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ORIGINAL ARTICLE

Anatomical analysis of the radial nerve and arcade of Frohse in the cubital fossa using human cadavers

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ABSTRACT

Background: The radial nerve (RN) is a peripheral nerve that originates from the posterior bundle of the brachial plexus and carries C5-Th1 fibers. In the cubital fossa radial nerve divides into a superficial branch of the radial nerve (SBRN) and a deep branch of the radial nerve (DBRN). Next DBRN enters under the arcade of Frohse (AF) and changes its name to posterior interosseous nerve of antebrachii (PIN). The AF was first described in 1908 by Frohs and Frankel. It is the superior proximal part of the supinator muscle, which can be tendinous or membranous.

Materials and methods: Eight dissected upper limbs were examined to measure the distances and characteristics of the RN, DBRN, SBRN and AF, utilizing precise electronic caliper.

Results: The average distance from the point of branching of the RN into its terminal branches to the AF was 54.64 mm on average. In half of the cases DBRN divided before entering the AF. The average distance from the point of branching of the DBRN to the AF in these cases was 13.88 mm. The width of the AF averaged 8.60 mm. Five tendinous AF and three membranous AF were identified.

Conclusions: A thorough understanding of the anatomy of the radial nerve and its branches in the cubital fossa, as well as the AF, is important for the development of anatomy and may also contribute to the reduction of surgical complications during procedures in this area.

Keywords: radial nerve, arcade of Frohse, DBRN, cubital fossa, cadaver

INTRODUCTION

The radial nerve (RN) is a peripheral nerve that originates from the posterior fascicle of the brachial plexus [2, 4, 9] and carries C5-Th1 fibers [9]. It runs between the long head and the medial head of the triceps and further into the radial nerve groove of the humerus. The RN then perforates the lateral intermuscular septum and enters the anterior compartment of the arm. Before it reaches the forearm, it runs between the brachialis and brachioradialis muscles [2, 14, 26]. It is there that the radial canal, which is located between the brachialis muscle and the brachioradialis muscle at the level of the humeroradial joint, has its origin. The base of the canal is formed by the ulnar joint capsule and a fragment of the deep head of the supinator muscle, while from above it is formed by the brachialis, brachioradialis and extensor carpi radialis brevis muscle [19]. In turn, the radial canal ends with the distal edge of the supinator muscle [24]. At the level of the lateral epicondyle of the humerus, the RN divides into a superficial branch of the radial nerve (SBRN) and a deep branch of the radial nerve (DBRN) [2, 26]. DBRN runs between the two heads of the supinator muscle and enter under the arcade of Frohse (AF). The DBRN entering under the AF changes its name to the posterior interosseous nerve of antebrachii (PIN) [16]. The RN contains motor, sensory [9] and proprioceptive fibers (PIN fibers for the posterior capsule of the wrist joint) [23].

The AF was first described in 1908 by Frohs and Frankel [8]. It is the superior proximal part of the supinator muscle, which can be tendinous or membranous [20]. Understanding the anatomic relationships around the supinator muscle is crucial in reducing surgical complications [29].

MATERIALS AND METHODS

Eight upper limbs (four right upper limbs and four left upper limbs) were dissected, visualizing the RN, DBRN, SBRN and AF. Using an electronic caliper with ± 0.02 mm accuracy, the distance of the RN to the AF division, the distance of the DBRN division to the AF, the diameter of the RN at a distance of 1 cm from the end division, and the width of the AF were measured. In addition, the structure of the AF (tendinous or membranous) was visually assessed. The cadavers used for this study came from the Informed Cadaver Donation Program carried out by the Medical University of Silesia in Katowice since 2003.

RESULTS

The average distance from the point of branching of the RN into its terminal branches to the AF was 54.64 mm on average. In half of the cases DBRN divided before entering the AF. The average distance from the point of branching of the DBRN to the AF in these cases was 13.88 mm. Detailed measurement results are presented in Table 1. The division of the RN into the DBRN and SBRN, as well as the AF, is illustrated in Figure 1.

The diameter of the RN measured 10 mm proximally from the division site into terminal branches was 4.79 mm. The diameter of the DBRN measured 10 mm distally from the origin site averaged 4.09 mm, while the diameter of the SBRN measured 10 mm distally from the division site averaged 2.50 mm. Detailed results of the diameter measurements of the RN, DBRN, and SBRN are presented in Table 2.

The width of the AF averaged 8.60 mm. Additionally, five tendinous AF (two left upper limbs and three right upper limbs) and three membranous AF (two left upper limbs and one right upper limb) were identified. Detailed results of the width measurement and assessment of AF structure are presented in Table 3.

DISCUSSION

The study showed that RN makes its division at a distance 54,64 mm from AF. Other studies have reported values of 46 mm [19], 36 mm [29], 51 mm [18]. Shreya Nair et al. [18] depended the description of the RN division on the level of the lateral and medial epicondyle of the humerus (transepicondylar distance), stating that the RN divides above the described location in most cases.

The DBRN usually enters under the AF as a single branch [12, 28]. However, there are cases described in the literature where the DBRN divides into two branches before entering under the AF [30]. Such cases were also observed in our study.

Measurements of RN, DBRN, and SBRN diameters conducted on human cadavers are not frequently described in the literature. Nair et al. measured the diameter of RN and SBRN at sites of their potential compression, obtaining results of 3.2 mm for RN and 2 mm for SBRN, respectively [18]. Welle et al. [31] assessed the RN diameter as 47 mm, but this measurement was taken at the level of the humeral shaft. Meng et al. [17] measured the diameter of DBRN proximal to AF, yielding results ranging from 1.0 to 1.5 mm.

In our study, the tendinous AF was observed more frequently. The results of other authors’ studies are presented in Table 4. Meta-analysis showed that tendinous AF occurs in

66% of cases [1]. The Table does not include the results of the study by Tatar et al. [28] because it was not conducted on adult cadavers, but on human fetuses. Nevertheless, the results of this study are interesting because membranous AF was found in all the cases described. This may imply that the change in AF structure from membranous to tendinous occurs with age. Similar results were presented by Spinner M [27] and Caetano EB [3]. In the literature, the most common classification of AF structure is tendinous or membranous. However, Debouck and Rooze [6] created a more complex classification of AF structure distinguishing type A (tendinous Arcade), type B (musculo-tendinous Arcade), type C (muscular Arcade) and type D (membranous Arcade). Geographical analysis conducted by Benes M et al. [1] showed the highest prevalence of tendinous AF in Asia (74%), followed by South America (73%), Europe (67%), and North America (42%).

In our study, the average width of AF was 8.60 mm. Data available in the literature are variable. Oztruk et al. [20] reported an AF width of 10.13 mm. Ebraheim et al. [7] described this dimension with a gender differentiation: in men, the width was 2.8 mm, while in women it was 2.5 mm.

A comprehensive knowledge of the anatomy of the RN, its terminal branches and the AF has a significant role in surgery and orthopedics. Approximately 1% of non-traumatic upper extremity disorders are compression of the RN or its branches [11, 28]. The possibility of compression of the RN–PIN branches was first pointed out in 1905 by Guillain G. et al. describing a case of a conductor [10]. Compression can occur at four locations: under the AF (the most common cause) [20], in the tendinous band forward of the radial bone, at the tendinous margin of the extensor carpi radialis brevis muscle, and through the radial recurrent artery (Henry's leash) [13]. The peak incidence of radial tunnel syndrome (RTS) is between the ages of 40 and 60 [15, 25]. RTS almost always affects the dominant limb [25].

The number of extremities used in the study was not high, but we consider this study to be of high value to the development of anatomy, especially in view of the deficiency of human bodies donated to science and the crisis in the teaching of anatomy at universities, which do not provide medical students with adequate access to human bodies during anatomy classes.

CONCLUSIONS

The availability of human cadavers used for scientific research and medical student education is limited. Many medical schools face a shortage of human cadavers in the dissection room. This makes scientific research conducted on human cadavers valuable. A thorough understanding of the anatomy of the radial nerve and its branches in the cubital fossa, as well as the arcade of Frohse, is important for the development of anatomy.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement

original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

Ethics statement

The study was reviewed and approved by an Ethics Committee. Number assigned by the Bioethics Committee: KAP/0724/7/2024.

Author contributions

Tomasz Lepich: conception, design, execution and interpretation of the data being published, Radosław Karaś: design, execution and interpretation of the data being published, wrote the paper, Kamil Kania: design, execution and interpretation of the data being published, wrote the paper, Konrad Barszczewski: execution and interpretation of the data being published, wrote the paper, Grzegorz Bajor: conception, scientific supervision.

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Conflict of interest

None declared.

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Table 1. Division of the RN into terminal branches and division distance of the DBRN to AF

Side	**Division RN to AF [mm]**	**Division DBRN to AF [mm]**
Left	88.50	–
Left	24.03	–
Left	47.58	16.21
Left	51.43	15.84
Right	95.05	12.31
Right	20.08	11.17
Right	49.40	–
Right	61.05	–

AF — arcade of Frohse; DBRN — deep branch of the radial nerve; RN — radial nerve.

Table 2. Results of measurements of the diameters of RN, DBRN, SBRN

Side	**Diameter RN [mm]**	**Diameter DBRN [mm]**	**Diameter SBRN [mm]**
Left	4.35	2.68	2.46
Left	4.75	4.18	1.48
Left	4.45	4.56	2.48
Left	4.92	4.27	2.77
Right	6.85	6.29	4.83
Right	3.65	3.82	1.48
Right	4.35	3.04	1.75
Right	5.00	3.87	2.73

DBRN — deep branch of the radial nerve; RN — radial nerve; SBRN — superficial branch of the radial nerve.

Table 3. Results of arcade of Frohse (AF) width measurements and assessment of its structure

Side	AF width [mm]	AF structure
Left	11.19	Tendinous
Left	8.11	Tendinous
Left	7.98	Membranous
Left	9.41	Membranous
Right	10.02	Membranous
Right	10.14	Tendinous
Right	7.36	Tendinous
Right	4.56	Tendinous

Table 4. A ratio of arcade of Frohse (AF) tendinous or AF membranous in other authors' studies results — own development

Number of upper extremities	AF tendinous	AF membranous	Reference
55	48 (87%)	7 (13%)	Ozturk A. et al. (2005) [20]
100	46 (46%)	54 (54%)	Hohenberger G. M. et al. (2020) [12]
60	48 (80%)	12 (20%)	Ozkan et al. [19]
20	14 (70%)	6 (30%)	Ebraheim et al. (2000) [7]
18	14 (78%)	4 (22%)	Hazani et al. (2008) [11]
31	21 (68%)	10 (32%)	Thomas et al. (2000) [29]
120	61 (51%)	59 (49%)	Papadopoulos et al. (1989) [21]
60	34 (57%)	26 (43%)	Prasartritha et al. (1993) [24]
30	26 (87%)	4 (13%)	Clavert et al. (2009) [5]
21	15 (71%)	6 (29%)	Meng et al. (2015) [17]
60	48 (80%)	12 (20%)	Paul et al. (2020) [22]
8	5 (62.5%)	3 (37.5%)	Results of this study

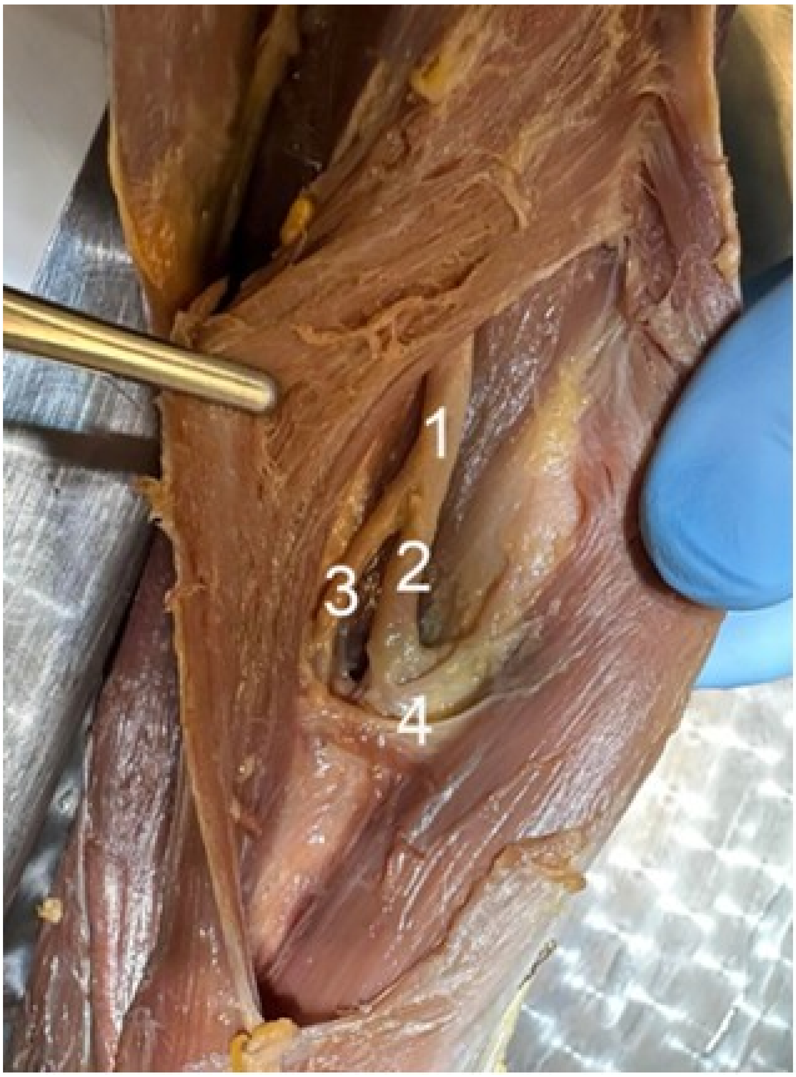

Figure 1. The division of the RN into the DBRN and SBRN, as well as the AF. 1 — RN, 2 — DBRN, 3 — SBRN, 4 — AF. AF — arcade of Frohse; DBRN — deep branch of the radial nerve; RN — radial nerve; SBRN — superficial branch of the radial nerve.