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Satisfactory Short-Term Results of Navigation-Assisted Gap-Balancing Total Knee Arthroplasty Using Ultracongruent Insert

Jung-Ro Yoon, MD, PhD [a], Jae-Hyuk Yang, MD, PhD [b], *

[a] Department of Orthopedic Surgery, Veterans Health Service Medical Center, Seoul, Republic of Korea
[b] Department of Orthopedic Surgery, Hanyang University Guri Hospital, Guri, Korea

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A B S T R A C T

Background: The use of highly conforming ultracongruent (UC) polyethylene insert is bone-preserving and became a relatively common alternative to the conventional posterior stabilized total knee arthroplasty (TKA) design. The purpose of this study was to analyze the short-term clinical and radiologic results of UC insert TKA using the navigation-assisted gap-balancing technique.
Methods: Two hundred thirty-three knees were operated with a mean follow-up period of 8.1 years (minimum of 5 years). Radiologic and clinical outcomes were assessed before operation and at latest follow-up using the Knee Society Score and Western Ontario and McMaster Universities Osteoarthritis Index score. For statistical analysis, paired sample *t*-test and analysis of variance were used. Significance was considered as $P < .05$.
Results: According to the preoperative deformities (valgus, mild varus, and moderate varus), there were 23 cases (9.9%) of valgus deformity, 180 cases (77.3%) of mild varus deformity, and 30 cases (12.9%) of moderate varus deformity. Overall, the results at mean 8.1 years revealed an improvement in mean Knee Society Score (54 ± 12 to 92 ± 3) and mean Western Ontario and McMaster Universities Osteoarthritis Index scores (62 ± 14 to 17 ± 3). Overall, 220 of 233 cases (94.4%) were in neutral alignment (between $-3°$ and $+3°$) at latest follow-up. There were no migrating or shifting prosthesis that should be considered as possible failure. There was 0% component revision rate.
Conclusion: Navigation-assisted gap-balancing technique using UC insert TKA had satisfactory short-term outcome. Strict gap-balancing technique using the offset-type-force-controlled-spreader-system aided in the satisfactory results.

Total knee arthroplasty (TKA) is a well-documented surgical procedure as being beneficial to patients with osteoarthritis of the knee [1]. Computer-assisted TKA allows the surgeon to accurately control parameters related to the implant position [2,3]. Although still in debate, it has been demonstrated that computer-assisted TKA resulted in fewer outliers in frontal leg alignment and tibial component positioning in comparison with conventionally performed TKA [4,5].

Gap-balancing affects the final knee kinematics [6], and inadequate correction of soft-tissue imbalance is considered an important factor for early TKA failure [7]. For optimum results, surgeons strive for equal and symmetrical flexion and extension gaps [8]. Out of various techniques and instruments for gap balance measurement suggested, for example, tension jigs, spacer blocks, laminar spreaders, trial components, electrical instruments, and navigation systems [9], gap balancing using the navigation system has been known as the reliable method, especially with the aid of force-controlled spreader system [8,10].

In earlier posterior cruciate ligament (PCL)-substituting TKA systems, a central polyethylene post at the posterior middle portion of the tibial insert was designed to articulate with a transverse metal cam on the femoral component to prevent abnormal posterior translation of the tibia [11]. Although this design has proved useful, clinical complications such as post-breakage and dislocation had been reported [12]. To improve results and reduce complications, a highly conforming ultracongruent (UC) polyethylene (PE) insert with a standard femoral component was introduced and has been an interesting alternative to the established posterior stabilized (PS) TKA design [13,14]. The UC design has an anterior buildup

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* Reprint requests: Jae-Hyuk Yang, MD, PhD, Department of Orthopedic Surgery, Hanyang University Guri Hospital, 153, Gyeongchunro, Guri, Gyeonggi-Do 11923, South Korea.

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and a more conforming articular surface for the prevention of anterior displacement of the condyles during knee flexion [13,14].

Despite the regular use of these UC inserts, there is only limited evidence about midterm or long-term outcome. Only few studies report 5- or 10-year results which demonstrated no differences to other TKA designs [15,16]. One of the concerns in using UC design is that the increased conformity may lead to increased wear and inferior long-term results [17]. The purpose of this retrospective study was to analyze the clinical and radiologic outcomes of UC PE insert TKA using the navigation-assisted gap-balancing technique with a minimum follow-up of 5 years.

Materials and Methods

This is a retrospective study on 233 consecutive patients who signed institutional review board consent for primary navigated TKA (Columbus UC; B. Braun Aesculap, Tuttlingen, Germany) along with strict gap-balancing technique between the period of August 2009 and August 2012. Inclusion criteria consisted of substantial pain and loss of function due to primary osteoarthritis of the knee. Exclusion criteria included previous knee surgery requiring the removal of metallic implants, rheumatoid arthritis, infection, and revision TKAs. The demographic and preoperative knee function characteristics of patients, as well as their knee deformities, are summarized in Table 1.

Surgical Technique Using Navigation System

The TKA surgeries were performed by a single surgeon (JHY) using the same surgical technique. All patients were implanted with full cemented type UC fixed-bearing design (Columbus UC, B. Braun Aesculap, Tuttlingen, Germany) using the navigation system (OrthoPilot, version 4.0; B. Braun Aesculap, Tuttlingen, Germany). None of the patients underwent patellar resurfacing.

Columbus TKA implant has a fixed platform with a posterior 3° polyethylene slope. Tibiofemoral sizes are interchangeable in all sizes. The UC polyethylene inserts are designed with a higher anterior buildup of 12.5 mm. The anterior buildup increases the articulating surface area and expands the circumference to accommodate and stabilize the femur during flexion (Fig. 1).

All 233 knees underwent the same surgical approach consisting of a midline skin incision and a medial parapatellar approach under an air tourniquet at 250 mmHg. The arrays of computer navigation system were set up by means of trackers, mounted to each femoral and tibial screw. Screws (1 each) were fixed to the anteromedial aspect of femur and tibia, respectively. To identify hip, knee, and ankle joint centers, the kinematic and the required anatomic selected points were registered. Osteophytes and both anterior and posterior cruciate ligaments were removed after registration process.

In previous studies assessing the intraoperative gap measurements during TKA, a difference of 2 or 3 mm in the measurements has been regarded as being clinically relevant [18]. Therefore, further surgical steps were carried out after achieving the gap difference of less than 3 mm. To balance the discrepancies between medial and lateral gaps at 90° of knee flexion, femoral rotation was adjusted to equalize flexion gaps, rotated such that the posterior condyles of the prosthetic femur are parallel to the tibia cutting surface (Fig. 2). However, if the femoral component rotation was beyond 0°-6°, that is, less than −1° or more than 7°, from the posterior condylar axis, further release of the soft tissues was not performed [19]. The anteroposterior translation of the femoral component was adjusted to yield equalized flexion-extension gaps. Once the level and the position of the femoral component have been decided, distal femoral bone cutting was performed. After confirming the distal cut level and the alignment by navigation system, the chamfer cut guide was placed as planned. The remaining femoral bone cuts were then performed. During gap measurements, offset-type-force-controlled-spreader-system (B. Braun Aesculap, Tuttlingen, Germany) was used in all cases (Fig. 3). When measuring the flexion gaps, the patella was maintained in reduced position and the medial parapatellar incision was partly sutured. After distracting with the offset-type-force-controlled-spreader-system, the gap data were recorded using the navigation system.

Because this navigation system provides the data from registered point of posterior femoral condyles, the relative femoral component rotation position is provided from the posterior condylar axis. The femoral component rotational data were recorded. The estimated joint line was calculated by subtracting the thickness of resected proximal tibia bone from the thickness of the polyethylene insert (referring the sum of the actual polyethylene thickness with tibial base plate thickness) [20]. The level of proximal tibia surface could be identified during the confirming step of the navigation system. The values were considered as positive if the joint line moved proximally (that is, closer to the hip) and negative if the joint line moved distally (that is, closer to the ankle).

Clinical and Radiologic Evaluation

Symptom severity was assessed at preoperative and at latest follow-up using the Knee Society Score (KSS) [21] and Western Ontario and McMaster Universities Osteoarthritis Index score [22]. Passive maximum knee range of motion (ROM) was measured using a goniometer. At these evaluations, assessments were performed by a physician assistant not directly involved in the surgical procedures. The possible adverse issues with TKA procedure were analyzed. Minor problems such as oozing persisting beyond 2 days after surgery, subcutaneous hematoma, hemarthrosis (requiring aspiration or surgical drainage), and ecchymosis (larger than 3 cm in diameter) and major problems such as prosthetic infection and/or any kind of additional operative procedure including revisional surgeries were recorded.

The standing anteroposterior, lateral, Merchant's view of the patellofemoral joint were taken preoperatively and postoperatively. Mechanical limb alignment was checked using a standing radiograph of the entire lower extremity. Radiographs were stored in a picture archiving and communication system (Maroview; Marotch, Seoul, Korea) in the format of Digital Imaging and Communications in Medicine files. Angular measurements were taken by using protractor function in Maroview picture archiving and communication system. Using the Knee Society radiographic evaluation and scoring system [23], the interface with a zonal assignment system

Table 1
Patient Demographics, Preoperative Deformities, and Functional Status Before and After TKA.

Male:female patients	63:170
Age (y)[a]	Male: 72.3 ± 12.3, female: 69.7 ± 11.3
BMI[a]	Male: 30.5 ± 4.5, female: 33.1 ± 4.3
Preoperative flexion contracture (°)[a]	7.3 ± 5.9
Preoperative full flexion (°)[a]	125 ± 13
Preoperative KSS scores[a]	54 ± 12
Preoperative WOMAC scores[a]	62 ± 14
Postoperative KSS scores[a]	92 ± 3
Postoperative WOMAC scores[a]	17 ± 3

BMI, body mass index; KSS, Knee Society Score; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[a] Mean ± standard deviation.