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RESEARCH ARTICLE

Variations of the Superficial Palmar Arch: A Cadaveric Study from South India

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Abstract

Background: The Superficial Palmar Arch (SPA) is an important part of the hand's vascular architecture. The ulnar artery, along with branches of the radial and median arteries, contributes to the formation of the superficial palmar arch. Surgeons need to be aware of the various variations of the SPA, especially while planning various surgical interventions in the hand. **Objectives:** To investigate the anatomical variations of the superficial palmar arch in cadaveric hands. **Methods:** The current cadaveric study was conducted at the Department of Anatomy, K.A.P.V. Government Medical College and MGMGH, Trichy. The study involved 50 hands (right and left hands were randomly selected) from the adult cadavers in the department of anatomy, K.A.P.V Government Medical College and MGMGH, Trichy. The hands which had evidence of trauma, pathological deformities and surgical procedures were excluded from the study. **Results:** We observed 5 variants of the superficial palmar arch; the commonest was the classical arch 34% (17/60). The variants observed were Ulnar Dominant type (26%), Radial Dominant (16%), Median Artery Contribution (14%) and the Complex Configuration (10%). The mean diameter of the ulnar arteries was 2.4 ± 0.2mm, while the mean radial artery was 2.3 ± 0.3mm. There was no significant difference in the presence of variants between the sides and among genders. **Conclusion:** We observed significant anatomical variations in the superficial palmar arch; this stresses the need for adequate knowledge regarding these variations, especially among surgeons specialising in hand surgery.

Keywords: Anatomical Variations, Cadaveric Study, Median Artery, Radial Artery, Superficial Palmar Arch, Ulnar Artery

1. Introduction

The superficial palmar arch is an arterial arcade and a dominant vascular structure in the palm. Superficial palmar arch is also known as superficial volar arch or superficial ulnar arch or arcus palmaris superficialis or arcus volaris superficialis. The palm is supplied by the superficial palmar arch. It lies inferior to the palmar aponeurosis and anterior to the long flexor tendons, lumbrical muscles and palmar digital branches of the median nerve. The convexity of the arch is directed distally with the distal border of thumb[1-3].

The vasculature develops by haemodynamically induced modelling and remodelling of multiple primitive vascular progenitors. Some of these anomalies are hereditary, while others are influenced by aberrant embryonic or environmental factors contributing to their aetiology. The development of the superficial palmar arch and its contributing arteries exhibits significant variety. The high rate of variations of the superficial palmar arch makes it an interesting area of study. The superficial palmar arch can be classified into complete and incomplete arches. A complete arch is defined as an anastomosis when all the vessels contributing to it (superficial branch of ulnar artery and completed by one of the branches of radial artery, *i.e.*, superficial palmar branch, arteria radialis indicis or arteria princeps pollicis). It is sometimes completed by the median artery. An incomplete arch has an absence of communication or anastomosis between the vessels constituting the arch. It is essential for surgeons, in addition to anatomists, to be aware of the various variations of the SPA, especially while planning various surgical interventions in the hand[4-7].

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2. Aim and Objectives

The superficial palmar arch shows variation in formation at the radial side. In the present study, we have recorded its data which would help in its clinical and surgical implications.

3. Review of Literature

Joshi *et al*. conducted an observational study among 100 upper limbs obtained from 50 cadavers in the department of Anatomy in Pune, India. The study was undertaken to study the anatomy of the superficial palmar arch and its variations. In the study, the cadavers were embalmed with 10% formalin and fixed. Palmar arches were dissected according to classical incisions and dissection procedures as per Cunningham's manual. They observed and recorded the variations of the superficial palmar arch. The variations were based on Adachi's and Coleman and Anson's classification of superficial palmar arches. They observed complete superficial palmar arches among 82% of the limbs, while incomplete superficial palmar arches were present among 18% of the limbs. The other variants observed were Ulnar type (66%), Radio ulnar type (30%) and Mediano ulnar type (4%). They concluded that the majority of hands showed a complete arch, which implied that collateral circulation is present in the majority of cases. They inferred that adequate knowledge of these variations would be useful in reducing the complications associated with radial artery harvesting for coronary bypass[6].

Challa *et al*.[8] conducted a cadaveric study to investigate the anatomical variations of the SPA using 60 cadavers. They classified the anatomical variations based on the arterial variations based on the structure and contributing arteries. They classified the variations into 5 types. The classical arch where the anastomosis was formed between the radial and ulnar arteries. The ulnar-dominant type of superficial palmar arch was formed by the ulnar artery alone. The radial dominant type was formed by the major contributions from the radial artery. The median artery contribution type received a major contribution from the median artery. The complex configuration type was formed by the ulnar, radial, and median arteries. They measured the ulnar and radial artery diameters and variations in the branching patterns of the common palmar digital arteries. They observed five main variations of the superficial palmar arch. They observed that the commonest variation was the classical Arch (32%), ulnar dominant (27%), radial dominant (15%), median artery contribution (13%) and Complex Configuration (13%). They observed the classic branching pattern of common palmar digital arteries in 40 hands. They observed no significant variation in the variations of superficial palmar arch types between the sides of hands and the gender of the cadavers. In their study, the mean diameters of the ulnar and radial arteries were 2.5 ± 0.3 mm and 2.2 ± 0.2 mm, respectively. Significant median artery contribution was present in 13% of the hands. The study highlights the importance of understanding these variations for anatomists and surgeons, particularly in hand surgeries, to minimise risks of iatrogenic injuries. The study concludes that knowledge of SPA variations is crucial for reconstructive hand surgeries and vascular procedures. They stressed the need for further research, which includes the usage of various imaging techniques to study the variations of the SPA *in vivo*, which could provide more detailed information about the functional implications[8].

Ramakrishnan *et al*.[9] conducted a cadaver-based study at the Department of Anatomy, Chettinad Hospital and Research Institute on 50 formalin-fixed hands. They conducted the study to document the anatomical variations in the Superficial Palmar Arch (SPA). They classified the variations based on the Coleman and Anson (1961). They classified the variations broadly into two categories, complete and incomplete. The variants in the complete group were further divided into 5 groups. They were Type A: classical radio ulnar arch, Type B: Ulnar arch, Type C: median ulnar arch, Type D: radio-median-ulnar arch, Type E: ulnar artery and a branch from deep arch. The variants in the incomplete group were further classified as Type F: radial and ulnar arteries without anastomosis, Type G: only ulnar artery without supply to the thumb and index finger, Type H: ulnar and median arteries without anastomosis. Their results showed that a complete arch of type A was seen in 43 (86%) hands, and type B was observed in 3(6%) hands. The incomplete arch was present in 4 hands (8%), while type H was seen in one hand (2%). They concluded that a thorough understanding of the vascular patterns in the palm is essential for microsurgical procedures,

amputations, the selection of the radial artery for coronary bypass grafting, and the prevention of potential complications during hand surgery. Recognising the existence of the median artery and its role in completing the arch is crucial for the closure of the radial or ulnar artery in instances of vascular trauma.

Mizoram *et al.*[10] conducted a cadaveric study in Durgapur, West Bengal, among 60 formalin-fixed hands. The study aimed to document the prevalence of superficial palmar arch variations among the cadavers dissected in the department of anatomy as part of the teaching curriculum. They observed that the normal complete arch was observed in 83.3 of % upper limbs, while anomalous branching patterns were observed in 16.7% of the limbs. Among the observed variants of the superficial palmar arch, an Incomplete arch with radial side contributed by the median artery was seen in 3.33% of the limbs, while an incomplete arch entirely contributed by the superficial branch of the ulnar artery was seen in 6.66%. The superficial palmar arch with a triple artery anastomosis was observed in one limb, and an incomplete arch with the superficial palmar branch of the radial artery supplying the radial side by giving rise to arteria radialis indices and princeps pollicis and remaining digital branches coming from the ulnar artery was seen in 3 specimens[10].

4. Materials and Methods

The current cadaveric study was conducted at the Department of Anatomy, K.A.P.V. Government Medical College and MGMGH, Trichy. The study involved 50 hands (right and left hands) from the adult cadavers in the Department of Anatomy, K.A.P.V. Government Medical College and MGMGH, Trichy. The hands which had evidence of trauma, pathological deformities and surgical procedures were excluded from the study. The collected data were entered and analysed using SPSS version 23.0. In the present study, the Superficial palmar arch was classified into five main types, namely the classical arch (Type A), which is formed by the anastomosis between the superficial branch of the radial artery and the ulnar artery. The ulnar dominant type (Type B) is formed only by the ulnar artery. The radial dominant type (Type C) is formed primarily by the radial artery. The median artery contribution (Type D) includes major contributions from the median artery. The complex configuration type (Type E) is formed by the combination of contributions from the ulnar, radial, and median arteries. The study also included measurement of the ulnar and radial arteries. These measurements were undertaken using a standardised digital caliper at the point of entry into the hand. The results were recorded to the nearest 0.1 mm.

5. Results (Including Observations)

In the present study, we examined 50 hands from formalin-fixed cadavers in the department of anatomy at K.A.P.V. Government Medical College and Hospital, Trichy. Among the examined limbs, 25 were right and left-sided. The limbs were dissected from 28 male and 22 female cadavers (Table 1).

The classical arch (Type A) was the most commonly observed (34%) type of superficial palmar arch. The ulnar dominant type (Type B) constituted 26%, while the radial dominant type (Type C) constituted 16% of the dissected limbs. The median artery contribution (Type D) and complex configuration type (Type E) were observed among 14% and 10% of the dissected limbs, respectively. In the present study, the average diameter of the ulnar artery at the point of entry into the hand was 2.4 ± 0.2 mm, while the radial artery measured an average of 2.3 ± 0.3 mm. (Table 2). The correlation

Table 1. Distribution of side, gender and Superficial Palmar Arch variants

	Frequency (n=50)	Percentage
Side		
Right	**25**	**50**
Left	**25**	**50**
Gender		
Male	**28**	**56**
Female	**22**	**44**
Variants of SPA		
Type A - Classical Arch	**17**	**34**
Type B - Ulnar Dominant	**13**	**26**
Type C - Radial Dominant	**8**	**16**
Type D - Median Artery Contribution	**7**	**14**
Type E - Complex configuration	**5**	**10**

Table 2. Arterial diameter measurements

	Mean	Standard deviation
Diameter		
Ulnar artery	2.4 mm	0.2 mm
Radial artery	2.3 mm	0.3 mm

between the various SPA variations between right and left hands revealed no significant difference, though the classical arch (Type A) was the most common variation among both the right and left hands. Similar trends were observed in all the variants of the superficial palmar arch in both limbs. The correlation between the various SPA variations between gender showed that the classical arch was the most common variation among both male and female cadavers. Similarly, trends were observed in all the variants of the superficial palmar arch among both genders. Though no statistical significance was observed with regard to gender distribution and the variants of the superficial palmar arch (Table 3).

6. Discussion

Recent advances in therapeutic microsurgical techniques in reconstructive surgeries in the hand and the grafting of the radial artery graft for Coronary Artery Bypass Grafting (CABG) have increased understanding of the vascular architecture of the palm, especially the anatomical variations. The development of anomalies of blood vessels may be attributed to various reasons, including the abnormal paths in the primitive vascular plexuses, the persistence of vessels which should be normally obliterated, the disappearance of vessels which should have been retained normally and incomplete development of the blood vessels. The present cadaveric study was undertaken among 50 cadaveric hands to document the anatomical variations of the superficial palmar arch (SPA). We observed 5 types of anatomical variations of the superficial palmar arch. The most commonly observed variation was the classical arch (Type A), present in 34% of the hands. This classical arch, formed by the anastomosis between the radial and ulnar arteries, is the most commonly observed configuration in various published literature and anatomical texts[1-3]. The second most prevalent type was Type B (26%), where the ulnar artery alone formed the arch, highlighting its dominance in supplying the hand. The other variants included Types C (16%), D (14%), and E (10%), were less frequently observed. The increased observation of the median artery contribution among 14% of the limbs reiterates the role of preoperative imaging to identify and preserve this vessel during surgical procedures. These findings indicate that though variations do exist, the classical and ulnar-dominant patterns are the most commonly observed types of superior palmar arch[8,11].

The diameters of the ulnar and radial arteries serve as vital reference points for surgeons, especially those handling reconstructive and microsurgeries. In the present study, the average diameter of the ulnar artery at the point of entry into the hand was 2.4 ± 0.2 mm, while the radial artery measured an average of 2.3 ± 0.3 mm. Similar observations have been reported by Challa *et al.*[8], who have reported similar findings in their cadaveric study. These measurements are essential for the planning of the surgical procedures, including the required instruments and modification and tailoring of the techniques to enhance positive patient outcomes.

We compared the distribution of various types of superficial palmar arches and the side of the hands (right and left), and gender revealed no significant variations. This indicates that though the variations were not dependent on the side of hand and gender,

Table 3. Correlation between gender, side and Superficial Palmar Arch variants

	Type A (n=17)	Type B (n=13)	Type C (n=8)	Type D (n=7)	Type E (n=5)	p value
Side						
Right	9	7	4	3	2	0.97
Left	8	6	4	4	3	
Gender						
Male	10	8	5	3	2	0.85
Female	7	5	3	4	3	

*pvalue of 0.05 was considered to be statistically significant

further research may be beneficial in reinforcing the applicability of these results across different patient populations. Challa *et al.*[8], Singh *et al.*[11] and Sembian *et al.*[12] have reported similar findings in their respective studies. Further research should be focused on the application of newer imaging techniques to examine the anatomical variants of the superficial palmar arch. These studies, if undertaken at multiple centres among various ethnic groups, would potentially yield more comprehensive insights into the functional implications of these anatomical disparities.

7. Summary and Conclusion

We observed significant anatomical variations in the superficial palmar arch; this stresses the need for adequate knowledge regarding these variations, especially among surgeons specialising in hand surgery. Understanding these variations can aid in optimising surgical approaches, reducing the risk of complications, and enhancing positive patient outcomes. The findings contribute to the existing body of knowledge and provide a foundation for further research in the current geographical area.

7.1 Limitations

The present study was a single-centre study; hence, the generalisability of the observations cannot be determined. Larger studies conducted among multiple centres and among various ethnic populations could contribute to exploring the incidence of factors like age and ethnicity in the incidence of anatomical variations of the superficial palmar arch.

8. References

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