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RESEARCH ARTICLE

Anatomic characterization of the radial and ulnar nutrient arteries in humans

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ABSTRACT

Background: The localization of nutrient foramens has been extensively studied in humans and other vertebrate animals. However, accurate information on the origin and extraosseous course of the nutrient arteries in some types of long tubular bones is lacking. *Terminologia Anatomica*, the international standard on human anatomic terminology, lists the radial nutrient artery (RNA) and the ulnar nutrient artery (UNA) as branches of the radial and ulnar arteries, respectively. Anatomy textbooks published in both German- and English-speaking countries regard both the RNA and UNA as branches of the anterior interosseous artery.
Methods: To clarify the anatomic characteristics of the RNA and UNA in humans, we reexamined the origin and course of these arteries by cadaveric dissection.
Results: Almost all RNAs and UNAs branched from the ulnar artery or its tributaries. In typical cases, the RNA branched from the anterior interosseous artery and the UNA branched from the proximal part of the ulnar artery or the anterior interosseous artery. These findings are reasonable from the perspective of regional anatomy, since the ulnar artery passes more deeply than the radial artery in the proximal forearm and thus the proximal part of the ulnar artery and its major branches are situated more closely to the radial and ulnar nutrient foramens.
Conclusions: Based on our findings, it is necessary to correct the position of the RNA and UNA in the arterial hierarchy of *T. Anatomica* for accurate morphological description.

1. Introduction

Long tubular bones are supplied by several kinds of arteries including epiphyseal, metaphyseal, nutrient, and periosteal arteries, which distribute to the epiphysis, metaphysis, diaphysis, and periosteal surface, respectively. The nutrient artery enters from the nutrient foramen and canal into the medullary cavity of the diaphysis and serves as a primary artery to the bone marrow (Brookes and Revell, 1998). The localization of nutrient foramina and direction of the nutrient canals have previously been studied in humans and other vertebrate animals (Carroll, 1963; Forriol Campos et al., 1987; Mysorekar, 1967; Payton, 1934; Trueta and Caladias, 1964). However, accurate information on the origin and extraosseous course of the nutrient arteries in some types of long tubular bones is lacking.

For instance, the humeral nutrient artery is listed as one of the branches of the profunda brachii artery in the international standard on human anatomic terminology, *Terminologia Anatomica*, and the anatomy textbooks published in German-speaking countries (Gegenbaur, 1892; Henle, 1968; Hoffmann, 1878; Hyrtl, 1846; Luschka, 1865). However, this description is unconvincing because the profunda brachii artery and the humeral nutrient foramen are situated distant to one another. Recently, we re-examined the origin and extraosseous course of the humeral nutrient artery by cadaveric dissection and revealed that this artery branches directly from the brachial artery as a small ascending branch, similar to muscular branches of the brachialis (Ichimura et al., 2017).

A similar problem in *T. Anatomica* is also found in regard to the radial nutrient artery (RNA). The ulna and radius possess one nutrient foramen on the proximal half of the anterior surface near the attachment of the antebrachial interosseous membrane, which has been confirmed by many reports using dried bone specimens

Abbreviations: RNA, radial nutrient artery; UNA, ulnar nutrient artery.

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Table 1
Descriptions of the RNA and UNA from anatomy textbooks.

Authors	Book title	Origins of the RNA and UNA
Henle (1968)	Handbuch der Systematischen Anatomie des Menschen	Anterior interosseous artery
Luschka (1865)	Die Anatomie des Menschen	Anterior interosseous artery
Hoffmann (1878)	Lehrbuch der Anatomie des Menschen	Anterior interosseous artery
Schäfer and Thane (1890)	Quain's Elements of Anatomy	Anterior interosseous artery
Gegenbaur (1892)	Lehrbuch der Anatomie des Menschen	No description
His et al. (1903)	Handbuch der Anatomie des Menschen	Anterior interosseous artery
Kopsch (1914)	Rauber's Lehrbuch der Anatomie des Menschen	Median artery (discribed as a branch of the anterior interosseous artery)
Adachi (1928)	Das Arteriensystem der Japaner (Bd. 1)	No description
Huber (1930)	Piersol's Human Anatomy (9th ed)	Anterior interosseous artery
Lanz and Wachsmuth (1935)	Praktische Anatomie. Arm.	No description
Schaeffer (1953)	Morris' Human Anatomy, a Complete Systematic Treties (11th ed)	Anterior interosseous artery
Davis and Davis (1963)	Gray's Anatomy, Descriptive and Applied (33th ed.)	Anterior interosseous artery
Voss and Herrlinger (1968)	Taschenbuch der Anatomie (Bd. 2, 13. Auflage)	Anterior interosseous artery
Romanes (1981)	Cunningham's Textbook of Anatomy (12th ed.)	Anterior interosseous artery
Fleischhauer (1985)	Benninghoff Makroskopische und mikroskopische Anatomie des Menschen (Bd. 2)	Anterior interosseous artery
Lippert and Pabst (1985)	Arterial Variations in Man, Classification and Frequency	No description
Bergman et al. (1988)	Compendium of Human Anatomic Variation: Text, Atlas, and World Literature	No description
Doyle and Botte (2003)	Surgical Anatomy of the Hand and Upper Extremity (vol. 1)	Anterior interosseous artery
Federative Committee on Anatomical Terminology (1998)	Terminologia Anatomica: International Anatomical Terminology	RNA: Radial artery UNA: Ulnar artery

(Mysorekar, 1967; Skawina and Wyczolkowski, 1987; Trueta and Caladias, 1964). *T. Anatomica* lists the RNA and the ulnar nutrient artery (UNA) as branches of radial and ulnar arteries, respectively (Table A.1a). Highly referenced anatomy textbooks regard the RNA and UNA as branches of the anterior interosseous artery, which is one of the branches of the ulnar artery (Table 1, Table A.2) (Davis and Davis, 1963; Doyle and Botte, 2003; Fleischhauer, 1985; Henle, 1968; Hoffmann, 1878; Luschka, 1865; His et al., 1903; Huber, 1930; Kopsch, 1914; Romanes, 1981; Schäfer and Thane, 1890; Schaeffer, 1953; Voss and Herrlinger, 1968), although some textbooks do not refer to the RNA and UNA (Adachi, 1928; Gegenbaur, 1892; Lanz and Wachsmuth,1935; Lippert and Pabst, 1985; Bergman et al., 1988). Therefore, we sought to resolve the discrepancy in the description on the RNA between anatomy textbooks and *T. Anatomica*. For this purpose, we re-evaluated the anatomic characteristics of the RNA and the UNA, through cadaveric dissection.

2. Materials and methods

All cadavers were of individuals who donated their bodies for medical education and research to the Juntendo University School of Medicine. Prior to the donation, written consent was obtained from individuals and families. The protocol for this study was approved by the Ethics Committee of the Juntendo University School of Medicine (Approval No. 2014138).

To study the localization of the nutrient foramen in the radius and ulna, 54 pairs of dried radii and ulnae from 27 adult Japanese cadavers were used. To examine the origin and course of the RNA and UNA, 67 forearms (right side, 44; left side, 23) were collected from 49 embalmed Japanese cadavers (18 females, 31 males) (Table A.3). To embalm the cadavers and clearly visualize small arterial branches, 10% formalin was injected from the femoral artery followed by an injection of Liquitex Professional Acrylic ink (Naphthol Crimson, Liquitex Artist Materials, Piscataway, NJ, USA). No evidence of any significant pathology, surgical procedures, or traumatic lesions to the upper extremities was seen in any of the cadavers. The arterial tree in the anterior forearm was recorded by line drawings in all specimens.

3. Results

3.1. Localization of nutrient foramens in radii and ulnae

For easy identification of the RNA and UNA on cadaveric dissection, we first studied the localization of the nutrient foramens in 54 pairs of dried radii and ulnae. The radial and ulnar nutrient foramens were macroscopically seen in all the radii and ulnae examined. In most of the radii, one nutrient foramen was located on the anterior or lateral surface near the proximal half of the anterior edge, which corresponded to the lateral margin of the flexor pollicis longus origin (Fig. 1a). In only two radii, the nutrient foramen was found on the posterior surface (Fig. 1a). In most of the ulnae, one nutrient foramen was found at the proximal half of the anterior surface, between the anterior and interosseous borders (Fig. 1b). In only one ulna, the nutrient foramen was found behind the interosseous border (Fig. 1b). Both radial and ulnar nutrient canals ran proximally from the nutrient foramina. The above findings on the localization of the nutrient foramen and the direction of the nutrient canal correspond well to previous reports (Mysorekar, 1967; Skawina and Wyczolkowski, 1987; Trueta and Caladias, 1964).

3.2. The major branches of the radial and ulnar arteries in the proximal forearm

The RNA and UNA originated from various arteries in the proximal half of the forearm; we thus described the arterial tree of this region to easily understand the origin of the RNA and UNA. The main arteries of the proximal forearm were the radial and ulnar arteries, which bifurcated from the brachial artery at the cubital fossa. In the proximal forearm, the radial artery passed superficially over several antebrachial muscles, such as the brachial head of the pronator teres, the radial head of the flexor digitorum superficialis, and the flexor pollicis longus (Fig. A.4). The ulnar artery