Proper Entry Point for Femoral Intramedullary Guide in Total Knee Arthroplasty

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Background: *Postoperative tibiofemoral alignment of the lower extremity is one of the most important factors that will assure a successful long-term outcome of a total knee arthroplasty. In this regard, most surgeons prefer to use an intramedullary guide than an extramedullary one for the femoral cut. However, the entry point for the guiding rod is crucial for an appropriate femoral cut and femoral component positioning. The ideal entry point of the guiding rod should be the central axis of the distal femur in both coronal (anterior view) and sagittal planes (lateral view).*
Objective: *The authors studied the proper entry point for the femoral intramedullary guiding rod in total knee arthroplasty by using the top of the femoral intercondylar notch as the referenced point.*
Material and Method: *A series of radiographs for twenty-nine femurs from thirty-one cadavers, both anterior-posterior and lateral views, were evaluated in this study.*
Results: *75.8 percent of the entry points in the coronal plane were at least 1mm medial to the top of the femoral intercondylar notch. 82.7 percent of the entry points in the sagittal plane were superior to the top of the femoral intercondylar notch more than 10 mm. The proper entry point at the distal femur should be 1.5 $\pm$ 2.01 mm medial and 12 $\pm$ 2.72 mm superior to the top of the femoral intercondylar notch.*
Conclusion: *The result of this study could be useful for surgeons who prefer intramedullary guide system in total knee arthroplasty.*

Keywords: *Entry point of femoral guide, Entry point, Femoral intramedullary guide, Total knee arthroplasty*

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One of the successful factors in total knee arthroplasty (TKA) is restoration of the mechanical axis of the lower extremity. Many studies have shown that a successful long-term outcome of TKA depends on the tibiofemoral alignment[1-6]. Tew and Waugh reported that TKA was most likely to survive successfully with the coronal tibiofemoral angle close to 7° valgus[2]. At this angle the prosthesis was least subjected to force which might loosen or cause excessive wear of the components. Many studies reported high rates of clinical failure when the appropriate alignment was not achieved[2-6].

Accordingly, two basic aligning instruments could be used for distal femoral cut in TKA, *i.e.*, intramedullary and extramedullary alignment rods. At present, most surgeons would favor the intramedullary guiding rod as it is easy to use and more accurate when compared to the extramedullary one. The entry point for the femoral intramedullary guide is very important as it affects the final alignment. Reed and Gollish showed that a malposition of the entry hole of the cutting guide into the femoral canal might introduce an error up to 3.2° valgus or varus of the femoral cut, and the prosthetic components would be subjected to excessive varus or valgus stress (Fig. 1)[7]. The entry point should be as close as possible to the central axis of the femur both in the coronal and sagittal planes, and the guiding rod should be inserted parallel to both femoral planes. Referring to most surgical techniques, the entry point for the femoral intramedullary guide varied from a few millimeters to 10 millimeters anterior

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Fig. 1 The entry hole of the intramedullary guide rod is offset from the coronal axis of the femur could cause malalignment of the femoral cut

to the origin of the posterior cruciate ligament (PCL) with a few millimeters medial to the femoral groove or the center of the femoral groove[8,9]. Because of the variations of the area of the origin of the PCL and also the varying distances from the origin of the PCL, it is not uncommon to miss the proper entry point for a femoral guiding rod.

Objective

The purpose of this study was to identify the proper entry point for a femoral intramedullary guide in relation to a bony anatomical landmark: the top of the femoral intercondylar notch, which should be more reliable and easier to be located during the operation.

Material and Method

A series of radiographs of twenty-nine femurs from thirty-one cadavers, both anterior-posterior and lateral views, were evaluated in this study. There were 23 males and 6 females: 2 were excluded because of their broken femurs. Their average age was 64.4 (31-91) years for the males, and 76.2 (49-88) years for the females. There were 20 right sides and 9 left sides. The highest point of each femoral intercondylar notch, with the knee in 90° of flexion, was marked as the top of the notch for the reference point. Then each distal femoral articular surface was marked with two sets of five nails; the gap between each nail was 5 mm.

The first set was placed in horizontal line through the top of the femoral intercondylar notch, with the middle nail was placed at the top of the femoral intercondylar notch. Anterior-posterior radiography of each femur was taken for the measurement of the entry point in the coronal plane. After removal of the first set of nails, the second set was placed in vertical line through the top of the femoral intercondylar notch, with the lowest nail was placed at the top of the femoral intercondylar notch. Then lateral radiography of each femur was taken for the measurement of the entry point in the sagittal plane (Fig. 2, 3).

The coronal femoral anatomical axis was drawn as a line connecting the midpoint of the shaft of the femur at 10 centimeters and 20 centimeters proximal to the line tangential to both distal femoral condyles. The coronal entry point is the intersection point of the coronal femoral axis and the distal femoral articular surface. This point was measured medial or lateral in relation to the top of the femoral intercondylar notch (the middle nail) (Fig. 3).

The sagittal femoral anatomical axis was drawn as a line connecting the midpoint of the shaft of

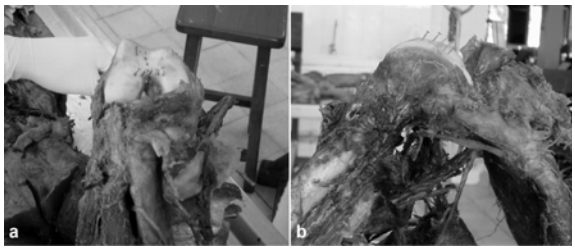


Fig. 2 Marking the distal femur with nails: (a) in horizontal line through the top of the notch for coronal axis measurement; (b) in vertical line through the top of the notch for sagittal axis measurement

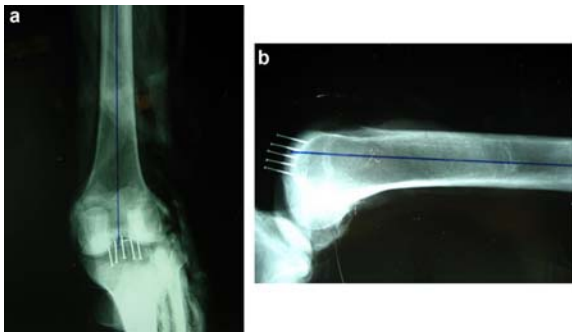


Fig. 3 Measurement of the axis of femur intersected the femoral articular surface: (a) in coronal plane, the middle nail was at the top of the notch; (b) in sagittal plane, the lowest nail was at the top of the notch

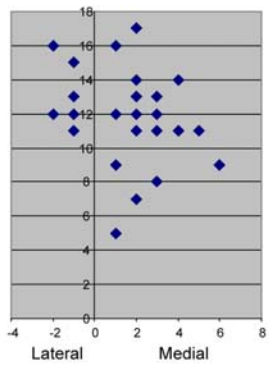
the femur at 10 centimeters and 20 centimeters proximal to the distal femoral condyles. The sagittal entry point is the intersection point of the sagittal femoral axis and the distal femoral articular surface. This point was measured from the superior to the top of the femoral intercondylar notch (the lowest nail) (Fig. 3). The point that both femoral axes intersect to the distal articular surface was determined as the proper entry point for the femoral guiding rod.

Results

The distribution of the entry points at the distal femoral articular surface is shown in Fig. 4. The mean of the entry point in the femoral coronal plane was 1.5 $\pm$ 2.01 mm (range -2 to 6mm) medial to the top of the femoral intercondylar notch and the mean of the entry point in the femoral sagittal plane was 12 $\pm$ 2.72 mm (range 5 to 17 mm) superior to the top of the femoral intercondylar notch. The median of the entry points in the coronal and sagittal planes were 2 mm medial to and 12mm superior to the top of the intercondylar notch. Seventy-five and eight-tenth percent (22 of 29) of the entry points of the coronal axis were at least 1 mm medial to the top of the femoral intercondylar notch. Eighty-two and seven-tenth percent (24 of 29) of the entry points of the sagittal axis were superior to the top of the femoral intercondylar notch more than 10 mm.

Discussion

In order to increase the survival of the TKA, the mechanical axis of the knee should be restored. The intramedullary femoral alignment provides a satisfactory angle for the distal femoral cut. Anyway, either an improper entry point or an over drill of the entry hole will cause an error of the position of the intramedullary guiding rod[7-9]. To achieve the correct alignment, a proper entry point should be identified. Most surgical techniques suggest the origin of the PCL as the reference landmark. We found that the wide area of the PCL origin without any specific spot has made this landmark unreliable. In this study, the top of the femoral intercondylar notch was employed as the referenced spot. It was convenient and more consistent to be identified during the operative procedure.



Entry points of femurs, 0,0 represents the top of femoral intercondylar notch

Fig. 4 The distribution of entry points at the distal femurs

The result of our study showed that the entry point for femoral alignment rod was individually based (Fig. 4), with an average 12 mm from the top of the femoral intercondylar notch and 1.5 mm medial to the top of the femoral intercondylar notch. The majority of the entry points were superior to the top of the femoral intercondylar notch more than 10 mm and at least 1 mm medial to the top of the femoral intercondylar notch. Most of the sagittal entry points in this study were more anterior compared to the points that were suggested by most surgical techniques. The majority of the coronal axes of the femur did not pass through the center of the intercondylar notch, similar to other studies[7-10].

In this study, the femoral anatomical axis was measured at the distal femur instead of the whole femur based on two reasons. First, the length of the intramedullary guiding rod is 22.5 cm, which was inserted into the distal femur. Second, Oswald et al reported that measurement of the range of the distal femoral anatomical axis was similar to the traditional measurement[11].

Although intramedullary femoral alignment guide in TKA is an excellent technique in most cases. Surgeons should be cautious in patients with femoral deformity and extra-large femoral canal. Preoperative long film of the entire femur radiographic study would prevent the error from this condition. An extramedullary femoral guide used in addition to an intramedullary guide, a long guiding rod or variable rod diameters, could potentially enhance the accuracy. Novotny et al showed that using 8 mm diameter intramedullary rod of 101.6 mm and 228.6 mm lengths. There was approximately 10° angular error resulted from 101.6 mm rod and about 3° error from the 228.6 mm rod, if the entry point was 7 mm offset to the optimal entry point[12]. He suggested using a long guiding rod to minimize the error of the alignment.

The limitation of this study included its small sample size and imbalanced distribution of both

genders and sides of the samples. However, with the more specific referenced landmark, the top of the intercondylar notch, the result of this study could be useful for surgeons to locate the entry point properly. An experienced surgeon is likely to use other clues to evaluate the alignment and does not have to entirely rely on the guiding system. Over reliance on the guiding system and poor understanding of its rationale often lead to errors and subsequent malalignment as discussed above.

Conclusion

An intramedullary guiding rod is preferred in femoral cut and alignment by most surgeons. However, the entry point of the intramedullary guiding rod affects the femoral alignment. To minimize the error of the femoral alignment, the entry point should be close to the central axis of the femur and the intramedullary guiding rod should be inserted parallel to the central axis of the femur both in the coronal and sagittal planes. The authors recommended using the top of the femoral intercondylar notch, instead of the PCL origin, as the referenced landmark. The proper entry point was 1.5 mm medial to and 12mm superior to the top of the femoral intercondylar notch. We also recommended using a long guiding rod to achieve a more accurate alignment.

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References

1. Teter KE, Bregman D, Colwell CW Jr. The efficacy of intramedullary femoral alignment in total knee replacement. Clin Orthop Relat Res 1995; 117-21.
2. Tew M, Waugh W. Tibiofemoral alignment and the results of knee replacement. J Bone Joint Surg Br 1985; 67: 551-6.
3. Bargren JH, Blaha JD, Freeman MA. Alignment in total knee arthroplasty. Correlated biomechanical and clinical observations. Clin Orthop Relat Res 1983; 178-83.
4. Moreland JR. Mechanisms of failure in total knee arthroplasty. Clin Orthop Relat Res 1988; 49-64.
5. Wasielewski RC, Galante JO, Leighty RM, Natarajan RN, Rosenberg AG. Wear patterns on retrieved polyethylene tibial inserts and their relationship to technical considerations during total knee arthroplasty. Clin Orthop Relat Res 1994; 31-43.
6. Ritter MA, Faris PM, Keating EM, Meding JB. Postoperative alignment of total knee replacement. Its effect on survival. Clin Orthop Relat Res 1994; 153-6.
7. Reed SC, Gollish J. The accuracy of femoral intramedullary guides in total knee arthroplasty. J Arthroplasty 1997; 12: 677-82.
8. Insall JN. Surgical techniques and instrumentation in total knee arthroplasty. In: Insall JN, Winsor RE, Scott WN, Kelly MA, Aglietti P, editors. Surgery of the knee. 2nd ed. New York: Churchill Livingstone; 1993: 739-804
9. Insall JN, Easly ME. Surgical techniques and instrumentation in total knee arthroplasty. In: Insall JN, Scott WN, editors. Surgery of the knee. 3rd ed. Philadelphia: Churchill Livingstone; 2001: 1553-620.
10. Moreland JR, Bassett LW, Hanker GJ. Radiographic analysis of the axial alignment of the lower extremity. J Bone Joint Surg Am 1987; 69: 745-9.
11. Oswald MH, Jakob RP, Schneider E, Hoogewoud HM. Radiological analysis of normal axial alignment of femur and tibia in view of total knee arthroplasty. J Arthroplasty 1993; 8: 419-26.
12. Novotny J, Gonzalez MH, Amirouche FM, Li YC. Geometric analysis of potential error in using femoral intramedullary guides in total knee arthroplasty. J Arthroplasty 2001; 16: 641-7.

ตำแหน่งที่เหมาะสมสำหรับการใส่เครื่องมือนำร่องชนิดใส่ในโพรงกระดูกฟีเมอร์ในการผ่าตัดเปลี่ยนข้อเข่าเทียม

ยงศักดิ์ หวังรุ่งทรัพย์, ศรนรินทร์ เชิดทวีทรัพย์

ภูมิหลัง: ปัจจัยสำคัญที่มีผลให้ข้อเข่าเทียมสามารถใช้งานได้ยาวนาน คือแนวกระดูกฟีเมอร์และกระดูกทิเบียหลังการเปลี่ยนข้อเข่าเทียม แพทย์ส่วนมากนิยมที่จะใช้เครื่องมือนำร่องชนิดใส่ในโพรงกระดูกฟีเมอร์ ในการกำหนดแนวการตัดกระดูกฟีเมอร์ ทั้งนี้ตำแหน่งที่จะสอดใส่แกนของเครื่องมือชนิดนี้มีผลอย่างมากต่อแนวการตัดกระดูกและส่งผลต่อแนวของข้อเข่าเทียมด้วย ตำแหน่งที่เหมาะสมสำหรับสอดเครื่องมือนี้ เข้าในโพรงกระดูกฟีเมอร์ควรจะเป็นจุดที่อยู่ในแนวแกนกลางของกระดูกฟีเมอร์ทั้งในแนวระนาบ coronal และแนวระนาบ sagittal

วัตถุประสงค์: เพื่อศึกษาหาตำแหน่งที่เหมาะสมสำหรับสอดเครื่องมือนี้เข้าในโพรงกระดูกฟีเมอร์

วัสดุและวิธีการ: คณะผู้นิพนธ์ได้ศึกษารวบรวมข้อมูลจากกระดูกฟีเมอร์ของอาจารย์ใหญ่ 29 ข้าง เพื่อหาตำแหน่งที่เหมาะสมสำหรับการสอดใส่เครื่องมือนำร่องชนิดใส่ในโพรงกระดูกฟีเมอร์โดยใช้จุดสูงสุดของ femoral intercondylar notch เป็นจุดอ้างอิง

ผลการศึกษา: พบว่าร้อยละ 82.7 ของตำแหน่งที่เหมาะสมนี้อยู่เหนือต่อจุดอ้างอิงมากกว่า 10 มิลลิเมตร. และร้อยละ 75.8 ของตำแหน่งนี้อยู่ด้านในต่อจุดอ้างอิงอย่างน้อย 1 มิลลิเมตร ตำแหน่งที่เหมาะสม สำหรับสอดเครื่องมือนำร่องเข้าโพรงกระดูกฟีเมอร์คือ จุดที่อยู่เหนือจุดอ้างอิง 12 ± 2.72 มิลลิเมตร และอยู่ด้านในต่อจุดอ้างอิง 1.5 ± 2.01 มิลลิเมตร

สรุป: ผลการศึกษานี้สามารถนำไปใช้เป็นข้อมูลในการทำผ่าตัดเปลี่ยนข้อเข่าเทียมที่ใช้เครื่องมือนำร่องชนิดใส่ในโพรงกระดูกฟีเมอร์