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Computer-Assisted Total Knee Arthroplasty for Significant Tibial Deformities

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Abstract: Computer-assisted total knee arthroplasty has been demonstrated to provide reproducible limb mechanical alignment within 3° from the neutral mechanical axis. However, restoring proper implant and extremity alignment remains a significant challenge with proximal tibial deficiencies. In this prospective study, we describe the use of computer navigation to quantify the amount of bone loss on the medial or lateral tibial plateau and the use of these data to assess the need for augmentation with metallic tibial wedges. In this study, we demonstrate that computer-assisted total knee arthroplasty in patients with significant tibial deformities can accurately measure severe tibial deformities, predict tibial augment thickness, and provide excellent mechanical alignment and restore the joint line without excessive bony resection, repeated osteotomies, and repeated augment trialing. **Keywords:** computer-assisted total knee arthroplasty, tibial deformities, metal augment, metal wedge.
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The long-term success of a primary total knee arthroplasty (TKA) is dependent, in part, on proper mechanical axis restoration and soft tissue balancing. Computer-assisted (CAS) TKA has been shown to provide reproducible limb mechanical alignment within 3° from the neutral mechanical axis [1-4]. However, in the presence of proximal tibial bony deficiencies, restoring proper implant and extremity alignment remains a significant challenge. Preservation of proximal tibial bone has been demonstrated to be advantageous. Quantification of tibial plateau deformities traditionally has been performed by preoperative radiographic templating followed by manual intraoperative measurement between the bottom of the tibial tray and base of the tibial defect. Alternatively, CAS TKA may allow any significant tibial plateau deformity to be quantified before performing tibial osteotomies. Augmentation of tibial bony defects is performed to achieve stability. Options for managing tibial bone defects in primary TKA include cementation, cementation with screw augmentation, modular metallic wedges, autograft bone grafting, allograft bone grafting, and custom prostheses. The most common technique currently used is the use of prosthetic tibial augments [5].

In this prospective study, we describe the use of computer navigation to quantify the amount of bone loss on the medial or lateral tibial plateau and the subsequent use of these data to assess the need for and use of augmentation with metallic tibial wedges to minimize proximal tibial resection and preserve host bone.

Materials and Methods

A total of 439 consecutive CAS TKA procedures were performed by 1 senior surgeon (LP) at the Northwestern Memorial Hospital from July 2006 through October 2009. In all cases, the tibial deformity was quantified and recorded intraoperatively using the OrthoPilot image-free computer navigation software (Aesculap, Tuttlingen, Germany). Navigation instruments quantified the tibial deformities by inputting the lowest point on the deformed tibial plateau and the midpoint on the nondeformed tibial plateau.

Institutional review board approval was obtained. Inclusion criteria included patients who underwent a navigated TKA in whom the navigated measured difference between the values of medial tibial plateau and lateral tibial plateau exceeded 13 mm, and the tibial deformity involved greater than one-third of the tibial plateau. Tibial deformities greater than 13 mm and involving greater than one-third of the tibial plateau used tibial augmentation. For all procedures using tibial augmentation, we noted the navigated measured bony

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defect size, location and size of tibial wedges, prostheses used, and polyethylene size.

In cases using medial or lateral tibial augmentation, preoperative and postoperative anteroposterior and lateral knee radiographs and long leg standing anteroposterior radiographs were reviewed. Postoperative mechanical alignment was measured using long-standing anteroposterior radiographs. Joint line restoration was measured using the Figgie method with preoperative and postoperative lateral knee radiographs. The Figgie method measurement for joint line restoration is a measurement from the tibial tubercle to the distal aspect of the femoral component [6]. All radiographic measurements were performed using GE Healthcare Imaging Software (GE Healthcare Imaging, Wauwatosa, Wis).

Preoperative and postoperative Knee Society Scores and knee function scores were collected for a minimum 2-year follow-up.

Computer-Assisted Wedge Augmentation Technique

A minimally invasive midvastus or medial parapatellar approach without patellar eversion was used for all TKAs. Subsequently, navigation pins were placed, followed by registration of femoral bony landmarks. The femur was subsequently prepared. The decision to use a cruciate-retaining or posterior-stabilized femoral component was based on assessment of posterior cruciate ligament competency and the senior surgeon's judgment regarding knee range of motion and posterior cruciate ligament tightness. Then, bony registration was carried out for the tibia. The discrepancy between the medial and lateral tibial plateaus was registered. At this point, using objective measurements obtained via the navigation software, a determination was made regarding using and sizing of tibial augmentation. The tibial resection was then performed. Then, an outrigger jig (Figs. 1 and 2) was placed on the deformed tibial plateau, and the appropriately sized wedge cut was performed. The patella was then resected and prepared to receive an asymmetric patellar component. Upon achieving proper soft tissue balancing, the 3 components, femoral component, modular short-stem tibia with baseplate, and patellar component, were cemented in place, and a trial polyethylene was placed. Upon curing of the cement, the final polyethylene was impacted into the baseplate.

Results

All 439 cases were reviewed. Thirteen knees (3.0%) had intraoperative measured tibial deformities greater than 13 mm and involving greater than one-third of the tibial plateau. The left knee was affected in 10 patients. The right knee was affected in 2 patients. One patient had bilateral knees affected. One patient was revised from a unicompartmental knee arthroplasty because of tibial subsidence. The medial tibial plateau was affected in all 13 knees. Nine knees underwent cruciate-retaining arthroplasty, and 4 knees underwent a cruciate-stabilized arthroplasty. All patients were independent community ambulators.

All 13 TKA procedures required medial tibial plateau metallic wedge augmentation to prevent excessive tibial resection and maintain host bone contact. The range of measured tibial plateau discrepancy was 15 to 23 mm with a mean tibial plateau discrepancy of 18 mm. Seven knees required a 5-mm tibial wedge, and 6 knees required a 10-mm tibial wedge. The mean polyethylene size used was 11 mm with a range of 9 to 19 mm.

Review of postoperative long-standing radiographs revealed the mean overall postoperative alignment to be 0.08° of valgus with a range from 2° valgus to 4° varus (Figs. 3 and 4). Measurements using the Figgie method comparing preoperative and postoperative lateral knee

Fig. 1. Outrigger jig with navigation marker.

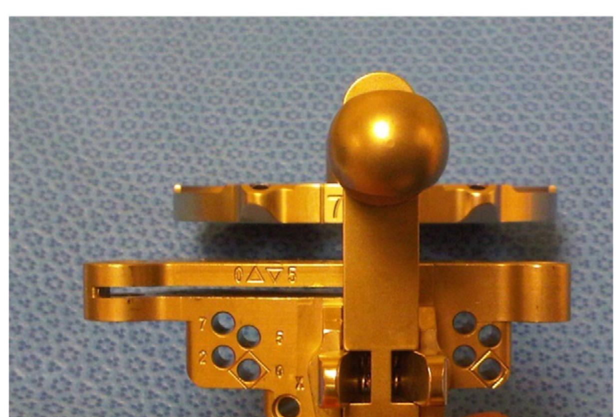

Fig. 2. Outrigger jig.

Fig. 3. Long-standing postoperative anteroposterior radiograph showing excellent alignment.

radiographs demonstrated mean joint line restoration to be 1.3 mm with a range of 0.2 to 3.7 mm (Fig. 5). At 2-year radiographic follow-up, 1 knee demonstrated a thin radiolucent line under medial tibial augment. Thus, in all 13 knees, joint line restoration was successful within 4 mm, and long-standing radiographs revealed excellent coronal alignment and mechanical axis restoration.

Mean preoperative Knee Society Scores and knee function scores for these 13 knees were 36.9 (21-57) and 66.2 (30-80), respectively. Postoperative Knee Society Scores and knee function scores were 91.4 (77-100) and 88.5 (65-100), respectively. We have a minimum of 2-year radiographic and clinical follow-up. No patients were lost to follow-up. No complications were encountered.

Discussion

Computer-assisted TKA has been demonstrated to reproducibly and accurately restore the mechanical axis and joint line in primary TKA. The longevity and success of TKA depends, in part, on appropriate component position, soft tissue balancing, and restoration of the mechanical axis. Bone deficiency of the proximal tibia in primary TKA presents a significant challenge in achieving a successful result. It has been shown that bony compressive strength rapidly decreases beyond 5 mm distal to the subchondral bone of the

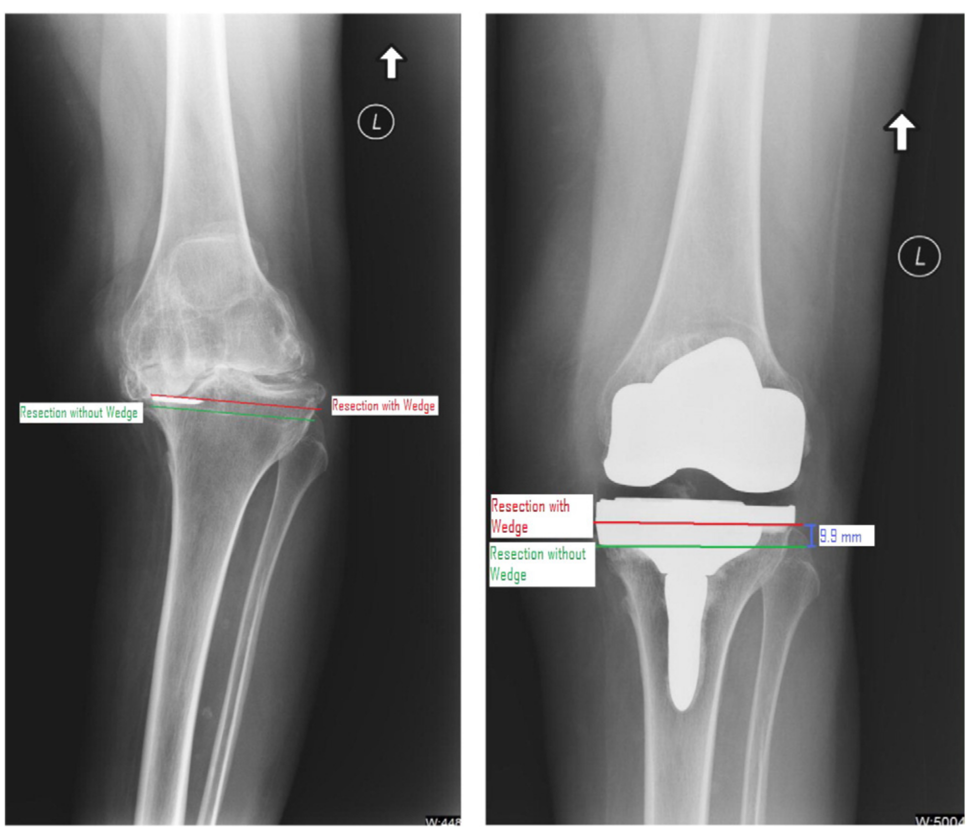

Fig. 4. Preoperative and postoperative anteroposterior radiographs showing excellent alignment.

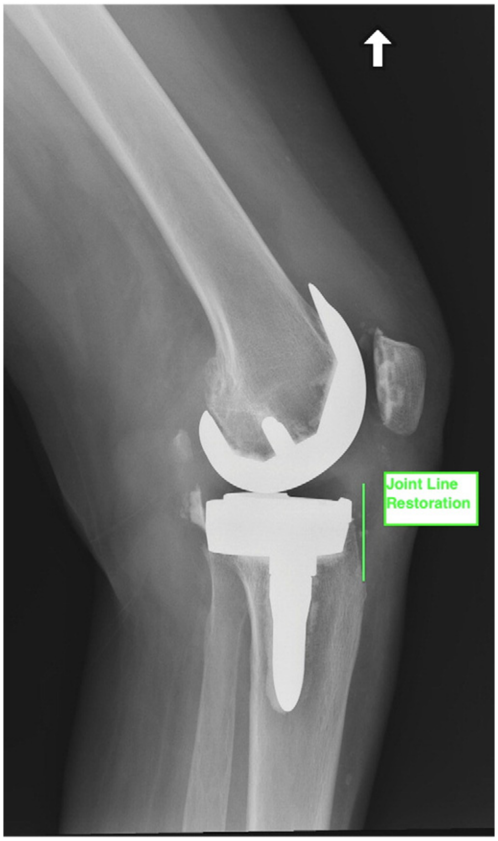

Fig. 5. Figgie method measuring joint line restoration on lateral radiograph.

proximal tibia [5]. Proximal tibial resection below 5 mm to the base of a bony defect may leave a weakened ledge for a tibial tray [7].

Four options are currently available for augmentation of tibial bony defects: bone cement, metallic wedges, allograft, and autograft. It is currently accepted that bone cement may be used for elderly, low-demand patients with contained defects less than 10 mm [8]. Laskin et al [8] reported a 33% failure rate at 5 years with autografts in primary TKA. Presently, there are insufficient data regarding long-term results of using allograft or autograft to fill bony tibial uncontained defects in TKA [9]. Brooks et al [10] showed that metallic augments affixed to the undersurface of a tibial tray can successfully augment tibial bone stock. However, Brand et al [5] showed that, at 3.5 years after surgery, there is a 25% incidence of radiolucent lines. It should be noted that, in their study, the presence of radiolucent lines was not associated with mechanical failure of the implant interface. We had 1 knee (7.6%) with a radiolucent line under the tibial augment with no associated mechanical failure of the implant interface at 2-year follow-up. A variety of metallic augments as well as attachment mechanisms such as bone cement or bolts is currently available. Although there are insufficient data to elucidate the optimal augment or augment attachment mechanism, in this study, we used metallic tibial augments attached to the undersurface of the tibial tray. A tibial stem extension was also used for 12 of the 13 CAS TKAs with tibial augment to in an effort to reduce the load at the bone implant interface at the site of augmentation.

The accuracy in mechanical axis restoration of CAS navigation instrumentation in TKA previously has been verified [1-4]. Traditionally, determination of tibial wedge sizing relies on manual measurement between the undersurface of a tibial tray and the base of the tibial defect. In this study, we show that computer-navigation instrumentation can be used to obtain the measured difference between the deformed and non-deformed tibial plateau. Moreover, this measurement was accurate in determining the size of the tibial wedge ultimately used.

Computer-assisted TKA instrumentation has been previously shown to result in restoration of the mechanical axis to within 3° of neutral in primary TKA [3]. In this study, we demonstrate that, in a subgroup of patients with significant proximal tibial bony deficiencies, CAS TKA can accurately predict the necessity and sizing of tibial augmentation. Our results show that we obtained excellent mechanical alignment with a mean of 0.08° valgus and excellent joint line restoration to within 4 mm. In addition, at a minimum of 2-year follow-up, these patients had excellent improvement in their Knee Society Scores and knee function scores with a mean improvement of 54.4 and 22.3, respectively.

The authors acknowledge that their study has some limitations. First, this is a single surgeon's experience. Although we have preoperative and postoperative Knee Society Scores and knee function scores for all patients who underwent CAS TKA with tibial augments, we do not have Knee Society Scores or knee function scores for patients who underwent CAS TKA without augments during the study period. Thus, we demonstrate improvement in postoperative patient clinical scores in patients with tibial augments without comparison with clinical scores in patients without augments. In addition, although 1 patient demonstrated a thin radiolucent line below the tibial augment at 2-year radiographic review (7.6%), the clinical implication of this radiolucency is unknown because our minimum clinical and radiographic follow-up was 2 years. A longer follow-up may help define the implications of this radiolucency. Brand et al [5] demonstrated a 25% incidence of radiolucency at 3.5-year follow-up with no mechanical failures.

To the authors' knowledge, this is the first study to examine the clinical and radiographic outcomes of computer-navigation TKA in patients with significant tibial deformities. This study shows that CAS TKA in patients with tibial deformities up to 23 mm can result in excellent restoration of mechanical axis and joint line with improvement in clinical function. To prevent excessive resection, attain bony conservation, and avoid repeat osteotomies and repeated wedge trialing, computer-navigation instrumentation may be useful.

Conclusion

Computer navigation is helpful in accurately measuring severe tibial deformities, predicting tibial augment thickness, and restoring the mechanical alignment and joint line without excessive bony resection, repeated osteotomies, and repeated augment trialing.

References

1. Bathis H, Perlick L, Tingart M, et al. Alignment in total knee arthroplasty. A comparison of computer-assisted surgery with the conventional technique. J Bone Joint Surg Br 2004;86:5.
2. Chauhan S, Scott R, Breidahl W, et al. Computer-assisted knee arthroplasty versus a conventional jig-based technique. A randomised, prospective trial. J Bone Joint Surg Br 2004;86:3.
3. Chin P, Yang K, Yeo S, et al. Randomized control trial comparing radiographic total knee arthroplasty implant placement using computer navigation versus conventional technique. J Arthroplasty 2005;20:5.
4. Decking R, Markmann Y, Fuchs J, et al. Leg axis after computer-navigated total knee arthroplasty: a prospective randomized trial comparing computer-navigated and manual implantation. J Arthroplasty 2005;20:3.
5. Brand M, Daley R, Ewald F. Tibial tray augmentation with modular metal wedges for tibial bone stock deficiency. Clin Orthop 1989;248:71.
6. Figgie H, Goldberg V, Heiple K, et al. The influence of tibial-patellofemoral location on function on the knee in patients with the posterior stabilized condylar knee prosthesis. JBJS Am 1986;68:7.
7. Harada Y, Wevers H, Cooke T. Distribution of bone strength in the proximal tibia. J Arthroplasty 1988;4:167.
8. Laskin RS. Total knee arthroplasty in the presence of large bony defects of the tibia and marked knee instability. Clin Orthop Rel Res 1989;248:66.
9. Cuckler J. Bone loss in total knee arthroplasty: graft augment and options. J Arthroplasty 2004;19:4.
10. Brooks P, Walker P, Scott R. Tibial component fixation in deficient tibial bone stock. Clin Orthop 1984;184:302.