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Original Research Article

Relation of radial nerve to superficial bony and soft tissue landmarks- a cadaveric study

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ABSTRACT

Background: Prevention of iatrogenic nerve injury during humerus fracture surgery would be of prodigious importance. Several methods were used to ease this type of injury but no flawless result is at hand. Therefore, this study was designed to predict the location of the radial nerve (RN) by bony as well as soft tissue landmarks and also identify the safe zone for RN in arm.
Methods: Fifty upper limbs belonging to 25 cadavers with no macroscopic deformity of their elbow joint were dissected for the study. RN was dissected in the spiral groove of the humerus and measurements were taken from different anatomical landmarks.
Results: There was no bilateral asymmetry as well as no statistical difference was observed in male and female measurements. The mean distance between olecranon to spiral groove 16.91±0.18 cm, olecranon to entry in Intermuscular septum 10.65±0.16 cm, triceps aponeurosis to RN in spiral groove 2.50±0.06 cm, medial epicondyle to upper margin of spiral groove 17.01±0.09 cm and lateral epicondyle to lower margin of spiral groove 10.97±0.12 cm was observed.
Conclusions: Understanding the zone of danger of humerus provide more safety during surgical intervention of humerus by predicting the location of RN by different bony and soft tissue landmarks.

Keywords: Iatrogenic injury, Humerus, Triceps aponeurosis, Olecranon process

INTRODUCTION

In high-energy trauma cases, humerus fractures are not unusual. RN injury after humeral fractures is very common. The secondary RN palsy may occur due to closed reduction challenges, pull or tear while surgery and impingement between fracture fragments.[1,2] In a systemic review, incidence of injury is reported around 11.8% which is more common in compression plating (10%) than intramedullary nailing (5%).[3,4] The lateral or anterolateral approaches are less likely allied with RN injury in contrast of posterior.[5]

The RN is the largest terminal branch of the posterior cord of brachial plexus with root value C5, C6, C7, C8 and T1. In axilla, it gives branches for long head, medial head of triceps brachii and posterior cutaneous nerve of arm. It passes posteriorly through the lower triangular space along with the profunda brachii artery. In spiral groove, branches for lateral and medial heads of triceps brachii, lower lateral cutaneous nerve of arm, posterior cutaneous nerve of forearm and branch to anconeus passing through the medial head of triceps are given. Then after piercing the lateral intermuscular septum at the lower part of humerus, nerve reaches in the anterior compartment of the arm. Here, it divides into its terminal branches: the superficial branch which is cutaneous and deep branch also known as posterior interosseous nerve (PIN).[6] Fractures of the lower third of shaft of the humerus and its operative fixation may result in RN injury.[1,2]

Numerous bony landmarks like lateral and medial epicondyle, olecreanon process were taken as landmark to foresee the location of the RN in spiral groove.[1,7-13] Conversely, the bony elements have lost their accurate positioning as in commuted fractures, humeral malunion /non-union, other landmarks need to be taken into attention to avoid iatrogenic injury to the nerve.[7,8] So soft tissue landmarks like the triceps aponeurosis was used to identify the RN in various cadaveric study.[9,10] All the aforementioned procedures have some degree of achievement in predicting the location of the nerve but have certain problems.

Therefore, the purpose of this study was to determine a landmark that is unique to any person which will locate the nerve exactly. So, in present study bony as well as soft tissue landmarks were used to predict the location of the RN and also to define the jeopardy region of RN in arm.

METHODS

This cross-sectional study was carried on voluntary donated cadavers to the department of anatomy of AIIMS Jodhpur during June 2020 to April 2022. 50 upper limbs belonging to 25 cadavers were dissected for the study after obtaining ethical permission from institutional ethical committee (letter no AIIMS/IEC/2020/3047 dated on 30/05/20). For each dissection, the cadaver was placed in a prone position on the dissection table. Both arms were placed in an extended position. An incision was made from the tip of the acromion process to the superior aspect of the olecranon process. The skin and subcutaneous tissues was removed. Distance between olecranon to RN in spiral groove were measured (Figure 1). The intramuscular septum between the long and lateral heads of the triceps muscle was identified. The intersection of this septum with the triceps aponeurosis was identified. Blunt dissection through the triceps musculature at a level two finger breadths proximal to the point was performed and the RN was identified lying on the periosteum of the posterior humerus. The distance between the point and the RN was measured. The RN was exposed on the lateral surface of the humerus before it penetrated the lateral intermuscular septum. It was then dissected proximally to where it emerged from the spiral groove of the humerus and measurements were taken from different anatomical landmarks like triceps aponeurosis (Figure 2) and medial epicondyle (Figure 3). The lateral border of the triceps aponeurosis was identified and the RN was exposed over the distal length of its course by dissecting the overlying muscle. The distance between the RN and the lateral margin of the triceps aponeurosis was measured.

Exclusion criteria

Cadavers with any macroscopic deformity of their elbow joint were excluded from the study.

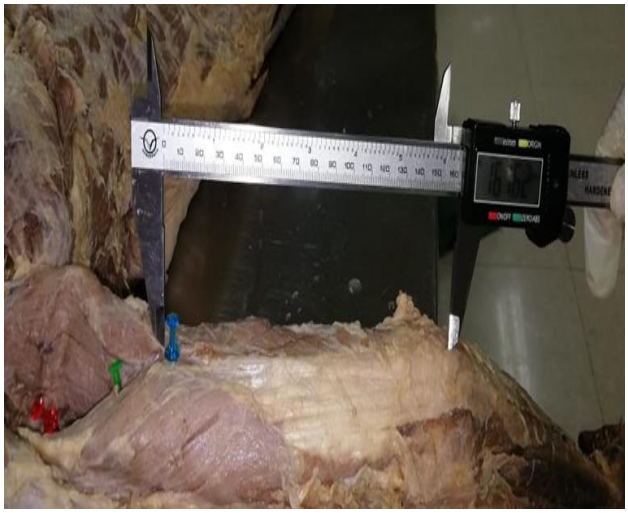

Figure 1: Measurement of distance between olecranon process to spiral groove.

Figure 2: Measurement of distance between triceps aponeurosis to RN in spiral groove.

Figure 3: Measurement of distance between medial epicondyle to upper margin of spiral groove.

Statistical analysis

SPSS software (IBM, version 20.0) was used for the statistical analysis. Descriptive statistics like range, mean, standard deviation was evaluated for all the parameters studied. Unpaired t test was used to assess differences in parameters between male and female.

RESULT

Bilateral asymmetry

The mean differences between the left and right sides were less than 1 mm; in all cases, when analysed by paired t test.

Table 1: Distance of RN from various bony as well as soft tissue landmarks.

Measurements	Male (mean ± SD) (cm)	Female (mean ± SD) (cm)
Olecranon to spiral groove (Figure 1)	16.91±0.18	16.95±0.11
Olecranon to entry in intermuscular septum	10.65±0.16	10.76±0.08
Triceps aponeurosis to RN in spiral groove (Figure 2)	2.50±0.06	2.48±0.03
Medial epicondyle to upper margin of spiral groove (Figure 3)	17.01±0.09	17.03±0.10
Lateral epicondyle to lower margin of spiral groove	10.97±0.12	11.03±0.12

Ten female and 15 male cadavers were taken for study. A total of 50 RNs from 25 cadavers were scanned. The mean age of the female cadaver was 45.1 years and male were 49.3 years. Distance of RN from various bony as well as soft tissue landmarks were showed in Table 1.

By using independent sample test, it was observed that prediction of localization of RN via taking distance between olecranon process to its entry in lateral intramuscular septum ($p<0.05$) in comparison of other parameters. No statistical difference was observed by unpaired t test, in male and female measurements indicate gender may not affect the location of RN.

DISCUSSION

The major concerns for treating surgeons are the knowledge of the RN location in the spiral groove and its association with a consistent and reliable anatomic landmark.

Numerous studies have been carried out on various ethnic populations to determine the relationship between RN and neighbouring bony landmarks. Although, plethora of cadaveric studies for localizing the RN by different bony and soft tissue landmarks exists, but none of them has been established superior for accuracy in prediction of RN location.

Comparison was done between results obtained in the present study using different bony and soft tissue landmarks with previous studies (Table 2). Most of the researchers have taken single parameter as well as in one gender for prediction of RN location. The results of present study are comparable with previous research.

Table 2: Comparison of different national and international studies for prediction of RN location by different landmarks.

Parameters	Gerwin et al[11]	Guse et al[12]	Uhl et al[14]	Carlan et al[15]	Chaudhry et al[8]	Arora et al[16]	Prasad et al[17]	Ismail et al[18]	Present study (cm)
No. of cadavers	10	24	75	27	55	10	28	100 (living)	25
Population	American	American	American	American	British	Indian	Indian	Turkey	Indian
Medial epicondyle to upper margin of spiral groove	20.7±1.2 cm	181±11 mm							17.01±0.09 (Men) 17.03±0.10 (women)
Lateral epicondyle to lower margin of spiral groove	14.2±0.6 cm	126±11 mm		10.9±1.5 cm	111±1.2 mm				10.97±0.12 (Men) 11.03±0.12 (Women)
Triceps aponeurosis to RN in spiral groove						2.51± 0.2 cm	39.7± 11.8 mm		2.50±0.06 (Men) 2.48±0.03 (Women)
Olecranon to spiral groove								16.22± 1.55	16.91±0.18 (Men) 16.95±0.11 (Women)

The posterior mid shaft where nerve lies in direct contact with humerus and on distal end where nerve pierce the lateral intermuscular septum are considered as dangerous zone while doing surgery (ref). the safe zone of humerus may be defined as the length of humerus proximal and distal to the point at which RN respectively begins and ends its course on posterior shaft of humerus. In present study distal safe zone which is from lateral epicondyle to lower margin of spiral groove is 10.97±0.12 cm (men) and 11.03±0.12 cm (women), while proximal safe zone is the distance from medial epicondyle to upper margin of spiral groove is 17.01±0.09 cm (men) and 17.03±0.10 cm (women). These results are comparable with previous studies. This information prevents iatrogenic RN injury during surgical exploration.

All the foregoing studies observing relationships between RN and bony landmarks were conducted in cadaveric specimens having intact humerus. There is likelihood that such anatomic relationships may not hold true in clinical situations. The relationships of the RN with various osseous landmarks did not have any correlative value and are difficult for surgeons to access intra operatively.[19]

The exact localization of the RN using these bony points seems to be debatable, and it may not be prudent for a surgeon to expect the existence of such relationships during fixation of fractures intraoperatively.[16] Therefore, in case of fracture and displacement of humerus, a non-osseous superficial soft tissue landmark may guide the orthopaedician to identify the RN and prevent potential iatrogenic injury.

Limitation

In the present study localization of RN was done was done for a simple and safe procedure during surgery. The study was undertaken on embalmed upper limbs in one position only with the axial rotation of the arm and the level of flexion or extension at the elbow fixed. But, in the operative setting, there is more mobility within arm as well as glide between separate tissues. Therefore, further studies in non-preserved cadaver specimens/ surgical settings would be needed to confirm measurements.

CONCLUSION

Knowledge of approximate distance of RN to these soft tissue and bony landmarks can be very useful for different approaches during surgery to avoid RN injury. Intraoperatively to identify, locate and protect RN, soft tissue landmark (confluence of TA) is most consistent and reliable. It is advisable to take the shortest distance as safe 'triceps split' to minimize the risk of nerve injury as the RN varies at different point within the spiral groove.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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