



Variations in Superficial Palmar Arch: Case Series with Clinico-anatomical Perspective

Yüzeysel Palmar Arkında Varyasyonlar: Klinik-anatomik Perspektifli Olgu Serileri

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ABSTRACT

The superficial palmar arch (SPA) is an important anastomotic network primarily formed by the superficial branch of the ulnar artery with one of the superficial branches of the radial artery. SPA variations were observed in three out of 20 cadaveric hand specimens. Two cases of unilateral incomplete SPA and the third case of a unilateral ulnar-to-median complete SPA were recorded. The incomplete SPA was located superficial to the flexor digitorum tendons and deep to the palmar aponeurosis. SPA in the remaining 17 hands was anatomically normal, with major contributions from the superficial palmar branch of the ulnar artery and minor contributions from the superficial palmar branch of the radial artery. These variations are clinically important, especially during procedures like arterial blood sampling, cardiac catheterization, and hemodialysis. Thus, anatomical variabilities in this region may cause complications with vascular occlusion if not ascertained before the procedure.

Keywords: Superficial palmar arch, median artery, incomplete palmar arch, complete palmar arch

ÖZ

Yüzeysel palmar ark (SPA), esas olarak ulnar arterin yüzeysel dalı ile radial arterin yüzeysel dallarından birinin oluşturduğu önemli bir anastomoz ağıdır. Kadavra örneklerinde 20 elden üçünde SPA varyasyonları gözlemlendi. İki tek taraflı inkomplet SPA olgusu ve üçüncü bir tek taraflı ulnardan medyana komplet SPA olgusu bulundu. İnkompelt SPA fleksör digitorum tendonlarının yüzeyselinde ve palmar aponevrozun derininde yerleşmiş bulundu. On yedi elin geri kalanındaki SPA anatomik olarak normaldi ve büyük katkı ulnar arterin yüzeysel palmar dalından ve küçük katkı radial arterin yüzeysel palmar dalından geliyordu. Bu varyasyonlar, arteriyel kan örnekleme, kardiyak kateterizasyon ve hemodiyaliz gibi prosedürler sırasında klinik olarak önemlidir. Bu bölgedeki anatomik değişiklikler işlem öncesi tespit edilmezse damar tıkanıklığı ile komplikasyonlara neden olabilir.

Anahtar kelimeler: Yüzeysel palmar ark, median arter, inkomplet palmar ark, tam palmar ark

INTRODUCTION

The complex intricate vascular patterns of the palm in the form of the superficial palmar arch (SPA) and deep palmar arch are challenging and fascinating areas of the hand anatomy. The vascular anatomy of the hand has become an extremely important area, with advancements in microsurgical functional hand reconstruction surgeries. The SPA is the direct continuation of the ulnar artery, with a contribution from the superficial palmar branch of the radial artery. Occasionally, the median

artery may contribute to the formation of SPA. The SPA is located dorsal to the palmar aponeurosis and ventral to the long flexor tendons and lumbrical in the hand¹. The literature suggests that the pattern of SPA formation is highly variable and that a complete SPA can be of the following types: ulnar, ulnar-to-radial, ulnar-to-median, and ulnar-to-median-to-radial^{2,3}. The incomplete SPA is a relatively common anatomical variation, albeit with a highly variable pattern of formation with no anastomoses between the committed arteries and, consequently, the incomplete arch is inefficient to maintain collateral

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circulation to the thumb and index fingers when the primary supply to them is either lost or reduced. The four classical varieties of incomplete SPA are designated as A, B, C, and D types by Coleman and Anson⁴. In type A (incidence >3%), both the superficial branches of the radial and ulnar arteries independently perfuse the hand, but without any anastomoses. Type B (incidence >13%) is an incomplete vascular arch formed solely by the ulnar artery. In type C (incidence 4%), the ulnar and median arteries supply the medial and lateral aspects of the palm similar to complete SPA but lacking anastomosis. Type D (incidence 1%) involves all three arteries (i.e., ulnar, median, and radial artery) perfusing the palm, but devoid of any collaterals among them. The Allen test, ultrasonography, or angiography should be performed to screen for incomplete SPA or patency of collateral circulation before performing routine procedures such as arterial blood gas (ABG) sampling and microsurgical procedures such as arterial graft and hand reconstruction surgeries. In addition to the variability in the anastomotic channels, SPA may demonstrate anatomical variability in its formation through the contribution from the median artery. The median artery accompanying the median nerve is the adult remnant of an embryonic vessel that normally regresses by the 8th week of intrauterine life⁵. The axis artery of the upper limb during embryogenesis is the median artery that usually regresses by the time the radial and ulnar artery fully develops⁶. A persistent median artery has been commonly reported, with an incidence rate of 1-16%⁷. However, as it is in close proximity with the median nerve right at its origin from the anterior interosseous artery coursing between the flexor digitorum and pronator teres distally within the carpal tunnel, it may, occasionally, lead to the development of compressive symptoms of the median nerve^{8,9}. This study aimed to explore the anatomical variabilities in the formation of SPA.

CASE REPORT

Twenty hands of 10 properly embalmed and formalin-fixed cadavers were used in this study. All the cadavers were donated to the department with written and informed consent for conducting whole-body dissection for educational and research purposes. The skin was reflected by a midline incision and cotton soaked in glycerin was applied intermittently to soften the area. Palmar aponeurosis was reflected to expose the SPA. All arteries contributing to the formation of SPA and the branches arising from the arch were exposed.

Case 1: The first case of incomplete SPA was observed in the right palm, wherein the superficial branch of the ulnar artery sprouted two branches superficial to the flexor digitorum tendons. The ulnar branch of the two continued as the common digital branches to the web space between the little finger and the ring finger and then supplied to the adjacent sides of the two digits with proper digital arteries. After a short course of approximately 0.5 cm, the radial branch re-divides into two common digital branches that perfuse the adjoining radial and ulnar sides of the middle three digits. One of the superficial branches of the radial artery appeared on the radial side of the palm by abnormally passing deep into the abductor pollicis brevis muscle. It continued further as the common digital artery to reach the web space between the thumb and the index finger and supplied to its adjoining sides. Therefore, this superficial branch of the radial artery mimics the *arteria radialis indicis*, albeit without any anastomoses (Figure 1, Case 1).

Case 2: The second case of incomplete SPA revealed a continuation of the superficial branch of the ulnar artery, which was observed to perfuse the palm similarly to that in the first case. This was noticed in the left palm (Figure 1, Case 2).

Case 3: The third cadaver exhibited unilateral left median artery completing the SPA, which arose from the anterior interosseous artery and then traveled along the median nerve under the cover of the pronator teres and superficial to flexor digitorum muscles until reaching the carpal tunnel. The SPA was formed distal to the flexor retinaculum in the palm with the contribution of the median artery and the ulnar artery. A common digital branch came from the median artery before joining the ulnar artery to complete the SPA. This common digital branch supplied the adjacent sides of the thumb and index finger via appropriate digital arteries. The remaining portion of the SPA in this cadaver supplied the palm with three common digital arteries and an appropriate digital artery on the ulnar side of the little finger (Figure 1, Case 3).

All incomplete SPAs were located superficial to the flexor digitorum tendons and immediately deep to the palmar aponeurosis. All these variations were unilateral. SPAs in the remaining 17 hands were anatomically normal, with major contributions from the ulnar artery and minor contributions from the superficial palmar branch of the radial artery.

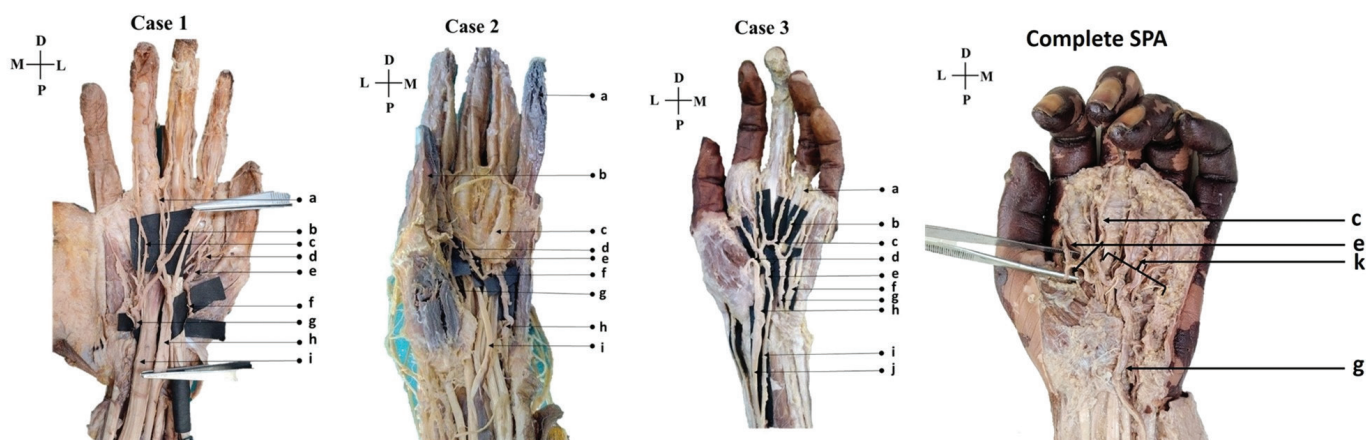


Figure 1. Case 1: a- proper digital artery to the ring finger, b- the common digital artery to the middle and index fingers, c- the common digital artery to the ring and little fingers, d- proper digital artery to the thumb, e- the radial artery superficial branch, f- the superficial branch of radial artery emerging deep to abductor pollicis brevis, g- the superficial branch of the ulnar artery, h- the median nerve in the wrist, i- flexor digitorum superficialis tendons.

Case 2: a- little finger, b- thumb, c- upturned palmar aponeurosis, d- common digital branch for index and middle finger, e- common digital branch for the middle and ring fingers, f- incomplete superficial palmar arch (SPA), g- the common digital branch of the median nerve, h- the superficial branch of the ulnar artery, i- the median nerve in the wrist.

Case 3: a- proper digital artery, b- common digital artery, c- SPA, d- the recurrent branch of the median nerve, e- the median artery, f- ulnar nerve, g- the ulnar artery continuing as SPA, h- the median nerve in the wrist, i- the median artery in the forearm, j- the median nerve in the forearm.

Complete SPA: Palm with complete SPA: c- the common digital artery, e- the superficial branch of the radial artery, g- the superficial branch of the ulnar artery, k- complete SPA formed by the ulnar artery superficial branch with superficial branch of radial artery.

DISCUSSION

Variable incidences as high as 50% of incomplete SPA have been consistently reported across studies^{10,11}. An elaborate Turkish cadaveric study involving 20 hands (similar to the sample size of the present study) revealed a 25% prevalence of incomplete SPA during the autopsy studies¹². A comparative comprehensive literature review is presented in Table 1 which summarizes the salient findings of the relevant studies concerning SPA formation and variations. A complete SPA and patent collateral circulation are prerequisites for procedures such as cardiac catheterization and hemodialysis. Because the arteries of the forearm are commonly utilized for these procedures, including the complex radial artery coronary grafting, a thorough knowledge of the normal vascular anatomy and every possible variant is desired^{13,14}.

The two described cases of incomplete SPA in this report match with type B of the classification system, as proposed by Coleman and Anson⁴ in the early 1960s. Several attempts have been made at different times to simplify the classification, and Kaplanoglu and Beton¹⁵

introduced three more categories, namely, types E, F, and G. Type E is characterized by an almost equal amount of perfusion of the palm and digits by the superficial branches of the radial and ulnar arteries. Type F resembles type B of Coleman’s classification system, with only the ulnar artery forming the incomplete SPA, while type G is a rare variety where the ulnar artery first sprouts two common digital arteries that re-divide into two and perfuse the lateral two and a half digits. In this report, Cases 1 and 2 fit the type B of Coleman’s classification system. The third case observed in the study revealed the median artery, a branch from the anterior interosseous artery completing the arch unilaterally on the left palm, in one of the 10 cadavers. This is usually considered a normal benign variant of complete SPA, wherein the median artery gives rise to a common digital branch, that is, it supplies to the palm and completes the arch. Although mostly benign, the perfusion of the palm through such a complete SPA can be compromised in pronator teres syndrome, compartment syndrome, and carpal tunnel syndrome, more so in coexisting co-morbid conditions such as in myxedema, rheumatoid arthritis,

Table 1. Comprehensive literature review of the relevant studies on the superficial palmar arch.				
Researchers	Sample size	Findings about superficial palmar arch		Study population & method of study
		Incidence	Other remarks	
Al-Turk and Metcalf ¹⁶ 1984	50	16%	The origin of radialis indicis and princeps pollicis arteries had frequent variations.	American, USG Doppler
Ikeda et al. ¹⁰ 1988	220	3.6%	The incomplete SPA frequency was almost the same as that of the complete arch of the radioulnar type.	Japanese, stereoscopic arteriography
Sañudo et al. ¹⁷ 1994	1	-	Persistent median artery in incomplete SPA.	Spanish, cadaveric
Gellman et al. ¹⁸ 2001	45	15.5	Ulnar artery continues as incomplete SPA in 11.1% but did not perfuse the thumb and index finger.	American, cadaveric vascular study after injection of Ward's red latex or Batson's compound injected into upper limb vessels followed by chemical debridement
Fazan et al. ¹⁹ 2004	46	57% on the right hand 48% on the left hand	In 10% the median artery substituted the radial artery to complete the SPA.	Brazilian, cadaveric
Bilge et al. ¹⁴ 2006	50	14%	The median artery completed the SPA in 8% of cases.	Turkish, cadaveric
Tsuruo et al. ²⁰ 2007	1	-	Bilateral persistent median artery completing SPA.	Japanese, cadaveric
Tağil et al. ¹² 2009	20	25%	Incomplete SPA in 25% of the case studies with absent Palmaris longus muscle in 33.3% of those with an anatomical variation of SPA.	Turkish
Dhar and Lal ²¹ 2008	1	-	The radial artery superficial branch coursed superficial to the thenar muscles replacing the radialis indicis artery.	Indian, cadaveric
Aughsteen ²² 2012	1	-	Two incomplete SPA formed by a superficial branch of the ulnar artery with a transverse communication superficial to the flexor retinaculum in the wrist having no contribution from the radial artery.	Jordanian, cadaveric
Singla et al. ⁷ 2012	60	-	6.6% of the studied cadaver had persistent median artery.	Indian, cadaveric
Feigl et al. ²³ 2012	702	52.15	4.5% of cadavers had persistent median artery.	Austria, cadaveric
Mohite et al. ²⁴ 2014	5	100%	Intermittent radial artery compression for 15 days in non-dominant hands of patients with incomplete SPA revealed collateral vessel development.	Indian, Doppler ultrasound
Gharravi et al. ²⁵ 2013	1	-	Described a single case of incomplete SPA of type A.	Iranian, cadaveric
Joshi et al. ²⁶ 2014	100	18	Low incidence of incomplete SPA of type B.	Indian, cadaveric
Singh et al. ²⁷ 2016	50	8	Incomplete SPA of type A was more frequent.	African, cadaveric

Table 1. continued				
Researchers	Sample size	Findings about superficial palmar arch		Study population & method of study
		Incidence	Other remarks	
van Leeuwen et al. ²⁸ 2017	234	-	The modified Allen test is a useful tool to detect SPA incompleteness with reasonable sensitivity and specificity.	Dutch, angiographic
Zarzecki et al. ¹ 2018	4841	18.7	Incomplete SPA of type B is the most frequent.	Polish, meta-analysis
Buch et al. ²⁹ 2019	1	-	Incomplete SPA of type B is the most frequent.	American, cadaveric
Gnanasekaran and Veeramani ³⁰ 2019	55	3.7%	Described and subdivided incomplete SPA into six sub-types.	Indian, cadaveric
Haładaj et al. ³¹ 2019	125	-	A persistent median artery was observed in 4% of specimens.	Polish, cadaveric
Sophia et al. ³² 2021	42	7.1	A persistent median artery was observed in 4.8%.	Indian, cadaveric
Solmaz et al. ³³ 2022	80	-	Incomplete SPA of type A was the most frequent.	Turkish, cadaveric + Radiological study of SPA of human fetuses

USG: Ultrasonography, SPA: Superficial palmar arch

and pregnancy. Overall, this case series reiterates and re-affirms that incomplete SPA and complete SPA with the median artery is an entity that could be encountered variably, and the exact percentage of incidence warrants evaluation in a large sample size. Thus, clinicians and hand surgeons should be well versed with every possible variant anatomy of this common, but extremely crucial incomplete SPA that will prevent untoward vascular events during invasive procedures on the arteries of the forearm and hand.

Incomplete SPA and variabilities in the formation of SPA with the contribution of the median artery are clinically important during procedures such as arterial blood sampling for ABG analyses, cardiac catheterization, and hemodialysis. Anatomical variabilities in this region may cause complications with a vascular compromise if left unexplored before the procedure. Therefore, the screening for the collateral patency of the SPA in hand by Doppler ultrasonography or angiography must be performed before any invasive procedures such as harvesting the radial artery for bypass grafts and free vascularized radial artery muscular flaps. Thorough knowledge of the common, as well as rare variants of the SPA, is thus desired for plastic and hand reconstructive surgeries.

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Ethics

Informed Consent: All cadavers used in this study were donated to the department with written and informed consent for carrying out whole-body dissection for educational and research purposes.

Peer-review: Externally peer-reviewed.

Author Contributions

Surgical and Medical Practices: D.B., R.K., Concept: D.B., R.K., S.S., Design: D.B., R.K., S.S., Data Collection and/or Processing: D.B., R.K., Analysis and/or Interpretation: D.B., R.K., S.S., Literature Search: D.B., R.K., Writing: D.B., R.K., S.S.

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