Accuracy of the Lesser Trochanter for Guiding Lag Screw Insertion in Hip Fracture Management

JIANLIN XIAO, MD; ZHONGLI GAO, MD; YANGGUO QIN, MD; XUEZHOU LI, MD; AO WANG, MD; LANYU ZHU, MD; JINCHENG WANG, MD

abstract

The goal of this study was to evaluate the accuracy of the lesser trochanter for entry of lag screw placement in the fixation of hip fractures. Radiographs of the pelvis with both hips in 50 Chinese patients were analyzed to determine the accuracy of using the lesser trochanter as a reference landmark for inserting lag screws. The femoral neck was divided into 4 parts, and the second distal part was classified as the safe zone. Cobb angles of 125° and 130° were used as representative lag screw insertion angles, referencing the lateral cortex of the lesser trochanter for measurement, and insertion tracks were drawn on the neck of the femur. The accuracy of lag screw placement in the defined safe zone was evaluated. Accuracy of placement in the safe zone for entry points at the superior tip, apex, and inferior tip of the lesser trochanter were 78%, 39%, and 0%, respectively, for the 125° Cobb angle. Rates for the superior tip, apex, and inferior tip of the lesser trochanter were 31%, 74%, and 6%, respectively, for the 130° Cobb angle. The entry point at the level of the inferior tip of the lesser trochanter had incidence rates of 95% and 71% for cutout for 125° and 130° screws, respectively. The authors found that the superior tip of the lesser trochanter was a good reference point for 125° lag screw insertion and that the apex of the lesser trochanter was a good reference point for 130° lag screw insertion. Entry at the level of the inferior tip of the lesser trochanter has a very high rate of cutout and should be avoided. [Orthopedics. 2014; 37(12):e1080-e1084.]

Figure: Placement of a 125° instrument using the superior tip of the lesser trochanter for insertion of the lag screw in the safe zone. The width of the femoral neck is divided into 4 parts (2D1=D2=D3=2D4). Line AB of the Cobb angle tool is the axis of the femoral shaft, and line CE is the lag screw insertion track, with point C the lateral cortical entry point site corresponding to the most superior end of the lesser trochanter. Line FG is the width of the femur at the level of point B.
Hip fractures are among the most frequent fractures in the elderly. The incidence of these fractures is expected to increase during the next 15 to 20 years as the population ages. Early internal fixation is a prerequisite for rapid return to preinjury functional level and ensures reduced mortality and morbidity. A variety of implants, such as cannulated hip screws, proximal femoral nail anti-rotation, gamma nails, dynamic hip systems, and percutaneous compression plating, have been used, depending on surgeon preference and fracture type, with uniform good results. The most common reason for mechanical failure of an implant is cutout through the femoral head and neck, and the most common reason for cutout of implants is improper placement in the head and neck of the femur. Biomechanical studies recommend placement of the lag screw in the inferior half of the femoral head in the anteroposterior (AP) plane, minimizing the tip-apex distance. The crucial part of the operation is insertion of a hip screw into the femoral neck in an exact position over the guidewire. Many techniques have been described for accurate placement of the guidewire in fixation, however, no technique has been universally accepted because of the lack of accuracy and reproducibility. Without a clear landmark for insertion, most surgeons rely on intraoperative judgment and images from an image intensifier to perform the procedure. Schultz and Schreiber reported use of the lesser trochanter as a guide for operative fixation of hip fractures. In clinical practice, the authors found that referencing the lesser trochanter would result in a good lag screw position. However, they found no large clinical studies that showed the accuracy of using the lesser trochanter as an intraoperative reference landmark for lag screw placement.

The goal of this study was to identify the correct entry point for lag screw insertion in the AP plane as well as to verify the accuracy of the lesser trochanter as a reference landmark for entry of the lag screw in hip fractures with the use of picture archiving and communication system software.

**Materials and Methods**

Sample and Procedures

The study was approved by the institutional review board of China-Japan Union Hospital of Jilin University. Radiographs were taken from the hospital picture archiving and communication system database from June 2010 to June 2013. The study included 25 men and 25 women, with an average age of 40.94 years (range, 18-70). Standard films (both legs fully extended, with 15º toe medial rotation) were considered adequate to perform measurements if both proximal femurs were included and both obturator foramina appeared equal on radiographs. Radiographs that showed evidence of previous hip surgery or other hip pathology were excluded. The study was performed at standard workstations available in clinical areas with a minimum screen size of 48 cm (19 in). To optimize measurement, a full-screen view was used and the image was magnified by a factor of 4 to maximize resolution.

The inner width of the medullary canal of the femoral neck (the cortical bone of both sides was excluded) was measured with the tool at its narrowest level and then divided into 4 parts ($2D_1 = D_2 = D_3 = 2D_4$; Figure 1). The authors classified the second distal part on the narrowest level of the neck ($D_3$; Figure 1) as the femur neck safe zone. This was in accordance with the previous definition given by Herman, who also recommended placement of the lag screw in the safe zone. The femoral shaft axis was generated by identifying the midpoint of the diaphysis at 2 different points (points A and B) distal to the flare of the lesser and greater trochanters. The width of the femurs at the level of point B (line FG) was also measured in all cases. Three lines were marked at the levels of the superior tip, apex, and inferior tip of the lesser trochanter, all perpendicular to the axis of the femoral shaft. The Cobb angle measurement tool was set at defined angles of 125º and 130º, which were closest to the neck shaft angle of the Asian population. According to Figure 1, line AB of the Cobb angle tool represented the femoral shaft axis discussed earlier, and line CE, oriented from the lateral cortical point (point C) at the level of the proximal femoral nail anti-rotation to the neck, represented the lag screw position. The authors calculated the rate of lag screw position in the safe zone. Variations in femoral width and correlation of width and penetration of screws were also studied.

Data Analysis

For statistical analysis of numeric data, paired t test and chi-square test were performed with SPSS version 19.0 software (SPSS, Chicago, Illinois). $P<.05$ was considered statistically significant.

Results

For this study, 50 AP pelvic radiographs were analyzed, for a total of 100
hip measurements. Mean age was 40.94 years (range, 18-70), and 25 men and 25 women were included. Mean femur width at the level of point B was 33.21±2.81 mm (female, 31.64±2.24 mm; male, 34.95±2.27 mm), and a significant difference was found between men and women (P<.001). Table 1 shows that, for the 125° lag screw, in 78 of 100 (78%) (female, 38%; male, 40%) cases, the position of the lag screw was in the safe zone when the superior end of the lesser trochanter was used for reference. When the apex of the lesser trochanter was used as a landmark, in 39 of 100 (39%) (female, 17%; male, 22%) cases, the position of the lag screw was in the safe zone. No significant difference was found between men and women. However, when the inferior end of the lesser trochanter was used as a landmark, no screw track corresponded to placement in the safe zone. Moreover, in 95 of 100 (95%) cases, screw cutout of the neck was observed at the inferior end of the lesser trochanter as the entry point.

As shown in Table 2, when the 130° lag screw trajectory was templated, the use of the entry point corresponding to the superior end of the lesser trochanter resulted in accurate positioning of the lag screw in the safe zone in 31 of 100 (31%) (female, 19%; male, 12%) cases. When the entry point corresponding to the apex of the lesser trochanter was used, in 74 of 100 (74%) (female, 36%; male, 38%) cases, the position of the lag screw was in the safe zone, and only 6 of 100 (6%) cases were associated with the position of the lag screw in the safe zone at the inferior end of the lesser trochanter. No significant difference was found between men and women. However, in 71 of 100 (71%) cases, cutout of the medullary neck was observed at the level of the inferior end of the lesser trochanter, which is intuitively shown in Figure 2. In this figure, screw cutout of the neck included D1 and D4, showing that in nearly all cases penetration was presented at the level of the inferior end of the lesser trochanter.

**Table 1**

<table>
<thead>
<tr>
<th>Femoral Neck Zone</th>
<th>Superior End of Lesser Trochanter</th>
<th>Apex of Lesser Trochanter</th>
<th>Inferior End of Lesser Trochanter</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1, No.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D2, No.</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D3 (safe zone), No.</td>
<td>78</td>
<td>39</td>
<td>0</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>D4, No.</td>
<td>2</td>
<td>29</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Out of neck, No.</td>
<td>0</td>
<td>32</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Safe zone ratio</td>
<td>78%</td>
<td>39%</td>
<td>0%</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>Femoral Neck Zone</th>
<th>Superior End of Lesser Trochanter</th>
<th>Apex of Lesser Trochanter</th>
<th>Inferior End of Lesser Trochanter</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1, No.</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D2, No.</td>
<td>65</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D3 (safe zone), No.</td>
<td>31</td>
<td>74</td>
<td>6</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>D4, No.</td>
<td>0</td>
<td>12</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Out of neck, No.</td>
<td>0</td>
<td>10</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Safe zone ratio</td>
<td>31%</td>
<td>74%</td>
<td>6%</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

**Figure 2:** Safe zone ratio and screw cutout (of neck) ratio for lag screw insertion at 125° and 130°. Abbreviation: LT, lesser trochanter.

**Discussion**

This is the first report to test and describe the reliability and accuracy of the use of the lesser trochanter as a reference landmark for lag screw insertion in hip.
fracture. This study was done with picture archiving and communication system software, which is commonly used in clinical practice. Wilson et al\textsuperscript{24} confirmed the accuracy, utility, and reliability of this software as a tool for measurement. The current study showed that the lateral femoral cortex at the superior tip of the lesser trochanter offers an ideal landmark for insertion of the 125° lag screw in the femoral neck, with placement in this zone confirmed for 78% of screws. Similarly, the lateral femoral cortex at the level of the apex of the lesser trochanter was ideally suited for insertion of a 130° lag screw, with 74% landing in the safe zone. The result did not differ significantly between men and women. In contrast, the inferior tip of the lesser trochanter should be avoided if possible because it had the highest incidence of cutout in this study.

Cannulated hip screws, proximal femoral nail anti-rotation, gamma nails, dynamic hip systems, and percutaneous compression plating have become the most commonly used devices for hip fractures in many hospitals.\textsuperscript{2,5} Radiographs are necessary for orthopedic surgeons to confirm reduction of the fracture and the position of the guidewire or hip lag screw in the femoral neck. With conventional fixation techniques, surgeons usually cannot determine the exact entry point of the guidewire of the hip lag screw. Therefore, they must spend significant time determining the entry point with repeated radiographic exposure in the AP plane. In contrast, with lateral plane confirmation of accurate placement, which is easier after suitable anteverision, an entry point can be made in the center of the lateral femoral cortex in a lateral view. Several methods have been described for accurate guidewire placement in fixation.\textsuperscript{14,22} Some authors locate the entry point approximately 2 cm below the vastus lateralis ridge; however, this method is not reproducible without a reliable osseous landmark. Adams and Stossel\textsuperscript{14} used staples as groin skin markers to guide the placement of the guidewire, and Aronson and Carlson\textsuperscript{15} used a marker pen instead of staples in the treatment of slipped capital femoral epiphysis. These techniques are less accurate because the reference radiopaque staples inevitably move when reduction is made and traction is applied to the skin edges. Subsequently, Browbank et al,\textsuperscript{16} Schep et al,\textsuperscript{17} and Mayman et al\textsuperscript{18} described in vitro techniques using fluoroscopy-based navigation to estimate the position of the guidewire in fixation. These authors confirmed the benefits of using fluoroscopy-based navigation in vitro, but this technique is expensive. Brown et al\textsuperscript{19} confirmed the benefit of rapid prototyping in surgical planning, especially in reducing surgical time and blood loss. However, the procedure involves creating preoperative molds that require computed tomography scan (exposing the patient to radiation), additional time before surgical intervention, and added costs, making it unsuitable for routine use. Hamelinck et al\textsuperscript{20} and Dirhold et al\textsuperscript{25} indicated that the currently used navigation system is safe and accurate; however, limitations, including prolonged surgical time, technical errors, and cost, prevent its widespread use. Nishiura et al\textsuperscript{21} reported the insertion of a lag screw in the operative treatment of trochanteric femoral fractures with a short intramedullary nail on both planes. However, they did not clearly define a reference landmark on the AP plane, and the study showed no decreased radiation exposure. Sheng et al\textsuperscript{22} proposed a geometric equation to calculate the entry point of a Kirschner wire, but the procedure required exposing the lesser trochanter to increased trauma and surgery time.

In contrast to the previously discussed techniques, Schultz and Schreiber\textsuperscript{23} first considered using the lesser trochanter as a reference landmark. However, because the lesser trochanter is not a single point but a large anatomic structure that includes a superior tip, an apex, and an inferior tip, it was essential to define these entry points accurately as landmarks for positioning the lag screw in the femoral neck. The current study, based on a picture archiving and communication system, was thus contemplated, showing the accuracy of the lesser trochanter for guidewire insertion of the lag screw and providing a reference landmark.

Because there is a medial-lateral angle of 5° or 6° for proximal femoral nail anti-rotation or gamma nails, the authors’ study focused on 125° and 130° instruments. For 125° and 130° cannulated hip screws, dynamic hip systems, and percutaneous compression plating instruments, the superior tip and apex of the lesser trochanter should be used as reference points, respectively, but for 125° proximal femoral nail anti-rotation and gamma nails, the apex of the lesser trochanter should be used, as for the 5° or 6° medial-lateral angle. As shown in Figure 2, the authors recommend avoiding use of the inferior tip of the lesser trochanter as a reference point for insertion of the lag screw. Considering the diameter of the lag screw, placement of the screw in D\textsubscript{1} and D\textsubscript{3} may also result in penetration to the femoral neck and should be avoided if possible. However, this may not be true for the D\textsubscript{2} zone, where the lag screw may be inserted into the femoral head successfully, but may not provide the desired stability.\textsuperscript{12}

Based on the current findings, surgeons can also do preoperative planning by using the healthy hip and the available tools in the picture archiving and communication system software. The ideal position (D\textsubscript{2}) for lag screw placement is drawn on the healthy side and its relation to the lesser trochanter is calculated. To aid this process intraoperatively, a metal marker can be used to determine the entry point under radiographic C-arm image intensifier control.

The current study had some limitations. One limitation was the lack of multivariate analysis with a focus on correlation between insertion site and anthropometric neck shaft angle, and further study is needed. Another limitation was that for
proximal femoral nail anti-rotation and gamma nails, the authors provided the reference for lag screw insertion only for 120° and 125° instruments, without 130° instruments.

**Conclusion**

The authors confirmed the accuracy of the use of the lesser trochanter as a reference for insertion of a lag screw. They recommend use of the superior tip and apex of the lesser trochanter as a reliable reference point for lag screw insertion. The inferior tip of the lesser trochanter should be avoided if possible.

**References**