

Anatomical Variations Of The Superficial Palmar Arch In Human Cadaveric Hands

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Abstract

Background: The superficial palmar arch (SPA) is a critical vascular structure that supplies the palmar hand and exhibits considerable anatomical variation. These variations hold clinical significance in reconstructive surgery, trauma management, and vascular interventions. The current study aims to assess the formation and branching patterns of the superficial palmar arch.

Materials and Methods: A descriptive cross-sectional study was performed on 40 cadaveric hands dissected at RIMS, Imphal, from December 2023 to November 2024.

Results: Complete arches were observed in 72.5% (29/40) and incomplete in 27.5% (11/40). The radioulnar type was most prevalent (65%), followed by the ulnar type (27.5%), and the median-ulnar type (7.5%). These results align closely with prior studies, though inter-population variation was noted.

Conclusion: Understanding SPA variations is essential for preventing ischemic complications during surgical interventions involving the hand's vascular system. Preoperative assessment is recommended to mitigate risks associated with anatomical variability.

Key Words: Superficial palmar arch, Ulnar artery, Radio-ulnar artery, Median-ulnar artery

Date of Submission: 27-03-2026

Date of Acceptance: 07-04-2026

I. Introduction

The superficial palmar arch (SPA) is a vital vascular network in the human hand, primarily responsible for the blood supply to the palmar surface, digits, and associated soft tissues, bones, and joints. It is predominantly formed by the ulnar artery, with contributions from the superficial palmar branch of the radial artery, and occasionally by the arteria radialis indicis, princeps pollicis artery, or median artery.¹ Anatomically, the SPA is covered by palmaris brevis and palmar aponeurosis, and it lies superficial to the flexor digiti minimi, branches of the median nerve, and tendons of the long flexors and lumbricals, rendering it susceptible to injury during surgical procedures.^{1,2,3,4}

The SPA gives rise to three common palmar digital arteries and one proper digital artery, supplying the soft tissues, bones, and joints of the hand. The lateral sides of the index finger and thumb receive blood mainly from branches of the deep radial artery. Variations in the SPA are clinically significant for reconstructive hand surgery, microvascular procedures, reimplantation, flap reconstruction, and radial artery harvesting.⁵ It also plays an important role for radiologists while performing angiographic procedures.⁶

The SPA is classified based on the completeness of arterial anastomosis: 1) Complete arch: Full anastomosis among contributing arteries (~80% of cases) and 2) Incomplete arch: Partial or absent anastomosis (~20% of cases).^{7,8} According to Adachi the SPA is classified as: Type I – Ulnar type: Formed solely by the ulnar artery, Type II – Radioulnar type: Classical arch formed by ulnar and radial arteries and Type III – Median-ulnar type: The median artery contributes alongside the ulnar artery.⁹

When the ulnar or persistent median artery adequately perfuses the hand, the radial artery becomes less critical, permitting its use in coronary artery bypass grafting (CABG), finger reimplantation, and reconstructive surgery.^{10,11} The radial artery has been frequently employed in the coronary artery bypass grafting, with the superficial palmar branch as a landmark for distal radial artery dissection.^{8,11,12} The aim of the study is to evaluate the formation, branching patterns, and types of the superficial palmar arch, and to quantify the prevalence of complete and incomplete arches.

II. Materials And Methods

A descriptive cross-sectional study was conducted on 40 cadaveric hands at the Department of Anatomy, RIMS, Imphal (December 2023–November 2024).

The SPA was exposed via standard dissection methods. Arches were classified as complete or incomplete, then further categorised according to Adachi’s system into ulnar, radioulnar, and median–ulnar types.⁹ Data were tabulated and compared with existing literature.

Study Design: Descriptive cross-sectional study

Study Location: Department of Anatomy, RIMS, Imphal

Study Duration: 1 year (Dec 2023 – Nov 2024)

Sample size: 40 upper limbs

Sample size calculation: The sample size was estimated using the formula $n = Z_{(a/2)}^2 PQ/d^2 = 39.0093$, rounded to 40

Where $Z_{(a/2)} = 1.96$, $P = 3.8\%$, $Q = 96.2\%$ & d (absolute allowable error) = 6
(Taking $P = 3.8\%$ as reported by Joshi SB et al 2014).

Inclusion criteria: Cadavers and upper limb specimens used by the MBBS students available during the study period.

Exclusion criteria: Deformed, mutilated specimens.

III. Results

Table 1: Incidence of Complete and Incomplete Arches:

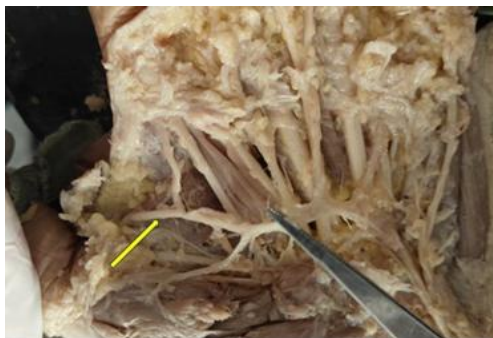
Type	Number	Percentage
Complete arches	29	72.5%
Incomplete arches	11	27.5%

Table 2: Classification of SPA

Type	Description	Number	Percentage
Type I – Ulnar	A. Formed by only ulnar artery, branches being 3 common digital arteries and 1 proper digital artery as branches	8	20
	B. Formed by only ulnar artery, 3 common digital arteries and 1 proper digital artery and princeps pollicis and radialis indicis arising from the arch	3	7.5
Type II – Radioulnar	Formed by ulnar and radial arteries, branches being 3 common digital arteries, 1 proper digital artery and a common digital artery for thumb and index finger	26	65.0
Type III – Median–Ulnar	Formed by ulnar and median arteries, branches being 3 common digital arteries and 1 proper digital artery	3	7.5
Total		40	100



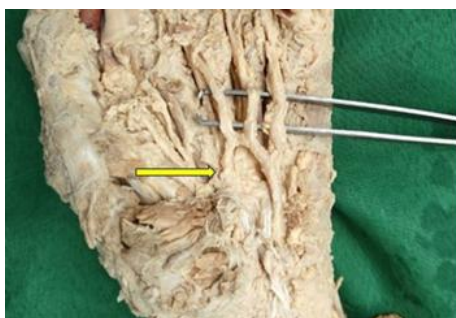
Type IA - SPA formed by the contribution of the ulnar artery only with 3 common digital arteries and 1 proper digital artery.



Type IB - SPA formed by the contribution of the ulnar artery and also have 3 common digital arteries and 1 proper digital artery and princeps pollicis and radialis indicis arising from the arch.



Type II - SPA was formed by the contribution of the ulnar and radial arteries with 3 common digital arteries, 1 proper digital artery and a common digital artery for thumb and index finger.



Type III - SPA was formed by the ulnar artery and median artery of the forearm and had 3 common digital arteries and 1 proper digital artery.

IV. Discussion

The superficial palmar arch (SPA) constitutes the principal arterial arcade supplying the palm and digits of the hand. Variations in its formation are of considerable clinical importance in hand surgery, reconstructive procedures, and vascular interventions. In the present study, 40 specimens of SPA were examined, of which 29 (72.5%) exhibited a complete arch and 11 (27.5%) an incomplete arch. The arches were classified into three types based on arterial contributions: ulnar type (Type I), radioulnar type (Type II), and median-ulnar type (Type III).

The ulnar type (Type I), formed exclusively by the ulnar artery, was observed in 27.5% of cases in the present study. This type was further subdivided into Type IA, in which the ulnar artery gave rise to three common palmar digital arteries and one proper digital artery to the little finger (20%), and Type IB, in which the ulnar artery gave rise to the 3 common digital arteries and 1 proper digital artery and princeps pollicis and radialis indicis arteries (7.5%). Previous studies have reported a wide range in the prevalence of the ulnar type.

Tian et al reported 31.9% (including 26.3% Type IA and 8.3% Type IB), Dawani et al reported 56.7%, Loukas et al reported 35%, and Gellman et al reported 31.1% (with 11.1% Type IA), the last one being relatively closer to the findings of the present study.^{7,13,14,15} Other investigators, such as Joshi et al and Singh et al, reported prevalences of 66% and 46%, respectively.^{12,16} In this configuration, the ulnar artery serves as the sole source of digital perfusion, emphasising its dominance in certain individuals.

The radioulnar type (Type II), considered the classical configuration of the SPA, was the most prevalent pattern in the present study, accounting for 65% of cases. In this type, the arch is formed by an anastomosis between the radial and ulnar arteries, giving rise to three common palmar digital arteries, one proper digital artery and a common digital artery supplying the thumb and index finger. The prevalence observed in the present study is comparable to that reported by Tian et al (63.8%).⁷ However, several other studies have reported lower frequencies, including Joshi et al (30%), Dawani et al (36.7%), Loukas et al (40%), Gellman et al (35.5%), Singh et al (44%).^{12,13,14,15,16} The radioulnar configuration provides robust collateral circulation within the palm and is considered the most reliable arrangement for surgical procedures involving manipulation or harvesting of either the radial or ulnar artery.

The median-ulnar type (Type III), in which the arch is formed by the ulnar artery in conjunction with a persistent median artery, branches being 3 common digital arteries and 1 proper digital artery, was observed in 7.5% of cases. Comparable studies have reported variable frequencies for this pattern, including 3.8% by Joshi et al, 3.3% by Dawani et al, and 15% by Loukas et al.^{12,13,14} The persistence of the median artery represents an embryological remnant and contributes to the formation of the SPA in a minority of individuals.¹⁷ This variant is clinically significant, as the median artery may provide an additional source of blood supply to the hand, particularly when either the radial or ulnar artery is compromised.

In the present study, complete superficial palmar arches, formed by an anastomosis between the ulnar artery and either the radial or median artery, were observed in 72.5% of specimens. Variable findings have been reported by Tian et al (68.1%), Joshi et al (82%), Dawani et al (96.7%), Loukas et al (90%), Gellman et al (84.4%), Ottone et al (58%), and Coleman et al (80%).^{7,12,13,14,15,18,19} In contrast, incomplete arches, characterised by the absence of a complete anastomotic loop, were observed in 27.5% of cases. Other authors have reported varying frequencies of incomplete arches, including Tian et al (31.9%), Joshi et al (18%), Loukas et al (10%), Gellman et al (15.6%), and Ottone et al (42%), while Dawani et al reported a lower prevalence of 3.3%.^{7,12,13,14,15,18} These differences may be attributed to variations in population characteristics, sample size, and classification criteria. The present findings are generally consistent with both classical and contemporary anatomical studies, which demonstrate that the radioulnar type is the predominant pattern of the SPA, followed by the ulnar and median-ulnar types. This variability highlights population-specific differences in SPA morphology.¹²

The observed variations in SPA formation can be explained by the embryological development of the upper limb vasculature. During early development, the median artery serves as the primary arterial supply to the developing hand. Subsequently, the radial and ulnar arteries enlarge and gradually replace the median artery as the dominant sources of blood supply. Although the median artery typically regresses, its persistence may contribute to the formation of median-ulnar or other variant arches. These developmental processes account for the anatomical variations observed across different populations.

Table 3: Comparative Prevalence of SPA Types Across Studies

Study	Ulnar Type (%)	Radioulnar Type (%)	Median-Ulnar Type (%)
Present Study	27.5	65	7.5
Dawani et al.	56.7	36.7	3.3
Loukas et al.	35	40	15
Tian et al.	31.9	63.8	-
Gellman et al.	31.1	35.5	-
Joshi et al.	66	30	3.8
Singh et al.	46	44	-

Table 4: Comparative Incidence of Complete and Incomplete SPA

Study	Complete Arch (%)	Incomplete Arch (%)
Present Study	72.5	27.5
Dawani et al.	96.7	3.3
Loukas et al.	90	10
Tian et al.	68.1	31.9
Gellman et al.	84.4	15.6
Joshi et al.	82	18
Otton et al.	58	42
Coleman & Anson (1961)	80	20

V. Conclusion

Knowledge of variations in the SPA is essential in vascular and reconstructive surgery of the hand. A complete arch provides effective collateral circulation, thereby reducing the risk of ischemia during procedures such as radial artery harvesting and arterial cannulation, as well as in cases of traumatic injury. In contrast, incomplete arches or atypical variants may compromise collateral blood flow, increasing the risk of ischemic complications. Therefore, preoperative assessment using clinical tests such as Allen's test, along with imaging modalities including Doppler ultrasonography or angiography, is strongly recommended prior to surgical intervention.

In conclusion, the present study demonstrates that the radioulnar type (Type II) is the most common configuration of the superficial palmar arch, followed by the ulnar type (Type I) and the median-ulnar type (Type III). The prevalence of complete arches (72.5%) observed in this study is in agreement with previously reported anatomical data. Nevertheless, the presence of incomplete arches and less common variants underscores the influence of population-specific and embryological factors. These findings emphasise the importance of detailed anatomical knowledge of SPA patterns for safe surgical planning, trauma management, and vascular interventions of the hand.

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