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The Accurate Depth of Drilling the Saw Bone with K-wire, Drill Bit and Steinmann Pin

Aasis Unnanuntana, MD
Saranatra Wikakul, MD
Department of Orthopaedic Surgery, Faculty of Medicine, Siriraj Hospital, Mahidol University.

Abstract

Objectives: **The purposes of this study were to determine the accuracy of free-hand technique in utilizing various instruments and whether using a protective device to prevent over-penetration of the instrument would reduce the chance of injury to the adjacent soft tissue structures.**

Materials and Methods: **Forty orthopaedic residents at Siriraj Hospital were enrolled in this study. A 3.2 mm. drill bit, a 2.0 mm. K-wire, and Steinmann pin no.5 were inserted into an artificial saw bone with a cordless electric driver and stopped when they felt that the instrument had penetrated through the far cortex. The distance from the tip of the instrument to the far cortex of the saw bone was measured. This procedure was repeated 3 times. Then, with the same group of orthopaedic residents, the width of the saw bone was measured radiographically. The actual width of the saw bone was reduced by 10% due to the radiographic magnification. A protective device was then used to prevent the instrument from over-penetrating into the saw bone by adjusting the length of the protective device from the tip of the instrument according to the x-ray measurement. This experiment was repeated 3 times, data were collected, and mean values were calculated. The results from the 2 groups were compared by using paired t-test.**

Results: **The mean distances for the 3.2 mm. drill bit, 2.0 mm. K-wire, and Steinmann pin no.5 were 8.06 mm. (2.33 mm.-17.37 mm.), 5.09 mm. (1.33 mm.- 11 mm.), and 4.9 mm. (0.67 mm.-12 mm.) respectively in the free-hand technique group, and 1.42 mm. (0.33 mm.-3.33 mm.), 1.53 mm. (0.33 mm.-2.67 mm.), and 1.44 mm. (0.33 mm.-3.0 mm.) respectively in the protective device group. The differences were statistically significant between the 2 groups (p <0.001). There were 10 times out of 360 times of drilling that the protective device touched the near cortex of the saw bone before the instrument penetrated through the far cortex.**

Conclusions: **Our study indicated that the over-penetrated distances were longer in the free-hand technique group than in the protective device group. We recommend the use of any kind of protective device which would reduce over-penetration to prevent injury to the surrounding soft tissue.**

Introduction

Many fractures can be treated successfully with various surgical methods. However, as the numbers of surgery increase, the complications from these surgical procedures increase as well. One of these complications is soft tissue injury from slipped drill or too deeply placed K-wire or Steimann pin which causes injuries to adjacent neurovascular structures as a result of over-penetration (Figure 1).

Leroux M, et al. evaluated the placement of K-wire in the hand and wrist regions in 10 cadaveric

Correspondence address: *Aasis Unnanuntana, MD, Department of Orthopaedic Surgery, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok-Noi, Bangkok 10400, Thailand. E-mail: siaun@mahidol.ac.th*

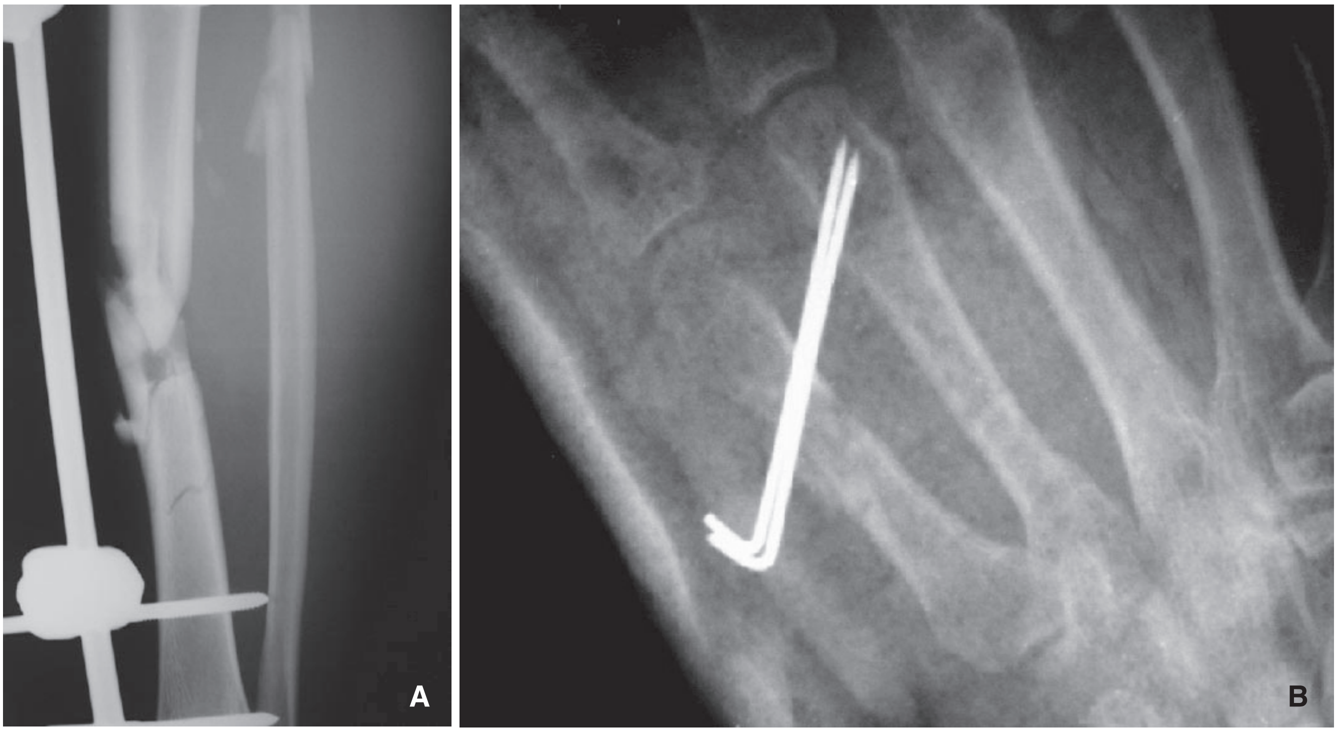

Fig. 1 The K-wire and Schanz screw that were placed too deep.

forearms, they found that a branch of superficial radial nerve was injured in 22% of the specimens and the cephalic vein in 33% of the specimens. The radial nerve was not injured but the K-wire was very close at approximately 1 mm in 22% of the specimens.[1] Siegel A et al reported an injury to the external iliac vein following the use of guide wire of the dynamic hip screw.[2] Chelcron reported 3 cases of trapezial fracture in which the radial artery was injured. The injury in 1 patient was related to the placement of the internal fixation.[3]

These complications can be avoided by careful advancement of the implant step by step.[4-6] However, many orthopaedic surgeons still insert the implants or drill relatively fast and rely only on their skills. They may not pay enough attention to the soft tissue around the opposite cortex.

Objective

This study was carried out to determine the accuracy of free-hand technique by utilizing various instruments (3.2 mm drill bit, 2.0 mm K-wire, 5 mm Steinmann pin) which were inserted through the saw bone and to study the effectiveness of protective devices to prevent over-penetration of the instruments.

Research Design

Experimental study

Materials and Methods

Forty orthopaedic residents at Siriraj Hospital were enrolled in this study. Drill bit 3.2 mm, K-wire 2.0 mm, Steinmann pin 5 mm were inserted into an artificial saw bone made by resin and placed in a leg model (Figure 2). The 3.2 mm. drill bit, 2.0 mm. K-wire and 5 mm. Steinmann pin were inserted into the saw bone with a cordless electric driver and stopped when the surgeons felt that the instruments had penetrated through the far cortex. The distance from the tip of each instrument to the far cortex of the saw bone was measured (Figure 3). This procedure was repeated 3 times. The data were collected and calculated for the mean values.

In the next step of the study, the same group of orthopaedic residents measured the width of the saw bone radiographically before insertion (Figure 4).

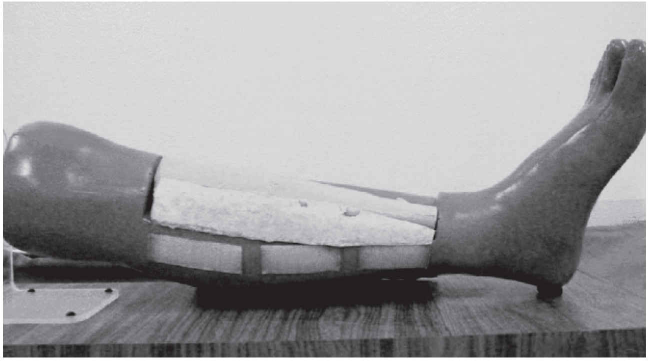

Fig. 2 The saw bone in a leg model

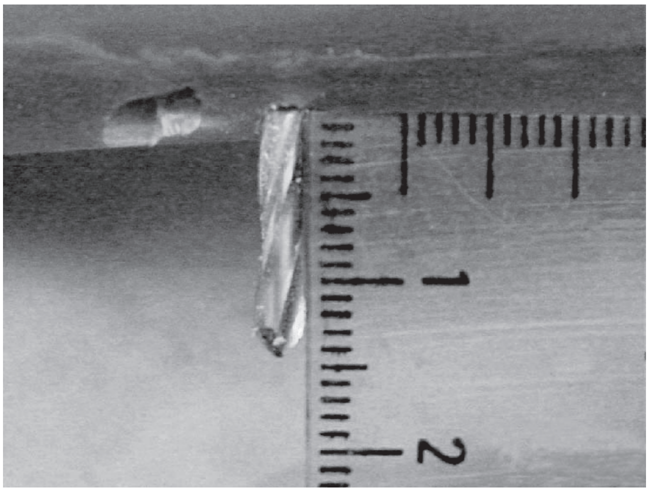

Fig. 3 The distance from the tip of the instrument to the far cortex of the saw bone was measured by a standard ruler.

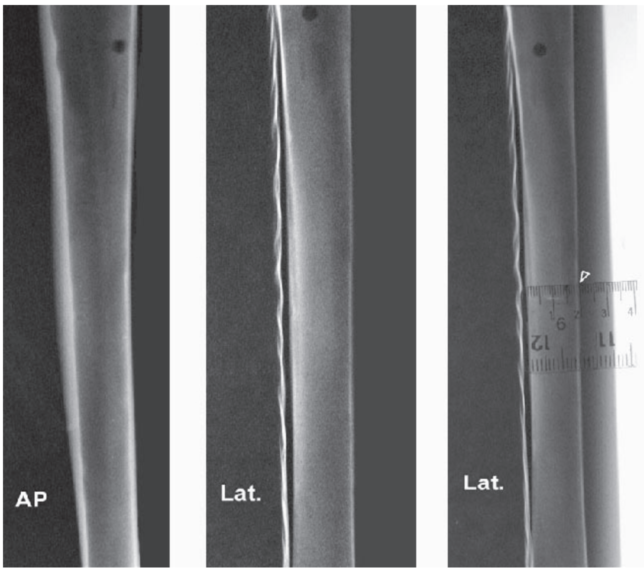

Fig. 4 The width of the saw bone was measured in AP and lateral view in the area where the instrument would be placed.

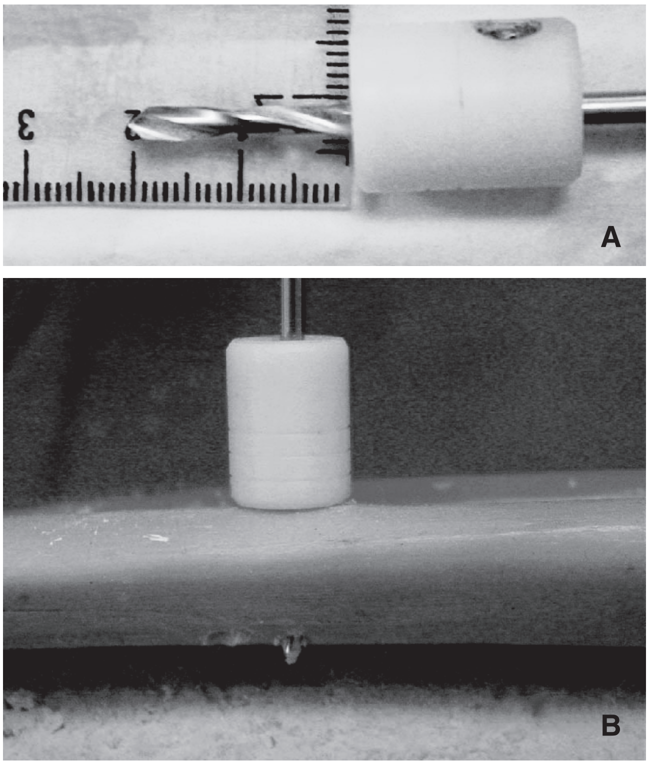

Fig. 5 Protective device connected to the instrument to prevent the over-penetration.

The actual width of the saw bone was reduced by 10% due to the radiographic magnification. The residents used our protective device to prevent the instrument from over-penetrating through the saw bone by adjusting the length of the protective device from the tip of the instrument according to the X-ray measurement (Figure 5). This was also repeated 3 times and then the data were collected and calculated in the same fashion.

The data between the two groups were compared using paired T test at the 0.05 significant level.

Results

The distance from the tip of the instrument to the far cortex of the saw bone was measured 3 times to increase the intra-observer reliability and the average value was determined (Table 1).

The mean value of all 3 instruments in the protective device group was lower than the free hand group, particularly for the 3.2 mm drill bit in which the mean value of the over-penetrated distance was approximately 8 mm. The over-penetrated distance of

Table 1 The distance from the tip of the instrument to the far cortex of the saw bone, measured 3 times

	N	Mean	Median	Mode
3.2 mm drill bit	40	8.0583	7.1667	4.33
3.2 mm drill bit + protective device	40	1.4167	1.3333	1.33
2.0 mm K- wire	40	5.0917	4.667	1.33
2.0 mm K- wire + protective device	40	1.5333	1.333	1.33
5 mm Steinmann pin	40	4.900	4.667	4.00*
5 mm Steinmann pin + protective device	40	1.4417	1.333	1.33

**Multiple mode exist. The smallest value is shown.*

Table 2 The over-penetrated distance of each instrument

	N	Minimum (mm.)	Maximum (mm.)	Mean (mm.)	Std. Deviation	95% CI	Significant (2-tailed)
Drill bit	40	2.33	17.33	8.06	4.34	5.288-	
Drill bit + protective device	40	0.33	3.33	1.41	0.64	7.995	<0.0001
2.0 mm K-wire	40	1.33	11.00	5.09	2.59	2.761-	
2.0 mm K-wire + protective device	40	0.33	2.67	1.53	0.65	4.355	<0.0001
Steinmann pin	40	0.67	12.00	4.90	2.94	2.479-	
Steinmann pin + protective device	40	0.33	3.00	1.44	0.71	4.436	<0.0001

all 3 instruments with the protective device was approximately 1.5 mm.

The difference of the over-penetrated distance of each of the instruments was statistically significant between the 2 groups (Table 2).

Out of 360 times of drilling, the protective device touched the near cortex of the saw bone 10 times before the instrument penetrated through the far cortex.

Discussion

Although neurovascular complications from utilizing the internal and external fixations are minimal, they have serious consequences once they occur.[7-10] Factors leading to these complications include location, congenital anomaly, the instrument itself and the skill or experience of surgeons. Special attention has to be paid when inserting the instrument to the area in which the neurovascular structure lies close to the bone such as at the region of hand and wrist. A patient who has congenital anomaly may have anatomical variations of the neurovascular structure to which we have to pay more attention. A sharp tip instrument will make it easier to sense penetration than a dull tip and a larger instrument requires more inserting power, which might cause over-penetration for a smaller instrument. From this study, it was found that the 3.2 mm drill bit had the highest mean value of over-penetration. This can be explained by the fact that the drill bit is duller than the K-wire and the Steinmann pin. Also, an experienced surgeon would detect the sensation of penetration through the far cortex better than an inexperienced one.

In this study, we tried to control all factors which could vary the over-penetrated distance by employing orthopaedic residents with the same level of experience and using identical instruments which were regularly changed when they became dull.

The protective device in this experiment was invented to protect over-penetration. A pre-operative radiograph of the bone is required for calculating the depth of the instrument to be inserted. This is quite difficult in clinical use because we cannot obtain the actual size of the bone in routine radiographic examination as we could with the saw bone in this experiment. The true AP and lateral view of the patient's bone and the difference in radiographic magnification will not always be detectable at 10% radiographic magnification. If the direction of application of the instrument is not perpendicular to the bony cortex, the protective device will not work. From this study, in 10 out of 360 times of drilling, the protective device touched the near cortex of the saw bone before the instrument penetrated through the far cortex. This can be explained by the deviation of direction from predicted pre-operative radiogram while inserting the instrument into the saw bone.

Therefore, special attention has to be paid before inserting instruments into the critical area of bone. The protective device should be used, or direct surgical exposure of the neurovascular structure may be required in order to protect this vital structure.

Conclusions

Over-penetrated distance was higher in the free-hand technique group than that in the group when the protective device was used. We recommend using any kind of protective device that can reduce over-penetration to prevent injury to the surrounding soft tissue.

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