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Safety of the limited open technique of bone-transfixing threaded-pin placement for external fixation of distal radial fractures: a cadaver study

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Objective: To examine the safety of threaded-pin placement for fixation of distal radial fractures using a limited open approach.

Design: A cadaver study.

Methods: Four-millimetre Schanz threaded pins were inserted into the radius and 3-mm screw pins into the second metacarpal of 20 cadaver arms. Each threaded pin was inserted in the dorsoradial oblique plane through a limited open, 5- to 10-mm longitudinal incision. Open exploration of the threaded-pin sites was then carried out.

Outcome measures: Injury to nerves, muscles and tendons and the proximity of these structures to the threaded pins.

Results: There were no injuries to the extensor tendons, superficial radial or lateral antebrachial nerves of the forearm, or to the soft tissues overlying the metacarpal. The lateral antebrachial nerve was the closest nerve to the radial pins and a branch of the superficial radial nerve was closest to the metacarpal pins. The superficial radial nerve was not close to the radial pins.

Conclusion: Limited open threaded-pin fixation of distal radial fractures in the dorsolateral plane appears to be safe.

Objectif : Examiner la sécurité de la mise en place de broches à vis dans des cas de fractures distales du radius en utilisant une approche ouverte limitée.

Conception : Étude sur des cadavres.

Méthodes : On a inséré des broches à vis de Schanz de 4 mm dans le radius et des broches à vis de 3 mm dans le second métacarpe de 20 bras de cadavre. Chaque broche a été insérée dans le plan dorsoradial oblique par une incision longitudinale ouverte limitée de 5 à 10 mm. On a procédé ensuite à une exploration ouverte des sites des broches à vis.

Mesures de résultats : Traumatisme aux nerfs, aux muscles et aux tendons et proximité de ces structures et des broches à vis.

Résultats : Il n'y a eu aucun traumatisme aux tendons extenseurs, aux nerfs radial superficiel ou racial latéral de l'avant-bras, ni aux tissus mous qui recouvrent le métacarpe. Le nerf brachial latéral était le plus proche des broches insérées dans le radius et une ramification du nerf radial superficiel était la plus proche des broches insérées dans le métacarpe. Le nerf radial superficiel n'était pas proche des broches insérées dans le radius.

Conclusion : La fixation ouverte limitée, au moyen de broches à vis, de fractures à la partie distale du radius dans le plan dorsolatéral semble sans danger.

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Immobilization with an external fixator is a common method of treating unstable distal radial fractures. Complications from misplacement of the bone-transfixing threaded pins do occur. The superficial branch of the radial nerve, the lateral antebrachial nerve and the extensor tendons are the structures at greatest risk. Supported by cadaver and clinical studies several authors have suggested that percutaneous placement of threaded pins for external fixators in the forearm is unsafe.[1–3]

There are 3 techniques for inserting the threaded pins into the distal radius: percutaneous, open and limited open techniques.

In 1983, Cooney[4] advocated one such percutaneous technique. He placed the first radial pin 8 cm proximal to the radial styloid. Many surgeons advocate the full open approach. An incision at least 1 cm is made and the nerves and tendons are identified and formally protected.[1,2,5–7] In the limited open technique a short, 5- to 10-mm skin incision is made, and injury to the deep soft-tissue structures is avoided by blunt dissection to bone under direct vision. To our knowledge, no one has adequately evaluated the safety of the limited open technique.

The purpose of this descriptive anatomic study was to evaluate the safety of the limited approach in cadaver specimens.

Methods

Schanz threaded pins were inserted in 20 embalmed cadaver forearms and hands, 2 each into the second metacarpal (3.0-mm threaded pins) and the radius (4.0-mm threaded pins). The following materials were used: a Makita power hand drill, a 2.5-mm drill bit, the triple trochar guide, 3.0- and 4.0-mm. Schanz threaded pins and a universal chuck handle.

The technique used was intended to simulate the clinical situation in the operating room. In the forearm the distal threaded-pin site was selected by palpating dorsally the obliquely traversing proximal edge of the thumb abductor pollicis longus (APL) and extensor pollicis brevis (EPB) muscles. Just proximal to this border, on the dorsoradial aspect of the distal forearm, a 5- to 10-mm longitudinal incision was made through skin only. Blunt dissection under direct vision was then carried out to expose bone and retract the soft tissues (Fig. 1). The radial and ulnar edges of the radius were palpated with the tip of the drill to ensure that drilling was directed between the 2 surfaces, across the diameter of the radius. The trochar guide was positioned perpendicular to the long axis of the radius and inclined approximately 45° dorsoradially from the radial side in the coronal plane, so that both cortices were drilled in this dorsoradial to volar–ulnar direction. A 4.0-mm Schanz threaded pin was inserted manually with a universal chuck handle. A second threaded pin was then introduced approximately 2 cm proximal to the first, using the same technique.

Two 3.0-mm Schanz threaded pins were introduced into the second metacarpal by a similar technique: that is, a dorsoradial longitudinal incision was made over the second metacarpal base, and access to the bone was achieved by blunt dissection between the extensor tendon and the radial intrinsic tendons. The trochar system was not used. The second threaded pin was placed approximately 2 cm more distally. In both instances the threaded pin was inserted approximately 45° dorsally inclined from the radial coronal plane.

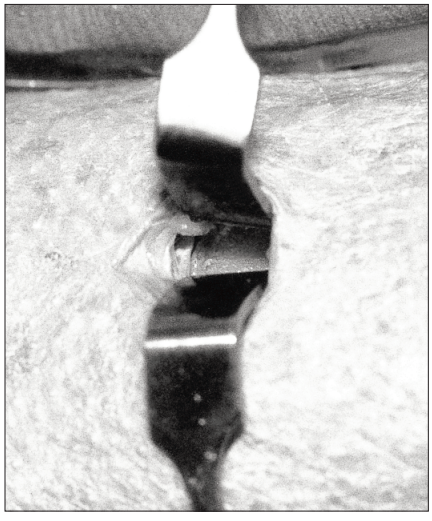

FIG. 1. Limited open technique for radial threaded-pin placement: radial exposure and soft-tissue retraction prior to drilling.

Then, in both the radius and second metacarpal a careful open exploration of the threaded-pin sites, identifying the superficial radial and lateral antebrachial cutaneous nerves, the extrinsic dorsal thumb muscles and the extensor tendons, was carried out on each of the 20 cadaver upper extremities. This was done to assess any injury to these structures and to determine the proximity of these structures to the threaded pins. In addition, the distance from the radial styloid process to the proximal border of the extrinsic thumb APL and EPB tendons was measured to evaluate Cooney's 4 fingerbreadths rule.[4]

Results

In the distal radius, the threaded pins did not cause any injury to the tendons, nerves or thumb APL, EPB and extensor pollicis longus muscles in any of the 20 cadaver specimens. The lateral antebrachial nerve was the closest major nerve to the radial threaded pins in all specimens. The closest tendons were the extensor carpi radialis brevis and the extensor carpi radialis longus. The superficial radial nerve was not close to the radial threaded-pin sites. Over the second metacarpal a branch of the superficial radial nerve was the closest important structure to the second metacarpal threaded pins.

The distance from the radial styloid to the proximal border of the thumb

extrinsic extensor and abductor muscles was measured. The range was from 5.5 to 9.5 cm with mean and median distances of 7.4 cm and 7.5 cm respectively. The distance was greater than 8 cm in only 1 specimen.

Discussion

In surgical procedures involving the distal radius, there are several potential causes of injury to the tendons and nerves. Injury may result from the initial force, cast compression, misplaced internal fixation devices (if they were used to supplement the fixation) or misplaced external fixator threaded pins.

Cooney's 4 fingerbreadths rule (or 8 cm) from the radial styloid is a close approximation of the proximal border of the thumb APL and EPB muscles. There is, however, no predictably safe corridor for percutaneous threaded-pin placement. MacKinnon and Dellon[8] have shown that there is considerable variability in the anatomy of the lateral antebrachial nerve. Complications with percutaneous threaded-pin placement are well documented in cadaver studies.[1–3] This has led many to advocate a full open approach for threaded-pin placement.[1,2,5–7]

Because there were no injuries to the tendons, nerves or thumb muscles in these 20 cadaver limbs, the formulas that are usually used to calculate the probability of injury cannot be applied. This situation, in which there was a zero numerator, was statistically analysed by applying the "rule of three" to evaluate the possibility of complications, given our sample size of 20.[9,10] This can be arrived at by the following formula: 3/n. Therefore, statistically there was a 95% probability that the tendon or nerve injury rate is from 0 to 15%. In the clinical situation, however, if one adheres to the technique tested, wherein the bone is directly exposed by blunt dissection before drilling and insertion of the Schanz threaded pins, the likelihood of injury to one or more of these structures should be 0.

It is important to point out that the construct of the external fixator may influence the decision regarding the direction of the threaded pins relative to the coronal plane. We employed only a dorsoradial plane for threaded-pin placement. Some prefer to place the threaded pins in the coronal plane, which places the superficial radial nerve at greater risk.[1,2,6,11,12] Our study does not address the safety of the limited open approach for such radially located threaded-pin sites. It may be preferable to use a full open approach for this construct.

Conclusions

We do not believe that the 4 fingerbreadths rule is reliably safe for percutaneous threaded-pin placement owing to anatomic variations of important neural and musculotendinous structures. Rather, the surgeon should palpate the thumb extrinsic extensor and abductor muscles and place the threaded pins proximal to them (generally a minimum of 8 cm proximal to the tip of the radial styloid) and use a limited open technique, with a 5- to 10-mm incision. This has become our preferred technique in the clinical setting. Alternatively, a formal open technique could be used.

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