Navigated Revision TKR: A Comparative Study With Conventional Instruments

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abstract

We selected 86 cases for the study: 50 navigated revision total knee replacements (TKRs) and 36 conventional revision TKRs. We hypothesized that the rate of satisfactory implantation would be higher for navigated revision TKR than for conventional revision TKR. The primary criterion was the rate of optimally implanted prostheses on postoperative anteroposterior and lateral long leg radiographs. Thirty-one navigated cases (62%) and 14 conventional cases (39%) had an optimal global implantation ($P<.05$). The use of a standard navigation software for revision TKR allows a significant improvement of the accuracy of implantation. However, development of dedicated software will allow addressing more precisely the specific features of a revision TKR, such as stem extension navigation, defects filling, and joint line reconstruction.

The number of revision total knee replacements (TKRs) has dramatically increased in recent years and may account for 10% of all TKRs. Causes for revision TKR include septic failure, knee instability, implant malpositioning, implant breakage, patellar maltracking, and aseptic loosening or wear. Revision TKR is a challenging procedure, especially because most of the standard bony and ligamentous landmarks are lost due to the primary implantation. However, as for primary TKR, restoration of the joint line, adequate limb axis correction, and ligamentous stability are considered critical for the short- and long-term outcome of revision TKR.

There are no available data that define the range of tolerable leg alignment. However, it is logical to assume that the same range that is tolerable after primary TKR might be accepted after revision TKR, that is, $\pm 3^\circ$ off the neutral alignment. Conventional instruments with intramedullary or extramedullary rods have been developed for primary replacement and have been adapted for use in revision cases. It has been demonstrated that their accuracy has been less than optimal for primary cases. One might assume that these conventional instruments, which rely on visual or anatomic alignments of intramedullary or extramedullary rods, are associated with significant higher variation of the leg axis correction for revision cases. The efficiency of navigation systems has been extensively demonstrated for primary TKR. It was logical to adapt this technology for revision TKR as well.

For more than 10 years, we have used a non–image-based navigation system for primary TKR. We wanted to use the same operative technique for revision cases and to compare the accuracy of implantation of navigated revision TKR with conventional revision TKR and primary TKR. We hypothesized that the rate of satisfactory implantation would be higher for navigated revision TKR than for conventional revision TKR.

MATERIALS AND METHODS
Operative Technique

The navigated technique (OrthoPi- lot, B. Braun Aesculap Tuttlingen, Germany) has been described elsewhere. Briefly, arrays were fixed by a screw on the distal femur and on the proximal...
tibia, and strapped on the dorsal part of the foot. A kinematic registration of the hip, knee, and ankle joints was performed. A navigated stylus was used to palpate relevant anatomic points. Then the system displayed the orientation of the mechanical axes of the femur and the tibia. Navigated resection guides were oriented and fixed to the bones along these axes to the desired position. The bone resections were performed with a conventional saw blade.

The same software and the same instruments were used for revision TKR. Kinematic and anatomic registration was performed with the index implants left in place (Figure 1), without any difference in comparison to primary TKR. Navigated resection guides were oriented and fixed to the bones along these axes to the desired position (Figure 2). The bone resections were performed with a conventional saw blade. The prosthesis was implanted with either normal or extension stems as appropriate.

Two groups of cases were defined: navigated revision TKR (group A) and conventional revision TKR (group B). We identified on the operative theater list of our institution all TKRs performed in 2007 and 2008, and all revision TKRs implanted during this period were included: 50 into group A and 36 into group B.

**Data Collection**

Preoperatively for each patient, we gathered the following data: age, gender, height, body weight, body mass index (BMI), reason for revision, knee score and function score according to the Knee Society Scoring System, and coronal femorotibial angle. The accuracy of implantation was retrospectively analyzed on postoperative long leg radiographs in unipodal support. Coronal mechanical femorotibial angle and coronal and sagittal orientations of both femoral and tibial components were assessed. The TKR was expected to be implanted with the following requirements: a coronal femorotibial mechanical angle of $0^\circ \pm 3^\circ$, a coronal angle of $90^\circ \pm 3^\circ$ between the horizontal axis of the femoral or tibial implant and the mechanical femoral or tibial axis, and a sagittal angle of $90^\circ \pm 3^\circ$ between the horizontal axis of the tibial implant and the proximal posterior tibial cortex. A prosthesis was considered optimally implanted when all criteria were fulfilled.

**RESULTS**

We selected 86 cases for the study: 50 navigated revision TKRs and 36 conventional revision TKRs. There were 57 female and 29 male patients, with a mean age of $70.6 \pm 7.7$ years (range, 44-88 years). The mean BMI was $31.1 \pm 4.8$ (range, 23.5-42.3). The main reasons for revision were aseptic loosening.
DISCUSSION

Navigation systems have been validated for primary TKR. However, there are few papers about the use of such systems for revision TKR.\textsuperscript{13,14} Perlick et al\textsuperscript{13} hypothesized that a significantly better leg alignment and component orientation would be achieved when using a navigation system rather than conventional technique. They compared 2 groups of 25 revision TKRs done using either a CT-free navigation system or conventional manual technique. The postoperative alignment was measured on long leg coronal and sagittal radiographs. The mechanical limb axis was significantly better corrected in the navigated group (92\% vs 76\%). All navigated femoral components were well aligned in the coronal plane, whereas only 84\% were well aligned in the conventional group (P<.05). All navigated tibial components were well aligned in the coronal plane, whereas only 94\% were well aligned in the conventional group (P>.05). The sagittal alignment of both femoral and tibial implants were also improved in the navigation group (P>.05). The level of the joint line was also more accurately restored with help of the navigation system.

Massin et al\textsuperscript{15} reported their experience in 19 cases using a navigation system combining intraoperative surface bone registration and preoperative CT scan imaging, with a retrospective comparison to 10 nonnavigated revision cases performed at the same time by the same surgeon. Although the researchers observed no significant difference in the number of outliers for the 2 series, navigation appeared to be valuable in reconstructing both bone extremities while controlling the level of the joint line. We used the OrthoPilot non–image-based navigation system for revision TKR, and our results were similar to those already published. The global accuracy of implantation was improved when using this technology compared with conventional manual technique. Differences, although not significant, were also observed for all individual items in favor of the navigated technique. We confirm the results of the 2 previous studies: navigation has the potential to enhance TKR revision accuracy. However, the accuracy obtained for a primary implantation was not achieved, although the same navigation software and technique were used.\textsuperscript{4} We believe that the main reason for this discrepancy is that the standard navigation software did not allow navigating the stem extensions. In several cases, we observed that the bone resection at the joint level was well oriented, but the axis to the bone medullary canal could not be compensated by the available angled stems. Consequently, the prosthesis implanted with a stem extension was forced to the direction of the diaphyseal axis, with a mismatch with the articular resection. We conclude that the standard navigation software is not perfectly fitted to revision TKR procedure. It would be desirable to allow navigating the stem extension before implantation (Figure 3).

Furthermore, the standard navigation software offers no possibility for dealing with bone loss and reconstruction of the joint line height. A dedicated application for TKR revision, including these improvements, is available, and the first experiences reported by the development team are encouraging.\textsuperscript{15} However, this new application needs to be validated on a larger scale.

There may be some drawbacks to using a navigation system for revision TKR as has been discussed for primary TKR.\textsuperscript{16} Possible drawbacks include increased cost, increased operative time, and risk of fracture at the tracking holes. In our study, we observed no complications related to the use of navigation.
We believe that the improvement in the quality of implantation outweighs these possible disadvantages.

**CONCLUSION**

The use of a standard navigation software for revision TKR allows a significant improvement of the accuracy of implantation. However, development of dedicated software will address more precisely the specific features of a revision TKR, such as defects filling and joint line reconstruction.

**REFERENCES**