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Mechanical accuracy of navigated minimally invasive total knee arthroplasty (MIS TKA)

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ABSTRACT

This study was designed to provide evidence that computer-navigated minimally invasive total knee arthroplasty (MIS CN-TKA) enables identical mechanical accuracy as conventional computer navigated total knee arthroplasty (CN-TKA) while reducing rehabilitation time and hospital stay of the patients. Two groups of 20 patients requiring total knee arthroplasty due to degenerative or posttraumatic knee osteoarthritis were included. Twenty consecutive patients received conventional CN-TKA and 20 consecutive patients received minimally invasive CN-TKA. Mechanical and rotational alignments were measured preoperatively and 6 months postoperatively on long-standing radiographs, on conventional coronal and sagittal views and on CT-scans of the knee. Length of skin incision, operating time, blood loss, length of hospital stay, postoperative ROM and HSS as well as KSS scores were determined. Postoperative mechanical axis improved significantly in both groups. Coronal and sagittal component positioning were accurate in both groups without significant differences. Rotational alignment showed the desired reproducible values without significant differences between the two groups. The posterior slope of the tibial component was significantly reconstructed to match the preoperative condition in both groups. The coronal alignment of the femoral and tibial components showed accurate reproducible results for implantation of both components in both groups. Length of skin incision was significantly shorter in the MIS CN-TKA. Duration of hospital stay was significantly reduced in the MIS CN-TKA group. Operating time and blood loss were similar in both groups. Postoperative ROM after the first 3 months was significantly higher in MIS CN-TKA, but after 6 months differences were minimal. Clinical outcome scores were identical for both groups 6 months after surgery. The advantages of CN-TKA are well known. Performing computer navigated TKA in combination with a minimally invasive approach in this study lead to a reduction of hospital stay and an initially increased ROM without differences in operating time and blood loss. Computer navigation in TKA preserves accurate coronal, sagittal and rotational components alignment even with a minimally invasive approach.

1. Introduction

Total knee arthroplasty TKA has emerged as one of the most successful treatments in orthopedic surgery. Numerous long-term follow-up studies have reported on high clinical success rates of 72–100% at 10–20 years with reference to pain reduction, functional improvement and overall patient satisfaction [1–5]. Although TKA is generally successful and despite the advances in the surgical techniques, instrumentation and implant designs, between 5 and 8% of all cases still show complications like chronic anterior knee pain, loosening, instability, malpositioning, infection or fractures [6–8]. Correct alignment of implanted components is considered one important factor, which should be controlled by the surgeon through surgery. Malposition of total knee arthroplasty TKA affects implant fixation and leads to an increased risk of loosening, instability and decreased survival rates of the prosthesis. It has further been suggested that the most common cause of revision TKA is error in surgical technique, as small changes in component positioning can lead to significant changes in postoperative performance [9]. The relationship between preciseness of the implant position and longevity has been clearly shown [10–23]. The accuracy to adjust the rotational alignment of the femoral component is a further prerequisite to avoid malfunctioning in TKAs. It is well known that even small deviations of rotational alignment of the components have a considerable influence on patellar tracking, stability and on the overall biomechanics of the joint. Computer-assisted navigation systems have been designed to increase precision of the implantation of TKAs. Several studies have demonstrated that computer-assisted navigated TKA achieves straight mechanical axes measured on full-length standing radiographs of the lower extremity and reduces the number of outliers in the alignment of the limb compared to traditional

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Table 1
Patient inclusion and exclusion criteria

Inclusions
Patients requiring a primary TKA
Male or non-pregnant female patients
Older than 18 years at the time of surgery
Patients with diagnosis of osteoarthritis
No previous osteosynthesis of the involved knee during the last 12 months
Patients who were capable of and have given, informed consent for participation in the study
Exclusions
Patients requiring revision surgery of a previous implanted TKA
Patients with a diagnosis of rheumatoid arthritis
Patients with active infection
Patients with malignancy
Patients with an immobile hip or ankle arthrodesis
Patients with neurological deficit
Previous history of unicompartmental knee arthroplasty or patellar prosthesis
Patients with concurrent illness, which are likely to affect their outcome

mechanical instrumented TKA [9,10,24–31]. Although knee navigation systems are not yet universally accepted, several investigators have demonstrated on the basis of conventional radiography and computer-tomography that TKA, implanted with computer-assisted navigation and conventional approach, has more accurate component alignment than those instrumented conventionally [9,10,20,24–33].

Minimally invasive surgical (MIS) approaches have been successfully used in numerous types of surgical procedures, both arthroscopic and open. The introduction of MIS approaches for knee replacement has partially been driven by the application of small incisions and minimal soft-tissue approaches in the performance of unicompartmental knee arthroplasty [31,34]. Despite some motivating factors, including a possible reduction in duration of hospitalization and costs, one should not discount that the patients driven desires includes concerns about postoperative pain, prolonged rehabilitation, and less than-ideal functional outcomes associated with conventional surgical approaches. Furthermore, procedures obtaining these results by using standard approaches might require an arduous recovery period for the patients. However, concern is driven about loss of accuracy for implant placement as well as increased complications considering skin slough and infection, if a minimally invasive approach is used [35,36]. Recently, it was even advised not to use MIS technique for TKA if the surgeon is not performing a high volume of arthroplasties because of an unacceptable high learning curve [37,38]. Although several recently published studies have demonstrated improved early clinical outcomes using minimally invasive approaches, there are still surgeons who are cautious and skeptic to embrace MIS approaches, preferring to use a standard technique that has consistently provided good clinical outcomes [39–43]. Furthermore, two papers lately reported for the first time that good alignment of TKA correlates with better clinical function, improved quality of life, quicker rehabilitation and earlier hospital discharge [44,45].

This study was performed to show the reproducibility of intra- and postoperative mechanical accuracy of TKA by the use of an imageless computer-assisted navigation system. The primary research objective was to examine the accuracy of the mechanical axis in postoperative radiographic alignment of the implanted prosthesis performed by using computer-assisted navigation with conventional versus minimally invasive approaches. The second research objective was to study the accuracy and influence of a minimally invasive approach on the components position in the coronal, sagittal and axial planes. The hypothesis of this study was that with computer-assisted navigation the advantages of a minimally invasive approach might be used for TKA without an increased risk of mechanical axis malalignment and/or components malpositioning.

2. Methods

2.1. Demographics

Forty patients with degenerative or posttraumatic knee osteoarthritis were evaluated in this study. Inclusion and exclusion criteria are described in Table 1. Twenty consecutive TKAs, performed with a computer-navigated conventional TKA (CN-TKA), were followed and compared to 20 consecutive TKAs performed with a computer-navigated minimally invasive approach (MIS CN-TKA), whose demographic data are reported in Table 2. No significant differences were seen between the two groups for age, gender, preoperative mechanical axis, etiology, flexion, Hospital for Special Surgery knee score, KSS knee and KSS function scores (Table 2) [46,47].

In the CN-TKA group a standard medial parapatellar approach was used, whereas in the MIS CN-TKA group a mid-vastus approach was performed. All surgeries were performed by only a single surgeon (NB), who is a high volume arthroplasty surgeon and uses computer-navigation routinely for many years. At least 50 cases of minimally-invasive CN-TKA have been performed prior to the current study.

2.2. Surgical techniques

The Stryker Knee Navigation System (Stryker Leibinger, Software V 3.0) used in this study is an active wireless PC-based guidance system

Table 2
Demographic data and preoperative patient data

Variable	Conventional CN-TKA[1]	MIS CN-TKA[2]	*p* value
Age (years)	67 (range: 37–87)	68 (range: 48–76)	NS
Gender (female/male)	11/9	12/8	NS
Etiology: primary OA/post-traumatic OA	16/4	16/4	NS
Flexion	120° (range, 110°–130°)	118° (range, 110°–127°)	NS
Mechanical axis	4.5° valgus (range, 18° varus/16° valgus; SD 6.98)	4.7° valgus (range, 16° varus/13° valgus; SD 5.64)	NS
HSS score	34.9 (range, 11–57; SD 15.51)	33.9 (range, 12–60; SD 15.30)	NS
IKSS knee score	52.6 (range, 27–71; SD 14.19)	52.4 (range, 27–69; SD 14.00)	NS
IKSS function score	52.6 (range, 20–80; SD 14.71)	51.1 (range, 20–70; SD 14.73)	NS

[1]Conventional computer-navigated TKA (CN-TKA), [2]Minimally invasive surgery computer-navigated TKA (MIS CN-TKA), OA = Osteoarthritis, HSS = Hospital for Special Surgery, IKSS = International Knee Society Score, SD = Standard deviation; NS = not significant.