A STUDY ON MORPHOMETRIC STUDY OF RADIAL NERVE AND ITS VARIATIONS

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ABSTRACT

Background: Radial nerve is the largest branch (C5, 6, 7, 8, T1) from the posterior cord of brachial plexus. Knowledge of radial nerve is not only useful for anatomist but also for plastic surgeons, orthopedicians and physiotherapists. Radial nerve injury is most common nerve injury complicating fracture of humerus. Radial nerve injury is commonly seen in humerus shaft fracture surgery when performing in the radial groove and in the supracondylar region .

Methodology: In the present study, a total of 100 upper limb specimens were dissected and studied. After thorough dissection and notification of observations the relevant photographs of the same were taken. The observations made were tabulated, statistically, analysed and compared with earlier studies.

Results: In the present study the average length from tip of the posterior lateral aspect of the acromion to the lateral epicondyle was 27.9 cm. The radial nerve was found to be in direct contact with the position humerus from 17.1cm to 10.8cm proximal to the central aspect of lateral epicandyle of humerus. The length of contact of radial nerve with the posterior humerus was (6.9 ± 0.9 cm). It was found that in 80% of specimens the radial nerve divided into two terminal branches (superficial branch of radial nerve and deep branch of radial nerve) and in the remaining 20% specimens it divided into three branches the third being the nerve to extensor carpi radialis brevis. The radial nerve divided above the level of lateral epicondyle in 77% of specimens, at the level of lateral epicondyle in 8% and below the level

of lateral epicondyle in 15% of specimens. The distance from the point of division of radial nerve into terminal branches to the level of lateral epicondyle is with the mean length of 2.7 ± 0.1 cm.

Conclusion: Hence gross anatomical knowledge of radial nerve's origin, course, branches, distribution and communication is of vital importance. Anatomical variation of radial nerves are important to medical personnel especially to orthopedicians, radiologist, neurophysicians plastic surgeons and physiotherapists for surgical planning and avoidance of iatrogenic injury to nerve during surgeries, nerve grafting, neurophysiologic evaluation to diagnose neuropathies.

Keywords: Radial nerve, epicondyle, humerus, Anatomical variation, Neuropathies.

INTRODUCTION

The radial nerve arises as the continuation of the posterior cord of the brachial plexus. In the lower part of the axilla, radial nerve passes downward to reach arm and in the upper part of the arm, it continues behind the brachial artery and passes posterolateral (with the profunda brachii vessels) through the lower triangular space, below the teres major, and the humerus. It then enters the radial groove of humerus with the profunda vessels. In the radial groove, the nerve runs downwards and laterally between the lateral and medial heads of the triceps, in contact with the humerus. The nerve pierces the lateral intermuscular septum, 5cm below the deltoid tuberosity and then passes into the anterior compartment of the arm. In the cubital fossa the radial nerve appears in the gap between the brachialis and the brachioradialis .The radial nerve divides into two terminal branches in the cubital fossa at the level of the lateral epicondyle of humerus.

The main sites, vulnerable for radial nerve injury are the spiral groove and the lateral intermuscular septum. The radial nerve is vulnerable to injury during operative procedures of the humerus. The radial nerve is described as the landmark for surgeries of the arm.

The most common indication for surgical exposure of the radial nerve, along the course from the axillary fossa to proximal part of the forearm, is the repair of the radial nerve in open or closed traumatic injuries or graft suture repair which permits valid functional recovery of the nerve in most of the cases.

Surgical exposure of the radial nerve is also necessary for excision of nerve tumors and for the treatment of entrapment neuropathies in consequences to compression at various anatomical sites, such as the lateral head of triceps muscle, lateral intermuscular septum, proximal portion of the radial tunnel and supinator muscle.

Many efforts have been made by several authors to obtain precise anatomical data regarding the course of radial nerve and its topographical relations, measurement of the radial nerve with reference to reliable anatomical landmarks in the arm of the embalmed specimens, for choosing correct surgical procedures and for allowing safe positioning of implant fixation.

AIMS AND OBJECTIVES

AIM: The present study aims at **"**morphometric study of radial nerve and its variations**"** in cadaveric dissection.

OBJECTIVES:

- ❖ The objective of the study is to dissect and expose the radial nerve.
- ❖ To identify and record the morphometry of radial nerve and its variations during the above study.
- ❖ To compare the observation of the present study with the observations of authors who conducted similar study previously.

MATERIALS & METHOD

The present study aims **"**Morphometric study of radial nerve and its variations**"** in cadaveric dissection, this study was undertaken at the Department of Anatomy, Rangaraya Medical College, Kakinada and Department of Anatomy Andhra Medical College, Visakhapatnam.

- Post-mortem bodies from the Department of Forensic Medicine, Government general hospital, Kakinada and Department of Forensic Medicine, King George Hospitals, Visakhapatnam.

Sample size:

This study was carried out on 100 superior extremities of formalin embalmed human cadavers over a period of two years between October 2012 to September 2014

The cadavers were preserved with exposure to routine techniques, and careful observation was done on both sides with naked eye examination.

Inclusion Criteria: Formalin embalmed upper limb specimens irrespective of age, sex or race.

Exclusion Criteria: Upper limbs showing gross asymmetry, any injury to the nerve, or fracture of humerus, or radius or ulna or any surgical procedure that disturbed the course of radial nerve will be excluded as unsuitable

Materials used:

1. Forceps
2. Scalpel
3. Pointer
4. Scissor
5. Measuring tape
6. Digital camera.

METHOD OF STUDY

The radial nerve was dissected and exposed in the axilla, posterior aspect of the arm and in front of the elbow region, forearm and back of forearm A measuring tape was used to measure the various parameters in cadaveric specimens. With the help of measuring tape the following length of the radial nerve were recorded.

- Humerus length is measured from a point of tip posterolateral angle of the acromion to the centre of the lateral epicondyle.

- A zone of humerus where the radial nerve was in direct contact with the posterior surface of humerus was identified.
- The proximal point where the radial nerve is direct contact with posterior surface of humerus is marked.
- The distal point where the radial nerve is direct contact with posterior surface of humerus is marked.
- The distance from the point of proximal point where the radial nerve is direct contact with posterior surface of humerus to the centre of the lateral epicondyle is measured.
- The distance from the point of distal point where the radial nerve is direct contact with posterior surface of humerus to the centre of the lateral epicondyle is measured.
- The length of the radial nerve from the (proximal point to the distal point) where the radial nerve is direct contact with posterior surface of humerus is measured.

The relationship of the radial nerve to the posterior humerus was analysed for the presence of a spiral groove and inter posed soft tissue between the radial nerve and periostium of the humerus in each specimen.

The anatomy of the lateral intermuscular septum was observed in all specimen the septum was then incised to define the continuation of the radial nerve as it coursed lateral to the humerus in the anterior compartment

In front of the arm the radial nerve was identified in the interval between the brachioradialis and brachialis.

- The termination of radial nerve into superficial branch and deep branch of radial nerve was identified and noted.

- The distance from the point of division of radial nerve in the cubital fossa to the level of centre of lateral epicondyle of humerus was measured.

All measurements were determined by means of a measuring tape, photographs were taken

Table No:1 Parameters measured in the present study

S.no	Parameters	cm
1	Length of humerus (C - L)	
2	Distance from proximal point of radial nerve in radial grooved to centre of lateral epicondyle(Prn-L)	
3	Distance from distal point of radial nerve in radial groove t o centre of lateral epicondyle (Drn - L)	
4	Length of radial nerve segment on posterior humerus (Prn - Drn)	
5	Distance from lateral epicondyle to point of division of radial nerve (L-E)	
6	Level of bifurcation with relation to lateral epicondyle	
7	Number of terminal branches	

OBSERVATIONS

The present study "THE MORPHOMETRIC STUDY OF RADIAL NERVE AND ITS VARIATIONS" was done on 100 upper limbs specimen.

In the present study

- Average humerus length from the centre of posterior lateral aspect of the acromion to the lateral epicondyle was 27.9 ± 1.2 cm.
- The radial nerve was found to be in direct contact with the posterior humerus from 17.1 to 10.8 cm proximal to the central

aspect of the lateral epicondyle.

- The length of contact of the radial nerve with the posterior humerus was 6.9 ± 0.9 cm. (Photo-32)

The branch to the medial head of the triceps coursed distally to eventually supply the anconeus. There was no observable or palpable structural groove in the humerus in the area of the radial nerve in any specimen. The radial nerve was in direct contact with periosteum in all specimens, without interposed muscle or fascial tissue. The nerve became increasingly more fixed in position as it approachedlateral intermuscular septum and then pierced the lateral intermuscular septum.

The lateral intermuscular septum originated from the lateral border of the humerus. It was noted to be a thin but rigid and easily defined structure.

Along the distal half of the humerus, the septum lay in the anterior lateral quadrant of the arm, oriented in a plane that was in midposition between the coronal and sagittal planes. On entering the anterior compartment, the nerve had very little mobility as it was interposed between the obliquely oriented septum and the lateral aspect of the humerus. The nerve was separated from the humerus in this area by a few fibres of brachioradialis muscle. As it extended distally, the nerve coursed anterior to the humerus and became protected by brachialis at the level of proximal aspect of the lateral metaphyseal flare.

It was found that in 80% of specimen the radial nerve divided into terminal branches (superficial branch of radial nerve and the deep branch of the radial nerve) and in the remaining 20% specimen it divided into three branches the third being the nerve to extensor carpi radialis brevis.

In the present study the radial nerve divided

- Above the level of lateral epicondyle in 77% of specimens.
- At the level of lateral epicondyle in 8% of specimen .
- And below the level of lateral epicondyle in 15% of specimens.

The distance from the point of division of radial nerve into terminal branches to the level of lateral epicondyle is with the mean length of 2.7 ± 0.1 cm.

S.no	Parameters	cm
1	Length of humerus (C - L)	27.9±1.2
2	Distance from proximal point of radial nerve in radial grooved to centre of lateral epicondyle (Prn-L)	17.1±0.6
3	Distance from distal point of radial nerve in radial groove t o centre of lateral epicondyle (Drn - L)	10.8±1.1
4	Length of radial nerve segment on posterior humerus (Prn - Drn)	6.9±0.9
5	Distance from lateral epicondyle to point of division of radial nerve (L-E)	2.7±0.1
6	Level of bifurcation with relation to lateral epicondyle	Above – 77% At the level – 8% Below – 15%
7	Number of terminal branches	Two – 80% Three – 20%

C – tip of acromion process

L –centre of lateral epicondyle of humerus

Prn – proximal point of radial nerve in radial groove

Drn - distal point of radial nerve in radial groove

E – site of division of radial nerve in cubital fossa

Table No:2 Data recorded in the present study

DISCUSSION

The present study is compared with various standard text books and works done by various authors. Several of the findings in this anatomic study confirm and extend the observations of previous investigators.

Gerwin et al[1] found that the radial nerve crossed the posterior humerus without muscle or fascial interposition from 20.7 ±1.2 cm proximal to the medial epicondyle to 14.2 ± 0.6 cm proximal to the lateral epicondyle and that it pierced the lateral intermuscular septum 10.2 cm ± 0.2 cm proximal to the lateral epicondyle.

Previous reports noted that the radial nerve crossed the midline of the humerus 15.8 cm ±1.1cm and 15.2 cm ±1.1 cm proximal to the distal articular surface in male and female specimens, respectively.Bono et al[3] reported that the radial nerve pierced the lateral intermuscular septum 12.3 ± 2.3 cm proximal to the olecranon fossa.

Carlan D[2] reported that a 6.3 ± 1.7 cm segment of radial nerve was found to be in direct contact with the posterior humerus. In the present study it was measured a 6.9 ± 0.9 cm segment of radial nerve that laid directly on the periosteum of the posterior aspect of the humerus. There was no evidence of a structural spiral groove in the humerus, despite previous reports of a “humeral groove” or “shallow groove,” and further we did not find interposed triceps muscle between nerve and periosteum in this region.

The findings in this study confirm those stated in Grant’s atlas of Anatomy (11th edition) that the radial nerve is applied directly to the periosteum along the posterior aspect of the humerus.

The findings in the present study illustrate several anatomic findings and relationships.Previous reports on the branching of the radial nerve within the region of the posterior humerus have been inconsistent.

Sunderland[11] reported that all muscular branches to the triceps exit from the radial nerve prior to the spiral groove except the main branch to the medial head.

Hollingshead[12] reported that the radial nerve gives off 3 branches to the triceps while in the spiral groove.

The radial nerve was found to cross the posterior midline of the humerus in the midaspect of this segment, which consistently correlated with the level of the palpable distal aspect of the deltoid tuberosity.

After piercing the lateral intermuscular septum, the nerve remained closely approximated to the lateral surface of the humerus to the level of the most proximal aspect of the lateral metaphyseal flare. In this segment, the radial nerve was found to be interposed between the obliquely oriented lateral intermuscular septum and the lateral aspect of the humerus, separated by a few fibers of the brachioradialis muscle.

In the present study it was found that the radial nerve coursed anterior to the humerus at the level of the metaphyseal flare, where it was separated from bone by the brachialis muscle.

The results of this study helps to explain the intimate relationship of the radial nerve with the posterior humerus renders the nerve susceptible to injury with midshaft fractures and with bicortical fixation of the humerus from an anterior approach. In the region of the readily palpable deltoid tuberosity, nerve injury may be avoided by knowledge of the direct posterior location of the radial nerve.

In addition, hardware inserted from an anterior to posterior direction within this 6-cm region of humerus, centred over the distal deltoid tuberosity, should penetrate the posterior cortex minimally to minimize the risk of chronic nerve irritation.

It has been noted in previous reports that the radial nerve is tethered and at risk laterally as it pierces the lateral intermuscular septum.In this study, we confirmed this observation and, in addition, noted that the nerve was immobilized by the obliquely oriented lateral intermuscular septum well distal to its entrance into the anterior compartment. The nerve was not well protected until it reached the level of the lateral metaphyseal flare where it became separated from bone by the brachialis muscle.These findings helps to explain the high incidence of radial nerve palsy with distal-third humerus fractures.

In addition, the findings in the present study demonstrate the vulnerability of the radial nerve when bicortical fixation of the humerus is carried out through a medial approach, from 10.8 ± 1.1 cm proximal to the lateral epicondyle to the most proximal aspect of the lateral metaphyseal flare.

Understanding the regional anatomy, using subperiosteal dissection with placement of retractors laterally, and avoidance of protruding hardware along the lateral cortex may minimize the potential for nerve injury.

Sharadkumar et al [4]in their study done on 100 specimen reported that, the radial nerve bifurcated into sbrn and pin in 78 specimen and trifurcated in 22 specimen i.e sbrn , pin and the third nerve is nerve to ecrb

Meenakshi khullar et al[5] reported that the radial nerve bifurcated in 80% specimen and trifurcated in 20% specimen

In the present study conducted on 100 specimen the radial nerve bifurcated in 80 specimen and trifurcated in 20 specimen

Table : 3 Division of radial nerve

Division of radial nerve	**Number of specimen**	**%**
Into two branches	**80**	**80%**
Into three branches	**20**	**20%**

Table : 4 Comparison with previous studies

Author	**Into two branches**	**Into three branches**
Salisbury	**92%**	**8%**
Al – Qattan[6]	**80%**	**20%**
Abrahams et al[7]	**70%**	**30%**
Thomas et al[8]	**54.84%**	**45.16%**
Meenakshi et al[5]	**80%**	**20%**
Sharadkumar et al[4]	**78%**	**22%**
Present study	**80%**	**20%**

Linell found the bifurcation of the radial nerve to vary from 4.5 cm. above the lateral epicondyle to 4 cm. below lateral epicondyle, 9 of the specimens showing the nerve divided above lateral epicondyle, 3 at the level of the lateral epicondyle, and 11 below the lateral epicondyle;

Sunderland (1946)[11] found among 20 specimens no divisions above the lateral epicondyle level, 4 at the level of lateral epicondyle, and the remainder from 1 to 3 cm. below lateral epicondyle.

In a study conducted by Yasir Sultan Khuroo et al,[9] the radial nerve division occurred Above the lateral epicondyle in 40%. At the level of lateral epicondyle 6.6% . below the epicondyle in 53.3%

Meenkshi khullar et al[5] reported this as 41.6%,30%,28.3%. respectively

Sharadkumar et al[4] as 60% ,30%,10%. respectively

Abrams[7] reported that all branches were given below the lateral epicondyle

In the present study the division of radial nerve occurred:

- Above the lateral epicondyle – 77%
- At the level of lateral epicondyle – 8%
- Below the lateral epicondyle – 15%

Table: 5 Division of radial nerve with relation to the level of lateral epicondyle

Division of radial nerve	**Numberof specimen**	**%**
Above the level of lateral epicondyle	**77**	**77%**
At level of lateral epicondyle	**8**	**8%**
Below the level of lateral epicondyle	**15**	**15%**

In the present study, The distance from the point of division of radial nerve into superficial and posterior interosseous branches to the level of lateral epicondyle is with the mean length 2.7 ± 0.1 cm.

K. Subasini, S.D. Nalinikumari. [10]reported the mean distance from the upper limit of lateral epicondyle to the site of division of radial nerve into superficial and posterior interosseous branches as 29 (10 ±) mm.

CONCLUSION

Analysis of topographical relation of the radial nerve in the arm and the proximal part of forearm with reference to easily detectable anatomical landmarks was done successfully by conducting dissection. The radial nerve is at risk in its course around the humerus. Knowledge of safe zones helps to provide a framework for plastic surgeons to remember dangerous anatomical locations. This study provides reliable and objective data of surgical anatomy of the radial nerve, and it correlates with previous study, which should always be kept in mind by surgeons approaching to the surgery of the arm in order to avoid iatrogenic injuries.

Acknowledgment

The author thankful to Department of Anatomy for providing all the facilities to carry out this work.

Conflict of Interest: None

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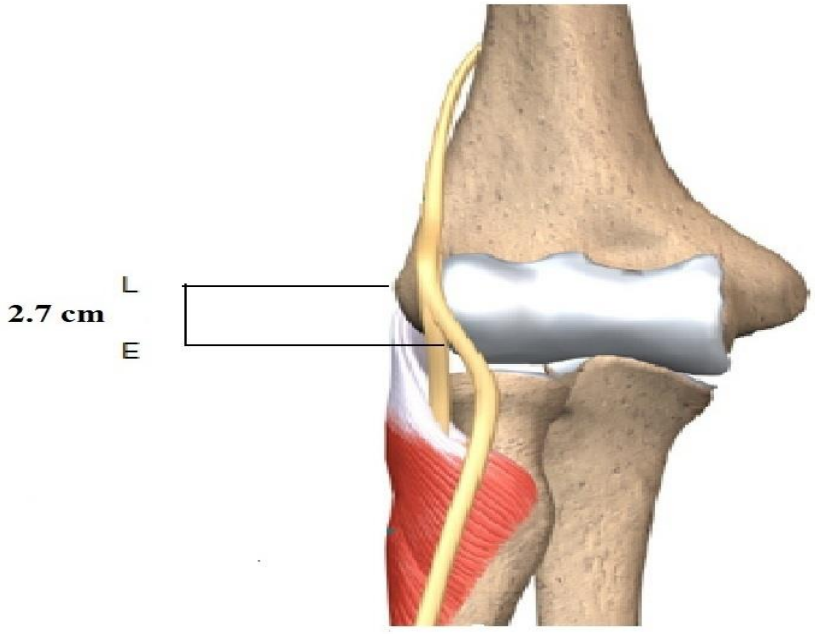
Figures

PLATE : 1



SCHEMATIC DRAWING INDICATING RELATIONSHIP OF RADIAL NERVE WITH OSSEOUS LANMARKS AT ELBOW

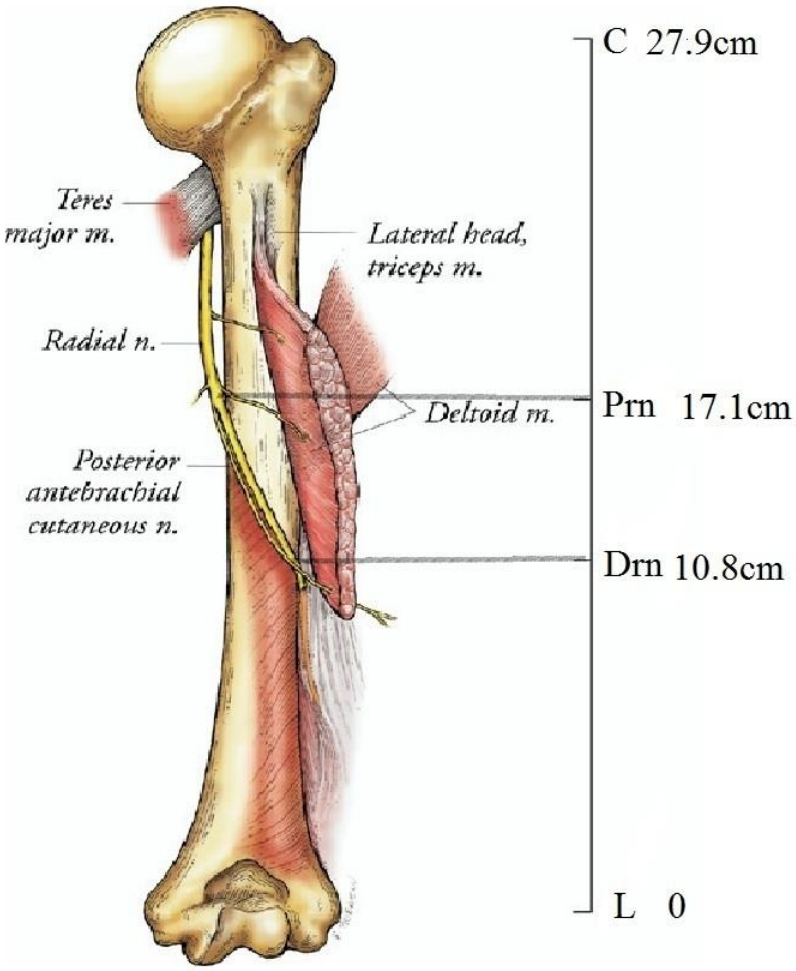

C 27.9cm
Teres major m.
Lateral head, triceps m.
Radial n.
Deltoid m.
Prn 17.1cm
Posterior antebrachial cutaneous n.
Drn 10.8cm
L 0

Fig 2.