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Original Article

Is there a safe zone to avoid superficial radial nerve injury with Kirschner wire fixation in the treatment of distal radius? A cadaveric study

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ABSTRACT

Aim of the study: To determine the relation of the superficial radial nerve to bony landmarks and to identify a safe zone for K-wire pinning in the distal radius.

Method: The superficial radial nerve was dissected in sixteen upper extremities of preserved cadavers.

Results: We found that the superficial radial nerve emerged from under brachioradialis at a mean distance of 8.45 (± 1.22) cm proximal to the radial styloid. The mean distance from the first major branching point of the superficial radial nerve to the radial styloid were 4.8 ± 0.4 cm.

All branches of the superficial radial nerve were found to lie in the radial half of an isosceles triangle formed by the radial styloid, Lister's tubercle and the exit point of the superficial radial nerve. There is an elliptical area just proximal to the Lister's tubercle. This area is not crossed by any tendons or nerve. It is bounded by the extensor carpi radialis brevis, extensor pollicis longus.

Conclusion: Pinning through the radial styloid is unsafe as the branches of the superficial radial nerve pass close to it. The ulnar half of the isosceles triangle is safe regarding the nerve. The elliptical zone just proximal to the Lister's tubercle is safe regarding the tendons and nerve.

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1. Introduction

Kirschner wires (K-wires) is a popular technique either alone or to supplement external fixation for displaced fractures of the distal radius. However, the morbidity of nerve damage is often underestimated and can be avoided. Injury to branches

of the superficial radial nerve (SRN) was reported in 20% of patients in which percutaneous pinning was done for distal radial fractures.¹

In this study we hypothesized that identification of the anatomy of the SRN in relation to easily identifiable anatomical landmarks might minimize the risk of nerve injury during surgical approaches to the distal radius.

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Our objective is to identify a safe surgical zone to avoid injury of SRN during Kirschner wire fixation in treatment of distal radial fractures.

2. Materials and methods

Sixteen embalmed cadaveric forearms were dissected to identify the SRN, and cephalic vein. These structures were traced from the elbow to their final arborization about the wrist.

Each specimen was carefully dissected, while preserving the tissue planes. First, a dorsolateral incision was made, from the elbow to the metacarpophalangeal joints. The cephalic vein was then identified and preserved. The sensory branch of the radial nerve was then dissected out as it emerges from under the brachioradialis muscle, at the middle third of the forearm. The nerve was then dissected distally to its terminal branches.

The relation of the SRN to the cephalic vein was noted. The course of any SRN branch over the wrist and hand was recorded.

The following measurements was performed in this study: distance between the radial styloid process (RSP) and the point of exit of the SRN to the subcutaneous tissue, distance between the RSP and the first branching point of the superficial radial nerve (SRN1st), distance between the closest branch of the SRN and the Lister's tubercle (LT), distance between the closest branch of the SRN and the RSP.

Measurements were expressed as both absolute distances and as relative lengths compared to the cadavers' forearm lengths. Forearm length was measured as the distance between the lateral epicondyle of humerus and the radial styloid process.

3. Results

The SBRN emerged from under brachioradialis at a mean distance of 8.45 (± 1.22) cm proximal to the RS process (Fig. 1).

Fig. 1 – Exit of superficial radial nerve from under the brachioradialis muscle.

Fig. 2 – The distance from nerve exit to the radial styloid and from nerve branching point (NBP) to the radial styloid (RS).

This represented 32.8% of the length of the forearm. The forearms in the study were $25.32 \pm (2.31)$ cm long.

Mean distances from the first major branching point of the SRN to the RSP were 4.8 ± 0.4 cm which were approximately 17% of the forearm length (Fig. 2).

The nerve branched constantly according to Ikiz and Ucerler² as a type 1 in 11 specimens (68.75%), type 2 in 5 specimens (31.25%) (Figs. 3 and 4).

All branches crossed the tendon of extensor polices longus (EPL) within 2.69 cm of the distal edge of the extensor retinaculum (Fig. 5).

The mean distance between the LT and the closest branch of the SRN was 2.7 cm (SD 0.52) (Fig. 6).

The closest branch of SRN was approximately 4 mm in average away from the RSP (Fig. 7).

In 13 specimens (81.25%) the cephalic vein crossed the SRN superficially once while it crossed the nerve twice in only three specimens. Mean distance from the radial styloid to the point where the vein crossed the nerve was 5.8 cm (Fig. 8). The dorsal vein of the thumb which is a tributary of the cephalic vein emerges proximally to the styloid process of the radius at an average of 4.3 cm. The dorsal vein of the thumb always crosses over one of the two main branches of the superficial radial nerve. The SRN passes over the first dorsal compartment of the wrist in 37.5% of the cases.

Fig. 3 – Branches of superficial radial nerve type 1.

Fig. 4 – Branches of superficial radial nerve type 2.

All branches of the SRN were found to lie in the radial half of an isosceles triangle formed by the radial styloid, Lister's tubercle and the exit point of the SRN from under the brachioradialis muscle (Fig. 9).

There is an elliptical area of about 1 cm in width and 2.5 cm in length just proximal to the Lister's tubercle. This area is not crossed by any tendons or nerve. It is bounded by the extensor carpiradialis brevis, extensor pollicis longus and abductor pollicis longus (Fig. 10).

4. Discussion

After the superficial radial nerve had emerged from between brachioradialis and extensor carpiradialis longus, it has a subcutaneous course.³ The course of the superficial radial nerve should be considered during placement of K-wires for fixation of the distal radius. Singh et al,¹ in his study reported that injury of the superficial radial nerve was seen in eight patients (20%) due to Kirschner wiring of the distal radius. Four patients (10%) had complete sensory loss in one of the branches of the superficial radial nerve. Two (5%) patients had reduced sensation with two-point discrimination greater than 4 mm when compared to the non-injured hand. Painful neuromas were found in two patients (5%).

Fig. 5 – Branches of superficial radial nerve cross the tendon of extensor pollicis longus (the arrow).

Fig. 6 – Distance between the Lister's tubercle and the most medial branches of the superficial radial nerve.

In a study by Biedermann and Gerber⁴ involving 20 patients who underwent stabilization of a distal radial fracture by means of K-wires, 19 patients showed excellent results, one patient reported temporary sensory loss in the region supplied by the dorsal branch of the superficial radial nerve.

Hochwald et al⁵ compared percutaneous and open techniques for the placement of K-wires into the distal radius in cadaveric specimens. They found that in the percutaneous group the superficial radial nerve was touching the K-wires in 8/22 (36.4%) cases in comparison to 1/22 (4.5%) in the limited open technique.

In the current study, the sensory branch of the radial nerve has a subcutaneous course at a mean distance of 8.45 cm proximal to the radial styloid process. This was approximately 32.8% of the forearm length indicated by the distance from lateral humeral epicondyle to radial styloid process. Our results is consistent with results of Robson et al,⁶ who reported that superficial radial nerve emerged at a distance of 8.31 cm proximal to the radial styloid. Auerbach et al,⁷ reported similar distances, with an average of 8.6 cm (range 6.1–11.8 cm).

In all specimens, we found that superficial radial nerve run alongside the cephalic vein. The dorsal vein of the thumb which is a tributary of the cephalic vein emerges proximally to the styloid process of the radius at an average of 4.3 cm. The dorsal vein of the thumb always crosses over one of the two

Fig. 7 – Distance between the radial styloid and the most lateral branches of the superficial radial nerve.

Fig. 8 – The cephalic vein crossed the SRN superficially (the arrow).

main branches of the superficial radial nerve. This make nerve injury is at risk when accidentally puncturing the posterior wall of dorsal vein of the thumb during intravenous injection or K-wiring in this area.

Terminal branching of the SRN was categorized into three types according to Ikiz and Ucerler.² Type 1 was the most common branching pattern of SRN in this study (68.75%). This is higher than the previous reported.² Type 2 was observed in 31.25% in the present study compared to those of Ikiz and Ucerler (8.33%).² Type 3 was not observed in this study compared to those of Ikiz and Ucerler (2.08%).²

Steinberg et al,⁸ stated that the anatomical snuff box is a safe zone for pinning of the distal radius. In the current study, we found that the dorsal branch of the SRN to thumb passes over snuff box in 37.5% of cases. Huanmanop et al,⁹ found that the SRN passed over the snuff box and first dorsal compartment of the wrist in 64.6% of cases. This make us to agree with Korcek and Wongworawat¹⁰ that the percutaneous pinning of the distal radius through the safe zone identified by Steinberg et al,⁸ is not safe because there is a risk of SRN injury in this zone.

Crossing of the superficial radial nerve over the first dorsal compartment has a clinically significance in treatment of De Quervain's disease. We think that use a longitudinal rather than transverse or z-incision for treatment of De Quervain's disease may be less traumatic to the nerve.

Fig. 9 – The SRN and its branches (black arrow) lie in the radial half of an isosceles triangle bounded by the Lister's tubercle (LT), the radial styloid (RS) and exit point of the SRN.

Fig. 10 – An elliptical zone bounded by extensor polices longus (EPL), extensor carpiradialis brevis (ECRB) and Lister's tubercle (LT).

The extensor pollicis longus tendon is the most frequently injured tendon in a dorsal approach of distal radius as it passes against the ulnar aspect of the Lister's tubercle.¹¹ Hochwald et al,⁵ in a cadaveric study, reported that pins placed via the dorsal approach injured extensor tendons in 41% of cases if they were placed percutaneously, and in 5% of cases if they were placed through a limited open approach.

In this study, we found that if we draw an isosceles triangle bounded by the styloid process of the radius and the Lister's tubercle distally and the exit point of the SRN proximally and divided this triangle into two halves longitudinally, the radial half of this triangle will be unsafe as most of the branches of the SRN are present in this half. The ulnar half of this triangle was found to be safe regarding the nerve, but, the tendons still at risk (Fig. 9). Clinically, we can draw this isosceles triangle by drawing the axi-symmetry of the line segment between the styloid process of the radius (point A) and the Lister's tubercle (point B) then draw two lines (each of them 8.45 cm in length approximately) one from point A and the other from point B to the axi-symmetry (Fig. 11). However, there is an elliptical area

Fig. 11 – The isosceles triangle can be drawn by drawing the axi-symmetry of the line segment between the styloid process of the radius (point A) and the Lister's tubercle (point B) then draw two lines (each of them 8.45 cm in length approximately) one from point A and the other from point B to the axi-symmetry.

of about 1 cm in width and 2.5 cm in length just proximal to the Lister's tubercle. This area is not crossed by any tendons or nerve.

5. Conclusion

Pinning through the radial styloid is unsafe as the branches of the SRN pass close to it. The ulnar half of our triangle is safe regarding the nerve. The elliptical zone just proximal to the Lister's tubercle is safe regarding the tendons and nerve. A further clinical study is required to support our findings.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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