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ORIGINAL ARTICLE

Morphological study of superficial palmar arch and the significance in clinical operation

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ABSTRACT

Background: The superficial palmar arch is a crucial blood supply to the palm. However, it exhibits significant variations, posing challenges in surgical procedures. Gaining a comprehensive understanding of the relationship between different types, physiological indices, and the clinical significance of the superficial palmar arch will enhance the accuracy of diagnosing and treating patients.

Materials and methods: In this study, we dissected a total of 72 specimens, comprising 39 males and 33 females. We observed the type, length, and diameter of the superficial palmar arch and analyzed its correlation with the disease. Additionally, we conducted Doppler ultrasound measurements on 20 healthy volunteers (10 males and 10 females) and 18 patients with superficial palmar arch injury (10 males and 8 females) to assess the classification, diameter, intimal thickness, and blood flow velocity of the superficial palmar arch. We collected information on 9 male patients with finger fracture and observed the classification of the superficial palmar arch, fracture healing time, and basic function recovery time. Lastly, we analyzed rare variant specimens encountered during the anatomy process.

Results: In the exploration of human anatomy, there were four types of superficial palmar arch: ulnar artery arch type in 17 cases (23.61%), radial ulnar artery type in 46 cases (63.89%), ulnar artery without arch type in 6 cases (8.33%), and 3 cases (4.17%) of double arch type of radial and ulnar artery. One case non-arched type was found in imaging examination (5%). In one elderly male specimen, the hand's superficial palmar arch artery was tortuous and dilated. In addition, there was a positive correlation between the diameter and length of the superficial palmar arch (except the second common palmar digital artery in women), among which the ulnar artery and the third common palmar digital artery had the strongest correlation. Compared to healthy volunteers, patients with ulnar injury in the Radial-ulnar artery type exhibited a decrease in the diameter and blood flow velocity of the ulnar artery, as well as the second and third common palmar digital arteries. No such change was observed in patients with radial injury. Additionally, patients with ulnar injury in other types of Radial-ulnar artery also experienced a decrease in the diameter and blood flow velocity of the ulnar artery. Finger fracture patients with Ulnar artery with arch and Ulnar artery without arch had shorter fracture healing time and basic function recovery time compared to those with Radial-ulnar artery type.

Conclusions: This study investigated the relationship between the classification, physiological index, and clinical significance of the superficial palmar arch at all levels. The results demonstrated that when the superficial palmar arch is damaged, it is important to consider both the classification and the site of damage, as this can potentially result in improved therapeutic outcomes. These findings provide a basis for future clinical research.

Keywords: superficial palmar arch, radial artery, ulnar artery, applied anatomy, hand surgery operation

INTRODUCTION

In recent years, there has been significant advancement in the study of hand-related anatomy, with its findings being effectively utilized in clinical research. Notable examples include the investigation of ulnar artery branch flap, the utilization of radial artery extraction in cerebral vascular bypass, transplantation of severely severed fingers, and upper limb flap repair for hand deletion [1–6]. The proportion of hand trauma has been increasing yearly due to the rapid development of industrial production. Standard surgical procedures for hand injuries include broken hand replantation and flap transplantation. Proficiency in navigating hand blood vessels and being aware of possible mutations is crucial for the success of these surgeries.

Radial artery harvesting is frequently employed in coronary artery bypass grafting, with its superficial palmar branch often serving as an indicator of distal radial artery dissection [7–10]. Consequently, a comprehensive understanding of the course and potential variations of the radial-ulnar artery can significantly mitigate the likelihood of surgical errors. Suppose there is an incomplete formation of the superficial palmar arch or variations and narrow abnormalities in the radial-ulnar artery. In that case, it can significantly increase the risk associated with the relevant procedure [8, 11]. The classification of the superficial metacarpal arch is a highly intricate topic with several variations. While there have been international studies on the morphological classification of the superficial palmar arch, research is scarce on the diameter of the arteries comprising the superficial palmar arch [12–14]. Arterial diameter is a crucial factor influencing blood flow and various indicators, and it plays a vital role in maintaining typical local structures and promoting efficient blood reperfusion. Understanding the vascular diameter of the superficial palmar arch in its normal state holds significant importance for guiding surgical or pharmacologic interventions and facilitating post-treatment repairs. Therefore, studying the morphologic typing and arterial diameter of superficial palmar arches is indispensable, and it also has clinical significance.

In the past, the research on superficial palmar arch is mostly limited to the superficial study of morphology, but lack of discussion of clinical significance. In this study, 72 gross specimens were dissected and the hands of 20 volunteers were examined. The classification, length, diameter, intimal thickness and blood flow velocity of superficial palmar arch were observed. Compared with the previous typing studies of superficial palmar arch, this study not only found a new typing: Double arch type of radial and ulnar artery. The significance of various physiological parameters of superficial palmar arch was also explored. Finally, these results are discussed in depth combined with clinical application. It is expected to provide new anatomical knowledge for practical clinical work.

MATERIALS AND METHODS

Material source

The anatomical study specimens comprised 72 embalmed and fixed adult gross specimens from the Human Anatomy Teaching and Research Laboratory of Guizhou Medical University. These specimens were voluntarily donated, including 39 male specimens and 33 females. The age range for males was 46–84 years, and for females was 48–88. All specimens were only perfused with a neutral formalin solution at a concentration of 10–20%. It is important to note that none of the selected specimens had a history of hypertension, as indicated by the antemortem data. The research process is shown in Fig. 1.

For our additional clinical study, we selected a group of 20 volunteers, comprising 10 men and 10 women. The age range for men was 42–76 years, while for women it was 44–80 years. The male participants had a height range of 164–174 cm and a weight range of 50–62 kg. The height of the female was 161–172 cm and the weight was 48–59 kg. Volunteers must rule out hypertension, diabetes, heart failure and other diseases that can affect the cardiovascular system. Doppler ultrasound instrument (Canon Aplio i800, Japan) was used to explore the blood vessels of the hand, the classification of superficial palmar arch, vascular diameter, wall thickness and blood flow velocity. The classification of superficial palmar arch, vessel diameter and flow velocity in different genders were initially explored to facilitate preclinical assessment of situations that might be encountered intraoperatively. Ethical review has been approved, approval number (2023-65).

Methods of human anatomy and measurement

The specimen was placed on the surgical operating table. Initially, a transverse incision was made along the third carpal transverse and the lateral side of the second finger to the medial side of the fifth finger. Subsequently, a longitudinal incision was made along the anterior carpal transverse incision's midpoint, extending to the middle finger's end (Fig. 2A).

The skin was carefully turned over to expose the superficial, deep fascia and the palmar tendon membrane after removing the superficial fascia and the short palmaris muscle. The palmar tendon membrane was severed at the finger web gap and turned upward. Along the lateral aspect of the pea bone, the lateral carpometacarpal ligament was excised, opening the lateral carpal ulnar canal to free the ulnar artery. The superficial palmar arch was traced along the main trunk of the ulnar artery. The composition of the superficial palmar arch was observed. Then the common palmar artery of the finger and the intrinsic palmar artery of the finger were freed along the arch (Fig. 2B).

The gross specimens of superficial palmar arch were photographed with camera (Sony α-6400, Japan). The length and diameter of artery were measured with Vernier caliper (500-153-30, Mitutoyo, Japan). The length of the ulnar artery was defined as the point from the transverse striation of the second wrist to the first common palmar digital artery (Fig. 2Ca). The length of the palmar artery of the third finger was defined as the bifurcation of the root of the finger (Fig. 2Cb). The length of the superficial palmar branch of the radial artery was defined as the point that passes through the thenar to the place where the first branch vessel is sent out (Fig. 2Cc). The diameter is measured at the midpoint of each segment.

Imaging measurement method

Two hours after the meal, the volunteers sat for 20 minutes with their arms flat and chest level. Doppler ultrasound examination was carried out at room temperature 21℃ and atmospheric pressure of 88.79 KPa. The pressure applied by the probe during the examination is standardized to avoid compressing the vessel and its eponymous vein. The Gate Size used for measuring the ulnar radial artery was 1 mm, while for measuring the three metacarpal arteries it was 0.5 mm and the tilt angle was 60°. The classification, length, diameter, intimal thickness and blood flow velocity of superficial palmar arch were investigated. Measuring the diameter refers to the distance between the center of the blood vessel and the adventitia on both sides (Fig. 2Dd). On the other hand, measuring the intimal thickness refers to measuring the thickness of the intimal layer on one side of the blood vessel (Fig. 2De).

Clinical research

A total of 18 patients (age 47 to 68), consisting of 8 women and 10 men, who had undergone superficial palmar arch vascular anastomosis due to palmar injury within the past 3 years and did not experience any significant postoperative complications, were included in this study. The patients were divided into two groups based on the location of the injury: ulnar injury and radial injury, with the middle finger serving as the dividing point. Doppler ultrasound was used to examine the classification, diameter, intimal thickness, and blood flow velocity of the superficial palmar arch, following the same standards as described above. The measured results were then compared with those of healthy volunteers after conducting statistical analysis.

A total of 9 male patients (age 48 to 59) with different types of superficial palmar arch were included in the study. These patients underwent surgery following finger fracture caused by trauma, and subsequently underwent professional rehabilitation training. The objective was to observe the time taken for fracture healing and the recovery of basic hand function. The obtained results were subjected to statistical analysis.

Statistical assessment

Statistical analysis was conducted using SPSS 27.0 software. Each group's mean and standard deviation were calculated, and the experimental results were expressed as mean ± standard error (SEM). Subsequently, correlation analysis was performed for each vessel length and the corresponding outer diameter. Then the R language and the package “corrplot”, “ggplot2”, “vcd”, “psych”, “ggrepel” and “ggcorrplot” were used to analyze the correlation between the diameter and length of blood vessels, and the correlation heat map was made. The correlation coefficient > 0.4 was considered to be significant, which was verified with the results obtained by SPSS.

RESULTS

Classification of the superficial palmar arch

In this experiment,72 gross specimens were dissected to study the way of vascular anastomosis. The findings revealed that the superficial palmar arch could be classified into four types: ulnar artery with arch (Fig. 3A), ulnar artery without arch (Fig. 3B), radial-ulnar artery type (Fig. 3C), and double arch type of radial and ulnar artery (Fig. 3D). The classification statistics for each specimen are presented in Table 1.

The ulnar artery with arch type (Fig. 3A) refers to the superficial palmar arch formed by the ulnar artery alone. This arch gives off branches to the thumb, which then form the main artery of the thumb. The ulnar artery without arch type (Fig. 3B) consists only of the ulnar artery, but its trunk goes straight to the base of the finger, not to the radial side. This type does not have branches of blood vessels to the thumb. The radial-ulnar artery type (Fig. 3C) is characterized by the superficial palmar arch formed by the radial artery’s superficial palmar branch and the ulnar artery's terminal branch. Lastly, the double arch type of radial and ulnar artery (Fig. 3D) is composed of the superficial metacarpal branch of the radial artery and the ulnar artery, but on the basis of forming the first superficial palmar arch, there is a thicker blood vessel between the radial and ulnar arteries, forming the second arch type. The distal arch sends out three palmar digital arteries in turn.

The overall results showed that the radial-ulnar artery type corresponded to a more significant percentage of both and were more prominent in females than males. The proportion of Ulnar artery without arch type is the second, and it is also more male. The proportion of the other two types is similar between male and female.

Analysis of diameter and length measurements of the superficial metacarpal arch

The findings (Table 2), in the same height and weight range, reveal that males generally exhibited greater length and external diameter for each vessel than females. Muscles need a lot of oxygen under exercise load, and this characteristic of the superficial palmar arch may be to adapt to the more developed hand muscles of men to produce more strength. Additionally, among the three common palmar arteries, the second common palmar artery displayed greater length and external diameter than the other two arteries, and this may be due to the effect of this artery supplying blood to the longest middle finger.

Based on the correlation analysis of the measured data, it was found that there was a positive correlation between the length and diameter of each segment of the superficial palmar arch (Table 3 and Fig. 4), except for the second common palmar digital artery of the female (Fig. 4C, D). In the vast majority of samples, the strong correlation of ulnar artery can be predicted. after all, it is the blood vessel that mainly makes up the superficial palmar arch. In some people without the superficial palmar branch of the radial artery, this is associated with an even more important need for blood supply. But surprisingly, the correlation intensity of the third common palmar digital artery is even stronger than that of the ulnar artery. Is this result caused by proximity to the superficial palmar arch? Or because it supplies blood to the ring finger, it has something to do with the most loyal and romantic finger and needs more blood irrigation (just a joke).

Imaging analysis of superficial palmar arch

Results of subtyping of palmar superficial arch in volunteers showed that a total of 4 types of superficial palmar arch (Table 4) were found in this stage□ulnar artery with arch, ulnar artery without arch, radial-ulnar artery type, non-arched type□non-arched type is a type that has not been found in gross anatomy (Fig. 5G). This type had both superficial palmar branch of radial artery and ulnar artery, but there was no relationship between them. The First common palmar digital artery originated from the superficial metacarpal branch of the radial artery, and the Second and third metacarpal arteries of finger originated from the ulnar artery. The volunteers did not detect any abnormality in hand activity and function.

Radial-ulnar artery type (RUT) and other types (OT) were divided into two groups for analysis, while non-arched type was summarized in RUT for analysis. The diameter of ulnar artery in OT is larger than that in RUT (Fig. 5A, D), and the intima and blood flow velocity also have this trend (Fig. 5B, C, E, F and Fig. 6A, B). Even in most RUT, the diameter of the ulnar artery is larger than that of the superficial palmar branch of the radial artery. These results suggest that there may be a compensatory relationship between the radial artery and the ulnar artery (Fig. 6C, D). There was no significant difference in intimal thickness of metacarpal arteries among the three fingers, but the diameter and blood flow velocity decreased from ulnar to radial. In other words, the third common palmar digital artery is the largest and the first common palmar digital artery is the smallest. This difference is consistent between the two genders (Fig. 5). This result also confirms the above inference that the proximal metacarpal digital artery is also affected by the increased compensation of the unilateral ulnar artery.

Results of clinical analysis

After collecting and analyzing the clinical data, we examined the data based on sex, classification of superficial palmar arch, and the site of damage. Among the 10 male patients, there were 7 cases of RUT and 3 cases of OT. Similarly, among the 8 female patients, there were 5 cases of RUT and 3 cases of OT. Our data collection revealed that in the RUT type (Table 5), the diameter and blood flow velocity of the ulnar artery, as well as the second and third common palmar digital artery, were lower in comparison to the healthy volunteers. However, there were no significant changes observed in the radial damage. In the case of the OT type (Table 6), the diameter and blood flow velocity of the ulnar artery decreased in patients with ulnar injury. On the other hand, the diameter and blood flow velocity of the third common palmar digital artery decreased in male patients. Additionally, 5 patients with RUT type and ulnar injury reported experiencing numbness in the ulnar side and fingertips of their palms from 1 to 2 years after exercising. This condition was not observed before or after the operation.

After observing patients with finger fractures (Table 7), it was found that there are two types of patients: Ulnar artery without arch and Ulnar artery with arch. Both types experience shorter times for bone healing and basic recovery of finger function compared to Radial-ulnar artery type patients.

Analysis of anomalies in the superficial palmar arch

This variant is observed in an elderly male specimen. The right hand showed a tortuous dilated superficial palmar arch and was missing the superficial palmar branch of the radial artery (ulnar artery with arch). Similarly, the left hand exhibited an ulnar artery without an arch (Fig. 7, 8). This variant was compared with another specimen from an average elderly male in the same batch, as described below.

In the right hand of the variant specimen, compared with the right hand of the normal specimen, the ulnar artery begins to enlarge gradually below the radial-ulnar joint, and both the ulnar artery of the little finger and the first common palmar digital artery appear to have a tortuous course. The common palmar artery of both the second and third fingers displayed a consistently tortuous path, with a prominent ‘C’ shape observed in the palmar aspect of the second finger. In the variant specimen, the main trunk of the right ulnar artery continued its tortuous path toward the thumb and bifurcated into two arteries. One artery extended towards the radial side of the second finger, while the other artery joined with the radial artery to form the main artery supplying the thumb. Both arteries exhibited tortuous characteristics. Standard specimens have the ulnar artery traveling in the same position but without tortuosity and have a confluent superficial palmar branch of the radial artery on the side of the emanating branch. In the variant specimen of the left hand, the ulnar artery enters the palm and then passes through two successive circular tortuosity. It gives off two arteries: the ulnar palmar collateral artery of the little finger and the common palmar artery of all three fingers. These arteries are slightly tortuous but do not branch off towards the thumb. The situation in the left hand of a normal specimen is similar to that of the right hand.

DISCUSSION

Guidance on the application of anatomical classification of superficial palmar arch in hand surgery

This study observed five types of superficial palmar arches: ulnar artery with arch, ulnar artery without arch, radial-ulnar artery type, double arch type of radial and ulnar artery, and non-arched type. These different types may be attributed to the gradual degeneration of the median artery, which forms the superficial palmar capillary plexus, and its replacement by the radial and ulnar arteries. The ulnar artery appeared earlier and connected with the deep palmar arch, while the radial artery appeared later and was connected with the superficial palmar arch [12, 15–17]. As a result, the superficial palmar branch of the radial artery was sometimes absent. Some scholars suggest that the disappearance of certain vessels that are usually present persisted while the preservation of vessels that are typically absent occurred. This indicates that the primitive vascular plexus chose a different pathway during development, leading to incomplete development of the vasculature and the formation of different subtypes [14].

Since the ulnar artery with arch and the ulnar artery without arch form the superficial palmar arch alone in the five types of classification, safer surgical protocols need to be specified for these patients in hand surgery. Care must be taken to ensure that the hand is not severely ischemic during surgery when the ulnar artery and its branches are used as a flap donor. After an injury to the ulnar side of the hand, patients with ulnar artery type need to be treated promptly to ensure the blood supply to avoid ischemic necrosis of the hand because the superficial palmar arch is supplied by the ulnar artery alone.

When arterial cannulation of the radial artery is performed, hand ischemia is less likely to occur in the normal radial-ulnar phenotype with more abundant collateral circulation. In the remaining types with less collateral circulation, the probability of hand ischemia is significantly increased if thrombosis occurs during cannulation. The risk of hand ischemia increases when radial artery extraction is performed with incomplete superficial palmar branch configuration or radial artery atherosclerosis in the radial-ulnar model.

The first dorsal metacarpal artery flap is commonly used in reconstructive surgery for distal limb defects [18, 19]. It comes in different forms, including the island flap, the pedicled flap, and the retrograde flap. In most cases, the artery of this flap travels to the index finger and thumb, resulting in a low probability of ischemia. However, in the ulnar artery without arch type, where there is no artery supplying the index finger and thumb, it is not recommended to use the first dorsal metacarpal artery for flap creation. Doing so would significantly increase the risk of index finger and thumb ischemia.

The non-arched type needs to pay attention to the unilateral injury of the radial and ulnar side during the operation, because the blood supply on both sides is independent, and blood circulation needs to be established as soon as possible to prevent the occurrence of ischemic necrosis.

Guidance on the use of superficial palmar arch alignment length and diameter in hand

surgery

The results showed that the vascular length and diameter of superficial palmar arch and its branches in males were larger than those in females. Except for the second common palmar digital artery of the female, the diameter and length of the other vessels were positively correlated.

Among the several types which are not composed of the superficial palmar branch of the radial artery, it can be known that the parameters of the ulnar artery have been enhanced, regardless of the diameter or blood flow velocity. This change may be related to the compensatory blood supply of the ulnar artery. At the same time, we also found that when the diameter of the superficial palmar branch of the radial artery is smaller, some of the ulnar artery have larger diameter, which also supports this conclusion. In these types, the diameter and blood flow velocity of the three metacarpal arteries decreased gradually from the side near the ulnar artery to the side close to the radial artery. However, they are all larger than the values of the same blood vessels of the same sex, which means whether the blood vessels will adapt to this change and make structural changes under the action of long-term blood pressure.

This correlation has some clinical guidance. The Allen test is often used to determine whether the collateral circulation between the radial and ulnar arteries is rich. Referring to the results of the present study, if the subject is a woman with a long vascular course, releasing the ulnar artery after acute compression may lead to a false-negative result in the Allen test since the small diameter of the vessel requires a certain amount of time for arterial blood flow to recover. In some surgical patients, the superficial palmar arch gives rise to branches that travel to the index finger and thumb, which are supplied with arterial blood by the superficial palmar arch and the first dorsal metacarpal artery, which originates from the radial artery. Suppose the superficial palmar arch branches travel longer than the first dorsal metacarpal artery. In that case, the outer diameter of the vessel becomes smaller, and the first dorsal metacarpal artery may regain its blood supply faster when both are subjected to an acute compression test. When this occurs in patients with ulnar arteries without arches, false-positive results may occur, thus interfering with the diagnosis.

When performing dissection and reimplantation in the palm, it is common to use the superficial vein as a graft vessel to compensate for the missing artery. It is crucial to locate a vessel that closely matches the morphology, length, and diameter of the vessels in the superficial palmar arch. Understanding the relationship between the course and diameter of the vessels in the superficial palmar arch in both men and women makes it feasible to identify a suitable replacement vein for timely and precise anastomosis with the damaged vessel. In patients with non-radioulnar injuries, the ulnar tube has a large diameter and rapid blood flow, so it is necessary to quickly stop the bleeding and repair it. Because of the small diameter and slow blood flow after radial injury, it is necessary to find suitable blood vessels for reconstruction in time to ensure blood supply.

In clinical practice, it is essential to carefully consider the morphologic typing of the superficial palmar arch, the length of the vascular course, the diameter size, and their relationship. This information can assist in making more efficient and effective decisions regarding diagnosis and treatment options. By doing so, the potential risks of adverse outcomes can be avoided.

Practical guiding significance of clinical cases

The results indicate that in the most common Radial-ulnar artery type injury, the diameter and blood flow velocity of the ulnar artery and the second and third metacarpal arteries near the ulnar side decrease after the injury and subsequent operation. However, the damage to the radial side of the palm does not show significant changes. In the superficial palmar arch composed of ulnar artery alone, there is a decrease in both the diameter and blood flow velocity of the ulnar artery after the injury. This suggests that injury to the ulnar side of the palm gradually alters the nature of the superficial palmar arch, particularly affecting the ulnar vessels after the operation.

This can result in insufficient blood supply to certain areas, leading to more serious complications following another injury. In the emergency department, doctors often prioritize the severity of the injury and perform vascular anastomosis as quickly as possible, paying little attention to the differences in the types of superficial palmar arch. However, it may be beneficial to develop more targeted surgical approaches based on the specific location of the palm injury. These findings highlight the importance of protecting the larger vessels on the ulnar side when using pedicled skin flaps to repair injuries in other areas of body. Improper removal of the flap can potentially cause injuries to the ulnar part of the palm.

Patients with Radial-ulnar artery type were found to have injuries in the ulnar part of the palm, congestion, and numbness in their palms within 1 to 2 years after the operation. Based on the measured results, it is possible that blood fills the hands after exercise, but the blood vessels narrow and the blood flow is not smooth. These findings partially support these assumptions, which serve as a foundation for further clinical research on hand conditions. However, additional experiments are required to validate these conclusions.

The blood supply to the fingers mainly comes from the proper palmar digital artery, which is distributed along the contralateral margin of fingers 2–5. The proper palmar digital artery is a branch of the common palmar digital artery of the superficial arch of the palm. Therefore, the blood supply to the fingers is closely connected to the superficial palmar arch. The collected data indicate that the superficial palmar arch, which is composed of the ulnar artery, is shorter in bone healing time and basic function recovery time compared to the radial-ulnar artery type. This difference may be attributed to the increased nutritional requirement after finger damage, as different types of superficial palmar arch have varying capacities for blood compensation.

Speculation on the cause of the formation of the anomalous superficial arch

During the present study, we discovered an elderly male specimen with a substantial diameter in one of his hands. Upon observation, it was noted that the superficial palmar arch displayed a significantly expanded diameter and exhibited severe tortuosity compared to other specimens from the same group of elderly males. As a result, we reported this variant specimen in a separate study alongside the normal elderly male specimens from the same batch.

Autopsies conducted by Troisi L et al. [20]. found that the probability of absence of the superficial palmar branch of the radial artery was 5.3%. In contrast, Bundi B N reported a 5–

7% incidence of a superficial palmar branch of the radial artery variant after 100 autopsies [21]. This shows that the condition is not very rare. However, instances of severe tortuosity and dilatation in hand vessels, along with the absence of the superficial palmar branch of the radial artery, are infrequently reported. A thorough literature review discovered that this arterial variation closely resembled the arterial morphology observed in tortuous dilatation, characterized by tortuous, dilated, and elongated arteries, among other features. However, this condition is typically observed in the vertebral-basilar arteries and carotid arteries and is associated with hypertension, hyperlipemia, atherosclerosis, and other related factors [22–24].

The possible causes of the anomaly observed in this specimen are analyzed as follows. In this case, the anomaly may be attributed to age-related vascular sclerosis, leading to increased pressure in the ulnar artery and tortuous dilatation. It is worth noting that the right leg of this specimen is disabled, and as a result, the hand often bears more force to support the body. This increased pressure may contribute to the tortuous and dilated superficial blood vessels, with the right hand showing more severe symptoms. However, no apparent abnormalities are observed in the superficial arch of the palm.

In hand surgery, paying attention to the alignment and curvature of the superficial palmar arch when dealing with this variant is essential. If the tortuous enlarged blood vessels are injured, it can lead to severe ischemia of the hand due to the high pressure and reliance solely on the ulnar artery for blood supply. Therefore, it is crucial to avoid such injuries to prevent severe blood loss and ischemia.

CONCLUSIONS

The superficial palmar arch is an important structure of the blood supply of the hand. This study provides valuable data for the classification, diameter, length, blood flow velocity and variation of superficial palmar arch, and is related to clinical significance, emphasizing their practical application in surgery. The anatomical characteristics of these vessels can be taken into account in clinical practice so that they can be diagnosed and treated more accurately.

Article information and declarations

Data availability statement

We declare that there is no problem accessing the dataset used.

Ethical approval

The experimental research procedure has been supported by The Ethics Committee of Guizhou Medical University and approved as (2023-65). The research project is in line with the moral code of the Helsinki Declaration of 1975. These methods are carried out in accordance with the approved guidelines.

Author contributions

Renwei Tian: Nature and level of contribution to the article; Hebei Tai: Project development, Material collection; Jingyi Chen, Yating Zhang: Experiment development; Data collection: Shaoqian Zhang, Jiayi Li: Data statistics; Data analysis: Xiaoying Li, Yan Linghu: Data visualization; Yumei Li: Source of funds; Manuscript review

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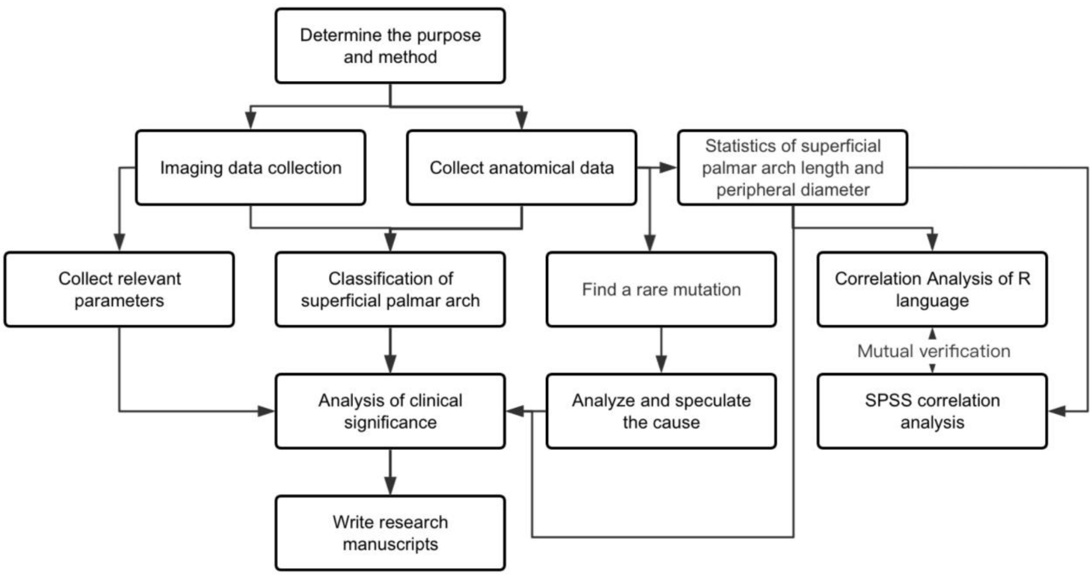

Figure 1. Research flow chart

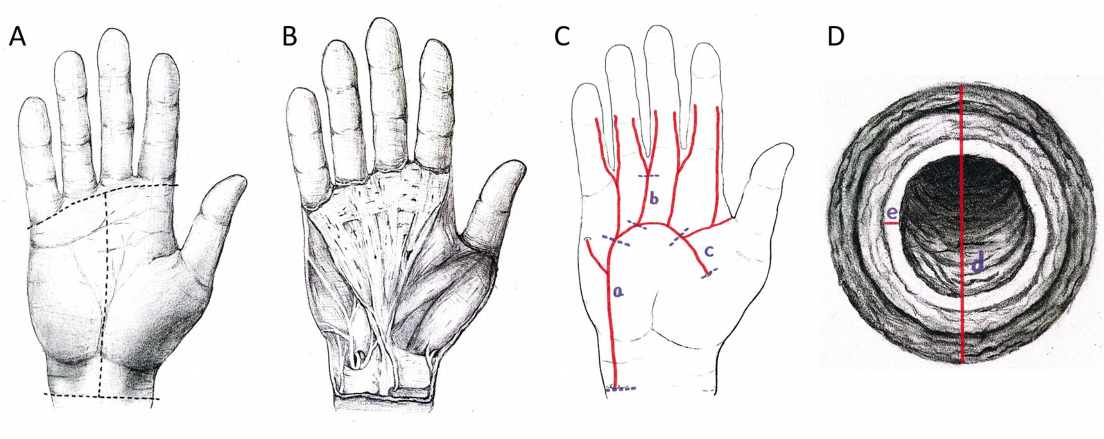

Figure 2A. Skin incision; **B.** Superficial structure of palm; **C.** Schematic diagram of vascular measurement method; **D.** Blood vessel cross section; a — the length of the ulnar artery was defined as the point from the transverse striation of the second wrist to the first common palmar digital artery; b — the length of the palmar artery of the third finger was defined as the bifurcation of the root of the finger; c — the length of the superficial palmar branch of the radial artery was defined as the point that passes through the thenar to the place where the first branch vessel is sent out; d — diameter of vessel; e — intimal thickness of vessel.

Table 1. The proportion of various types of gross anatomy

Gender	Ulnar artery with arch		Ulnar artery without arch		Radial-ulnar artery type		Double arch type of radial and ulnar artery	
	Cases（n）	Proportion（%）	Cases（n）	Proportion（%）	Cases（n）	Proportion（%）	Cases（n）	Proportion（%）
Male	9	23.08	4	10.26	24	61.54	2	5.13
Female	8	24.24	2	6.06	22	66.67	1	3.03
Total	17	23.61	6	8.33	46	63.89	3	4.17

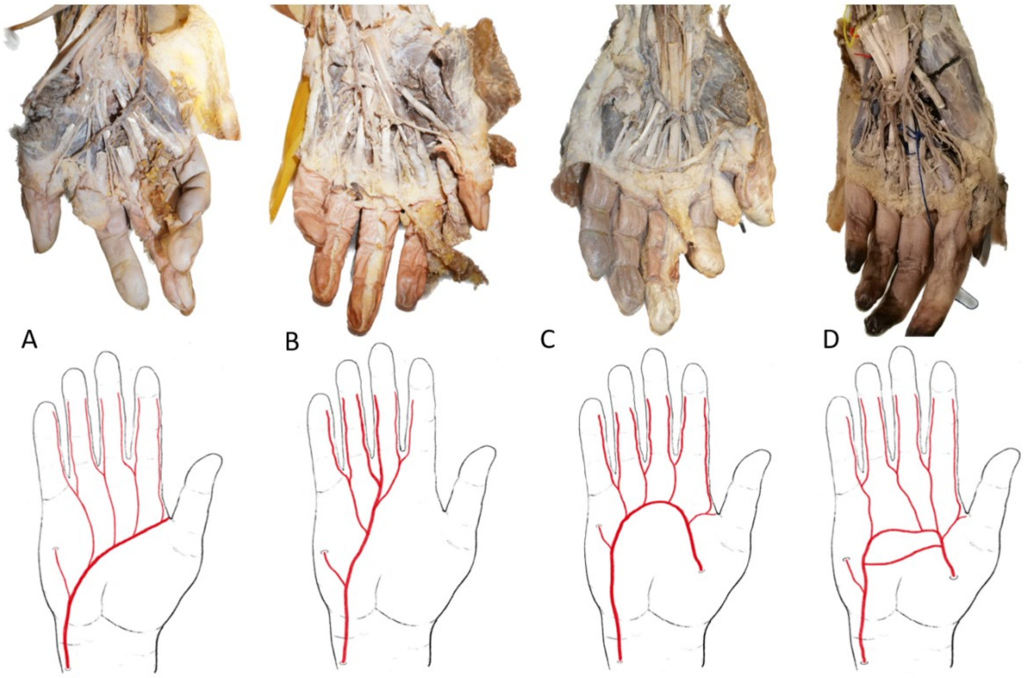

Figure 3. Classification of superficial palmar arch; **A.** Ulnar artery with arch (17 cases, 23.61%); **B.** Ulnar artery without arch (6 cases, 8.33%); **C.** Radial-ulnar artery type (46 cases, 63.89%); **D.** Double arch type of radial and ulnar artery (3 cases, 4.17%)

Table 2. Measurement data of each specimen

Gender	Superficial palmar branch of radial artery		Ulnar artery		First common palmar digital artery		Second common palmar digital artery		Third common palmar digital artery	
	Length (cm)	Diameter (mm)	Length (cm)	Diameter (mm)	Length (cm)	Diameter (mm)	Length (cm)	Diameter (mm)	Length (cm)	Diameter (mm)
Male	2.88 ± 0.44	3.08 ± 0.39	3.31 ± 0.55	3.58 ± 0.67	3.71 ± 0.35	2.98 ± 0.41	3.91 ± 0.50	3.20 ± 0.48	3.64 ± 0.42	2.66 ± 0.48
Female	2.47 ± 0.21	2.47 ± 0.28	2.55 ± 0.30	2.76 ± 0.39	2.70 ± 0.50	2.63 ± 0.35	2.98 ± 0.45	2.63 ± 0.38	2.62 ± 0.37	1.74 ± 0.32

Table 3. Detection of correlation between measured length and peripheral diameter of blood vessels

Gender	Superficial palmar branch of radial artery	Ulnar artery	First common palmar digital artery	Second common palmar digital artery	Third common palmar digital artery
Male	0.519**	0.768**	0.502**	0.849**	0.806**
Female	0.878**	0.904**	0.860**	0.325	0.990**

**p < 0.01

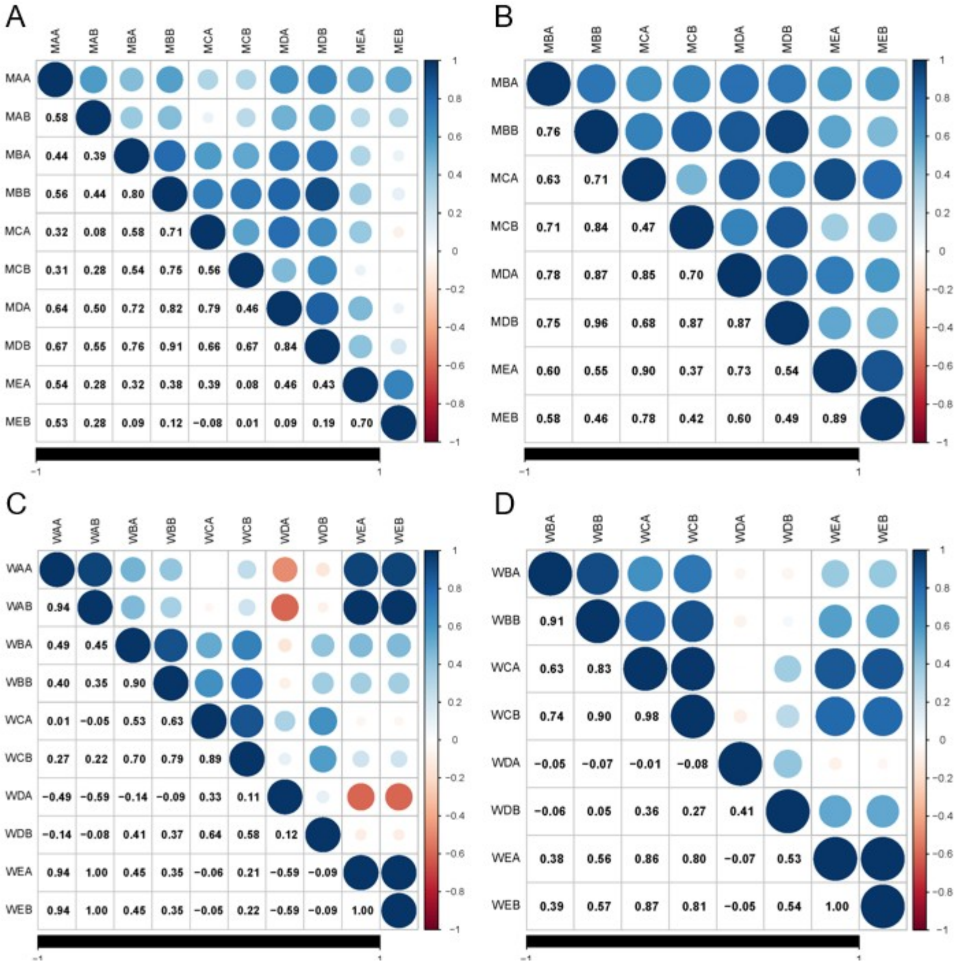

Figure 4A. Male radioulnar artery type and double arch type of radial and ulnar artery; **B.** Male other two types; **C.** Female radioulnar artery type and double arch type of radial and ulnar artery; **D.** Female other two types. Correlation analysis. The lower left corner represents the correlation coefficient, and the darker the upper right corner represents the stronger the correlation. The first letter M of the coordinates stands for male and W for female. The second letter A, B, C, D and E respectively stand for superficial palmar branch of radial artery, ulnar artery, first common palmar digital artery, second common palmar digital artery, third common palmar digital artery. The third letter A stands for length and B for peripheral diameter

Table 4. The proportion of various types of image examination

Gender	Ulnar artery with arch		Ulnar artery without arch		Radial-ulnar artery type		Non-arched type	
	Cases（n）	Proportion（%）	Cases（n）	Proportion（%）	Cases（n）	Proportion（%）	Cases（n）	Proportion（%）
Male	2	20	2	20	6	60	0	0
Female	3	30	2	20	4	40	1	10
Total	5	25	4	20	10	50	1	5

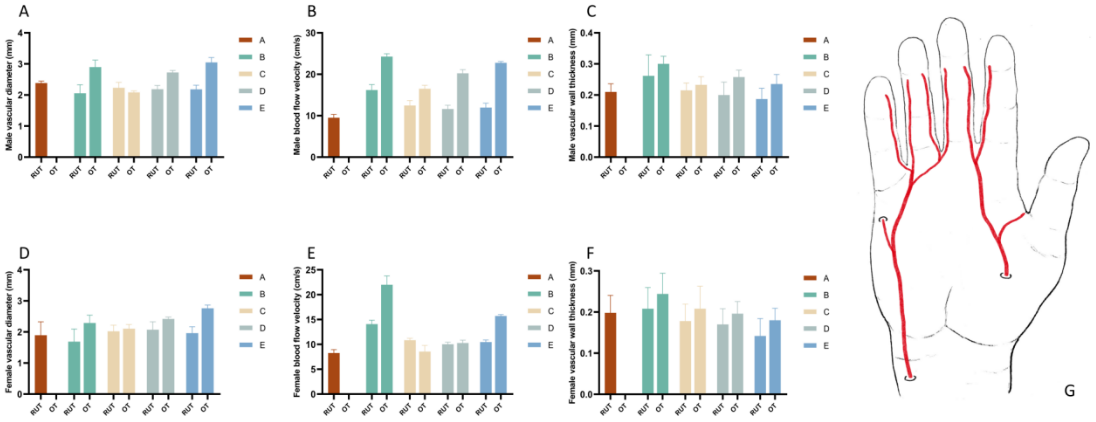

Figure 5A–F. Graphs of the results of imaging examination; **G.** Non-arched type

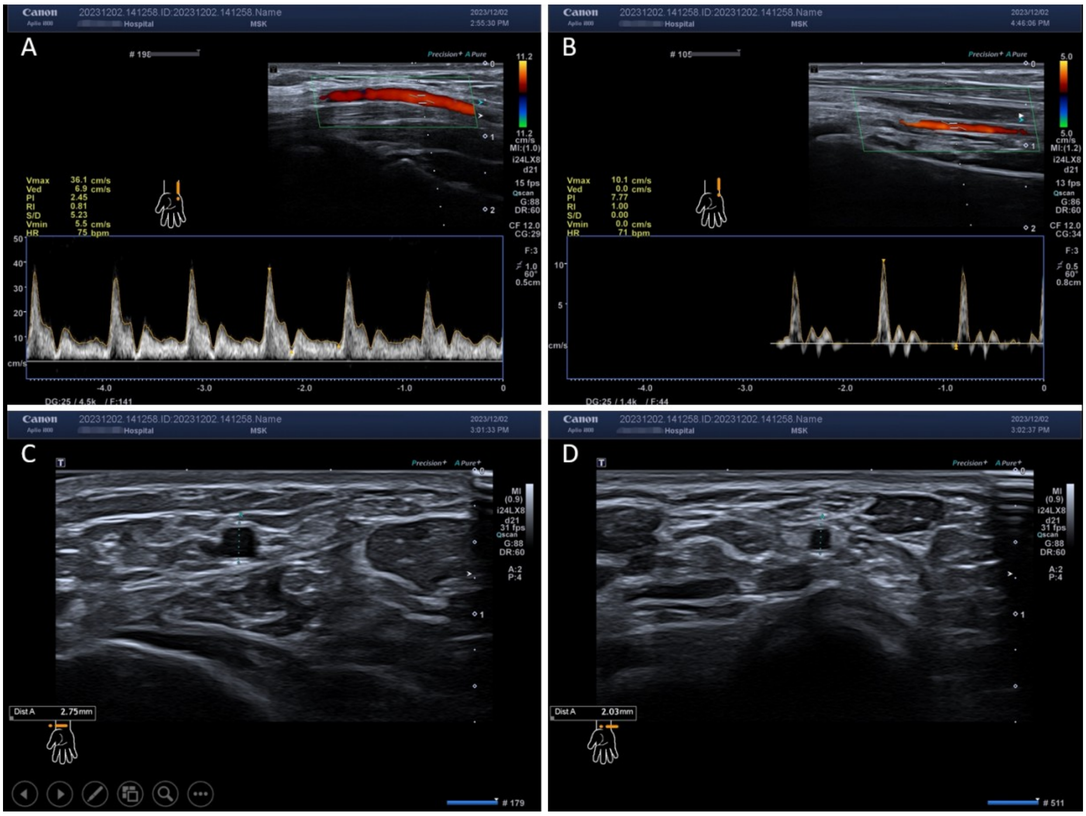

Figure 6A. Ulnar artery blood flow velocity of a ulnar artery with arch male (height 167 cm, weight 57 kg, age 68 years); **B.** Ulnar artery blood flow velocity of a radial-ulnar artery type male (height 165 cm, weight 55 kg, age 69 years); **C.** Peripheral diameter of superficial palmar branch of radial artery in a radial-ulnar artery type male (height 168 cm, weight 54 kg, age 64 years); **D.** The same peripheral diameter of ulnar artery as C male

Table 5. Measurement results of patients with Radial-ulnar artery type

First common palmar digital artery	
blood flow(cm/s)	Diameter (mm)
11.77 ± 0.15	2.08 ± 0.13
10.00 ± 0.85	2.11 ± 0.14
9.04 ± 0.42	2.02 ± 0.20
19.18 ± 1.84	2.00 ± 0.16
18.9 ± 4.53	2.01 ± 0.15
18.50 ± 3.00	2.23 ± 0.17

Ulnar artery			Superficial palmar branch of radial artery			Third common palmar digital artery			Second common palmar digital artery		
blood flow(cm/s)	Diameter (mm)	Intimal thickness(mm)	blood flow(cm/s)	Diameter (mm)	Intimal thickness(mm)	blood flow(cm/s)	Diameter (mm)	Intimal thickness(mm)	blood flow(cm/s)	Diameter (mm)	Intimal thickness(mm)
8.67 ± 0.71	1.14 ± 0.08	0.19 ± 0.02	12.00 ± 0.26	1.81 ± 0.14	0.17 ± 0.01	7.10 ± 0.44	1.29 ± 0.07	0.19 ± 0.02	8.27 ± 0.65	1.46 ± 0.06	0.20 ± 0.03
11.85 ± 0.78	1.77 ± 0.06	0.21 ± 0.03	12.25 ± 0.92	1.88 ± 0.06	0.15 ± 0.03	10.50 ± 1.84	2.16 ± 0.06	0.18 ± 0.01	10.90 ± 0.42	2.11 ± 0.12	0.18 ± 0.02
11.68 ± 1.65	1.69 ± 0.41	2.20 ± 0.04	12.26 ± 0.68	1.90 ± 0.43	0.14 ± 0.04	9.38 ± 0.60	1.96 ± 0.21	0.17 ± 0.04	10.44 ± 1.23	2.07 ± 0.26	0.18 ± 0.04
10.03 ± 0.57	1.14 ± 0.12	0.17 ± 0.03	13.9 ± 0.80	2.49 ± 0.14	0.17 ± 0.03	17.00 ± 1.70	1.49 ± 0.20	0.19 ± 0.06	17.95 ± 2.86	1.68 ± 0.36	0.21 ± 0.05
13.80 ± 1.67	1.94 ± 0.08	0.21 ± 0.02	16.00 ± 1.01	2.35 ± 0.06	0.24 ± 0.05	18.63 ± 1.34	1.82 ± 0.07	0.19 ± 0.03	21.33 ± 1.63	1.93 ± 0.14	0.18 ± 0.05
15.33 ± 4.38	2.29 ± 0.30	0.21 ± 0.03	14.67 ± 2.36	2.44 ± 0.16	0.19 ± 0.04	19.50 ± 1.22	2.18 ± 0.13	0.20 ± 0.04	19.87 ± 1.07	2.19 ± 0.12	0.22 ± 0.02

Table 6. Measurement results of other types of patients except Radial-ulnar artery type

Third common palmar digital artery		Second common palmar digital artery			First common palmar digital artery		
blood flow(cm/s)	Diameter (mm)	Intimal thickness(mm)	blood flow(cm/s)	Diameter (mm)	Intimal thickness(mm)	blood flow(cm/s)	Diameter (mm)
20.07 ± 1.76	2.41 ± 0.16	0.19 ± 0.02	16.50 ± 2.69	2.29 ± 0.27	0.19 ± 0.02	11.83 ± 1.21	2.06 ± 0.06
21.32 ± 1.14	2.76 ± 0.10	0.20 ± 0.03	16.68 ± 1.01	2.42 ± 0.06	0.21 ± 0.05	13.56 ± 1.23	2.10 ± 0.14
23.70 ± 0.72	2.58 ± 0.24	0.20 ± 0.01	19.27 ± 1.65	2.79 ± 0.12	0.21 ± 0.03	18.50 ± 0.96	1.88 ± 0.20
26.85 ± 1.32	3.05 ± 0.16	0.26 ± 0.02	22.10 ± 1.24	2.73 ± 0.06	0.23 ± 0.03	18.95 ± 0.95	2.09 ± 0.05

Gender	Injured site	Number	Intimal thickness(mm)
Female	Ulnar side	3	0.28 ± 0.02
Female	Radial side	2	0.22 ± 0.04
Female	Healthy volunteers		0.21 ± 0.05
Male	Ulnar side	4	0.21 ± 0.03
Male	Radial side	3	0.18 ± 0.04
Male	Healthy volunteers		0.26 ± 0.07

Gender	Injured site	Number	Ulnar artery			
			Intimal thickness(mm)	blood flow(cm/s)	Diameter (mm)	Intimal thickness(mm)
Female	Ulnar side	3	0.22 ± 0.01	17.73 ± 1.46	1.49 ± 0.05	0.18 ± 0.04
Female	Healthy volunteers		0.24 ± 0.05	25.98 ± 1.79	2.61 ± 0.16	0.18 ± 0.03
Male	Ulnar side	3	0.21 ± 0.04	30.20 ± 2.13	1.42 ± 0.15	0.23 ± 0.04
Male	Healthy volunteers		0.30 ± 0.02	35.60 ± 1.09	3.13 ± 0.33	0.24 ± 0.03

Table 7. Result statistics of patients with fracture

Type	Number of people	Bone healing time (week)	Functional recovery time (week)
Radial-ulnar artery type	4	6.75 ± 0.96	22.50 ± 2.52
Ulnar artery with arch	3	4.67 ± 0.58	16.33 ± 1.53
Ulnar artery without arch	2	4.50 ± 0.71	17.50 ± 0.71

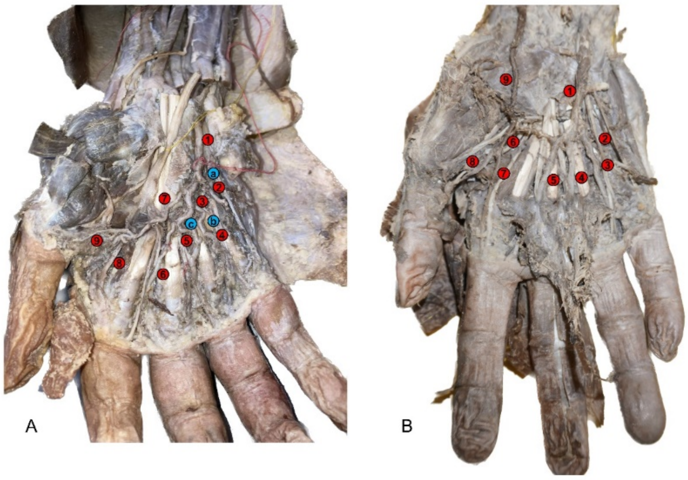

Figure 7. Comparison of right hand between normal and variant specimens **A.** Variant specimen right hand, ① ulnar artery; ②ulnar artery of little finger; ③ thick and short trunk; ④third common palmar digital artery; ⑤second common palmar digital artery; ⑥first common palmar digital artery; ⑦ ulnar artery running toward the thumb; ⑧ branches to the second finger;⑨branches to the thumb to form the main thumb artery; a bend of the ulnar metacarpal artery of the little finger; b the first ‘C’ bend of the third common palmar digital artery. c the first ‘C’ bend of the second common palmar digital artery; **B.** Normal specimen right hand, ① ulnar artery; ② ulnar artery of little finger; ③third common palmar digital artery; ④second common palmar digital artery; ⑤first common palmar digital artery; ⑥ short trunk; ⑦ running in the second digital branch; ⑧ forming branches of the main artery of thumb; ⑨ superficial palmar branch of radial artery

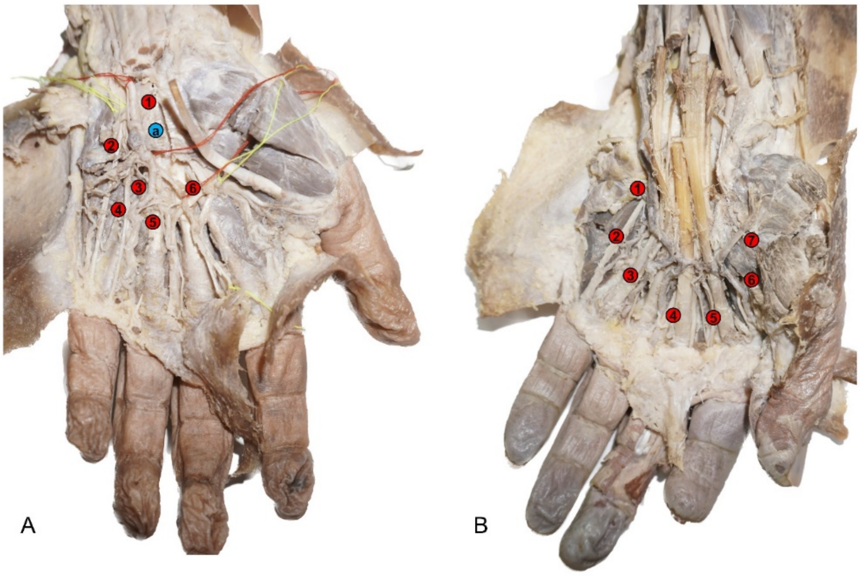

Figure 8. Comparison of left hand between normal and variant specimens **A.** Variant specimen left hand, ① ulnar artery; ② ulnar artery of little finger; ③ thick and short trunk; ④third common palmar digital artery; ⑤second common palmar digital artery; ⑥first common palmar digital artery; a two continuous circular bends; **B.** Normal specimen left hand, ① ulnar artery of the normal specimen; ② ulnar artery of the little finger; ③third common palmar digital artery; ④second common palmar digital artery; ⑤first common palmar digital artery; ⑥ branches toward the thumb. ⑦ Superficial palmar branch of radial artery