VASCULAR PATTERNS OF PLASTINATED HUMAN HANDS WITH SPECIAL REFERENCE TO ABNORMALITIES OF THE ARTERIAL PALMAR ARCHES

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INTRODUCTION

The vascular anatomy of the human hand is known to be of outstanding importance in medical, surgical and radiological sciences (Coleman and Anson, 1961; Kenesi et al., 1967; Braun et al., 1977), as well as in comparative anatomy and primatology (Manners-Smith, 1910; Sakka, 1972). The constitution, relationship and common abnormalities of both arterial palmar arches make their dissection difficult for students. The superficial palmar arch (Arcus palmaris superficialis) is often damaged during student dissection and subsequently much time is lost. Time is also lost trying to save the deep palmar arch (Arcus palmaris profundus). It was therefore decided to overcome this problem by producing plastinated specimens that would give the students a three dimensional view of the complete arteriovenous vascularization of the hand (Grodin and Olry, 1995). Initial trials of injecting diluted silicone resin were not successful. Part of the red resin, which had been injected first, was pushed from the arterial side via capillaries into the venous system. This led to the production of veins which were partly red, blue and purple. The next trials used pure silicone for the injection. One specimen was dissected to illustrate the superficial arterial palmar arch, a second one for the deep arterial palmar arch, and finally a third one for the venous drainage of the human hand.

SUBJECTS, MATERIALS AND METHODS

Hands, free of any obvious traumatic or surgical history (absence of scars and wrist injuries), were removed from frozen subjects in the midforearm.

Radial arteries from the frozen specimens were cannulated and water maintained at 25 cm of hydrostatic pressure was attached to the cannula. The cannulated specimens were held in cold running tap water for 12 hours while thawing. After thawing, ulnar arteries were also cannulated and any remaining blood was flushed from the vessels using a syringe filled with water via radial and ulnar arteries. A mixture of Biodur S-10/ S3/S6/S2, colored with red or blue Biodur Color Paste (AC50, AC52) was prepared to be injected into appropriate vessels. To prepare the injection mixture, a few drops of color paste were added to 30 ml of S-10/S3 mixture (100:1) and mixed until the color was uniform. After thorough mixing, 0.1 ml of S6 and 0.1 ml of S2 were added to the S-10/S3 color-mix and stirred for 3 minutes. Arterial injection was carried out via the ulnar artery. When the silicone mixture started to ooze out via the radial artery, it was ligated and injection was continued until we noticed red silicone also oozing out from smaller arteries. Then the ulnar artery was also ligated. After arterial injection, venous injection (Specimen 3) was performed via one dorsal metacarpal veins. The proximal ends of the veins were left open for exit of water. When the silicone mixture started to ooze out via many veins, the forearm was mass ligated and injection was continued along with delicate massaging to allow filling of the distal veins.

After vascular injection, hands were placed in cold modified Kaiserling's solution (Kaiserling, 1895) and stored in a cold room. Composition of the fixative solution was: potassium acetate (600 g), potassium nitrate (300g), formaldehyde 37% (400 ml), sugar (2000 g) and water (19.6L). Dissection was started in 24 hours and specimens were kept in the fixative solution for 3 to 5 weeks in the cold room.

After dissection was completed, the specimens were rinsed in cold tap water for 12 hours, dehydrated in 4 successive baths of acetone at -20°C over a 4 week period, and defatted in room temperature in acetone for 5 days before being impregnated at -20°C with Biodur silicone S10, according to the standard technique (von Hagens, 1985; von Hagens et al., 1987).

RESULTS

The superficial palmar arch (Specimen 1) is supplied mainly by the ulnar artery. When the ulnar artery is the main supply to the palmar arch, it is referred to as "ulnar type" (Adachi, 1928). The superficial arch gives rise to three common palmar digital arteries (Aa. digitales palmares communes) and each of these divide into two proper palmar digital arteries (Aa. digitales palmares propriae) (Fig. 1). However, the radial participation to the superficial arch is in this case very particular: it shows what we believe to be a persistent antebrachial dorsal superficial artery (Arteria antebrachialis dorsalis superficialis) which does not traverse the first interosseous space (Georgeiwski, 1905). The relationship of the radial artery and its embryological remnant seem to resemble the type VI described by Adachi (1928) who assigned a frequency of 1.5% to this kind of anomaly (Fig. 2).

The deep palmar arch (Specimen 2), which is known to be less variable than the superficial one (Braun et al., 1977), also showed an anomaly. Its medial origin arises from the palmar digital artery of the little finger (Fig. 3) and not from the ulnar artery, an anomaly which was not described by Adachi (1928).

The superficial venous drainage of the hand (Specimen 3) show's a classical plexiform morphology with some dorsal metacarpal veins and their anastomotic network (Fig. 4). It is noteworthy that the color mixture was stopped here and there by venous valves which even occur in the small veins (Fig. 5). Deep veins were also colored via the numerous interconnections between the superficial and deep venous networks (Fig. 6).

DISCUSSION

The aim of this study was to provide plastinated human hand specimens which would help students to understand the vascular anatomy of the hand. The complexity of this region, as well as its numerous vascular variations (Adachi, 1928; Coleman and Anson, 1961; Kenesi et al., 1967), dishearten most students who try to dissect the complex venous and arterial patterns of the hand. Plastinated specimens are therefore appreciated as students can regularly refer to models during their anatomical curriculum (Olry and Grondin, 1994; C6te et al, 1995).

We have shown that an appropriate arterial injection is capable of filling and thus coloring the whole arterial network, including very small size subcutaneous vessels (Fig. 6). The size of the smallest colored arterioles were accurately measured using an optical comparator (Mitutoyo). Their size was 0. 1mm. This could provide an opportunity for the analysis of very thin vascular networks in the future.

A complete rinsing of the venous system is very important. A sole injection in a dorsal metacarpal vein allowed the filling of both superficial and deep venous networks provided that the veins were compressed several times when we noticed a venous valve stopping the color mixture. The presence of numerous valves explains that some veins were filled against the current and that water remained trapped in some veins . 5).

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SUMMARY

Specimens were dissected and plastinated in order to demonstrate the arterial and venous vascularization of human hands. Vessels were injected with appropriate colors and plastination was performed according to the standard S-10 technique. We showed that 1) a sole injection via ulnar artery is capable of filling very small size arterioles and 2) injection via only one dorsal metacarpal vein allows to completely fill the superficial and deep venous systems, provided that veins are carefully massaged during the injection to open the valves.

Figure 1. Palmar aspect of the superficial palmar arch. Ulnar artery (arrow), common palmar digital arteries (arrowheads).

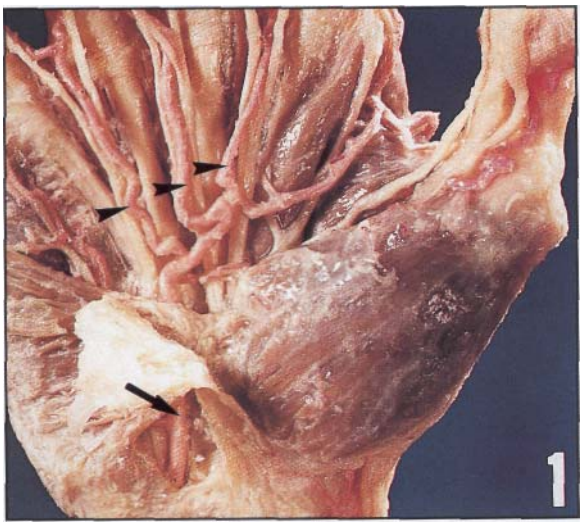

Figure 2. Radial aspect of the radial participation to the superficial palmar arch. Radial artery (arrow), putative antebrachial dorsal superficial artery (arrowheads).

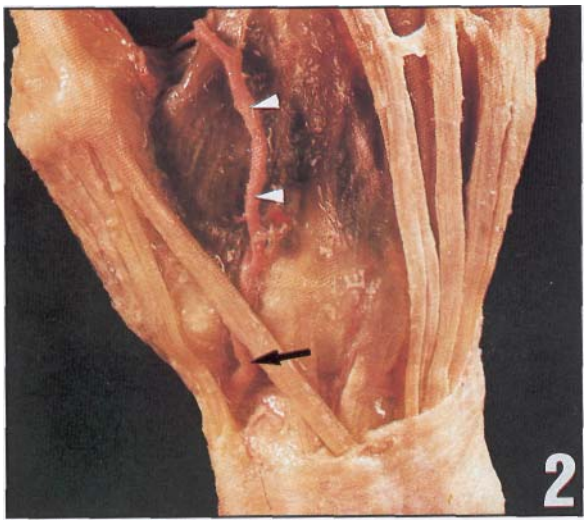

Figure3. Palmar aspect of the deep palmar arch. Deep palmar arch (white arrow), digital artery of the little finger (black arrows).

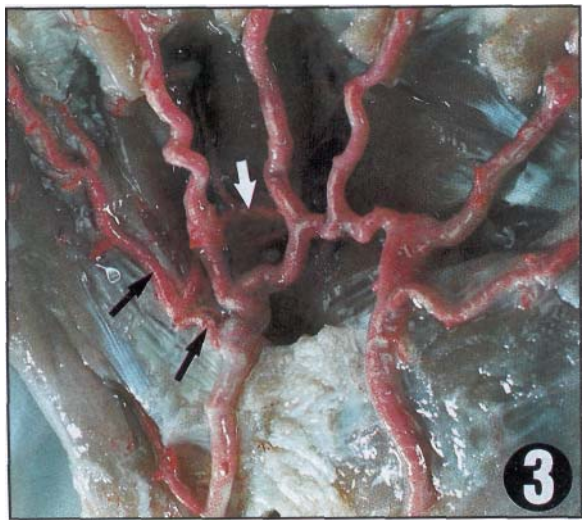

Figure 4. Dorsal venous network of the hand. Artifact due to the breakage of venous wall at the site of injection (arrow).

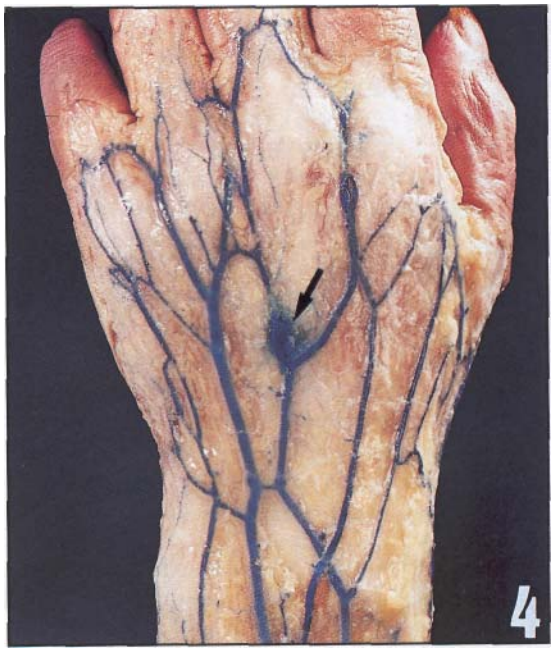

Figure 5. Close-up of the dorsal metacarpal veins. Location of small venous valves (arrowheads), remaining water trapped upstream of a venous valve (arrow).

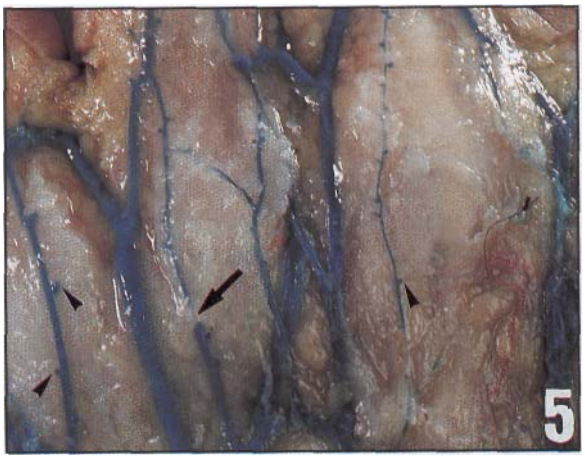

Figure 6. Close-up of the radial aspect of the wrist region. Radial artery (star) flanked by both radial veins, subcutaneous arteriole (arrow).