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Computer Navigation Results in Less Severe Flexion Contracture Following Total Knee Arthroplasty

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ABSTRACT

We compared postoperative flexion contracture in navigated total knee arthroplasty (TKA) versus conventional TKA. Two groups (Group 1: conventional, Group 2: navigated) of 235 consecutive patients matched for age and gender were retrospectively compared. Range of motion, mechanical axes, Knee Society Scores, Oxford Knee Scores and Short Form-36® (SF-36) scores were collected prospectively and compared preoperatively and at 2 years following TKA. At 2 years, patients who underwent navigated TKA averaged significantly lesser flexion contracture of 1 degree compared to 6 degrees in patients who underwent conventional TKA. There were a significantly larger proportion of outliers in the conventional group. Computer navigation results in less severe flexion contracture and less frequent flexion contracture of more than 5 degrees as compared to conventional techniques.

The aim of total knee arthroplasty (TKA) is to alleviate symptoms of osteoarthritis and to produce an excellent functional outcome in all patients, in particular a range of motion that does not limit the activities of daily living [1]. Flexion contracture is a common sequelae to knee osteoarthritis, especially in association to genu varum [2]. Various techniques have been described to correct this deformity intra-operatively, including soft-tissue release and additional bony resection [3,4]. Correction of flexion contracture at the time of surgery is important as post-operative flexion contracture increases the biomechanical demand on the quadriceps during ambulation and may increase the contact forces across the patellofemoral joint, posterior condyles and posterior tibial plateau [1,5,6]. Computer navigation has been implemented in TKA to augment the accuracy of the surgical procedure. Numerous studies have shown computer navigation to increase the accuracy of bony cuts in the coronal and sagittal planes [7,8]. Several studies have shown improved short-term outcomes and measurements in computer-navigated TKA as compared to conventional TKA [9–12]. To correct flexion contracture during TKA, most surgeons rely on clinical judgement at the time of surgery. At the end of the procedure, the final range of motion is often visually assessed and there is a chance that residual flexion contracture may be missed. Computer navigation offers the surgeon an additional tool in the assessment of the final flexion range of the prosthetic knee, particularly in obese patients. Computer generated images and calculated final flexion range can be used to ascertain the post-operative flexion contracture in patients undergoing navigated TKA. To date, we know of no studies that have reported on the impact of computer navigation on flexion contracture following total knee arthroplasty.

We asked if patients undergoing navigated TKA had less severe flexion contracture at 2 years following surgery as compared to patients undergoing conventional TKA thereby implying that computer navigation is more accurate than visual and clinical assessment of residual flexion contracture after prosthetic fitting.

Materials and Methods

The study design is that of a retrospective analysis of prospectively collected data from 2006 to 2010 involving 470 patients, stratified into 2 groups based on use of computer navigation and matched for age and gender. The institutional review board of our institution approved the study. The senior author of this paper performed all of the operations. This surgeon had performed more than 200 computer-navigated total knee arthroplasties by the time of this study in an institution, which is one of the centres of excellence for joint arthroplasty in the region.

The inclusion criteria consisted of a diagnosis of osteoarthritis, any degree of genu varum deformity, any degree of flexion contracture and less than 15 degrees of genu valgum deformity. The exclusion criteria consisted of previous knee surgery that required the removal of metallic implants, revision TKA, active joint infection, postoperative peri-prosthetic fractures or bilateral TKA. The choice of navigated TKA and conventional TKA was determined by the availability of the

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navigation system on the day of surgery as well as patient preference. All patients in this study had a minimum follow-up period of two years and underwent similar post-operative rehabilitation.

Group 1 consisted of 235 patients who underwent conventional TKA while Group 2 consisted of 235 patients who underwent navigated TKA. The two groups were similar in terms of patient demographics and preoperative outcomes scores and measurements (Table 1).

In patients undergoing conventional TKA, a midline skin incision was made and the joint was exposed through a medial parapatellar approach. The patella was then everted. A medial or lateral soft tissue release was then performed depending on the demands of the knee deformity. The menisci and the anterior cruciate ligament were excised. The posterior cruciate ligament was recessed but kept intact. The knee was flexed and the tibia was manoeuvred anteriorly for the bone cuts. Tibial bone cuts were performed with use of an extramedullary guidance jig. Thereafter, femoral bone cuts were performed with use of an intramedullary guidance jig. Flexion and extension gaps were checked and balanced with further soft tissue release. Trial implant components were inserted. Osteotomy was performed on the patella with the final thickness not less than 12 mm. The range of motion, stability, rotational balance, posterior cruciate ligament tension and patellar tracking were manually checked with the trial components in place. The definitive metal-backed fixed bearing implants (PFC CR; Depuy Orthopaedic International, Leeds, UK) were then cemented (Smartset; Depuy Orthopaedic International, Leeds, UK). All excess cement was removed and the surgical field irrigated copiously before wound closure in layers with sutures.

In patients undergoing navigated TKA, a mini medial parapatellar approach was combined with a computer navigation system, Ci Mi Total Knee Replacement Version 1.0 by BrainLab/Depuy Orthopaedic Inc. (Johnson and Johnson, Leeds, UK). The computer navigation system (Ci-CAS; Depuy International) was set up opposite to the involved limb. A midline skin incision of less than 10 cm was made. An abbreviated quadriceps tendon-splitting approach as described by Scuderi et al. was used to enter the joint [13]. The incision did not extend more than 2 cm into the tendon proximal to the patella. The patella was subluxated laterally with the medial facet being osteotomized to provide improved vision of the surgical field. Dual 3-mm unicortical pins were drilled into the tibia and femur through individual stab incisions, and the respective passive infrared reflectors were attached to the pins. Registration for bone morphing was performed with the use of a pointer with attached passive reflectors. During rotation of the femur, kinematic analysis was used to obtain the position of the centre of the femoral head. The orientation and position of a slotted cutting block were guided by the computer with the use of a plane verifier. The block was subsequently pinned in place. Bone cuts were then made under computer guidance, with the tibial cuts preceding the femoral cuts. The medullary canals were not violated. The resulting bone cuts were verified with the computer. Pie-crusting technique was adopted to achieve medial or lateral release. Gap balancing was performed with spacer blocks. Limb alignment, joint stability and patellar tracking throughout the full range of movement were checked and recorded. The definitive metal-backed fixed bearing implants (PFC CR; Depuy Orthopaedic International, Leeds, UK) were then cemented (Smartset; Depuy Orthopaedic International, Leeds, UK) with the tibial components preceding the femoral components. All excess cement was removed. Data and images provided by the computer included the accuracy of the bone cuts with respect to the mechanical axis as well as the final limb alignment. Data on the final range of motion including presence of flexion contracture was computed and displayed. The coronal, sagittal and rotational positions of the implant were recorded. The surgical field was irrigated copiously before wound closure in layers with sutures.

The postoperative analgesia was standardized across both groups. All patients had intraoperative analgesia before wound closure via a periarticular infiltration with a concoction of bupivacaine, adrenaline, morphine and triamcinolone. No drains were inserted. Postoperatively, per-oral selective COX-2 inhibitors were prescribed on a regular basis, with intramuscular opioids being used for breakthrough pain. Peripheral blood samples were taken 24 hours postoperatively to ascertain the haemoglobin level. Mechanical prophylaxis against venous thromboembolism was instituted via thromboembolic deterrent (TED) stockings and intermittent pneumatic calf compressors. All patients ambulated at least with an aid by the second postoperative day. Patients were discharged home once they were able to actively flex the knee to 90 degrees, to perform an unassisted straight-leg raise, to ambulate independently, and to climb stairs. All patients underwent outpatient physiotherapy until their progress was satisfactory.

Two experienced independent physiotherapists performed the preoperative and postoperative assessment of all patients. Standardized plastic goniometer with 18-cm plastic movable limbs was used with 1° increments for measurements of range of motion. The patient was supine with the contralateral knee fully extended. The operated knee was then passively flexed by the physiotherapist into full flexion, and the measurement was obtained while the patient held the knee in that position. Any flexion contracture was also measured similarly with the standardized plastic goniometer. The physiotherapists were blind to the measurements of their colleagues. The mean value correct to the nearest 1° was used as the final range of motion. The patients were further evaluated with the Knee Society Score [14], SF-36 questionnaire [15] and the Oxford Knee score [16] at 3-month, 6-month and 2-year intervals. For the purposes of this study, only the 2-year results are presented. The various domains of the SF-36 questionnaire have been summarized into the mean physical component score (PCS) and mental component score (MCS) and compared for ease of presentation. Standardized four-foot anteroposterior weight bearing radiographs were done at 6 weeks postoperatively to measure the mechanical axes of the knees [17]. The overall limb alignment was taken as connecting line through the centre of the hip, the centre of the knee and the centre of the ankle.

All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) Version 20 (IBM® SPSS Statistics, Armonk, NY, USA). The Student t test was used to compare means and Z-score was used to compare proportions. The outcome scores, measurements and proportions of flexion contracture of both groups of patients were compared at 2 years of follow-up. The level of significance was set at $p < .05$.

Table 1
Demographic Data for Patients in the Study.

	Conventional Group (n = 234)	Navigated Group (n = 234)	*P*-Value
Mean Age (range) (*years*)	67 (59–74)	67 (59–74)	1.00
Gender*			
Male	56 (24)	56 (24)	1.00
Female	178 (76)	178 (76)	1.00
Mean body mass index (and range) (kg/m^2)	27.6 (18.6–46.2)	27.8 (18.2–38.9)	.628
Mean pre-operative fixed flexion deformity ± SD (*degrees*)	8 ± 10	7 ± 9	.256
Mean preoperative flexion range of motion ± SD (*degrees*)	115 ± 16	118 ± 18	.057
Mechanical axis ± SD (*degrees*)	9 ± 12 varus	9 ± 10 varus	1.00
Mean preoperative Knee Score ± SD	36 ± 17	39 ± 18	.064
Mean preoperative Function Score ± SD	52 ± 16	55 ± 18	.057
Mean preoperative score for Oxford Knee Questionnaire ± SD	35 ± 7	34 ± 8	.151
Mean preoperative score for SF-36 questionnaire			
Physical Component Score ± SD	42 ± 18	44 ± 15	.192
Mental Component Score ± SD	70 ± 24	72 ± 22	.350

* The data is given as the number of patients with the percentage in parenthesis.