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ORIGINAL ARTICLE

Parallel Pin Guide in Femoral Neck Fractures: Comparing the Effect of the Guide between Two Surgeons with Different Levels of Experience

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Purpose: Proper fixation of femoral neck fractures requires the parallel insertion of cannulated screws. Using a parallel pin guide has been definitively shown to improve the accuracy of pin insertion. However, no studies have addressed whether or not the surgeon's experience has any influence on the benefits of using a parallel pin guide.

Methods: The accuracy of parallel pin insertion was investigated in the laboratory to determine if the surgeon's experience has an effect on the usefulness of the guide. The experiment was carried out using a self-designed parallel pin guide, 24 Sawbones femurs and 48 pins. Two surgeons with different levels of experience performed the procedures with and without the parallel guide. After three pins had been inserted, fluorescent images were taken in anteroposterior (AP) and lateral (Lat) views. Then, two observers measured the divergent angles twice, using computers equipped with Agfa PAS systems. The data were analyzed with the Student *t* test and the Mann–Whitney U test.

Results: When the parallel pin guide was not used, the accuracy of parallel insertion of pins was not affected by the surgeon's experience ($p = 0.088$, 0.075). Although the difference was not statistically significant, the attending surgeon inserted the pins with a greater degree of parallelism. In contrast, when the parallel pin guide was used, the resident doctor was significantly more accurate than the attending surgeon ($p = 0.015$, 0.037).

Conclusion: Use of a parallel pin guide tended to improve the accuracy of parallel pin insertion in both surgeons. However, the effect of the guide was more obvious in the less experienced resident surgeon.

1. Introduction

Fractures of the femoral neck, which are common in elderly patients with osteoporosis, may result in osteonecrosis and nonunion even after anatomical reduction and rigid fixation. To reduce the frequency of these complications, it is paramount that the screws inserted are as parallel as possible.[1–4] Asnis et al designed a cannulated screw system including a multiple parallel pin guide to facilitate the insertion of parallel screws. Use of the guide significantly reduced the risk of osteonecrosis and non-union in both the short and long term.[5,6] More recently, Bosch recommended use of a three-bore parallel pin guide after serial tests for improving the accuracy of parallelism.[7]

These and other studies clearly indicate that the use of a parallel pin guide facilitates the insertion of parallel pins, leading to better clinical results. However, it has never been discussed whether or not the experience of an individual surgeon affects the accuracy of parallelism of pins inserted using a multiple parallel pin-guide. Our investigation in the laboratory explored the effects of the guide on the work of two surgeons with different experience levels.

2. Materials

Instruments used in the experiment included one parallel pin guide that we had designed ourselves, 24 Sawbones femurs (Vachon, WA, USA) and 48 pins. The guide (Figure 1) it consisted of three parallel stainless steel sheaths welded to a stainless steel handle. The sheaths were 3 mm in diameter, 75 mm in length. The 24 Sawbones specimens were all left femur. The 48 reusable threaded-head pins were 2.4 mm in diameter and 230 mm long.

3. Methods

There were six steps in this experiment. Two orthopedic surgeons performed the procedures. One is a senior attending doctor with 30 years of experience, and the other is a senior resident doctor with 4 years' experience. Two methods, that is, with and without the parallel pin guide, were used for the insertion of pins.

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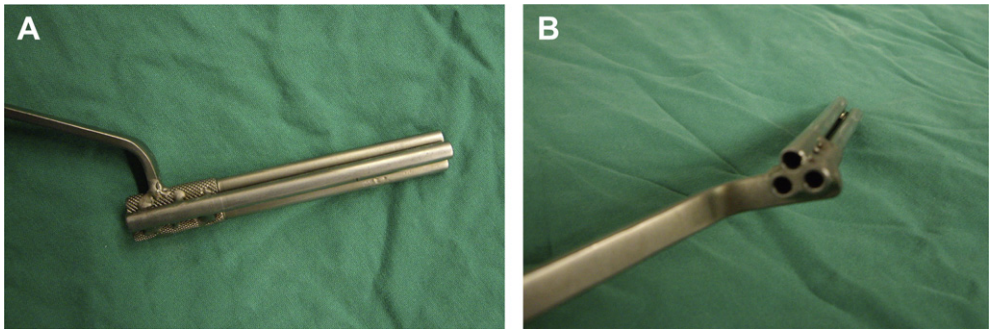

Figure 1 The parallel pin guide consisted of three parallel stainless steel sheaths welded onto a stainless steel handle: (A) lateral view; (B) anteroposterior view.

3.1. Step 1

The 24 Sawbones femurs were divided into four groups of six bones. Group A was designated 'Attending surgeon not using the guide'; Group B, 'Attending surgeon using the parallel pin guide'; Group C, 'Resident surgeon not using the guide'; Group D, 'Resident surgeon using the parallel pin guide' (Table 1).

3.2. Step 2

Three pins were inserted in each Sawbones femur, in a reversed triangular pattern (Figure 2).

3.3. Step 3

After three pins were inserted in each Sawbones femur, two fluorescent images were taken in anteroposterior (AP) and lateral (Lat) views (Figure 3).

3.4. Step 4

To reduce inter- and intra-observer inaccuracy, each divergent angle was measured twice by two observers on computers equipped with Agfa PAS systems (Agfa-Gevaert N.V. Mortsel, Belgium). The divergent angle was defined as the modulus of the angle between each pin. Thus, there were six divergent angles (three in AP and three in Lat view) in each Sawbone and four data points for each divergent angle.

3.5. Step 5

The four figures for each divergent angle were averaged to reduce inaccuracy from measurement. Therefore there were six averaged divergent angles relating to each Sawbone (36 angles in each group) for further analysis.

3.6. Step 6

All averaged angles were analyzed by the Student t test and Mann–Whitney U test. A p value < 0.05 was taken to be statistically significant.

Table 1 The Sawbones femurs were divided into four groups (A, B, C, D) of six bones each

	Attending surgeon	Resident surgeon
Not using guide	A	C
Using guide	B	D

4. Results

Table 2 shows the mean ± standard deviation of divergent angles in the four groups, calculated from 36 previous-averaged angles in each group. The results of each group were as follows (minimum and maximum angles in parentheses; these data had already been averaged from four original angles, to reduce inaccuracy from measurement):

Group A: 1.48 ± 1.85 (range, 0.1–3.225)
Group B: 1.05 ± 0.71 (range, 0.225–2.7)
Group C: 1.53 ± 0.89 (range, 0.2–2.975)
Group D: 0.7 ± 0.48 (range, 0–1.725)

Table 3 illustrates the results of the Student t test and Mann–Whitney U test.

The Student t test found no significant difference between the two surgeons when the pins were inserted without guidance [Group A/Group C: $p = 0.88$ (> 0.05)]). However, when using the parallel guide, the divergent angle of Group D pins (0.7 ± 0.48) was less than that of Group B pins (1.05 ± 0.71). The difference was significant between the two surgeons [Group B/Group D: $p = 0.015$ (< 0.05)]. Regarding the impact of fixation instruments, in the procedures carried out by the attending surgeon, the divergent angle of Group B pins (1.05 ± 0.71) was less than that of Group A pins (1.48 ± 1.85). However, the difference was not significant (Group A/Group B: $p = 0.204$). In contrast, when it came to the resident surgeon, the divergent angle of Group D pins (0.7 ± 0.48) was considerably less than that of Group C pins (1.53 ± 0.89). Clearly, the difference here is noticeable (Group C/Group D: $p = 0.0001$).

In the Mann–Whitney U test, the results were similar to those of the Student t test, which showed significant differences in Group C/Group D ($p = 0.0001$) and Group B/Group D ($p = 0.037$) but no significant differences in Group A/Group B ($p = 0.897$) and Group A/Group C ($p = 0.075$).

In summary, when not using the parallel pin guide, the accuracy of parallelism of pins was not affected by the surgeons' experience ($p = 0.088$, 0.075). Although the difference was not statistically significant, the attending surgeon inserted the pins with a greater degree of parallelism. In contrast, when using the parallel pin guide, the resident surgeon was significantly more accurate than the attending ($p = 0.015$, 0.037).

5. Discussion

Femoral neck fractures are commonly seen in osteoporotic bone following low-energy trauma. Close reduction and internal fixation results in less morbidity and mortality compared to prosthetic replacement.[1] However, avascular necrosis of the femoral head and nonunion of the fracture site are two of the most common

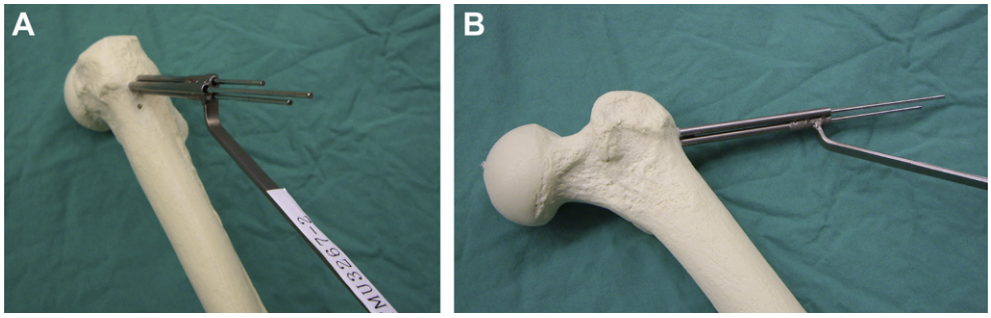

Figure 2 Insertion of three pins in a Sawbones femur, in a reversed triangular pattern, using the parallel pin guide: (A) anteroposterior view; (B) lateral view.

complications. To reduce these complications, anatomical reduction is the key procedure,[8] and fixation with parallel cannulated screws that enable the fracture fragments to slide and compress along the shafts of the partially threaded cannulated screws (telescopic effect).[7,9]

The positive effect of a multiple parallel pin guide has been demonstrated clinically by several authors in facilitating the insertion of parallel pins and improving short and long term outcomes.[5,6] However, the relationship between the effect of a guide and the operator's experience has never been explored with regard to inserting parallel pins. Therefore, our study investigated whether or not the surgeon's experience affected the accuracy of the parallel pins when using a multiple parallel pin guide.

Our results indicate that there were significant differences in Group C/Group D and Group B/Group D but no significant differences in Group A/Group B and Group A/Group C. In addition, the divergent angles in the tests carried out by a resident surgeon were greater than those in the tests performed by an attending surgeon when not using the guide (Group C vs. Group A), but were less when the guide was employed (Group D vs. Group B). Moreover, the divergent angles when the parallel guide was used were less than those when it was not used (Group B vs. Group A and Group D vs. Group C). In the groups of bones where the pins were inserted by a resident surgeon, there was a large difference between using and not using the parallel pin guide.

Unexpectedly, we found that a senior resident surgeon inserted the pins with more parallelism than an experienced attending surgeon when using a parallel pin guide (significant difference). We also showed that a senior resident surgeon seemed to insert the pins with less accuracy when not using a guide (non-significant difference). Thus, the effect of the parallel guide is more obvious in the less experienced resident doctor.

During the performance of the procedures, we found that leaving a small space between the guide and the pins allowed the operator to adjust the directions of the pins. Although the attending surgeon had solid experience, he may have relied more on his own

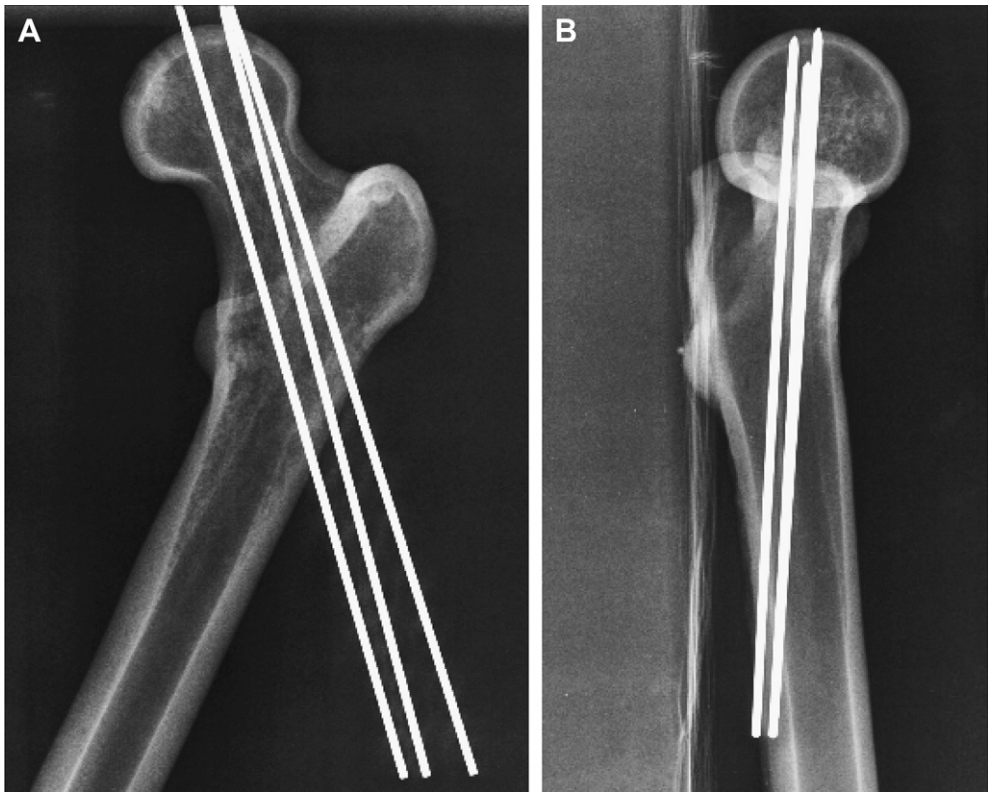

Figure 3 Fluorescent images showing the insertion of three pins in a Sawbones femur: (A) anteroposterior view; (B) lateral view.

Table 2 Mean of divergent angles between inserted pins in Groups A and B (attending surgeon), and in Groups C and D (resident surgeon), with and without the aid of a parallel pin guide

	N	Mean ± SD	SEM
Attending surgeon			
No guide used (Group A)	36	1.48264 ± 01.853990	0.308998
Guide used (Group B)	36	1.05625 ± 0.707545	0.117924
Resident surgeon			
No guide used (Group C)	36	1.53472 ± 0.891513	0.148586
Guide used (Group D)	36	0.70000 ± 0.475132	0.079189

SD = standard deviation; SEM = standard error of the mean.

Table 3 Significance of the differences between the performance of two surgeons when inserting femoral pins with and without the aid of a parallel pin guide

p value		
Groups compared	Student *t* test	Mann–Whitney U test
A/C	0.88	0.075
B/D	0.015	0.037
A/B	0.204	0.897
C/D	0.0001	0.0001

Group A = attending surgeon not using the parallel pin guide; Group B = attending surgeon using the guide; Group C, resident surgeon not using the parallel pin guide; Group D, resident surgeon using the guide.

hand-eye coordination, leading to a less accurate result. In other words, he may have slightly changed the insertion angle as he pushed in the pin. To prevent similar situations, the diameter of the sheath channel should be closer to the diameter of the guide pin. Thus, no gap should be left between the guide and the pins in order to force operators to follow the direction of the guide. However, the effectiveness of the guide was very noticeable for the senior resident surgeon, who followed the guide without adjustment.

On the basis of our experience, there are two principles to improve the parallelism of pins when using this simple, self-designed parallel guide. First, it is unreliable to use one hand to achieve two goals at the same time. The better technique is to use one hand to control the guide, letting the sleeve align the pin, and to use the other hand to exert pressure in line with the pin. The direction of the guide should follow the axis of the first pin, with insertion of the second pin following the axis of the guide. Second, to increase the accuracy of parallelism, the direction of the pin should be aligned by the guide that is closer to the entry point, not by the hand inserting the pin which is farther away.

Hence, we concluded that, when not using the guide, the attending surgeon inserted the pins with more parallelism because of better hand-eye coordination. However, use of the hand-eye coordination technique at the same time as employing the guide led to less accurate results. The resident surgeon, with less well developed hand-eye coordination, relied more on the guide, leading to better results. Moreover, we believe that, despite the simple design, the guide is an excellent instrument for resident surgeons in training. Finally, we have to restate the importance of following the direction of the guide precisely, even when it is in experienced hands.

The limitation of this study was the small number of Sawbones used in each group. Although the divergent angles were less when using the guide, the data at most allowed us to say that the use of the guide tends to improve the accuracy of parallelism in the attending surgeon. However, even though only a small number of Sawbones were used, the guide certainly improved the accuracy of the resident surgeon's placement of the pins. Therefore we believe that pin insertion can be performed with accuracy by resident doctors or surgeons with less experience if the above principles are followed. Moreover, we recommend the parallel pin guide to surgeons who have less experience or who work in a hospital where only a small number of femoral neck fractures are seen.

6. Summary

In the treatment of femoral neck fractures, parallelism between screws plays an incredibly important role in addition to adequate reduction. To align the screws in a parallel fashion, a three-bore parallel guide has been recommended by Manninger et al after serial tests.[10] The multiple parallel pin guide aids surgeons tremendously in achieving this.

In our study, it was apparent that the use of a parallel pin guide had a tendency to facilitate the insertion of pins for both operators, but this effect was more pronounced with the senior resident surgeon. When using the parallel pin guide, the divergence of pins inserted by the resident surgeon was less than that of the pins inserted by the attending surgeon.

7. Conclusion

In conclusion, the use of a parallel pin guide tended to improve the accuracy of parallelism in two surgeons having different levels of experience. However, the effect of the parallel pin guide was more obvious in the less experienced resident surgeon. Therefore we conclude that, despite the simple design, the guide is an excellent instrument for resident doctors in training. Moreover, we recommend the parallel pin guide to doctors who have little experience or work in a hospital where femoral neck fractures are less often seen. Finally, we have to remember the importance of following the direction of the guide, even when it is in experienced hands.

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