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Alignment of the femoral component in a mobile-bearing unicompartmental knee arthroplasty: A study in 10 cadaver femora

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Abstract

Use of an intramedullary rod is advised for the alignment of the femoral component of an Oxford phase-III prosthesis. There are users moving toward extramedullary alignment, which is merely an indicator of frustration with accuracy of intramedullary alignment. The results of our study with 10 cadaver femora demonstrate that use of a short and long intramedullary femoral rod may result in excessive flexion alignment error of the femoral component. Understanding of the extramedullary alignment possibility and experience with the visual alignment of the femoral drill guide is essential toward minimizing potential errors in the alignment of the femoral component.

Keywords: Unicompartmental knee; Alignment; Femoral component; Intramedullary rod; Extramedullary rod

1. Introduction

In carefully selected patients, the results of the Oxford unicompartmental arthroplasty have shown to be as good as those for total knee arthroplasty [1]. The principle of the Oxford unicompartmental knee [2] is that a polyethylene bearing, concavely spherical above and flat below, can maintain perfect congruity between the metal femoral condyle and the metal tibia plateau while allowing them complete freedom to rotate and slide. A spheric femoral component articulating with a congruous meniscal bearing provides a large area of contact in all positions. Small errors of alignment of the femoral component do not necessarily result in loosening [3] or loss of congruency. In the manual of surgical technique of the Oxford unicompartmental knee, the allowed alignment variation is 10° of varus or valgus in the coronal plane and 5° of flexion or extension in the sagittal plane for the femoral component.

It is possible to implant this prosthesis using a minimally invasive approach without everting the patella and thus avoiding damage to the synovial reflections of the suprapatellar pouch [4]. The femoral drill guide should ensure proper placement of the femoral component. The guide is visually aligned parallel to the long axis of the tibia and the fin on its side parallel to the intramedullary femoral rod in the coronal and sagittal planes. The femoral drill guide is not fixed to the intramedullary rod.

Currently there is an intense debate going on about the Oxford intramedullary rod both because of its usefulness and, as a secondary consideration, its length [5]. There is now a small but informed opinion group moving toward extramedullary alignment, which is merely an indicator of frustration with accuracy of intramedullary alignment.

The accuracy of the intramedullary alignment of the femoral component will be enlightened in this manuscript.

2. Materials and method

There are two different intramedullary rods on the market: the short thin rod (200 mm by 4 mm) and the long thin rod (300 mm by 4 mm). Both rods (used with the Oxford phase-III implant) are used in this experiment. Digital

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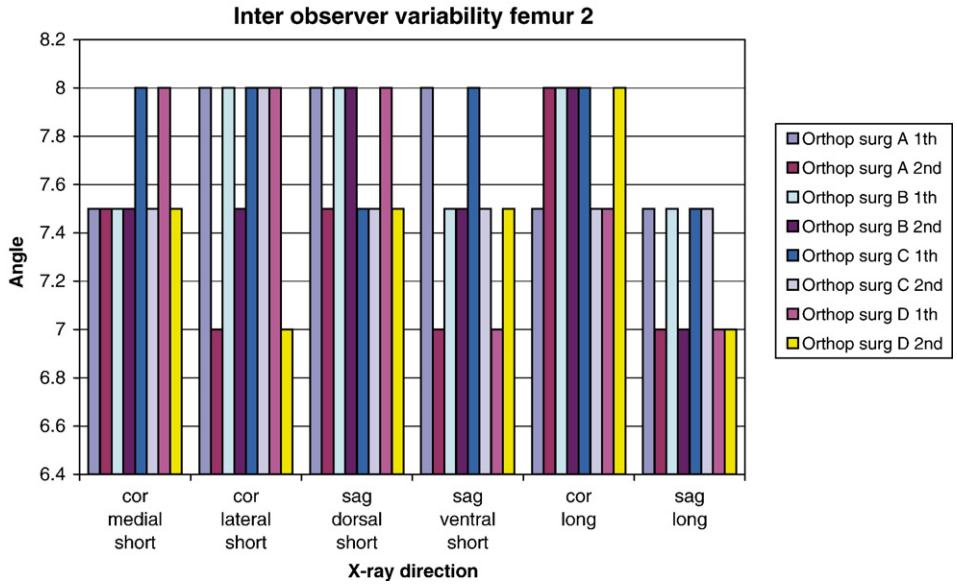

Fig. 1. The different angles (degrees) of femur 2 compared to the mechanical axis for the coronal view and the anatomical axis for the sagittal view. There are 6 X-rays of femur 2. Each direction shows the 2 measured angles per orthopedic surgeon.

X-rays were taken of the rods in ten cadaver femora, all dry specimens of the left leg. Factors such as age, sex and disease history were not available for the dry specimens. Variables investigated were rod length and possible positions of the rod compared to the mechanical axis on the anteroposterior X-rays (coronal view) and to the anatomical axis on the lateral X-rays (sagittal view) in ten different left cadaver femurs. The angles were measured in two separate sessions by four orthopedic surgeons. The manufacturer advises placing the intramedullary femoral rod in an anteromedial entry point (1 cm anteriorly to the anteromedial corner of the intercondylar notch). All rods were positioned in the anteromedial entry point and a varus/valgus stress was applied to the distal tip in order to push the proximal tip against the medial or lateral cortices respectively, while taking the anteroposterior X-rays. For the lateral X-rays, proximal tips of the rods were pushed against the ventral and dorsal cortices. All X-rays were taken in the same digital fashion. A metal head is projected to facilitate accurate measurements on the digital X-ray.

3. Results

The different angles of the intramedullary rod compared to the mechanical axis in the coronal view and the anatomical axis in the sagittal view were measured by each surgeon twice. With the advised entry point location of the rod in the femoral intramedullary canal (anteromedial), insertion of the rod in our cadaver study was easy. Fig. 1 shows the measurements for femur 2. Average intraobserver

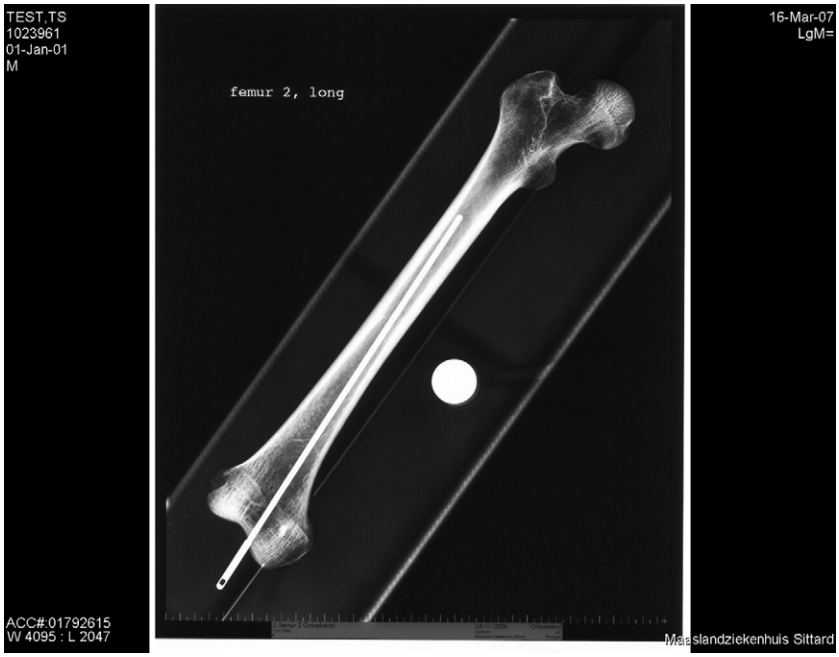

Fig. 2. The long rod in AP (coronal) view.

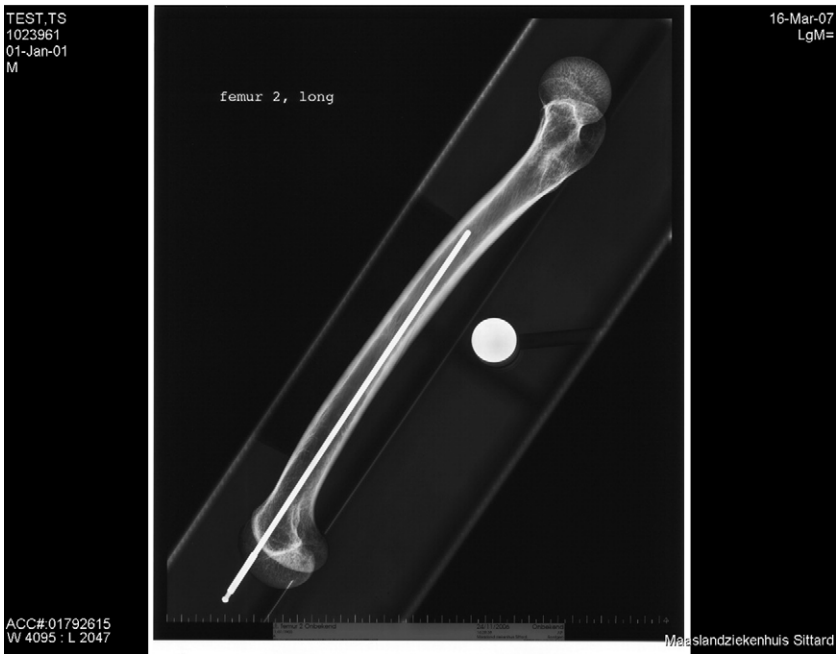

Fig. 3. The long rod in (sagittal) view.

correlation is 0.954 with a Cronbach alpha of 0.976, average interobserver correlation is 0.969 with a Cronbach alpha of 0.992.

For the long thin rod there was only one position possible in the intramedullary canal in all ten femora, an average of 6.5° (SD 0.9) in the coronal view compared to the mechanical axis and 4.4° (SD 1.6) in the sagittal view compared to the anatomical axis. The long rod is fixed in the femoral canal without possible movement in medial, lateral, dorsal or ventral direction.

Varus or valgus stress (Fig. 2) on the short rod in the other femora causes an average angle of 6.3 (SD 1.3) to 5.9° (SD 1.0) in the coronal view. In the sagittal view, pushing the proximal tip of the short rod to the ventral or dorsal cortex (Fig. 3) gives respectively an average angle of 4.3 (SD 2.0) and 4.0 (SD 1.9) compared to the anatomical axis. For femora 1, 8 and 9 there was no intramedullary movement possible of the short rod in any of the four directions while situated in the canal. With the first introduction of the short rod, the average angle in the coronal view was 5.9° (SD 1.4) and in the sagittal view 4.0° (SD 1.0). This is within the limits of the other seven femora.

In the sagittal plane, the long thin rod followed the femoral canal in an average of 4.4° (SD 1.6) of flexion. For the short rod, the average angle is 4.3° (SD 2.0) of flexion when the rod is pushed in flexion. The maximum potential error of both the short and long intramedullary rods in the sagittal plane is more than 5° in the sagittal plane in femora 2, 4 and 9.

4. Discussion

An intramedullary rod is advised for the alignment of the femoral component with the Oxford phase-III implant. With the minimally invasive technique the exposure is limited, so exact positioning of the prosthetic components is more difficult and alignment errors may result. Proper alignment does have its effect on the wear rate of the mobile bearing. Bearings with signs of impingement due to misalignment of the components have a maximum wear rate of 0.08 mm per year. Those bearings showing no signs of impingement have a mean wear rate of 0.01 mm per year [6].

With the Oxford phase-III unicompartmental knee arthroplasty, the femoral drill guide should be visually aligned parallel to the long axis of the tibia, in the middle of the condyle and parallel to the intramedullary femoral rod in the coronal and sagittal planes. The femoral drill guide is not fixed to the intramedullary rod, inducing an uncertainty factor in the positioning of the femoral drill guide, which results in an uncertain final position of the femoral component.

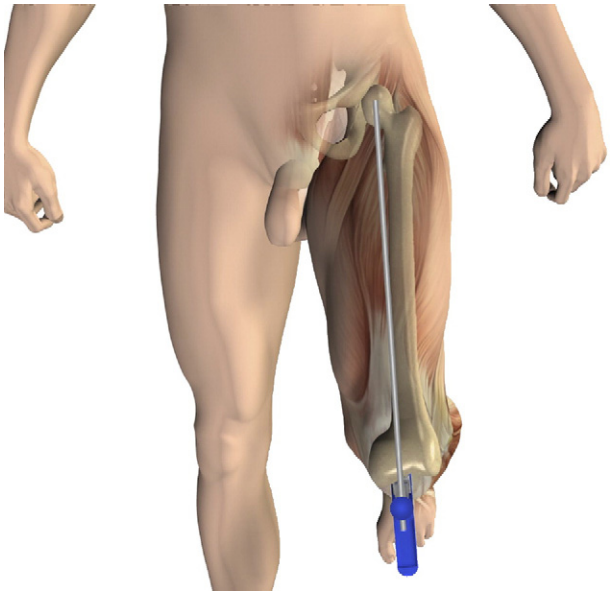

Fig. 4. By rotating the femoral drill guide, the extramedullary rod is pointed toward the head of the femur when viewed from above.

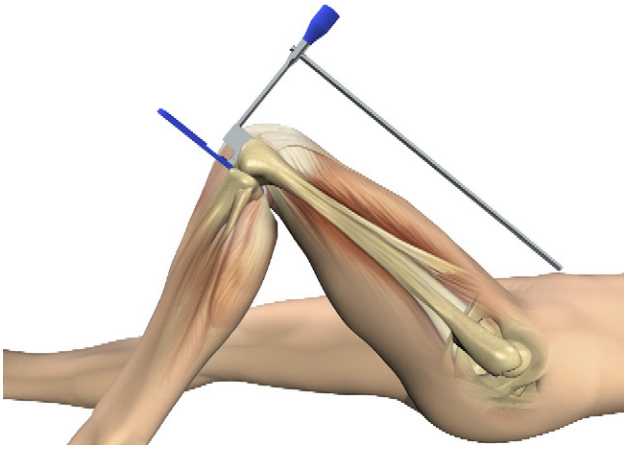

Fig. 5. By adjusting the degree of flexion of the knee, the extramedullary rod is made to lie parallel with the femur when viewed from the side.

Intramedullary alignment is in our clinical experience not always easy — the recommended anteromedial insertion site of the rod is not ideal for all patients. Interference of the rod with the medial cortex during insertion may prevent further insertion or cause valgus alignment of the rod compared with the anatomical axis. Flexion of the knee, to make the upper surface of the femoral drill guide lie parallel to the intramedullary rod, may be difficult because of impingement of the patella with the IM rod in the clinical setting.

The alternative is the extramedullary alignment where the rod is fixated to the femoral drill guide. The rod should be visually aligned with the femur in the clinical setting in the coronal and sagittal planes, and the femoral drill guide should also be positioned in the middle of the condyle and parallel to the long axis of the tibia. With the extramedullary alignment, the rod is fixed to the femoral drill guide (the drill guide is already prepared for extramedullary alignment by the manufacturer); the rod is now visually aligned parallel to the femur in the coronal plane (Fig. 4), and in the sagittal plane it is pointed toward the head of the femur (Fig. 5). The position of the drill guide is completely dependent on the expertise of the surgeon in the clinical setting. No special study is possible with the cadaver femur for this extramedullary alignment, as the rod and the femoral drill guide are not fixated to the femur.

The limitation of this analysis is that we only used ten dry femur specimens. The average canal width of our femora, 161 mm from the distal femoral surface, is 20 mm (range 14–24 mm) in the coronal plane and 18 mm (range 12–21 mm) in the sagittal plane. The mean canal diameter measured the half length of our femora, 13 mm (range 9–16 mm). This is more comparable with the average measurements of Ma [5] with forty-five cadaver femora, and less than the average dimensions of Novotny [7] with twenty cadaver femora. We can conclude that our cadaver femora were not abnormally large.

The average intraobserver correlation of 0.954 and interobserver correlation of 0.969 show good intraobserver and interobserver agreement. The high Cronbach alpha measured is due to the high number of homogeneous items.

With the 7-degree fin on the femoral drill guide there will be an average of less than 2° of valgus alignment of the femoral component compared to the mechanical axis in the coronal plane with the long and short rods. This is similar to the findings of Novotny et al. [7] and less than Ma et al. [5] and does not exceed the allowed alignment error of 10° varus of valgus. In this study, the maximum potential error of both the short and long intramedullary rods in the sagittal plane exceeds the allowed alignment error of 5° in the sagittal plane in femora 2, 4 and 9. The results of our study demonstrate that the short and long intramedullary femoral rods used for the phase-III Oxford unicompartmental knee arthroplasty may result in an excessive flexion alignment error of the femoral component.

Extramedullary alignment for the Oxford phase-3 unicompartmental knee arthroplasty is not mentioned in the current literature, but a small yet informed opinion group is now moving toward extramedullary alignment. Understanding of both alignment possibilities and experience with the visual alignment of the femoral drill guide are crucial toward minimizing potential errors in alignment of the femoral component. To rule out the uncertainties of the ‘on the eye’ positioning of the femoral drill guide in the clinical setting, the current instrumentation should be modified. Will fixation of the femoral drill guide to the intramedullary rod be possible, or is computer navigation the solution? Without these modifications the visual alignment is the most uncertain factor. Experience of the surgeon will be the key issue. A clinical trial should determine the place of the extramedullary alignment compared to the alignment advised by the manufacturer.

References

[1] Murray DW, Goodfellow JW, O’Connor JJ. The Oxford medial unicompartmental arthroplasty: a ten-year survival study. J Bone Joint Surg Br 1998;80:983–9.
[2] Goodfellow JW, Tibrewal SB, Sherman KP, O’Connor JJ. Unicompartmental Oxford Meniscal knee arthroplasty. J Arthroplasty 1987;2:1–9.
[3] Shakespeare D, Ledger M, Kinzel V. Accuracy of implantation of components in the Oxford knee using the minimally invasive approach. Knee 2005;12:405–9.
[4] Price AJ, Webb J, Topf H, Dodd CA, Goodfellow JW, Murray DW. Rapid recovery after oxford unicompartmental arthroplasty through a short incision. J Arthroplasty 2001;16:970–6.
[5] Ma B, Long W, Rudan JF, Ellis RE. Three-dimensional analysis of alignment error in using femoral intramedullary guides in unicompartmental knee arthroplasty. J Arthroplasty 2006;21:271–8.
[6] Psychoyios V, Crawford RW, O’Connor JJ, Murray DW. Wear of congruent meniscal bearings in unicompartmental knee arthroplasty: a retrieval study of 16 specimens. J Bone Joint Surg Br 1998;80:976–82.
[7] Novotny J, Gonzalez MH, Amirouche FM, Y.C.L. Geometric analysis of potential error in using femoral intramedullary guides in total knee arthroplasty. J Arthroplasty 2001;16:641–7.