Computer-assisted Revision of Failed Unicompartmental Knee Arthroplasty

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The authors performed a matched-paired study comparing 22 computer-assisted surgery (CAS)-unicompartmental knee replacement (UKR) revisions with a similar group of knee replacement revisions performed conventionally. The aim of the study was to assess differences in implants used in the revision, surgical time, limb alignment, joint line restoration, and procedure costs. In the conventional group, there was a higher percentage of posterior stabilized (PS) and condylar constrained knee (CCK) implants, as well as a higher percentage of augmentations/stems/offsets. There were no statistically significant differences in postoperative mechanical axis, surgical time, or hospital stay. There were fewer outliers and better joint line restoration in the CAS group. More blood transfusions were performed in the conventional group, and costs were higher in this group as well.

Revision of failed knee arthroplasty is a challenge because of the associated problems of bone loss, soft tissue balance, and restoration of the normal joint line. Some researchers believe that unicompartmental knee replacement (UKR) is highly demanding and associated with technical difficulties and worse results than primary total knee replacement (TKR). Other researchers report conversion of failed UKR to TKR with no particular intraoperative difficulties and similar results as those for primary TKR at a short follow-up. However, almost all authors report the necessity of using allografts, wedges, stems, and in some cases, even constrained or semiconstrained implants during UKR revision. For example, despite the availability of more conservative modern UKR designs, in 2006 Springer et al reported using metal wedge augmentation with 2 long stems in 23% of patients in his series of 22 UKR revisions. More recently Saragaglia et al reported metal wedge augmentation in >60% of patients in his series of 33 UKR revisions.

Computer-assisted surgery (CAS) has been developed to help surgeons perform reconstructive procedures, and to improve implants, alignment, and performances. Various studies have demonstrated the efficacy of CAS in primary knee replacement surgery, even with different systems. Furthermore, more accurate implant alignments and more precise bone cuts may lead to advancements in tissue-sparing surgery.

Nevertheless, few studies have analyzed the use of CAS in revision procedures. Perlick et al in 2005 reported that even in revision cases, CAS can achieve similar improved implant alignment as is achieved with traditional techniques. In 2008, Massin et al reported a more reliable joint line restoration using navigation in revision of failed TKR. However, no study in literature has reported the results of navigated revision of failed UKR.

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**Materials and Methods**

Among 878 computer-assisted knee replacements performed since 1999, 22 consecutive navigated UKR revisions were included in the study (group A). In all cases, the diagnosis was aseptic loose or painful medial implants. No cases of evident or suspected sepsis were included in the study. Navigation was used to assist the surgeon in assessing limb alignment, joint bone cuts, and ligament balancing.

At a minimum follow-up of 12 months, all patients were successfully matched to patients who had undergone a UKR revision in our hospital using traditional alignment guides (group B). Every patient was matched for gender, age, preoperative diagnosis, and intraoperative bone loss according to Anderson Orthopaedic Research Institute Bone Defect Classification. Patients were matched with a maximum difference in age of 3 years. In group A, the revision procedure was performed using a computed tomography (CT)-free computer-assisted alignment system (OrthoPilot 4.08, 4.2, and 4.3; Aesculap, Tuttlingen, Germany). In group A all procedures were performed by two of the authors (N.C., A.M.); in group B, different surgeons working in our hospital performed the procedures.

Twelve months after surgery each patient had long-leg standing anteroposterior radiographs and lateral radiographs of the knee using the same standard protocol. We painstakingly collaborated with our radiographers to obtain consistent films before embarking on this trial. The radiographs were repeated when malrotation was detected.

Radiographs were assessed by an independent radiologist blinded to the original procedure to determine the mechanical axis of the limb (hip-knee-ankle [HKA] angle) as primary radiologic outcome measure. The desired prosthesis alignment was considered to be an HKA angle of 180°. The number and percentage of outliers (prostheses with any alignment parameter beyond 3° of the desired value for HKA angle) was determined. Joint line restoration was performed according to Figgie’s indications, assessing the differences with the opposite untreated side on the lateral radiographs and considering 0 mm as the ideal value.

Furthermore, we considered a mean fixed extra cost of about €336 more for procedure in the navigated group typical of innovative surgical procedures like computer-assisted surgery as suggested in 2006 by Dong and Buxton.

Statistical analysis was carried out using SPSS for Windows Release 11.0 (SPSS Inc, Chicago, Illinois). Differences between the 2 groups were measured with an independent Student’s t test or Mann-Whitney nonparametric test depending on the data distribution of the continuous variables. Differences in the percentage of outliers for each parameter were tested using a Fisher exact test. A P value of <.05 was considered statistically significant for all analyses.

**Results**

Preoperative values are presented in Table 1 and postoperative values are presented in Table 2. In group A, mean patient age at the time of revision was 71.8 years (range, 62-83 years).
with a mean of 7.5 years (range, 2-15 years) elapsing from the original UKR surgery. In group B, mean patient age at the time of revision was 73.6 years (range, 66-81 years) with a mean of 8.2 years (range, 3-16 years) elapsing from the original UKR surgery. There were 14 female and 8 male patients for each group. The mean preoperative HKA angle was 174.1° (range, 172°-179°) and 175.1° (range, 173°-178°) for the navigated group and the manual group, respectively. Preoperatively, the mean Knee Society Score was 42.9 (range, 39-48) in the UKR group and 41.4 (range, 37-50) in the TKR group. The preoperative functional score was 46.9 (range, 42-53) for group A and 45.3 (range, 41-50) for group B.

No intraoperative or postoperative complication related to surgical technique was registered except the intraoperative breakage of a K-wire used to secure tracker fixation to the bone in the navigated group, without any influence on the final result (Figures 1, 2). The mean surgical time was longer in group A (104.3 minutes [range, 85-132 minutes]) than in group B (98.8 minutes [range, 80-122 minutes]); there was no statistically significant difference between the 2 groups.

Intraoperatively, according to the Anderson Orthopaedic Research Institute Bone Defect Classification, there were 10 cases of grade I and 12 cases of grade II for each group. In group A, the revision procedure was performed using again a UKR in 2 cases, a Bi-UKR in 1 case (Figure 3), a cruciate retaining (CR) TKR in 7 cases, and a PS TKR in 12 knees (Figure 4).

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<th>Table 2: Postoperative Results</th>
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<td><strong>Group A (22 Knees)</strong></td>
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<td><strong>CAS-UKR Revision</strong></td>
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Abbreviations: CAS, Computer-assisted surgery; CCK, condylar constrained knee; HKA, hip-knee-ankle; KSS, Knee Society Score; PS, posterior stabilized; SD, standard deviation; TKR, total knee replacement; UKR, unicompartmental knee revision.
In group B, the revision procedure was performed using a CR TKR in 5 cases, a PS TKR in 14 cases, and a CCK TKR in 3 cases. A 4-mm metal wedge augmentation was used in 3 cases in group A. Five 4-mm metal wedge augmentations and one 8-mm metal wedge augmentation were used in group B. Bone allografts were used in 2 cases only in group B. Two 80-mm uncemented tibial stems were used in group A, and two 80-mm and three 120-mm uncemented tibial stems were used in group B.

At the latest follow-up, the mean Knee Society Score was 80.04 (range, 74-88) and 77.9 (range, 73-87) for group A and B, respectively. No statistically significant difference was seen for the Knee Society Score between the 2 groups. The mean functional score was 82.3 (range, 70-100) for group A and 77.9 (range, 69-90) for group B. No statistically significant difference was seen for the functional score between the 2 groups.

In the navigated group, the patients remained in the hospital for a mean of 7.1 days (range, 4-10 days); in the traditional group, patients remained a mean of 8 days (range, 4-13 days). Postoperatively, patients in group B required a mean of 1.4 blood transfusions (range, 0-2) compared with 0.7 (range, 0-3) in group A.

At latest follow-up, the mean HKA angle was 179.4° (range, 177°-181°) in the navigated group and 178.1° (range, 175°-182°) in the traditional group with no statistical differences. All the navigated revision implants were positioned within 3° of an ideal HKA angle of 180° compared with 5 cases of outliers in group B. Joint line restoration was calculated in 20 patients in group A and in 19 patients in group B; 2 cases in group A and 3 cases in group B were excluded because a TKR had already been done on the opposite knee. At the latest follow-up, restoration of the joint line was statistically better in group A than in group B, with a mean value being statistically closer to 0 mm (Table 2).

Analyzing the mean cost of the procedure, considering mean implant cost, hospital costs, and a fixed extra cost for the navigated group, we estimated a mean of €131.4 less for each procedure in the navigated group.

**DISCUSSION**

Unicompartmental knee replacement revision has been considered either a challenging procedure or a routine primary replacement, according to different authors’ experiences. Springer et al in 2006 considered conversion of failed UKR to TKR as a technically demanding procedure and advocated careful preoperative planning. Reviewing the New Zealand Joint Arthroplasty National Register in 2010, Pearse et al reported a poorer outcome of a UKR converted to a primary TKR compared with a primary TKR.

Likewise, Levine et al in 1996 and Châtain et al in 2004 indicated that results of revision of failed UKRs are superior to those of failed TKRs and failed high tibial osteotomy, and were similar to their results of primary TKRs. Furthermore, Johnson et al reported similar clinical results between revised UKR and primary TKR at a 10-year follow-up.

One of the main difficulties during this surgical procedure is to address bone loss, which is a greater complication in revision procedures following the first generations of UKRs compared with procedures that used more conservative modern designs. Padgett et al have reported technical difficulties in revision procedures and failures following the use of cement to treat large bony defects, suggesting the need for bone augmentations, metal wedges, stems, and even constrained implants.
Theoretically, CAS can offer different advantages in these complicated cases. In 2007, Thielemann et al.\textsuperscript{21} pointed out how navigation can help surgeons achieve a neutral mechanical alignment of the limb and a restored joint line even in TKR revision. Furthermore, navigation provides the surgeon further information to avoid extensive use of augmentations and bone grafts with precise data on bone cuts, limb alignment and soft tissue balancing. In our experience of >800 implants, CAS has created a new concept of tissue-sparing surgery based not on shorter surgical approaches but rather on less invasive implants.

This is the first study in the literature to report the results of a series of CAS-UKRs and to compare the results with a matched traditional group.

At first follow-up, we detected no difference in clinical outcomes, but this was not the main objective of the study. Nevertheless, we demonstrated no difference in surgical time or rate of complications, even using navigation. As in previous reports in literature for primary TKRs, we demonstrated an improved mechanical axis with a significantly lower number of outliers compared with the traditional group. Furthermore, joint line was restored more anatomically in the navigated group.

Finally, we demonstrated in the navigated group a less frequent use of more invasive implants. Likewise, despite similar bone loss classification in the navigated group, we had the choice of using a Uni or a Bi-uni to revise a failed one with no CCK implant.

In 2007, Saldanha et al.\textsuperscript{6} using traditional alignment systems, advocated use of augmentations and wedges only in selected cases, and 83% of his cases did not require any form of reconstruction for bone loss. Furthermore, he reported a mean thickness of the tibial component, including the polyethylene insert, to be only slightly thicker than after primary TKR. Similarly, in our study we tried to reduce the need for wedges and augmentations in both the groups; according to our results, this was possible more frequently in the navigated group.

No intramedullary alignment system, less invasive surgeries, cheaper implants, and less need for bone transfusions could reduce the cost of the procedure, even with the addition of a fixed higher cost for the adoption of navigation. In our study, we demonstrated a mean reduction in cost of €121.4 when using navigation rather than traditional methods of revision of failed UKR.

**CONCLUSION**

Using modern software and following computer suggestions for a minimal bone cut and for an ideal joint line, we could recreate a more anatomic revision in terms of implant alignment and joint line restoration using less invasive implants. We believe that the advantages of CAS are demonstrated in such complicated cases as UKR revision. Using CAS, surgeons can appreciate the possibility of restoring limb alignment and joint line using tissue-sparing procedures while also realizing a cost savings in these demanding procedures.
REFERENCES


