artery (type 2), 15% of them had anastomosis between ulnar and median arteries (type 3), 6% showed anastomosis between ulnar, radial and



**Figure 1.** Cadaveric hand exhibiting the incomplete superficial palmar arch formed by ulnar artery alone; 1) superficial palmar branch of ulnar artery; 2) proper palmar digital artery; 3-5) common palmar digital arteries; 6) additional palmar digital branch to the first web space.



**Figure 2.** Cadaveric hand exhibiting the absence of superficial palmar arch; 1) superficial palmar branch of ulnar artery; 2) superficial palmar branch of radial artery; 3-6) common palmar digital arteries arising from the superficial palmar branches of ulnar and radial arteries.



**Figure 3.** Cadaveric hand showing the variation in branching of the superficial palmar arch; 1) superficial palmar branch of ulnar artery; 2) superficial palmar branch of radial artery; 3) proper palmar digital artery; 4-6) common palmar digital arteries; 7) additional palmar digital branch to the first web space; 8) arteria radialis indicis; 9) arteria princeps pollicis; 10) transverse communicating artery proximal to the arch.

median arteries (type 4) and in the remaining 4% cases, the arch was formed by a branch of the deep palmar arch communicating with the superficial arch. In contrast, Al-turk and Metcalf (1984) observed that 78% of the complete arches were having the classical radio-ulnar type, 4% had medioulnar type and 2% were of radiomedianoulnar type.

In the present study, there was a higher frequency of the classical type arches compared to that of previous studies from other authors. However the present study is in consistent with the findings of Al-turk and Metcalf (1984) as these authors observed this type of classical morphology in 78% of cases. The variant morphology of the arches was found in only 3 (6.25%) cases which is similar to the report of Latiff, Othman, Suhaimi et al. (2008), which observed the variant SPA in only one case (2%) from a study of 50 hand specimens.

Ottone, Prum, Dominguez et al. (2010) opined that the ulnar artery always takes part in the vascularization of the hand, whether it forms the arch or not. They proposed that any variations of the SPA depend completely on variations of the radial artery. In our series, we observed a case of SPA which was formed completely by the ulnar artery alone

(Figure 1). In the other case (Figure 2), the SPA was not observed. Bergman, Thompson, Afifi et al. (1988) described that, Jaschtschinski has observed 32% of absent cases of SPA. It was explained that, in cases where the SPA was not found, the lateral fingers are supplied by the superficial branch of radial artery. In these cases, harvesting the radial grafts can lead to dangerous complications like ischaemia and gangrene.

In the other specimen, we found that the arch gave an additional palmar digital branch to the first web space (Figure 3) which was dividing into arteria radialis indicis and arteria princeps pollicis. Ikeda, Ugawa, Kazihara et al. (1988) termed the artery which supplies the first web space and comes from the superficial arch as the first common palmar digital artery. The similar case was observed by Vollala, Nagabhooshana, Bhat et al. (2008) in which the superficial arch gave origin to four common palmar digital arteries instead of three and the first common palmar digital artery was divided into radialis indicis and princeps pollicis arteries. The arteries arising from the SPA which supply the first web space acquire great importance in case of absence of arterial supply from the deep arch to that region (VOLLALA, NAGABHOOSHANA, BHAT et al., 2008). In our specimen (Figure 3), it was observed that the thumb and radial side of the index finger were supplied by the superficial palmar arch instead of direct branches arising from radial artery. This finding is similar to that of Ruengsakulrach, Eizenberg, Fahrer et al. (2001) as they report that, in 66% of the hands all the fingers were supplied by the SPA. This case showed the predominance of the superficial arch over the deep arch in supplying the thumb and index finger.

Patnaik, Kalsey and Singla (2002) reports that, Manners Smith (1910) studied the comparative anatomy of arteries of hands in primates and proposed that many of the variations observed in human hand represent a persistence or reappearance of primitive patterns. His finding agrees with the embryological parallelism, ontogeny recapitulates phylogeny. Rodriguez-Niedenfuhr, Burton, Deu et al. (2001) described that, by stage 21 of the embryo, the radial artery acquires its final differentiated state. It was proposed that the arterial variations affecting the distal course of the radial artery must have established before the gestational stage 21 of the fetus (OTTONE, PRUM, DOMINGUEZ et al., 2010).

According to Bergman, Thompson, Afifi et al. (1988), the superficial arch can be reinforced by a large median artery which arises frequently from the anterior interosseus artery. Sometimes, the arch may be doubled, with the superficial branch of the ulnar and radial arteries dividing into two branches that anastomose across the palm. However in the present study, these kind of morphological variants were not observed.

The knowledge of arterial anatomy and its morphology may be of use in graft surgeries, especially when the arteries of upper limb are harvested for the coronary artery bypass grafts (LATIFF, OTHMAN, SUHAIMI et al., 2008). Recent advances in the microsurgical procedures for reconstructive hand surgeries have necessitated a clear understanding of the arterial variations (DHAR and LALL, 2008). The use of radial artery as the arterial bypass conduit is becoming popular among various hospitals. The harvesting of radial artery is an invasive procedure with potential risks, as suggested by sporadic reports of hand ischemia after the arterial removal (LOUKAS, HOLDMAN and HOLDMAN, 2005). It

was reported that the patients should be screened before harvesting the radial artery to confirm the presence of a viable collateral circulation in the hand (RUENGSAKULRACH, EIZENBERG, FAHRER et al., 2001). Cambron, Ferrada, Walcott et al. (2006) proposed that the colour doppler evaluation may be done in order to look for any arterial variations. According to Cable, Mullany and Schaff (1999), the Allen test could be used as a bedside evaluation to assess the collateral circulation.

The morphology of arterial arches of hand is important for microvascular surgeons as well as orthopaedicians (PATNAIK, KALSEY and SINGLA, 2002). The clamping of radial artery is contraindicated in cases of deficient collateral flow through the ulnar artery, as it can lead to ischemia and gangrene of the fingers (OTTONE, PRUM, DOMINGUEZ et al., 2010).

Injury to the SPA or ulnar artery can compromise the arterial supply of the fingers, especially if there is an insufficient anastomosis between the superficial and deep palmar arches (CALENOFF, 1972). Hence it is mandatory to conduct the investigations like Allen test, angiography and colour doppler studies of the hand before starting any invasive procedures including the vascular surgeries. We believe that the present study has provided the knowledge about few of the morphological variants of SPA in humans which will be enlightening for the clinicians who are involved in the surgical procedures of the hand. The knowledge about these variant arches is essential for the safe and successful outcome of the hand surgeries.

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