

Relation of the Radial Nerve with the Sulcus Nervi Radialis: A Morphometric Study

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Summary: The radial nerve's course from the axillary region, branch patterns and the relation of the nerve to fixed anatomical landmarks in the arm region were studied in 27 embalmed intact cadavers. The radial nerve and its relation with the sulcus nervus radialis (SNR) was analyzed. The direct contact of the nerve with humerus in SNR was observed during the dissections. The following measurements were made: the total length of the humerus (the palpable uppermost point of the tuberculum majus and the lateral epicondyle); proximal safe zone (the tuberculum majus and the proximal beginning of the SNR); distal safe zone (the intercondylar axis and the middle of SNR); lateral safe zone (the lateral epicondyle and the distal end of SNR).

In conclusion, it was aimed to correlate the osseous palpable landmarks of humerus with the course of the radial nerve for a safe surgery as the sulcus nervi radialis region is one of the main risky areas for the radial nerve palsies.

The radial nerve is a branch of the posterior cord of the brachial plexus which is one of the main structures on upper extremity function. At the beginning while it is anterior to the subscapularis, teres major and latissimus dorsi muscles; then it passes deep to the long head of triceps. It courses at the junction of the middle and distal thirds of the humerus in a space adjacent to the posterolateral aspect of the bone, with accompany of the profunda brachii artery, which is called as 'sulcus nervi radialis' 'spiral groove', 'musculospiral groove' or 'radial groove'. In the anatomy textbooks the sulcus is defined as an oblique space which is directed inferolaterally and consisting radial nerve as well as profunda brachii artery and its vein^{1,2)}.

The nerve then pierces the lateral intermuscular septum and courses over the lateral border of the brachialis and passes deep of brachioradialis and extensor carpi radialis longus and brevis and runs

directly over the annular ligament of the radial head. The nerve divides into two; namely superficial and posterior interosseous nerves distal to the lateral epicondyle^{2,3,4)}.

Precise knowledge of the morphometric anatomy is essential for surgical exploration. Although the surgeons dealing with the musculoskeletal system and especially its traumas should be familiar with the course of the main structures under the light of anatomical dissection studies; they should also expect some variations and differences in practice. A thorough knowledge is needed for a safe surgery especially in SNR region which is one of the main risky areas for the nerve palsies^{3,5)}.

Thus in this anatomic study, it was aimed to make the correlation between the osseous palpable landmarks of humerus and the course of the nerve which may help the surgeons.

Materials and Methods

The radial nerve was dissected in 27 arms of intact embalmed cadavers, in which 14 was the right side, while the remaining 13 was the left. No macroscopic pathology observed in the dissected extremities, except one of the left sides. It had a tumorous like lesion so it was excluded. Dissections were carried out by anatomists and orthopaedic surgeons while the cadavers were in prone position at the Ankara University, Medical Faculty, Department of Anatomy.

Twenty-four hours before dissection, about 50 ml of latex solution (BE-KAT-SAN Ltd., Istanbul, TURKEY) combined with Indian ink, was injected under manual pressure into the axillary artery of the formalin embalmed cadavers. This provided a detailed scene of the small arteries and helped in identification of the peripheral neural and vascular structures⁶.

The arms were in their fixed positions, the forearms were in neutral, the elbows were extended (about 10 degrees of flexion) and the arms were abducted about 15 to 20 degrees. Posteromedial approaches were used for the dissections. The proximal and distal end points of the nerve were marked by excising the nerve while travelling in the zone of SNR.

A digital caliper sensitive up to 0.1 mm. was used and expressed in millimetres for the measurements (Casio, Japan). The following measurements were made: the total length of the humerus (the palpable uppermost point of the tuberculum majus and the lateral epicondyle); proximal safe zone (the tuberculum majus and the proximal beginning of the SNR); distal safe zone (the intercondylar axis and the middle of SNR); lateral safe zone (the lateral epicondyle and the distal end of SNR) (Fig. 2).

Results

There were no significant differences between the right and the left sides when both upper ex-

tremities were in the similar fixed positions in the embalmed cadavers.

In our study we observed that the radial nerve was in direct contact with the humerus in the groove and the groove was formed by the lateral and medial heads of the triceps muscle (Fig. 1).

The average length of the humeri were 326.6 mm. within the range of 300 mm. to 390 mm. This measurement was between the two osseous palpable landmarks as the most upper palpable point of tuberculum majus and the lateral epicondyle.

The distal safe zone which was identified as the distance between the intercondylar axis and the middle margin of SNR was 157 mm. (130 mm.-175 mm.). During the posteromedial approach, it was probable to meet with the nerve at the proximal point of the distal safe zone. This was corresponding to the 48% of the total length.

The mean value for the proximal safe zone was 139 mm. with a range of 125 mm. to 160 mm. The proximal safe zone was defined as the distance between the tuberculum majus and upper margin of SNR.

The last measured parameter was the lateral safe zone. It was measured as 110.2 mm (90 mm. to 130 mm.) in a mean base. This was the distance of the lateral epicondyle to the end of the SNR (Table 1).

The average length of the SNR, beginning from the point where the radial nerve enters the spiral groove to the end of the SNR, was 62.6 mm. (45 mm.-75 mm.). (Fig. 2)

Discussion

The radial nerve entrapment occurs less frequently than the ulnar and median nerve entrapments. Three common sites considered as compression sites for the radial nerve are the spiral groove in the arm, the radial tunnel just distal to the elbow and proximal to the wrist in the cleavage between the brachioradialis and extensor carpi

Table 1. Morphometric analysis of the total specimens are given in Table 1

N = 27	Mean	Min.	Max.	STD
Total length (Humerus)	326.6	300	390	11.00
LSZ	110.2	90	130	8.38
DSZ	157	130	175	10.76
PSZ	139	125	160	11.6
The length of SNR	62.6	45	75	7.64

LSZ: Lateral safe zone, DSZ: Distal safe zone, PSZ: Proximal safe zone, SNR: Sulcus nervi radialis.

radialis longus muscles⁵.

The nerve most frequently injured in humeral fractures is the radial nerve because of its spiral course in the midshaft of the bone and relatively fixed position in the distal arm while penetrating the lateral intermuscular septum⁷.

The radial nerve injury is frequently seen in the distal third fractures of the humerus and this was first pointed out by Holstein and Lewis. They reported a closed spiral fracture at the distal third of the humerus in which the nerve entrapment between the fragments. In that spiral fracture the distal bone fragment displaced proximally and deviated radially⁸.

Pollock *et al.* reported about 4 to 12 percent of nerve lesion with humeral fractures and recommended close follow-up (clinical or electromyographic) for about 3–4 months and exploration if there had been no improvement⁹.

Although there is a tendency for conservative treatment of humeral fractures, 'the radial nerve palsy' accompanying the fracture is an indication for open reduction as well as exploring the nerve^{4,7,9}.

The anatomy, organogenesis and the relation of the radial nerve with the sulcus nervi radialis (SNR) is present in the literature. There are several theories about the organogenesis of SNR. The most popular one was made by Gagisin in 1972. According to his report, the thoracic and abdominal extremities both orientates similarly in the 9th week in-utero. In that stage the flexor sides of extremities are orientated to vertebro sternal axis. Later the extremities rotate internally about 90 degrees. It was believed that the SNR develops in that rotation period¹⁰.

Whitson reported his observations in cadaver dissections that the radial nerve did not have direct contact with the bone and the SNR was covered by fibrils of brachialis and the medial head of the triceps. He thought that the SNR was the origin of the brachialis and the radial nerve had contact with humerus only on the lateral supracondylar region¹¹. Our observations were not in consistency with Whitson's report. In our study the nerve was in direct contact with the humerus in the radial groove and the groove was formed by the lateral and medial heads of the triceps.

Anterolateral or posteromedial approaches to dissect the radial nerve in SNR are commonly used^{4,7}. The results of this study suggest during posteromedial approach that it was possible to find the nerve in a distance beginning from the point 157 mm. proximal to the intercondylar junction. This corresponds about 48% of the total length.

In the anterolateral approach the risk of meeting

the nerve was about 110.2 mm. proximal to the lateral epicondyle which was about 33% of the total length. This was called as lateral safe zone. One considers the minimum distance measured as a real safe zone for a percutaneous fixation during the application of an external fixator, should be maximum 130 mm. of a distance from the lateral epicondyle superiorly. But these measurements may not be accurate in a fractured bone, as in this particular case the bone might be shortened and deformed. Thus, a new reference point is needed. The tuberculum majus can be palpated easily, so the distance between the tuberculum majus and the beginning point of SNR was measured in our study. It was about 139 mm. with a range of 125 mm. to 160 mm. and this was about 42% of the total length and might be named as the superior safe zone.

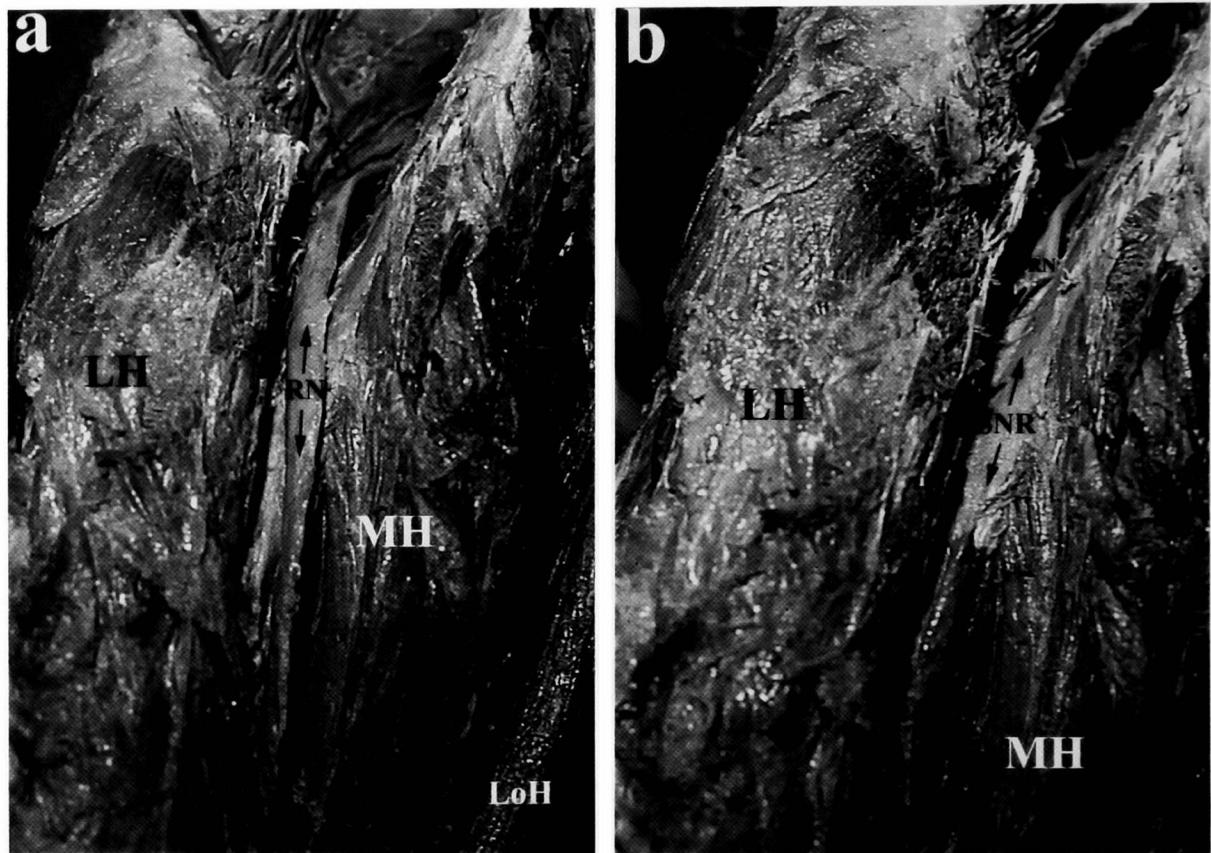
Guse and Ostrum measured the distance between the most distal point of SNR and the lateral epicondyle as 126 mm. (101 mm.–148 mm.) and the upper point of SNR and acromion as 124 mm. (97 mm.–142 mm.). The total length was reported as 302 mm.³. Our results differ from that study, although the total body lengths of the humeri were different.

The results of this study showed that the surgeons dealing especially with upper extremity should not only be aware of the possible variations but also expect certain differences in surgery due to some reasons which are the lenght of sulcus nervi radialis (SNR) and total length of the humerus.

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Explanation of Figures

Plate I

Fig. 1. Photograph showing a posterior view of one of the left extremities.

- A) Radial nerve courses between caput laterale and mediale of the triceps brachii (LH: Caput laterale of the triceps brachii, MH: Caput mediale of the triceps brachii, LoH: Caput longum of the triceps brachii, RN: Radial nerve)
- B) Sulcus nervi radialis can be seen after removing the radial nerve (LH: Caput laterale of the triceps brachii, MH: Caput mediale of the triceps brachii, SNR: Sulcus nervi radialis)

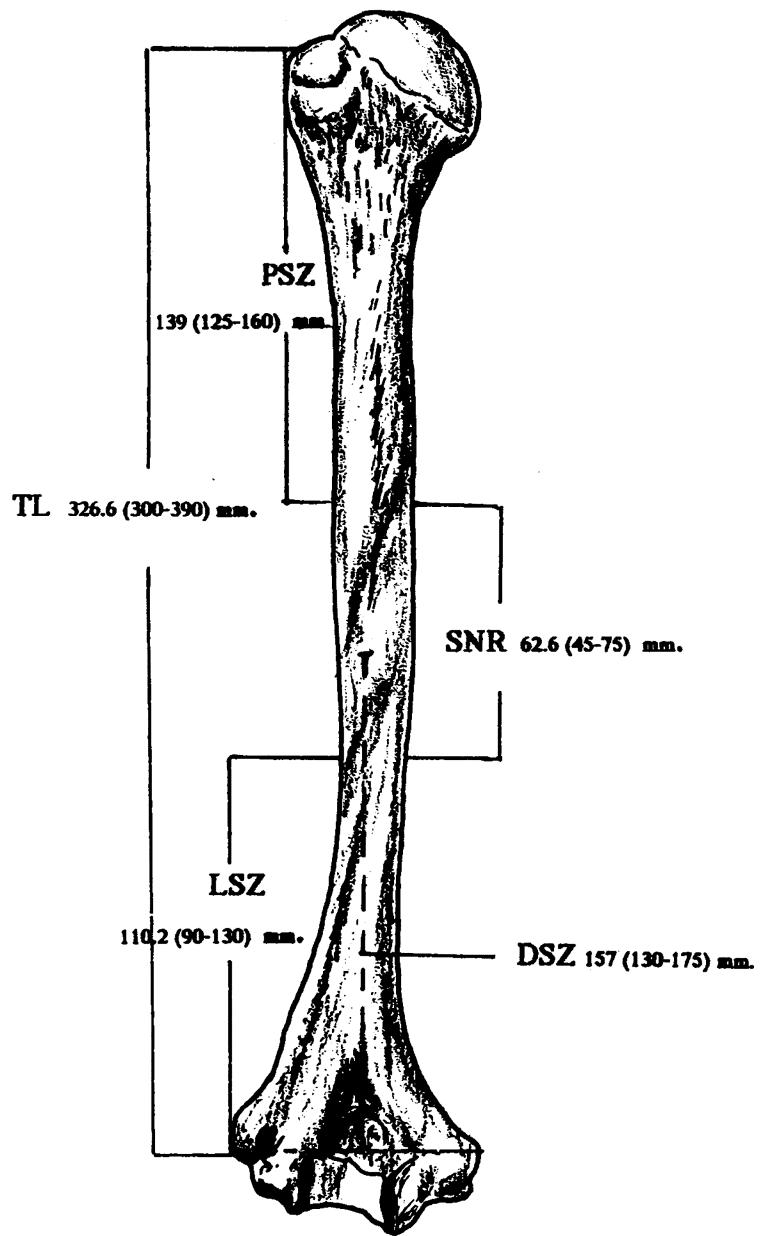
**Plate II**

Fig. 2. Schematic drawing of the posterior view of the humerus.

(PSZ: Proximal safe zone, TL: Total length, SNR: Sulcus nervi radialis, LSZ: Lateral safe zone, DSZ: Distal safe zone)