Patient-specific instrumentation for total knee replacement verified by computer navigation: a case report

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ABSTRACT
Patient-specific instrumentation (PSI) enables better restoration of the mechanical axis in total knee replacement (TKR) than conventional instrumentation (alignment guides) does. We verified the accuracy of the PSI by computer navigation. The PSI jigs were accurate only if they were pinned accurately onto the distal femur and proximal tibia. Any slight malposition of the jigs leads to malalignment of the bone cuts. In the absence of computer navigation, the accuracy of the jig alignments cannot be checked and may result in malalignment.

Key words: arthroplasty, replacement, knee; instrumentation; surgery, computer-assisted

INTRODUCTION
Malalignment of >3° valgus or varus to the mechanical axis in total knee replacement (TKR) is associated with early implant failure.1–5 Conventional TKR relies on intramedullary or extramedullary alignment guides, which are less consistent than computer navigation.6–10 Patient-specific instrumentation (PSI) is designed to replace conventional instrumentation without the need for computer navigation. We verified the use of PSI for TKR using computer navigation.

CASE REPORT
In November 2010, a 61-year-old man with right knee tricompartmental osteoarthritis underwent PSI TKR using the Nexgen LPS knee prosthesis. Magnetic resonance images of the lower limb were digitally templated for bone cuts, alignment, and implant size (Fig. 1), and alignment jigs conforming to the knee anatomy were made. These jigs were pinned to the knee and served as alignment guides for the cutting blocks.

The knee was approached through a midline incision and a medial parapatellar arthrotomy was performed using computer navigation. The femoral PSI jig was mounted on the femur and pinned (Fig. 2).
With the pins in situ, the PSI jig was removed and the Nexgen distal femur cutting block was placed over the anterior cortex pins. The alignment of the cutting block was checked using the navigation tracker. There were deviations from the mechanical axis by 2.5° valgus, 5° hyperextension sagittally, and 9 mm distal femoral cut thickness. These were significant deviations from the planned values of 0°, 2°, and 10 mm, respectively. The femur PSI jig was repositioned to conform to the distal femur anatomy. After pinning the jig and replacing it with the Nexgen cutting block, the alignment was rechecked with the navigation tracker. The position was more accurate at 0.5° varus (to the mechanical axis) and 2° flexion (in the sagittal

Figure 1  Patient-specific instrumentation digital templates imported from 3-dimensional magnetic resonance images.

Figure 2  The patient-specific instrumentation alignment jigs are pinned to (a) the distal femur and (b) the tibial plateau.
plane), but the depth of the intended cut was 9.0 mm (i.e. still 1 mm less than the planned value of 10 mm). This position was nevertheless acceptable, and the distal femur was then cut with an oscillating saw and checked with computer navigation. A second cut was needed to achieve the intended cut (0.5°, 2°, and 9.0 mm). A Nexgen Flex (size E) 4-in-one cutting block was mounted through the distal 2 pins. The rotational alignment was 3.5° externally rotated to the trans-epicondylar axis, which differed to the templated value of 0°. Nonetheless, we accepted this difference, and the 4-in-one cutting block was secured and the bone cut.

For the proximal tibial cut, the tibial PSI jig was fitted precisely onto the tibial plateau and conformed exactly to its anatomy. Two pins were inserted through the tibial plateau and 2 other pins were inserted through the anterior cortex of the tibia (Fig. 2). The conventional tibial cutting block was then placed through the anterior cortex pins. Its position and alignment were checked by the navigation tracker. The tibial PSI jig was accurate, as the navigation recorded 0° valgus/varus, 11 mm cut thickness, and a 3.5° posterior slope (0.5° less than the intended 4.0°). The tibia was then cut and checked by the navigation tracker. The values were as intended. The tibial plateau pins were to align the tibial base plate to the rotation that was templated. A hole in the tibial cut surface was created using keel and punch through the base plate to fit the final implant. The notch was cut to accept the implant.

A 10-mm trial insert was used and the knee was balanced in flexion and extension. Medial-lateral soft tissues were balanced, obviating the need for further medial release. Overall alignment was checked by the computer navigation; the overall axis was mechanically aligned with just 1.0° varus deviation and a fixed flexion deformity of 2.5° (Fig. 3). The patella was not resurfaced. The actual implants were then inserted and cemented.

**DISCUSSION**

PSI is designed to replace the alignment guides of conventional instrumentation and the trackers of computer navigation in TKR. Computed tomography has been used to develop patient-specific jigs that served as cutting blocks. The jigs were tested on 16 cadaveric knees and validated on 6 of the knees. Postoperative images confirmed that the patient-specific templates for fashioning the jigs were accurate, with a mean error of alignment of 1.7° and a mean error of resection of 0.8 mm (maximum 2.3° and 1.2 mm, respectively).

In our patient, the alignment was off target when the PSI jigs were not precisely mounted on the knee. Without the aid of the navigation, this inaccuracy would not have been detected and the bone cuts would have been inaccurate. If the distal femur were cut with 5° hyperextension sagitally, the risk of notching the anterior cortex of the distal femur
would have been high. In the absence of computer navigation, alignment and resection errors could lead to early implant loosening and notching fractures.

REFERENCES