

# Cadaveric Study of Superficial Palmar Arch Variations in Northern Thai Population by Using Epoxy Resin Injection Technique

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**Background:** Superficial palmar arch (SPA) is the main source of arterial supply to the palm while princeps pollicis artery is the main source of arterial supply to the thumb. The details about their possible variations are important for the reconstructive hand surgeons.

**Objective:** To find out the SPA patterns and arterial supply of thumb variations in Thai population by using epoxy resin injection technique.

**Material and Method:** The methods used were vascular injection by epoxy resin with blue resin color to brachial artery before dissection of 100 fresh cadaveric hands to find out the SPA pattern and the anatomical variation of the princeps pollicis artery.

**Results:** It was found that the SPA patterns of 100 cadaveric hands were composed of 13 patterns, which could be classified into two main types: arch type and non-arch type. Arch type was found in 67 hands (67%) and non-arch type 33 hands (33%). From 13 patterns, the most common was the ulnar + 1<sup>st</sup> dorsal interosseous pattern, which found in 27 hands (27%) and the less common, in 15 hands was ulnar pattern in both arch type and non-arch type. The princeps pollicis artery was present in all of the arch-type hands (67 hands) with its origin from the radial artery. It emerged deep in the 1<sup>st</sup> dorsal interosseous muscle in 66 hands (98.5%) and dorsally to this muscle in 1 hand (1.5%). Using epoxy resin injection before dissection was a good technique with less confusion for arteries and other tissues.

**Conclusion:** The authors found 13 superficial palmar arch patterns, 67 percent is arch type. The princeps pollicis artery always lies deep in the first dorsal interosseous muscle. This is essential knowledge for the hand surgeon to repair or reconstruct the injured limb.

**Keywords:** Superficial palmar arch (SPA), Variation, Princeps pollicis artery

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Superficial palmar arch (SPA) patterns and arteries of the thumb are important for hand surgeons. The SPA is a direct continuation of the ulnar artery. On entering the palm, it curves laterally deep into the palmar aponeurosis and is superficial to the long flexor tendons. The arch is completed on the lateral side by one of the branches of the radial artery<sup>(1)</sup>. The princeps pollicis artery (PPA) arises from the radial artery as it turns into the palm to form the deep palmar arch. It descends on the palmar aspect of the first metacarpal under the oblique head of the adductor pollicis, lateral to the first palmar interosseous muscle, after which the

artery divides into two branches<sup>(2)</sup>. The PPA is the usual nutrient supply to the first metacarpal bone and thumb<sup>(3)</sup>.

Although there are many previous studies, the techniques used in these studies<sup>(4-6)</sup>, most often dissected from embalmed cadaveric, may make it hard to distinguish arteries from other tissue. Ramirez and Gonzalez<sup>(7)</sup>, using a vascular injection technique with methyl methacrylate (a self-polymerizing synthetic resin) to study arteries of the thumbs enabling them to study vessels less than 1 mm in diameter. Therefore, ergo, epoxy resin was chosen for this study because it is inexpensive and easily obtained from a chemical wholesaler<sup>(8,9)</sup>. The objective of this study is to find out the SPA patterns and arterial of thumb variations in a Thai population by using epoxy resin injection technique.

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## Material and Method

The present study was conducted in Cadaveric Surgical Training Center, Faculty of Medicine, Chiang Mai University. One hundred fresh cadaveric hands were dissected to find out the SPA patterns and out of these 100, sixty-seven were dissected mainly to find out the course of princeps pollicis artery. Thus, 24 ml of epoxy resin mixed with hardener 6 ml, blue resin color and acetone was injected into the brachial artery at the cubital fossa. Then, the brachial artery was ligated proximally to prevent the back flow of epoxy resin. The dissection of the forearms and hands was performed after polymerization of epoxy resin, 4-5 hours after injection.

The skin and subcutaneous tissues covering the forearm and palm were removed with palmar aponeurosis to observe SPA and its branch (common palmar digital arteries and digitiminimi artery). SPA pattern was recorded according to a studied of Ottone et al<sup>(6)</sup>. The skin and subcutaneous tissues covering the dorsal of the thumb and the index were removed to observe the course of princeps pollicis artery and its palmar branch including radialisindicis artery (RI), ulnar digital artery of thumb (UDA) and radial digital artery of thumb (RDA). For statistical analysis, Chi-square test was used to compare the number of patterns between left and right hands and between male and female. The analysis was considered significant when *p*-values were less than 0.05.

## Results

### Superficial palmar arch (SPA)

The authors grouped the SPA into the type (arch type and non-arch type), subtype and pattern (Fig. 1) by following the study of Ottone et al<sup>(6)</sup>.

Arch type (67 hands): it was considered to arch type when ulnar artery anastomosed with some branch of radial artery and subdivided into 4 subtypes:

1) Ulnar-radiopalmar subtype (23): it is formed by the union between the ulnar artery and superficial branch of radial artery and subdivided into 3 patterns.

1.1) Ulnar pattern (15): the ulnar artery has a larger size than the superficial branch of radial artery.

1.2) Classic pattern (7): it is normally formed by anastomosis among the ulnar and radiopalmar arteries, both of the same size.

1.3) Radial pattern (1): the ulnar artery has a smaller size than the superficial branch of radial artery.

2) Ulnar-radial subtype (40): the arch has an antero-posterior (palmar to dorsal) arrangement and subdivided into 2 patterns.

2.1) Ulnar + radial proper pattern (13): the radial course the dorsal of hand and turn to the palmar side and anastomose with ulnar artery this level.

2.2) Ulnar + 1<sup>st</sup> dorsal interosseous pattern (27): anastomosis between ulnar artery and interosseous artery, branch of princeps pollicis artery or radial artery which lying dorsal or deep to 1<sup>st</sup> dorsal interosseous muscle.

3) Ulnar-median-radiopalmar subtype (pattern) (2): an anastomosis of artery including ulnar artery, superficial branch of radial artery and median artery.

4) Multiple connection subtype (pattern) (2): an anastomosis of artery including ulnar artery, deep palmar arch and 1<sup>st</sup> dorsal interosseous artery.

Non-arch type (33 hands): it was considered to belong to non-arch type when ulnar artery did not anastomose with some branch of radial artery and subdivided into 2 subtypes:

1) Dominant ulnar subtype (25): the ulnar artery is the only artery responsible for the formation of the SPA and subdivided into 4 patterns.

1.1) Ulnar I pattern (15): the ulnar artery is the only artery responsible for the formation of the SPA and absence of superficial branch of radial artery.

1.2) Ulnar II pattern (4): the ulnar artery is the only artery responsible for the formation of the SPA and absence of superficial branch of radial artery and 1<sup>st</sup> common palmar digital artery.

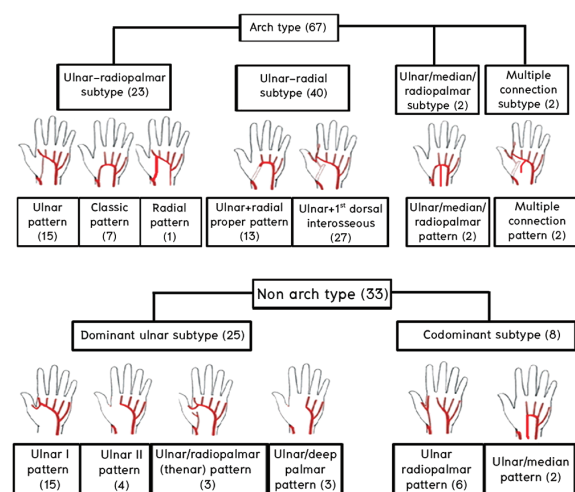


Fig. 1 Classification of SPA including the type (arch type and non arch type), subtype and pattern.

1.3) Ulnar-radiopalmar (thenar) pattern (3): the ulnar artery is the only artery responsible for the formation of the SPA but the superficial branch still present (small branch at the thenar eminence).

1.4) Ulnar-deep palmar pattern (3): the ulnar artery is the only artery responsible for the formation of the SPA but branch of artery to thumb, index and the ulnar side of middle finger is the branch from deep palmar arch.

2) Co-dominant subtype (8): presence of two or three arteries (ulnar artery, superficial branch of radial artery and median artery) which supply independent areas of palm and subdivided into 2 patterns.

2.1) Ulnar-radiopalmar pattern (6): ulnar artery and superficial branch of radial artery supply independent areas of palm.

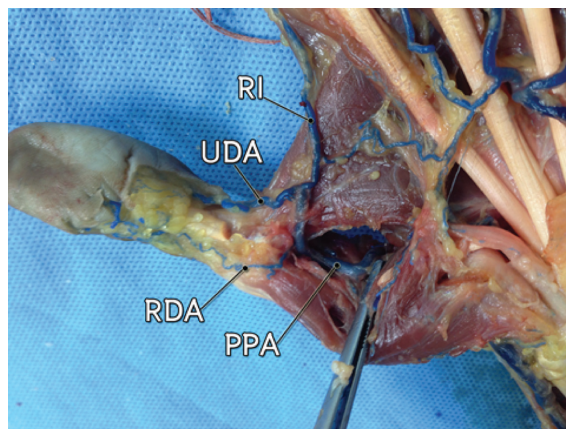
2.2) Ulnar-median pattern (2): ulnar artery and median artery supply the palm.

There was no significant difference in number of patterns when comparing each pattern by Chi-squared test between left and right hands and between male and female.

### *Princeps pollicis artery*

The princeps pollicis artery was present in all of the arch-type hands (67 hands, 100%) with its origin from the radial artery. It emerged deep in the 1<sup>st</sup> dorsal interosseous muscle in 66 hands (98.5%) and dorsally to this muscle in 1 hand (1.5%). The artery of the thumb in palmar side and artery of the index arise from ulnar digital artery (UDA), radial digital artery (RDA) and radialisindicis (RI), respectively (Fig. 2). The origins of these arteries are as in Table 1.

From Table 1, UDA largely takes origin from SPA + 1<sup>st</sup> dorsal interosseous artery while RDA and RI are largely origin from princeps pollicis artery.



**Fig. 2** Artery of thumb and index (RI = radialisindicis artery; UDA = ulnar digital artery; RDA = radial digital artery; PPA = princeps pollicis artery).

There was no statistically significant difference in number of patterns when comparing each pattern by Chi-squared test between left and right hands and between male and female ( $p$ -value >0.05).

### *Vascular injection with epoxy resin*

Studying SPA patterns and course of princeps pollicis artery by vascular injection technique is a good technique with less confusion between arteries and other tissues. Using epoxy resin mixed with blue resin color allows a clearly photographic record (Fig. 3, 4).

### **Discussion**

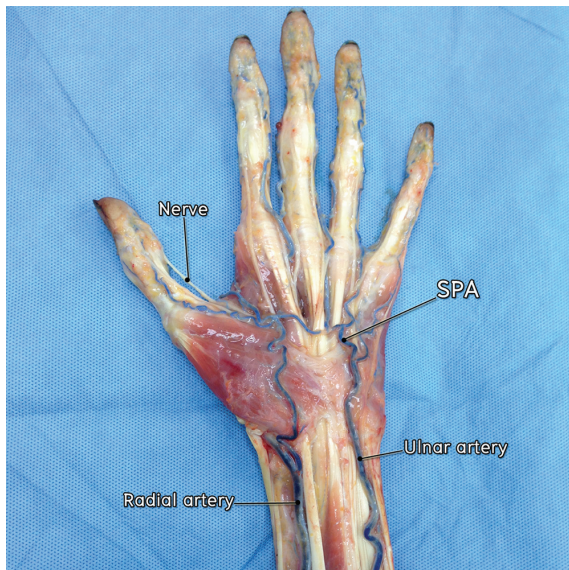
The SPA is the main source of arterial supply to the palm. Knowing SPA pattern is important for a hand surgeon to plan his or her procedure to help the patient.

From Table 2, we found a difference percentage of SPA type in each study because of the difference of

**Table 1.** The origins of ulnar digital artery (UDA), radial digital artery (RDA) and radialis indicis (RI)

Arteries	UDA (%)	RDA (%)	RI (%)
SPA (1 <sup>st</sup> common digital artery)	13 (19.0)	19 (29.0)	11 (16.5)
PPA	10 (15.0)	31 (46.0)	5 (7.5)
SPA + 1 <sup>st</sup> dorsal interosseal artery	28 (42.0)	5 (7.5)	28 (42.0)
SPA + PPA	14 (21.0)	9 (13.0)	12 (18.0)
DPA	-	-	9 (13.0)
SBRA	1 (1.5)	2 (3.0)	1 (1.5)
SPA + PPA + 1 <sup>st</sup> dorsal interosseal	1 (1.5)	1 (1.5)	1 (1.5)

SPA = superficial palmar arch; PPA = princeps pollicis artery; DPA = deep palmar arch; SBRA = superficial branch of radial artery



**Fig. 3** SPA in classic pattern with vascular injection technique by colored epoxy resin.

consideration in each study such as consideration by anastomosis of ulnar artery and radial artery or consideration by branch of SPA.

From our results, the authors found that ulnar artery is the main artery of SPA and the variations of the patterns caused by other arteries such as radial artery, median artery and 1<sup>st</sup> dorsal interosseous artery. This was due to the formation of blood vessels in the embryonic stage. This is explained by Rodriguez-Niedenfuhr et al<sup>(2)</sup>. Moreover, sex and side of hand are not affected the SPA patterns.

Radial and ulnar arteries are the major vessels of forearm and hand. The distal connection of these two arteries is very important in several procedures such as retrograde-flow radial or ulnar forearm flap. If the connection is absent or questionable, the vascular supply of the flap may be insufficient and lead to flap



**Fig. 4** Princes pollicis artery and 1<sup>st</sup> dorsal interosseous artery lying deep to 1<sup>st</sup> dorsal interosseous muscle (arrow head, princes pollicis artery; 1<sup>st</sup> dorsal interosseous artery).

necrosis or even acute limb ischemia<sup>(10)</sup>. Blood supply of hand and thumb depends on SPA patterns and princes pollicis artery. Therefore, these are essential knowledge for hand surgeon to repair or reconstruct the injured limb.

### Conclusion

The SPA is the main source of arterial supply to the palm and princes pollicis artery is the main artery of the thumb. In the present study, the authors found 13 SPA patterns and princes pollicis artery generally takes origin from radial artery and always lying deep to 1<sup>st</sup> dorsal interosseous muscle.

**Table 2.** Comparison of SPA type in this study and previous studies

Studies	Country	n	SPA	
Coleman and Anson	USA	650	Complete arch 78.5%	Incomplete arch 21.5%
Al-Turk and Metcalf	USA	50	Complete arch 84%	Incomplete arch 16%
Fazan et al.	Brazil	46	Complete arch 48%	Incomplete arch 52%
Bile et al.	Turkey	50	Complete arch 85%	Incomplete arch 14%
Ottone et al.	Argentina	86	Arch type 58%	Non arch type 14%
Madyastha et al.	India	48	Classic form 45 hand	Variation 3 hand
Sarkar et al.	Singapore	42	Complete arch 45%	Incomplete arch 55%
Present	Thailand	100	Arch type 67%	Non arch type 33%

### **What is already known on this topic?**

We found the variations of SPA patterns and princepspollicis artery generally origin from radial artery and always lying deep to 1<sup>st</sup> dorsal interosseous muscle.

### **What this study adds?**

In our study, we found a difference percentage of SPA type in each study because of the difference of consideration in each study such as consideration by anastomosis of ulnar artery and radial artery or consideration by branch of SPA. We found that ulnar artery is the main artery of SPA and the variations of the patterns caused by other arteries such as radial artery, median artery and 1<sup>st</sup> dorsal interosseous artery.

Studied SPA patterns and course of princepspollicis artery by vascular injection technique with epoxy resin is a good technique that is less confusing for arteries and other tissues and blood supply of hand and thumb depend on SPA patterns and princepspollicis artery. Therefore, these are essential knowledge for hand surgeon to repair or reconstruct the injured limb.

### **Acknowledgement**

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### **Potential conflicts of interest**

None.

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การศึกษาความแปรปรวนของหลอดเลือดแดง *superficial palmar arch* ในกลุ่มประชากรไทยโดยเทคนิคการฉีดยา *epoxy resin*

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**ภูมิหลัง:** หลอดเลือดแดง *superficial palmar arch* เป็นหลอดเลือดหลักของฝ่ามือและหลอดเลือดแดง *princeps pollicis* เป็นหลอดเลือดหลักของนิ้วหัวแม่มือ ความแปรปรวนของหลอดเลือดดังกล่าวมีความสำคัญมากต่อการผ่าตัด *reconstructive* ของศัลยแพทย์ทางมือ

**วัตถุประสงค์:** เพื่อศึกษาความแปรปรวนของหลอดเลือดแดง *superficial palmar arch (SPA)* ในประชากรไทย

**วัสดุและวิธีการ:** จากมือของอาจารย์ใหญ่ร่างสดจำนวน 100 มือ และศึกษาความแปรปรวนของหลอดเลือดแดง *princeps pollicis* จากมือของอาจารย์ใหญ่ร่างสดจำนวน 67 มือ จาก 100 มือดังกล่าว โดยการฉีดยา *epoxy resin*

**ผลการศึกษา:** พบว่ารูปแบบของ *SPA* แบ่งได้เป็นรูปแบบหลักคือ ชนิด *arch* ร้อยละ 67 และชนิด *non arch* ร้อยละ 33 และแบ่งเป็นรูปแบบย่อยได้ 13 pattern โดยที่พบมากที่สุดคือ *ulnar + 1<sup>st</sup> dorsal interosseous pattern* ร้อยละ 27 และรองลงมาคือ *ulnar pattern* ทั้งในชนิด *arch* และ *non arch* ที่พบรูปแบบนี้ร้อยละ 15 เท่ากัน ส่วนเพศชาย-หญิง และข้างซ้าย-ขวาของมือ ไม่มีผลต่อรูปแบบของหลอดเลือดแดง *SPA* ส่วนหลอดเลือดแดง *princeps pollicis* เป็นหลอดเลือดที่แตกแขนงมาจากหลอดเลือดแดง *radial* ในมือทุกข้าง โดยวางตัวอยู่ลึกต่อกล้ามเนื้อ *1<sup>st</sup> dorsal interosseous* 66 มือ ส่วนอีก 1 มือ วางตัวอยู่บนกล้ามเนื้อ *1<sup>st</sup> dorsal interosseous* นอกเหนือจากนี้การฉีดยา *epoxy resin* ที่ผสมด้วยสีผสมเรซินสีน้ำเงิน ก่อนการผ่าชำแหละ เป็นเทคนิคที่สามารถทำให้สังเกตหลอดเลือดแดงได้อย่างชัดเจน ป้องกันการสับสนกับโครงสร้างอื่นๆ ได้

**สรุป:** จากการศึกษาครั้งนี้ทำให้ได้ข้อมูลพื้นฐานเกี่ยวกับโครงสร้างทางมหกายวิภาคศาสตร์และความแปรปรวนของหลอดเลือดแดงเหล่านี้ที่พบในประชากรไทย ซึ่งน่าจะมีประโยชน์ต่อนักกายวิภาคศาสตร์และศัลยแพทย์ทางมือในการนำไปประยุกต์ใช้กับผู้ป่วยทั้งการวินิจฉัยและการรักษาโดยการผ่าตัดได้

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