A novel device for accurate placement of guide wire in cannulated screw fixation of femoral neck fracture: A pilot study

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Abstract

Background: Accurate placement of cannulated screws is the key to stable fixation of the femoral neck fracture. A novel device was developed to improve the accuracy of screw placement.

Methods: 20 synthetic femoral bones were divided into conventional technique group and the experimental group. Three Kirschner wire were inserted into the femoral neck fracture by conventional technique or by the novel guide device. The operative time, total drilling attempts and fluoroscopic frequency were evaluated.

Results: By using the guide device, the fluoroscopy and operation time of the experimental group were shorter than that of the conventional method. The total drilling attempts with the novel guide device were significantly lower than the conventional technique group.

Conclusion: This device can help trauma surgeons shorten the surgical time and reduce radiation exposure time. The use of this guide device can make screw fixation for femoral neck fracture easier.

Background

Femoral neck fracture is a common hip fracture in orthopedics. Internal fixation is preferred for femoral neck fracture in young people and non-displaced femoral neck fracture in elderly people with good physical condition[1,2]. Cannulated screws have been an accepted implant among several implants which have been used for femoral neck fracture[3,4,5]. Placing three cannulated screws in parallel with the inverted triangle can provide better biomechanical stability[6]. However, it is not easy for the surgeons to place screws at the right position. Accurately to insert guide wires accounts for a significant proportion of the total fluoroscopy and operative time.

In this study, the authors designed a novel device for accurate placement of guide wires in cannulated screw fixation of femoral neck fracture. The purpose of this study was to demonstrate the effectiveness of the device.

Materials And Methods

The device consists of two parts, the aiming part and the fixing part (FIG. 1). The aiming component is a 50-degree angle structure welded by two small stainless steel plates. Two mesh plates with equal size are vertically welded on the surface of a small steel plate. The holes in mesh plates are arranged in parallel columns and rows. The hole diameter is 2.5mm, and the hole margin is 2mm. The corresponding holes of the mesh plates form parallel guide channels to pass guide pin. The other plate is welded with a 3.5mm Kirschner wire. The fixing assembly is made of two steel buckles welded vertically.

Twenty synthetic right femur specimens with similar bone structure and mechanical characteristics to human bone were obtained from Hangzhou Osborn Technology Co., LTD. The femurs were covered with

sponge to simulate soft tissue. They were randomly divided into conventional technology group and experimental group. All operative procedures were performed by two attending orthopaedic surgeons.

Surgical Technique

In the conventional technology group: the first guide pin was drilled into the femoral neck at the insertion point 5cm below the femoral greater trochanter. Based on anteroposterior and lateral images, the guide pin was adjusted until it was in the inferocentral position of the femoral neck. Then use a parallel guide to place the posterosuperior and anterosuperior pins.

In the experimental group: a 3.0mm Kirschner wire was drilled vertically into the lateral cortex of the upper femur, connecting the guide device and the reference guide pin (Figure 2A). Fluoroscopic imaging was performed to ensure that the reference guide pin was in perfect position on anteroposterior view (Figure 2B) and parallel to the central axis of the femoral neck on lateral view (Figure 2C) by pulling, inserting or rotating the 3.5mm Kirschner wire in steel buckle. Its working principle is similar to the operation of inserting the spiral blade of proximal femoral nail antirotation into the femoral neck. Then insert the three guide wires onto the cortical bone surface through the guide channels, and anteroposterior and lateral radiographs of the guidewires were made. The trajectory of the guide wires was drawn on the screen to help to plan their placement in the femoral neck (Figure 3A, 3B). The position of the guide wires in the femur neck on anteroposterior view could be adjusted by the column. The position of the guide wires in the femur neck on lateral view was adjusted by rows. The Kirschner wires were drilled in the femoral neck when they were in the correct position of the femoral neck (Figure 3C, 3D)

Statistical Analysis

This was carried out using SPSS18.0 software (SPSS Inc., Chicago Illios) using chi-squared testing. Data are presented as mean± standard deviation or numbers, as appropriate The level of significance was set as a p value<0.05.

Results

The results were presented in the Table1. The operative time with the novel device were significantly lower than the operation with the conventional technique ($p \leq 0.05$). The fluoroscopic frequency and total drilling attempts were also significantly lower in the operation with the novel device ($p \leq 0.05$).

Discussion

Closed reduction and internal fixation have become the standard methods for the treatment of femoral neck fractures in patients 60 years of age or younger. Fixation with three parallel cannulated screws placed in an inverted triangle configuration, is a common method for femoral neck fracture [7]. If complication didn't occur, the patient can resume normal activities. The inverted triangle configuration is effective in reducing the rate of nonunion and implant failure [8]. However, accurate guide wire placement

necessitates high requirement for the surgeon and requires more fluoroscopic and operative time. So, we developed this device to make it easier.

The conventional method of screw placement for femoral neck fractures is mainly performed by surgeons with experience under fluoroscopic monitoring. During the screw fixation of femoral neck fracture with closed reduction, the femoral neck was not exposed and the desired position was not easily obtained due to the lack of necessary reference during the placement of the first guide pin, which often requires multiple drilling for success. Multiple drilling not only resulted in prolonged operation time, increased tissue damage, and increased doctor-patient exposure time to the X-ray radiation, but also can affect the mechanical strength of femoral neck fracture fixation [9].

By using the guide device, the fluoroscopy and operation time of the experimental group were shorter than of the conventional method. This is because in the experimental group, the three guide wires in the femoral neck can be inserted and observed at the same time with one fluoroscopy, while in the control group, each guide wire needs to be fluoroscopy separately. This present study demonstrated three advantages of the device. The first advantage is that the guide wires were accurately inserted in the femoral neck at one time in the experimental group. The hole spacing is 2mm in the device, so the position of the guide wires can be slightly adjusted to achieve the best position. The guide channels in the device are parallel. This ensures that the guide wire can be placed in a parallel inverted triangle configuration to the femoral neck. A second advantage is programmed surgical procedures. The surgeon's experience was not important in the experimental group. When the reference guide wire is in the exact position, the guide wire passing through the guide channel must be parallel to the central axis of the femoral neck. The surgeon only needs to select the right channel to insert the three guide wires onto the lateral cortex of the femur in an inverted triangle configuration. The third advantage is that the femoral cortex was not drilled frequently in the experimental group. Drill attempts on the femoral cortex were no more than three times. So the device was easy to operate.

Other researchers have developed guides to accurately place Kirschner wires. Yin et al. demonstrated a novel guidewire aiming device to improve the accuracy of guidewire insertion [10]. However, the operation was complicated. The navigation systems could improve accuracy [11,12,13], but the higher costs of the special instruments and increased radiation and operative time limited their clinical use [14].

Conclusions

This guide device can significantly improve the accuracy of injection, reduce tissue damage, shorten the operation time and reduce the amount of X-ray radiation. The operator's experience was not important. The use of this device can make percutaneous compression cannulated screw fixation for femoral neck fracture easier.

We believe this guide device can help to promote screw fixation technique in third world countries. This is helpful for an inexperienced hand. However, the utility of this device should be further verified in clinical practice.

Declarations

Ethics approval and consent to participate

The study was approved by the Institutional Review Board/Ethics Committee of the second Hospital of Shanxi Medical University. The study was conducted according to the ethical principles stated in the Declaration of Helsinki

Consent for Publication

The participants declare that they agree to publish the data described in the manuscript.

Availability of data and material

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request

Competing interests

The authors declare that they have no competing interests.

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Table

Table 1: Comparison of results in the two groups. The values are given as the mean and the standard deviation. Statistical significance was defined for $p \leq 0.05$.

Result	Experimental group	Conventional group	P
Operation Time (min)	20.8 ± 8.1	38.3 ± 5.6	0.04
Fluoroscopy Frequency(number)	6.5 ± 3.6	16.7 ± 8.4	0.01
Total drilling times	3.0 ± 0	16.9 ± 4.2	0.01

Figures

Figure 1

Picture of the guide device. (A) the aiming part ;(B) 3.5mm Kirschner wire; (C) the fixing part; (D) the reference guide pin

Figure 2

(A)The guide device was fixed on the surface of the femoral cortex and fluoroscopic imaging was performed(B,C). (B)The reference guide wire was in the inferior position of the femoral neck on anteroposterior imaging. (C)The reference guide wire was parallel to the central axis of the femoral neck on lateral imaging.

Figure 3

Insertion of the three guide wires: Anteroposterior(A,C) and lateral (B,D)fluoroscopic images were acquired. The trajectory of the guide wires (the red, green and blue lines in the A, B) in the femoral neck on the previously acquired anteroposterior and lateral radiographs is drawn. The guide wires were drilled into the femoral neck (C, D).