Total Knee Arthroplasty with a Novel Navigation System Within the Surgical Field

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KEYWORDS

• Total knee arthroplasty • Computer navigation • Total knee alignment • Smart instrumentation

KEY POINTS

- A new novel navigation system used within the surgical field has demonstrated reproducible accuracy in component alignment.
- All orientation information is captured by small electronic pods and transmitted via a local wireless (Wi-Fi) network, which directs the surgical workflow automatically to the femoral and tibial resection instruments.
- The system demonstrates accuracy comparable to optical navigation.
- iAssist provides a novel navigation system for all users. For surgeons who prefer conventional instrumentation, the electronic pods provide intelligence and accuracy to the resection guide, whereas for surgeons who prefer computer navigation, this system provides the same accuracy with simplicity.

INTRODUCTION

Over the past years, the effect of alignment on implant survival has been well documented,[1–4] with its influence on implant survival, component loosening, and clinical outcome scores. Numerous publications have documented the accuracy of computer-assisted navigation with knee arthroplasty,[5–8] with some early postoperative benefits in recuperation, clinical function,[9,10] and blood loss.[11]

Total knee arthroplasty navigation systems have been around since 1995 and have taken various forms: image-based navigation, imageless navigation, fluoroscopy-based navigation, electromagnetic navigation, and optical navigation. Adoption of these systems in the overall number of procedures is still limited to approximately 5%, mostly because of the perceived complexity and the additional time required in the use of these systems.

Patient-specific instruments (PSI) appeared around 2006 and have reached a greater use rate than computer navigation.[12–15] The surgical workflow with PSI is simpler than navigation, but requires preoperative imaging—either magnetic resonance imaging (MRI) or computed tomography (CT)—presurgical planning, and manufacturing of the resection guides. These personalized instruments are attractive, but have intraoperative obstacles that are not infrequently encountered, and therefore deviations from the preoperative plan may be necessary. In addition, once the bone isresected, there is no ability to validate the bone cuts.

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More recently, navigation systems have been developed using inertial electronic components,[16–18] which simplifies the tracking process, especially when compared with optical navigation systems. One of these new navigation systems is iAssist (Zimmer, Inc., Warsaw, IN, USA), which is an alignment system designed with the user interface built into disposable electronic pods that attach onto the femoral and tibial resection instruments. Within these pods are inertial electronic components or gyroscopes that exchange information using a secure local wireless (Wi-Fi) channel. After capture of the necessary data during the procedure, the alignment information is displayed to the surgeon directly on the pods within the surgical field. These pods are attached to either the femoral or tibial resection guides, which then guide the resection at the appropriate angles in both the coronal and sagittal planes. After bone resection, the accuracy of the alignment can be validated, confirming the position of both the femoral and tibial components.

The surgical workflow follows the classic method of femoral and tibia bone resection with each bone resected independently along the mechanical axis. The following section describes the surgical technique for the iAssist system.

Tibial Coordinate System Registration

As with other navigation systems, the coordinate system for each bone must be defined. For the iAssist system, an extramedullary tibial guide with an electronic digitizing pod secured to the tibia will identify the mechanical axis and guide the bone resection. The proximal position of the guide is positioned between the tibial spines in the center of the tibial joint surface. Two spikes secure the guide in this region. The distal portion of the alignment guide is mounted with a self-centering claw, which is positioned on the malleoli and fixes the instrument at the center of the ankle joint. The digitizer is then oriented in line with the medial third of the tibial tuberosity and fixed rigidly in place. Once secure, the alignment guide is positioned along the mechanical axis, as seen in Fig. 1A. The angular relationship between the electronic pod of the digitizer and the bone reference is registered by the system through 3 movements of the limb: abduction, adduction, and neutral position. This function activates the inertial mechanism and creates the coordinate system required for navigation. Once the information has been registered, the digitizer is removed and the data are transferred wirelessly to the electronic pod on the tibial cutting guide, which has 2 knobs to adjust the varus/valgus alignment and the tibial slope. The electronic pod, viewed entirely within the operative field, accurately reports the data with incremental visual cues, including red lights when out of alignment and green lights when the cutting guide is within the desired alignment and slope (see Fig. 1B). Once the position of the resection guide is satisfactory, the depth of resection is

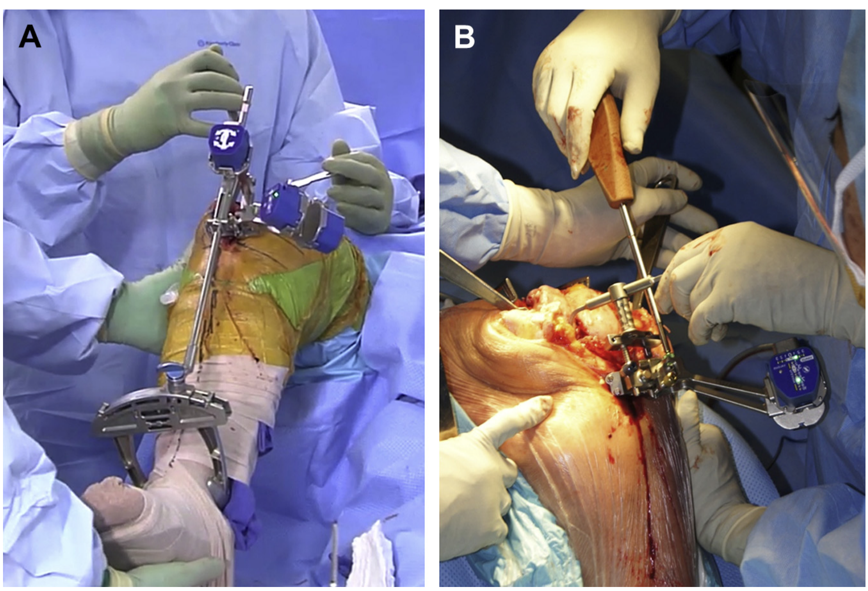

Fig. 1. (*A*) The tibia digitizer has been impacted to the proximal articular surface and fixed to the malleoli with its self-centering claw. On the medial side, a bone reference pod has been fixed just below the articular line. (*B*) Intraoperative view of the surgeon adjusting a tibial cut guide. A green light is clearly visible on the iAssist device, indicating proper varus/valgus orientation and slope.