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Prediction of the location of radial nerve in arm to avoid iatrogenic injury: Cadaveric study in Indian population

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Abstract

Background: The radial nerve arises from posterior cord of brachial plexus and descends distally to spiral groove, our aim is to study upper and lower margins of groove with respect of bony landmark like posterolateral aspect of Acromion process, medial and lateral epicondyle of humerus, which helps to identify radial nerve during humerus fracture fixation surgery and hence will reduce iatrogenic radial nerve injury.

Methods: Twenty formalin preserved cadaveric upper limbs obtained from anatomy department of Government medical college, Surat. Dissection done, Radial nerve isolated from low triangular space to lateral inter muscular septum and various measurements done for each specimen.

Result: Without sex or age differentiation the results of this study are: The mean humeral length was 30.6 ± 1.86 cm. Mean Distance of medial epicondyle to entry of radial nerve into spiral groove was 18.3 ± 1.48 cm. Mean Distance of lateral epicondyle to exit of radial nerve into spiral groove was 11.49 ± 1.46 cm. The mean length of radial nerve groove/spiral groove was 4.29 ± 1.28 cm.

Conclusion: Radial nerve is at the risk of injury with fracture & fixation in two areas. First along the spiral groove & second along the lateral aspect of humerus in distal third from proximal to lateral epicondyle to level of proximal aspect of metaphyseal flare. Our study has identified the point of intersection of radial nerve to humerus in Indian population. Understanding the safe zones and zone of danger of humerus provide more safety during surgical interference of humerus. To do this, radial nerve must be identified and protected. Wide incision and blunt dissection is still recommended to minimize the risk of radial nerve damage.

Keywords: Indian population, radial nerve, cadaveric

Introduction

One of the most common reasons for radial nerve palsy is an injury to the nerve associated with a fracture of the humeral shaft [1-4]. Regarding the literature, the overall incidence of radial nerve palsy in patients with humeral shaft fracture is between 7 and 17% [3]. One can differ between primary or traumatic nerve injury and secondary or iatrogenic nerve injury following fracture fixation or manipulation [3, 5, 6]. Claessen *et al.* found an incidence of 7% for iatrogenic radial nerve palsy in patients with humeral shaft fractures, and data in the literature vary between 6 and 32% [6-8].

The incidence of radial nerve injury after operative fixation of fractures of the shaft of the humerus has been reported to be between 1.9% and 3.3% and as high as 11.5% after nonunion repair [1-3].

The intimate relationship of the radial nerve with the humerus has led to injuries associated with interfragmentary entrapment after fracture fixation as well as direct nerve injury related to the insertion of fixation devices along the middle third and distal third of the humerus [4, 5]. Previous studies have indicated that the radial nerve is at risk during operative exposure and fixation of the humerus at the location of the lateral intermuscular septum as the nerve passes from the posterior to the anterior compartment of the arm [6-9].

The radial nerve arises from the posterior cord of the brachial plexus. The nerve, along with accompanying vessels, crosses medial to lateral obliquely over the posterior surface of the

humerus in the spiral groove. It then penetrates the lateral intramuscular septum near the junction of the middle and distal thirds of the humerus [9, 10].

Portion of radial nerve in spiral groove commonly encountered during posterior humerus approach. Purpose of study to find out upper margin and lower margins of radial nerve in spiral groove with respect to fixed bony landmarks like posterolateral acromion process center of, lateral and Medial epicondyle of humerus and also to determine the danger zone of radial nerve in arm (Figure 1, 2, 3).

Materials and method

20 upper limbs of 20 adult formalin preserved cadavers (age 18 to 70) Used in study. Cadaver obtained from the department of anatomy, Government medical college, Surat. Cadaver with identifiable upper limb trauma and any surgical scar were excluded from study. The posterolateral angle of acromion, centre of both lateral and medial epicondyle of humerus were used as Bony landmarks. The posterior aspect of arm dissected via triceps splitting approach to expose radial nerve from triangular space to point where the radial nerve pierces the lateral intermuscular septum. Spiral groove determine by short distance where radial nerve is in direct contact with posterior surface of humerus. A number of measurement made to determine the course of radial nerve with respect to previously reported bony landmarks. The length between upper margins of spiral groove to centre of medial epicondyle and length between lower margin of spiral groove to centre of lateral epicondyle measured. Total length of humerus from posterolateral angle of acromion to lateral epicondyle measured. (Figure 1, 2, 3)



Fig 1: Distance from lateral epicondyle to entry point of radial nerve



Fig 2: Total length of humerus from posterolateral angle of acromion to lateral epicondyle measure and mean distance from medial epicondyle to entry point of radial nerve from spiral groove



Fig 3: spiral groove

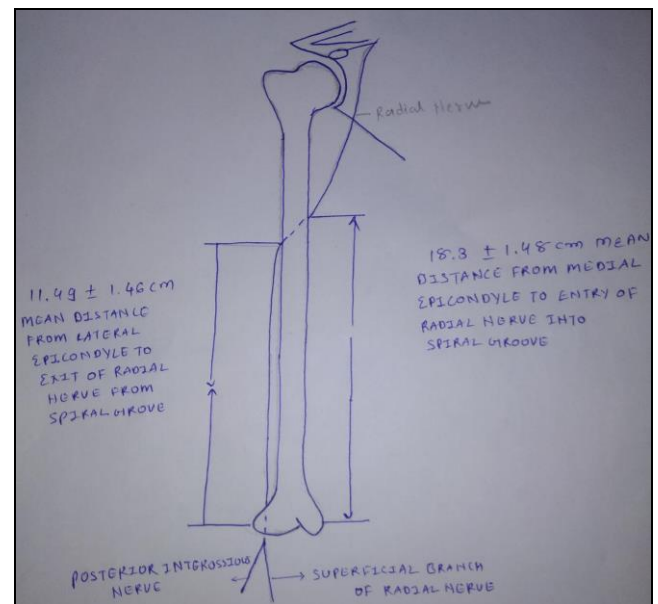


Fig 4: Line diagram of safe zone

Results

Without sex or age differentiation the results of this study are: The mean humeral length was 30.6 ± 1.86 cm.

Mean Distance of medial epicondyle to entry of radial nerve into spiral groove was 18.3 ± 1.48 cm.

Mean Distance of lateral epicondyle to exit of radial nerve into spiral groove was 11.49 ± 1.46 cm.

The mean length of radial nerve groove/spiral groove was 4.29 ± 1.28 cm.

Discussion

The radial nerve is one of the largest nerve of arm it forms one of the terminal branches of posterior cord of brachial plexus. It innervates muscles of arm as well as forearm. Brachial plexus form by ventral Rami of C5 to T1 nerve roots, ventral Rami of upper, middle and lower trunk divide into anterior and posterior division. The posterior division of all three trunks form the posterior cord. In axial the radial nerve located posterior to axillary artery from where it runs inferiorly along medial aspect of proximal humerus.

The radial nerve then descends along the radial groove to pierce lateral inter muscular septum. Proximal to lateral epicondyle where it runs between brachialis and brachioradialis muscle. As Radial nerve approaches lateral epicondyle it divides in superficial and posterior interosseous nerve.

An anatomic study, Guse T, Ostrum R. [15] reported that the proximal extent of the radial nerve in the spiral groove was $18.1 \text{ cm} \pm 1.1 \text{ cm}$ proximal to the medial epicondyle, whereas the distal extent of the radial nerve in the spiral groove was $12.6 \text{ cm} \pm 1.1 \text{ cm}$ proximal to the lateral epicondyle of the humerus.

In a similar study, Gerwin *et al.* [16] reported that the radial nerve ran along the posterior aspect of the humerus from $20.7 \text{ cm} \pm 1.2 \text{ cm}$ proximal to the medial epicondyle to $14.2 \text{ cm} \pm 0.6 \text{ cm}$ proximal to the lateral epicondyle of the humerus.

In another anatomic study on 55 formalin-preserved cadavers, Chaudhry *et al.* [17] analyzed the radial nerve in relation to the lateral epicondyle and lateral margin of the triceps aponeurosis. In their dissections, the radial nerve was $11.1 \pm 1.2 \text{ cm}$ away from the lateral epicondyle at the inferior margin of the spiral groove, and ran a course parallel and 22 mm to $27 \text{ mm} \pm 2 \text{ mm}$ lateral to the lateral margin of the triceps aponeurosis.

Bono *et al* [artical m.rochh] [18] defined danger zone "the point at the nerve pierces the lateral inter muscular septum, because nerve had very little mobility as it is interposed between the obliquely oriented septum and lateral aspect of humerus Carlan *et al* [19] A $6.3 \text{ cm} \pm 1.7$ segment of radial nerve was found to be in direct contact with the posterior humerus from $17.1 \text{ cm} \pm 1.6$ to $10.9 \text{ cm} \pm 1.5$ proximal to the central aspect of the lateral epicondyle, centered within $0.1 \text{ cm} \pm 0.2$ of the level of the most distal aspect of the deltoid tuberosity.

In another study: R.K. Jain, *et al.* [20] the radial nerve crossed the posterior aspect of the humerus from an mean of $18.5 \pm 0.79 \text{ cm}$ proximal to the medial epicondyle to $11.34 \pm 0.41 \text{ cm}$ proximal to the lateral epicondyle. The mean length of the radial nerve in the spiral groove varied from $4.3 \pm 0.75 \text{ cm}$. In this area, the radial nerve could be injured by operative procedures.

Results of our study: Without sex or age differentiation the results of this study are: The mean humeral length was $30.6 \pm 1.86 \text{ cm}$. Mean Distance of medial epicondyle to entry of radial nerve into spiral groove was $18.3 \pm 1.48 \text{ cm}$. Mean Distance of lateral epicondyle to exit of radial nerve into spiral groove was $11.49 \pm 1.46 \text{ cm}$. The mean length of radial nerve groove/spiral groove was $4.29 \pm 1.28 \text{ cm}$.

The previous study highlights two locations where radial nerve at risk.

1. The posterior mid shaft where nerve lies in direct contact with humerus.
2. Distal humerus where nerve pierces the lateral inter muscular septum.

Guse and ostrum defined safe zone of humerus as the length of humerus proximal and distal to the point at which radial nerve respectively begins and ends its course on posterior shaft of humerus.

We found distal safe zone: Mean Distance of lateral epicondyle to exit of radial nerve into spiral groove was $11.49 \pm 1.46 \text{ cm}$. Proximal safe zone: Mean Distance of medial epicondyle to entry of radial nerve into spiral groove was $18.3 \pm 1.48 \text{ cm}$.

By understanding the safe zone and danger zone and intimate relation of radial nerve with fixed bony landmarks will provide more safety during surgical fixation of humerus particularly for inexperienced Ortho surgeon to decrease iatrogenic radial nerve injury during surgery marking the

nerves approximate location before incision and isolating the nerve in that zone and protecting it should be done. Wide incision and blunt dissection still recommend to minimise risk of radial nerve damage.

In minimal invasive plate anterior bridge plate radial nerve is not at risk as forearm kept in supination during procedure and no screw inserted. In the danger zone of humerus, if screw insertion needed it should be unicortical.

The highest risk of injury to the radial nerve in external fixation is at point where pierces lateral intermuscular septum. When placing external fixator pins in lateral aspect of humerus, an area about 11 to 15 centimeter above tip lateral epicondyle should be approached carefully since radial nerve leads the spiral groove at this location. It has been proposed the need to make an incision big enough to visualise bone to minimise damage to radial nerve.

Conclusion

Knowing the approximate course of radial nerve to these bony landmarks can be very helpful for posterior approach as well as anterolateral approach to humerus fractures, as marking before incision will allow surgeon to know the approximate location nerve to find and thus avoiding iatrogenic injury. Radial nerve at the risk of injury with fracture & fixation in two areas. First along the spiral groove & second along the lateral aspect of humerus in distal third from proximal to lateral epicondyle to level of proximal aspect of metaphyseal flare. Our study has identified the point of intersection of radial nerve to humerus in Indian population. Understanding the safe zones and zone of danger of humerus provides more safety during surgical interference of humerus. In order to do this, radial nerve must be identified and protected. Wide incision and blunt dissection is still recommended to minimize the risk of radial nerve damage.

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Conflict of interest

None.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional ethical research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The manuscript has been read and approved by all the authors, the manuscript represents honest work.

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