Deep Palmar Arch in Man

İnsanda Arcus Palmaris Profundus

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ABSTRACT Objective: The importance of the vascular anatomy of the hand is evident especially in reconstruction of congenital anomalies, posttraumatic lesions and radial artery (RA) harvesting to use as an arterial bypass conduit. This study was performed to expand the data reported in the literature about the deep palmar arch in man. **Material and Methods:** Fifty hands out of 25 formalin fixed and red-colored latex injected cadavers were dissected. The diameters of the contributing branches and the palmar metacarpal arteries were measured. The configurations of the arches were classified and were evaluated for bilateralism. The position of the deep branch of the ulnar nerve (DBUN) to the deep palmar arch (DPA) was also evaluated. **Results:** Three types of complete arch were determined; type A (32%), type B (40%) and type C (26%). Only one incomplete arch was found (2%). The mean diameters of the participating terminal part of the RA, and theproximal and distal deep branches of the ulnar artery (UA) were measured as 2.60 mm, 1.77 mm and 1.63 mm, respectively. The mean diameter of the first palmar metacarpal artery was 1.5 mm, the 2nd was 1.41 mm and the 3rd was 1.45 mm. In 37 (74%) samples the DBUN crossed the DPA obliquely and dorsally, while in 12 (24%) samples it crossed the DPA on its palmar aspect. **Conclusion:** Understanding the arterial network and the variations of the hand is useful for surgical reconstruction procedures. Vessels of the deep arch have been found to be of sufficient size to allow microsurgical repair. The variable position of the DBUN in respect to the DPA is an important structure in this region surgery.

Key Words: Radial artery; ulnar artery; hand; anatomy

ÖZET Amaç: Elin vasküler anatomisinin önemi, konjenital veya posttravmatik el anomalilerinin rekonstrüksiyonunda ortaya çıkmaktadır. Ayrıca a. radialis son zamanlarda miyokardiyal revaskülarizasyonu sağlamak amacıyla da kullanılmaktadır. Bu çalışma, literatürde arcus palmaris profundus (APP) ile ilgili verilerin güncellenmesini ve artırılmasını amaçlamaktadır. **Gereç ve Yöntemler:** Formalin ile sabitlenmiş ve kırmızı boya ile renklendirilmiş lateks enjeksiyonu yapılmış, 25 kadavraya ait 50 el disseke edilmiştir. APP'ye katılan damarların ve aa. metacarpales palmares'in çapları ölçülmüştür. APP tiplendirilmiş ve simetri açısından değerlendirilmiştir. Ayrıca, r. profundus nervus ulnaris'in APP'ye göre pozisyonu değerlendirilmiştir. **Bulgular:** Üç tip komplet arcus belirlenmiştir: tip A (%32), tip B (%40) ve tip C (%26). Sadece bir tek inkomplet arcus (%2) gözlenmiştir. Arcus'a katılan a. radialis son kısmı ile a. ulnaris'in proksimal ve distal r. palmaris profundus'larının çapları sırasıyla 2.60 mm, 1.77 mm ve 1.63 mm olarak ölçülmüştür. Birinci a. metacarpalis palmaris'in çapı 1.5 mm, ikincisinin 1.41 mm ve üçüncüsünün 1.45 mm'dir. Otuz yedi (%74) örnekte r. profundus nervus ulnaris APP'yi dorsal tarafından, 12 (%24) örnekte ise palmar tarafından çaprazladığı görülmüştür. **Sonuç:** Elin vasküler yapısının ve varyasyonlarının iyi anlaşılması cerrahi rekonstrüksiyon girişimleri için çok önem taşımaktadır. Yapılan çalışma APP ve dallarının mikro cerrahi prosedürlerde kullanılabilir boyutlarda olduğunu göstermektedir. R. profundus nervus ulnaris'in APP'ye göre değişkenlik gösteren pozisyonu bölge cerrahisinde önemli bir durum olarak dikkati çekmektedir.

Anahtar Kelimeler: Arteria radialis; arteria ulnaris; el; anatomi

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The superficial and deep palmar arches supply the hand. These two arches balance the circulation by some compensatory variations.[1-6]

The importance of the vascular anatomy of the hand is evident especially in reconstruction of congenital anomalies, posttraumatic lesions and RA harvesting for use as an arterial bypass conduit.[2,3,7,8] Excluding the well-known superficial palmar arch, recent studies have shown that the deep palmar arch and its branches are adequate in size for some micro vascular reconstruction procedures. However, the variable conformation of the vessels and the potential of ischemia are the major difficulties of these surgical procedures.[9]

Nevertheless, Doppler flow-meter technique is suitable only for superficial palmar arch investigations.[10-12] The angiographic studies can only give general information about the deep palmar arch because of the small size and fair anastomoses of the vessels and unpredictable degrees of vasoconstriction and reactive vasodilatation problem secondary to the dye injection stress.[8,9] For these reasons, the macroscopic cadaver studies with improved techniques as arterial injection of polymer or latex solution for instance, are gaining importance.[5]

The deep palmar arch (DPA) is the terminal curve of the RA that lies under the lumbrical muscles and tendons of the flexor muscles at the level of the proximal extremities of the metacarpal bones. The ulnar contribution to this arch is the deep palmar branch of the ulnar artery (UA). The ulnar contribution may exist with two deep palmar branches of the UA, which are designated the proximal and the distal. Three palmar metacarpal arteries (PMA) arise from the convex side of the arch and some branches from the concave side to the rete carpale palmare. The arch also gives off some branches to the adjacent structures such as lumbrical muscles, synovial sheaths and perforating anastomotic arteries to the dorsal surface of the hand.[1-6,13,14]

MATERIAL AND METHODS

50 hands (25 left, 25 right hands) of 25 formalin fixed cadavers were dissected at the Anatomy Department of the Ege University Medical Faculty. Red-colored latex was injected into the brachial artery at the level of the elbow. The flexor retinaculum was opened and the flexor tendons were cut and were elevated to explore the deep palmar arch. The dissections were made with the help of a dissecting loop (magnification x 2.5).

The typecasting was made according to distribution and anatomical configuration of the DPA based on previous studies in the literature. The complete type of arch was subdivided into three types, according to the type of participation of their deep palmar branch of the UA either distal, proximal or both (Table 1).

With the help of a digital caliper (0.02 mm Shock & Proof), the diameter of the RA was taken at the level of the first metacarpal space while the deep branch(es) of UA, and PMAs were measured at their origin.

The configurations of the arches were also evaluated for bilateralism and symmetry.

Students t-test was performed for statistical analysis.

As an important adjacent structure, the position of the deep branch of the ulnar nerve to the DPA was also evaluated.

RESULTS

In this study, although at least one of the deep palmar branches of the UA was present in all specimens, an incomplete arch was determined on a

TABLE 1: The mean diameters (mm) of the corresponding vessels of the DPA and palmar metacarpal arteries.

RA	UA-p	UA-d	1st PMA	2nd PMA	3rd PMA
2.60 (± 0.47)	1.77 (± 0.44)	1.64 (± 0.52)	1.50 (± 0.38)	1.41 (± 0.35)	1.45 (± 0.33)

DPA: Deep palmar arch,
RA: Radial artery,
UA-p: Proximal deep branch of the ulnar artery,
UA-d: Distal deep branch of the ulnar artery,
PMA: Palmar metacarpal artery.

right hand (2%). The rest of the arches were complete (98%).

Complete arches were divided into three types:

Type A: The deep arch was formed by the deep branch of the RA and the distal deep branch of the UA. This type was found on 16 hands (32%) (Figure 1).

Type B: This most common type was formed by the deep branch of the RA and the proximal deep branch of the UA. This type was found on 20 hands (40%) (Figure 2).

Type C: The deep arch was formed by the deep branch of the RA and two deep branches (the distal and proximal) of the UA. This type was found on 13 hands (26%) (Figure 3).

Only one incomplete arch was found in our dissections (2%). In that sample the first palmar metacarpal artery was branched out from the RA, while the ulnar two from the deep branch of the UA (Figure 4).

The diameters of the arteries and branches were displayed in Table 2. There was no significant difference between the right and left palmar metacarpal arterial diameters ($p > 0.05$, Student's t-test) whether the arch was complete or incomplete.

In 37 (74%) samples the deep branch of the ulnar nerve crossed the DPA obliquely and dorsally (Figure 1), while in 12 (24%) samples it crossed the DPA on its palmar aspect (Figure 2).

DISCUSSION

DPA is one of the most important vascular structures in the hand that supplies the fingers, deep palmar region-including interosseous and lumbrical muscles and flexor tendons-and the dorsum of the hand with some anastomotic branches. This arch is mainly formed by the deep branch of the RA that receives one or two anastomotic deep branch(es) from the UA.[1,4,6,15,16] Some researches described different anastomotic branches to the DPA. Jurjus et al reported that the interosseous arteries contributed mainly to the formation of the DPA in one of 150 (0.66%) samples.[17] Dubreuil-Chambardel reported 19% of anterior interosseous artery contribution and classified it as type III.[1] Poteat reported a case of unilateral absence of the RA, in which the DPA was mainly formed by a branch from an increased interosseous artery that reached the palmar region from the dorsal aspect by passing through the third interosseous space.[18]

The other artery is the dorsal metacarpal artery that has been observed in 9% of examined 218 cases.[19] It has also been reported in 2 of 150 cases that median artery is ending as an anastomotic vessel to the deep palmar arch.[20]

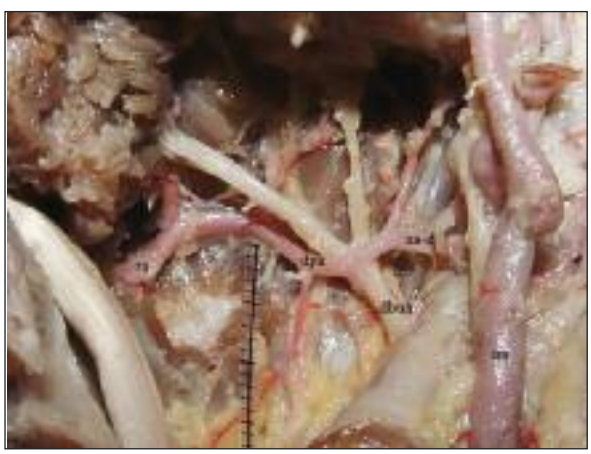

FIGURE 1: Type A. The deep branch of the ulnar nerve crosses obliquely and dorsally.
ra: Radial artery, **ua:** Ulnar artery, **dpa:** Deep palmar arch, **ua-d:** Distal deep branch of ulnar artery, **dbnu:** Deep branch of ulnar nerve.

FIGURE 2: Type B. The deep branch of the ulnar nerve crosses the DPA from the palmar aspect.
ra: Radial artery, **dpa:** Deep palmar arch, **ua-p:** Proximal deep branch of ulnar artery, **dbun:** Deep branch of ulnar nerve.

FIGURE 3: Type C.
ra: Radial artery, **ua:** Ulnar artery, **app:** Deep palmar arch, **ua-d:** Distal deep branch of ulnar artery, **ua-p:** Proximal deep branch of ulnar artery.

FIGURE 4: Incomplete type of DPA.
ra: Radial artery, **ua-d:** Deep branch of ulnar artery, **pma:** Palmar metacarpal artery.

The incomplete deep palmar arch was defined previously by many authors at different frequencies (Table 3). Only one incomplete arch was found in our dissection (2%) that was compatible with Coleman & Anson's group II type B DPA.[13] In this sample, the first palmar metacarpal artery branched out from RA, while the ulnar two from the deep branch of the UA.

The complete type A, which was composed by the RA and the proximal deep palmar branch of UA, has been observed in 20.9% to 46.7% of cases by other researchers and the most common type by Coleman and Anson and Gellman.[9,13] The present study revealed an average percentage (32%).

The formation of the arch by the RA anastomosing with the distal deep palmar branch, the complete type B, was reported as the most common pattern by Mezzogiorno.[5] The percentage of this pattern was 40% in present study and the most common type as mentioned above.

The complete type C, described as the anastomosis of the RA with two deep palmar branches (proximal and distal) of the UA has been reported in 13% to 32% of cases by some authors or has not been reported at all. This type was observed in 26% of cases in this study.

Findings about the complete types and side symmetry are to be carefully considered. Except one cadaver with an incomplete arch on the right hand, no differences at a significance level ($p > 0.05$) were observed in the right-left side comparison of the data of all the complete types.

External diameters of the DPA, its branches and corresponding vessels have rarely been defined in the literature. The mean diameter of the participating terminal part of the RA was measured as 2.60 (± 0.47) mm. The mean diameter of the proxi-

TABLE 2: Percentage frequency of the incomplete deep palmar in the literature.

Author(s)	Incomplete type of DPA
Jaschtschinski[14]	0.5%
Coleman & Anson[13]	3%
Ruengsakulrach[7]	10%
Ikeda[16]	23.1%
Mezzogiorno[5]	3.33%
Present study	2%

DPA: Deep palmar arch.

TABLE 3: Percentage frequency of various types of deep palmar arch in the literature.

Author(s)	Type A	Type B	Type C
Coleman&Anson[13]	49%	34.5%	13%
Gellman[9]	44.4%	33.4%	20%
Mezzogiorno[5]	23.3%	46.7%	-
Present study	32%	40%	26%

mal and distal deep branches of the UA was measured as 1.77 (± 0.44) mm and 1.63 (± 0.52) mm respectively.

Gellman et al reported the mean diameter of the palmar metacarpal arteries as 1.20 mm.[9] In this study, the diameters of the palmar metacarpal arteries were evaluated one by one. The mean diameter of the first palmar metacarpal artery was 1.50 (± 0.38) mm, the 2nd was 1.41 (± 0.35) mm and the 3rd was 1.45 (± 0.33) mm.

The position of the deep branch of the ulnar nerve, as an important adjacent structure to the DPA, was also evaluated. In 38 (76%) samples the deep branch of the ulnar nerve crossed the DPA obliquely and dorsally, while in 12 (24%) samples it crossed from the palmar aspect. Olave et al reported dorsal contiguity of the nerve in 50% of the cases.[21]

The RA is frequently the dominant source of blood supply to the hand. It is also suitable for some invasive procedures like catheter introduction or arterio-venous fistulae construction and a source of an arterial bypass graft for myocardial revascularization.[9]

Furthermore, understanding the arterial network and the variations of the hand is useful for surgical reconstruction procedures. Vessels of the deep arch have been found to be of sufficient size to allow microsurgical repair. Consequently, anatomical studies of the palmar region in more detail are needed to eliminate the lack of knowledge in the literature.

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