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Original article

Posterior tibial slope accuracy with patient-specific cutting guides during total knee arthroplasty: A preliminary study of 50 cases

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ABSTRACT

Background: Patient-specific cutting guides were recently introduced to facilitate total knee arthroplasty (TKA). Their accuracy in achieving optimal implant alignment remains controversial. The objective of this study was to evaluate postoperative radiographic outcomes of 50 TKA procedures with special attention to posterior tibial slope (PTS), which is difficult to control intraoperatively. We hypothesized that patient-specific cutting guides failed to consistently produce the planned PTS.
Material and methods: The Signature™ patient-specific cutting guides (Biomet) developed from magnetic resonance imaging data were used in a prospective case-series of 50 TKAs. The target PTS was 2°. Standardised digitised radiographs were obtained postoperatively and evaluated by an independent reader. Reproducibility of the radiographic measurements was assessed on 20 cases. The posterior cortical line of the proximal tibia was chosen as the reference for PTS measurement. Inaccuracy was defined as an at least 2° difference in either direction compared to the target.
Results: The implant PTS was within 2° of the target in 72% of knees. In the remaining 28%, PTS was either excessive ($n = 10$; maximum, 9°) or reversed ($n = 4$; maximum, –6°). The postoperative hip-knee-ankle angle was $0° \pm 3°$ in 88% of knees, and the greatest deviation was 9° of varus.
Conclusion: These findings support our hypothesis that patient-specific instrumentation decreases PTS accuracy. They are consistent with recently published data. In contrast, patient-specific instrumentation provided accurate alignment in the coronal plane.
Level of evidence: IV, cohort study.

1. Introduction

Over 5 years ago, patient-specific instrumentation for total knee arthroplasty (TKA) was introduced as an alternative to conventional instrumentation and computer assisted surgery, to improve the reproducibility and ease of the procedure, while decreasing its invasiveness [1–7]. By obviating the need for intramedullary femoral referencing, patient-specific cutting guides should also minimise blood loss [8] and shorten the operative time [2–4]. The costs associated with creating patient-specific guides [9,10] are offset to a variable extent by the elimination of the conventional aiming devices and the decrease in operating-room turnover time. The 3D data set provided by the software allows planning in all three planes, thereby optimising implant size selection [11,12] and positioning [13]. In several studies [14–17], compared to conventional instrumentation, patient-specific guides were associated with a significant decrease in the difference between the hip-knee-ankle (HKA) angle and neutral alignment. Patient-specific guides and computer navigation produced similar mechanical alignment of the femoral and tibial components in one study [18]. However, recent meta-analyses failed to demonstrate a convincing advantage of patient-specific guides in terms of implant alignment in the coronal plane [19–22]. Furthermore, two studies [23,24] showed significantly lower accuracy of patient-specific instrumentation in achieving the PTS, with respectively 23% and 24% fewer patients within 2° or 3° of the target value, compared to the group

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managed using conventional instrumentation. Thus, a major concern is the limited ability to control tibial alignment in the sagittal plane during the TKA procedure.

The objective of this study was to evaluate the postoperative radiographic outcomes of 50 TKAs with special attention to PTS, which is difficult to control intraoperatively. We hypothesised that patient-specific tibial cutting guides lacked accuracy in the sagittal plane, while ensuring good control of alignment in the coronal plane.

2. Material and methods

2.1. Patients and procedure

This prospective single-centre study included consecutive patients who underwent TKA performed by a senior orthopaedic surgeon between September 2012 and February 2013 because of tricompartmental knee osteoarthritis grade 2 or 3 in the Ahlbäck classification system [25]. Of the 63 eligible patients, the first 10 were excluded to allow for the learning curve. In addition, 2 patients were excluded because of metal artefacts on magnetic resonance imaging (MRI) and 1 because of a history of valgus tibial osteotomy with major epiphyseal deformity.

The remaining 50 patients (27 males and 23 females) had a mean age of 69.5 years (range, 52–85) and a mean body mass index (BMI) of 26.2 kg/m^2 (range, 21–44). The cementless, mobile bearing, polyethylene Vanguard-ROCC (Biomet Inc., Warsaw, IN, USA) prosthesis with a built-in PTS of 7° was implanted via the medial para-patellar approach in all 50 patients.

The knee-anatomy data set was created according to the MRI Signature™ protocol (Materialise, Leuven, Belgium). MRI was performed 6 weeks before the surgical procedure, using a 1.5-Tesla machine (Intera, Philips Healthcare, Eindhoven, The Netherlands). Three acquisitions were recorded: low-resolution T1-weighted axial images through the ankle and hip and high-resolution 1-mm sagittal images through the knee. After image segmentation and conversion to the DICOM format, the anatomic reference points were identified to allow construction of the skeletal landmarks (Table 1).

The height of the cut was determined by taking into account the thickness of the residual cartilage to identify the most proximal point on the healthy tibial plateau and the most distal point on the least damaged femoral condyle, along the mechanical axis of the limb. The surgeon determined the 3D angle values for implant position using the Signature Online Management System® (Materialise) with a pre-specified PTS of 2°. The patient-specific cutting guides rested on the epiphysis, at three sites: a cartilaginous site at the anterior portion of each tibial plateau and a bony antero-medial metaphyseal site located well above the anterior tibial tubercle. Two aiming devices supported by a metallic connector to the guide were used to position two guide pins. These pins served to orient the final cutting guide, whose resection height was adjustable (Fig. 1a and b).

PTS was evaluated using a simple extramedullary alignment guide, using the anterior tibial cortex as a visual landmark.

2.2. Postoperative evaluation

Digitised radiographs were obtained 3 months after the TKA procedure, using fluoroscopy to superimpose the femoral condyles. The posterior cortical line was drawn as the line tangent to the posterior edge of the posterior tibial cortex, 4 cm under the plane of the plateau, through two points located 5 cm apart, on a short film measuring 14 by 17 inches. The PTS of the implant was measured as the angle subtended by the line perpendicular to the posterior cortical line and the line through the plane of the tibial tray.

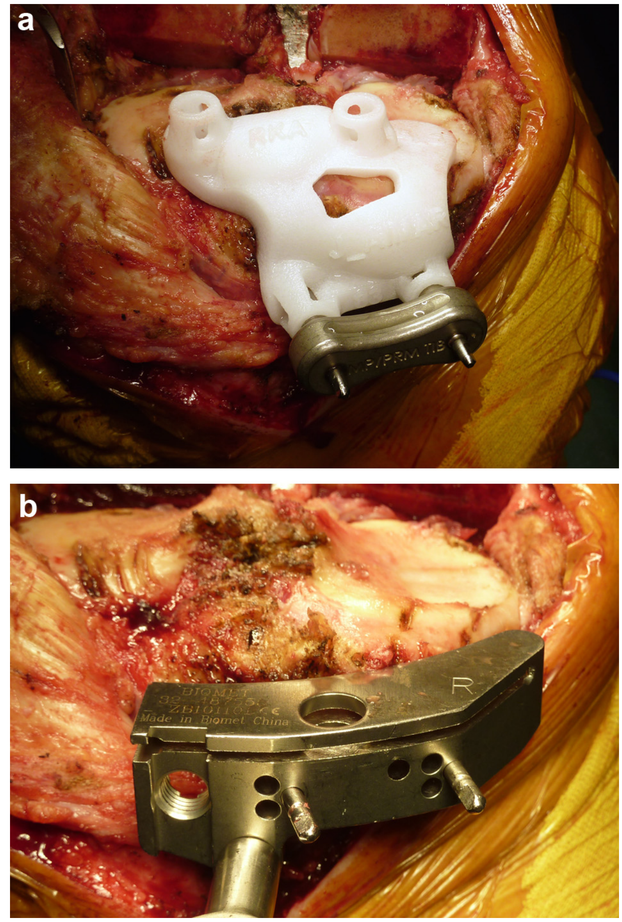

Fig. 1. a and b: Signature™ system used for the tibial epiphysis after implantation of the two positioning pins. Guide for the final tibial cut, with adjustable resection height.

Radiographic angle measurements were performed by an independent observer, who used Global Imaging software (Global Imaging On Line, Montreuil, France). The mechanical tibio-femoral implant angle in the coronal plane (HKA angle) was obtained using standardised telemetry in the standing position.

2.3. Statistical analysis

Descriptive statistics were computed using StatView software version 5.0 (SAS Institute, Cary, NC, USA) on a PC. The observer measured the HKA angle and PTS twice for the same 20 knees. Comparison of the two sets of values using Wilcoxon's test indicated excellent intra-observer reproducibility. The Shapiro–Wilk test established that the HKA angle and PTS values were normally distributed. The target ranges were 180° ± 3° for the HKA angle and 2° ± 2° for PTS.

3. Results

The implant PTS values produced an asymmetric box-and-whisker plot with a median at 1° and values representing posterior tibial slopes in more than 2/3 of the cases (Fig. 2). The target range of 2° ± 2° was achieved in 35 (70%) knees and the mean overall PTS was 2.06° ± 2.79°. In 15 (30%) knees, PTS was either excessive (n = 10; maximum value 9°) or reversed (n = 4; greatest anterior