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Navigated Lateral Unicompartmental Knee Arthroplasty - Technique and Case Report

Case Report

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Abstract: Lateral unicompartmental knee arthroplasty (UKA) outcomes have been inferior to those described after medial UKA. Inaccurate implant positioning and mechanical axis malalignment appear to be the most common technical errors. Rare studies or failure identification on lateral UKA are currently presented in the literature. We describe the utilization of computer-assisted lateral UKA placement for lateral knee osteoarthritis with a valgus malalignment of 10°. Navigation allows for a dynamic intraoperative visualisation of the mechanical axis, as well as for accurate component positioning and overall postoperative limb alignment. The systems allow the knee position to be captured with appropriate tension in extension and flexion prior to making definite cuts. Postoperatively, no instabilities occurred with a precise component placement. Navigation can be used in rare cases for lateral UKA.

Keywords: *Navigation • Lateral unicompartmental knee arthroplasty • Computer assisted surgery • Knee kinematics*

1. Introduction

The incidence of isolated lateral compartmental osteoarthritis of the knee is substantially lower than isolated varus gonarthrosis. The relative infrequency of this diagnosis has resulted in a paucity of well-described techniques or outcome studies of lateral unicompartmental knee arthroplasty (UKA). It is estimated that only 5% to 10% of all unicompartmental knee replacements are performed for isolated lateral-compartment disease [1,2].

Although UKA for the medial or lateral compartment was introduced in the late 1960's, the overall results have shown inferior longevity and reproducibility compared to conventional total knee arthroplasty (TKA). Furthermore, the outcomes of isolated lateral UKA have been inferior to those described after medial UKA [3,4]. Whereas short-term outcomes for cases of lateral UKA with a 5-year follow-up have reported to have an 89% survival rate, 10-year follow-up analysis has shown an overall survivorship of only 67% [3,5]

Although the precise cause of the relatively high failure rate of unicompartmental arthroplasty is not entirely known, it is believed to be multifactorial in nature. Improper patient selection and biomechanically unfavourable implant design have both been implicated. However, inaccurate implant positioning and secondary mechanical-axis malalignment appear to be the most common technical errors compromising the longevity of the implant [6,7]. Proper alignment of both implant

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components has been shown to be the major limiting factor during medial UKA, accounting for early failure of the implant [8-10]. Proper restoration of the coronal axis has been shown to have the highest correlation with the survival of the prosthesis.

Whereas techniques for total knee arthroplasty typically use reliable tools for intramedullary or extramedullary mechanical alignment, most techniques for performing UKA require significant "freehand" surgical judgement due to limited or potentially inaccurate instrumentation. Furthermore, recent interest in minimally invasive procedures with limited visualization of the joint have created additional challenges for the surgeon in achieving accurate component position and limb alignment.

Recent technological innovations in medial UKA have included the use of computer-assisted navigation technology. Computer-assisted navigation has been shown to improve postoperative leg alignment compared to conventional techniques [11]. Navigation generally has been shown to increase the congruency of the planned-versus-achieved leg alignment in corrective lower-limb osteotomies and component positioning in TKA [12-15].

In this case report, we describe the novel application of computer-assisted navigation in the placement of a lateral UKA for valgus osteoarthritis. Dynamic intraoperative visualisation of the mechanical axis allowed for accurate component positioning and overall limb alignmentpostoperatively.

2. Patient and Technique

An 86-year-old woman presented to our clinic with refractory knee pain. Despite multiple attempts at nonoperative management, her walking distance was reduced to half a block, and she was unable to climb any stairs. Clinical examination revealed a moderate valgus malalignment of the limb. She was neurovascularly intact, with range of motion in the knee from full extension to 110° of flexion. The knee was focally tender to palpation along the lateral joint line. The lateral and medial collateral ligaments were intact to stress examination, and the valgus deformity was passively correctable to slight valgus limb malalignment.

Bilateral anteroposterior radiographs of the lower limbs were obtained preoperatively. The right knee demonstrated a 10° valgus deformity. Severe lateral compartment osteoarthritis including joint narrowing and subchondral sclerosis was appreciated (Figure 1). The medial knee compartment, however, appeared well-preserved. The patient was not in favor of total knee arthroplasty, and she desired the least potentially invasive procedure that would allow a rapid return to activity and function. The risks and benefits of unicompartmental knee arthroplasty were reviewed, and the patient elected to proceed with a lateral UKA.

Figure 1. Preoperative radiographs of the 86-year-old patient.

2.1. Operative technique

After a combination of epidural and femoral-block anesthesia was administered, the patient was positioned supine, and the right lower extremity was prepared and draped in the usual sterile fashion. A commercial navigation system (BrainLAB, Heimstetten, Germany) including an image-free module for navigated unicompartmental lateral knee arthroplasty was used. Initially, two minimally invasive reference arrays were attached to the distal femur and the tibial shaft with two 3.0-mm Schanz screws. Registration of the mechanical leg axis is based on a pivoting mechanism of the hip to define the hip center. Percutaneous registration of the ankle joint was obtained with a navigated pointer tool. A 6-cm parapatellar lateral approach was performed, and the tibial plateau, tibial slope, distal lateral femoral condyles and proximal lateral ventral tibial shaft defined with the pointer-based palpation of predefined landmarks. On the basis of this data, the navigation system created an adapted bone model of the patient's anatomy and determined the mechanical axis of the lower extremity. It subsequently recommended the appropriate distal femoral and tibial resections necessary to achieve accurate placement of the components (Preservation

Figure 2. Tibia cut planned such that the new joint line, with the knee in 2° of valgus, was perpendicular to the tibial anatomic axis, based on the kinematic registration of the navigation system.

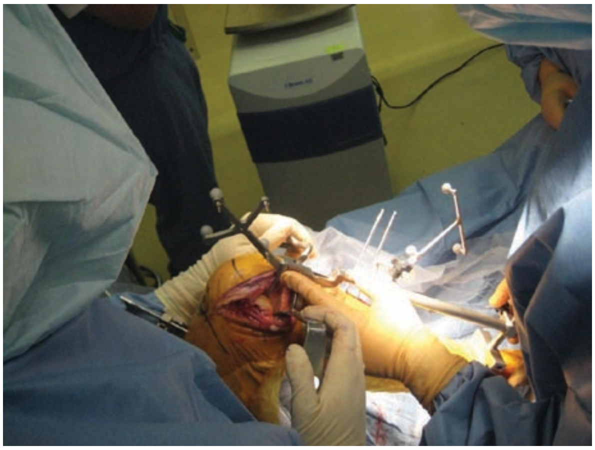
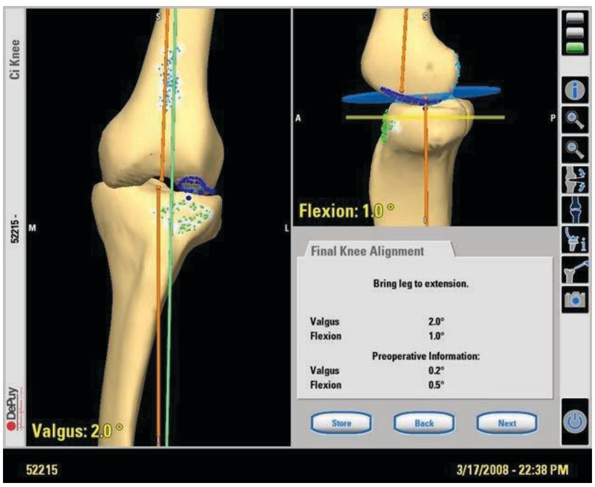


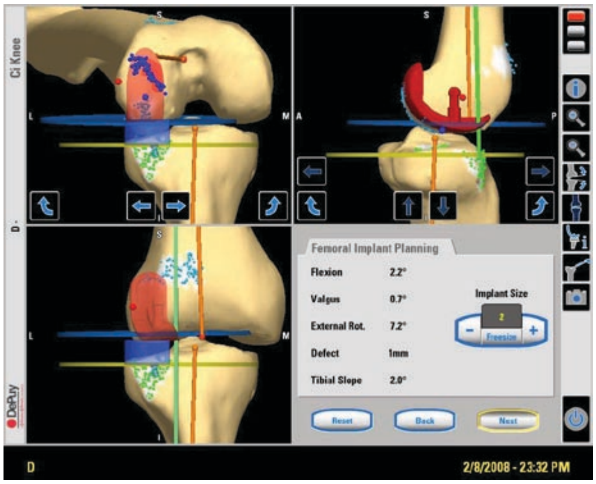
Figure 4. The final leg alignment of 2° of valgus achieved in full extension and documented with the navigation system. However, no final implant position was visualized on these screenshots.



System, Depuy, Warsaw IN). In our patient, a correction to 2° of valgus was planned.

Orientation of the tibial cutting plane was performed under real-time visualization by the navigation system (Figure 2). The tibial slope was adapted to match the patient's native slope. After removal of osteophytes, the patient's lower extremity was manually held in full extension with a varus load, and the navigated long-leg alignment was assessed. When the knee was in 2° of valgus, the position was saved on the navigation system. With this data, the tibia cut was planned, such that the new joint line, with the knee in 2° of valgus, was perpendicular to the tibial anatomic axis. This extension posture also determined the size of the distal resection, such that the extension space would accommodate

Figure 3. Recommendations of the appropriate distal femoral and tibial resections necessary to achieve accurate placement of the components made by the navigation system, according to the desired leg alignment.

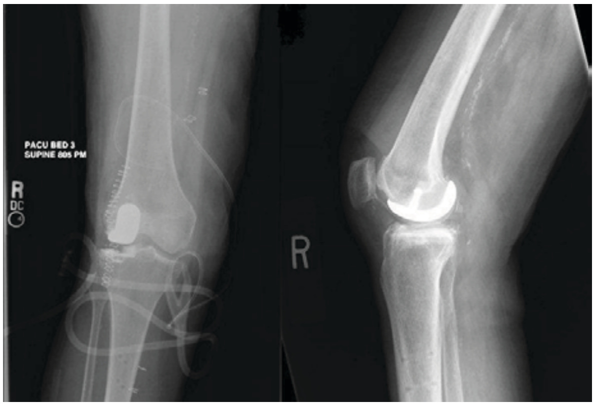


an 11-mm polyethylene tibial tray (Figure 3). On the basis of this plan, a modest tibial cut of only 1 mm was made from the lowest point of the lateral plateau, such that the tibial component would appropriately fill the extension gap present with the knee corrected to 2° of valgus. Following the tibial cut, shims were placed in the lateral compartment, with the knee flexed to 90°, until the lateral compartment felt stable and well tensioned in flexion (Figure 4). This posture was then saved by the navigation system. The femoral component was then sized, and the position was planned, such that the flexion and extension gap were equal. The resultant virtual plan therefore ensured a symmetric flexion and extension gap, corrected long-leg alignment to 2° of valgus, and a well tensioned lateral compartment in flexion.

The femoral cutting block was then navigated into place, and the requisite cuts were performed. An 11-mm all-polyethylene tibial tray was recommended and selected. Final implant position, range of motion, mechanical axis, and joint stability were examined with trial implants. The goal alignment of 2° of valgus was achieved. Final implants were prepared and cemented. Appropriate implantation and alignment were again confirmed with the navigation system (Figure 5). The soft tissues were closed in a routine, layered fashion.

The patient tolerated the procedure well, and her immediate postoperative course was uneventful. Three days postoperatively, she was discharged from the hospital and from physical therapy, since by that time she was walking with cane assistance. Six weeks postoperatively, she was ambulating without pain or any assistive device. The range of motion in the knee was 0 to 120° of flexion with no varus or valgus instability. Minimal effusion and slight scar tenderness were present

Figure 5. Postoperative radiographs after lateral navigated UKA.



in the knee. Weight-bearing long-leg radiographs demonstrated the right knee to be in 2° of valgus. Stable implant fixation of both components was found, with no signs of loosening. At 12 weeks' follow up, stable implant conditions were also shown radiographically.

3. Discussion

A resurgence of interest in unicompartmental knee arthroplasty has occurred in recent years. Correspondingly, interest in the use of minimally invasive UKA for varus gonarthrosis has increased [16]. Although new techniques and instruments have been developed, minimally invasive UKA is a technically demanding procedure, because limited visualization may compromise the accuracy of implant alignment and positioning.

Certain technical considerations must be fulfilled when performing a UKA, either of the lateral or medial compartment. Overcorrection of the deformity should be avoided, since excessive correction may result in mediolateral subluxation of the tibiofemoral articulation or in excessive force on the unresurfaced compartment, with early secondary degeneration. For this reason, undercorrection of the mechanical axis by 2° to 3° has been advocated [1,8].

Despite attempts at proper implant positioning, inaccurate implantation is still the most often implicated factor for early failure of the prosthesis [7,9,17]. Most unicondylar systems offer limited instrumentation that substantially relies on "freehand" surgical judgement for component positioning. Rates of inaccurate component implantation as high as 30% have been reported with non-navigated instrumentation [18]. The Swedish Knee Arthroplasty Register found the main indication for revision following lateral UKA to be component loosening in 31% of patients, progressive joint degeneration in 35% of patients, and other mechanical failure in 18% of patients [19] Mariani et al. found an even higher early failure rate of 38% at only 9 to 12 months postoperatively. All failures in their study were secondary to loosening of the femoral component [7]. Assor et al. found the main cause of failure to be rotatory malposition of the condylar implant [20]. Therefore, we conclude that the position of the UKA is critically related to the success and longevity of the prosthesis and that restoration of the alignment of the lower limb is an accepted prognostic factor for long-term survival.

Although outcomes following lateral UKA have been rarely reported compared to medial site applications, recent data suggest that lateral UKA is a reasonable alternative for isolated lateral femorotibial compartment disease. Long-term results after 13 yearshave showedsurvivorships of greater than 90% [21]. Repeated clinical and radiographic follow-up confirmed a reduction in pain and an increase in function and range-of-motion components in patients after lateral UKA after 60 months [22]. Comparative positive results including durable and reliable short-term to mid-term results, even through a medial approach after a mean follow-up time of 5 years, were also shown by another group [23,24]. Current trends in new technologies with use of custom-made interpositional devices or custom-made lateral unicompartmental knee replacement also seem to show promising results; however, long-term studies are not yet available [25].

Although the degree of ideal postoperative limb alignment after lateral UKA is controversial, we believe that general ligament balancing plays an important role in lateral UKA. Because a complete exposure of the lateral compartment cannot be achieved with a standard intraoperative approach, sufficient placement of both components and combined control of the resulting alignment is based mainly on the surgeon's experience. The navigation systems allow the knee position to be captured in appropriately tensioned extension and flexion prior to the making of definite cuts. From these knee postures, the implant positions can be virtually built so that the joint line is maintained, the gaps are symmetrical, and the appropriate alignment is achieved. Navigated control of the cutting blocks in accordance with the plan simplifies an appropriate bony resection.

Limitations of the navigation system are based on the need for invasive reference-marker fixations, the use of specified instruments, and some increased operation time in general. However, we believe that in rare cases where a lateral UKA is indicated in which minimal alterations of implant placement or resulting alignment are shown to have significant influence on the clinical results, those drawbacks should not be overestimated.

In summary, our case has demonstrated that navigated techniques allow for a proper implant placement in lateral UKA with controlled ligament balancing and a permanent measurement of the mechanical leg axis. Larger clinical studies will be needed to assess the generalizablity of this technique.

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