Primitive Results After Medial-Pivot Knee Arthroplasties

A Minimum 5-Year Follow-Up Study

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Abstract: Paradoxical anterior movement of the femoral condyles after total knee arthroplasty (TKA) often attenuates the extension mechanism and causes a suboptimal outcome. The medial-pivot implant design aimed to confine anterior movement and emulate physiologic knee kinematics. In our study, a consecutive series of 58 medial-pivot TKA were enrolled with a minimum 5-year follow-up. The Knee Society score improved from 30.5 to 91.1 in objective and from 36.7 to 82.3 in functional scale. The average range of motion was 115.4°. The medial-pivot TKA provided significant improvement in the postoperative range of motion, objective Knee Society score, pain scale, and functional score ($P < .05$) statistically. A larger sample and longer follow-up are recommended to draw definitive conclusions of this new implant design. **Keywords:** total knee arthroplasty, medial-pivot, paradoxical movement, femoral rollback.

Along with novel implant designs, new prosthetic materials, and refined surgical techniques, the survivorship and clinical results of total knee arthroplasty (TKA) have continued to improve over the past decades. Many of the new prosthetic designs have been presented to address more physiologic and stable knee kinematics, and different concepts have had significant impacts on the outcome and longevity of the knee replacements. Among these contemporary implant offerings, the issue on cruciate ligament retention or substitution remains to be debated. For the posterior-stabilized (PS) type TKA, the posterior cruciate ligament (PCL) is substituted with either the so-called cam-and-post mechanism or a scoop-shaped tibial polyethylene insert. Stability during knee flexion is increased [1], and the motion and rollback of the femoral component are mended. Contrary to this is the cruciate-retaining (CR) type implant, which preserves the PCL and relies on a taut ligament to provide stability and femoral rollback. Both types of implant have proven to provide good to excellent pain relief and restore knee function, however, clinical studies have not shown any type of implant possess more advantages over the other one [2,3].

The newly developed concept of the medial-pivot geometry was intended to achieve stability in the anteroposterior direction [4]. Distinct from other designs, the medial-pivot TKA is characterized by a unique femoral curvature and asymmetrical tibial polyethylene insert. The medial compartment of the polyethylene insert is ultracongruent and ultraconforming compared to the lateral compartment. Anterior-posterior translation of the medial compartment is therefore restricted [4,5], and posterior rolling of the femoral condyle is allowed only in the lateral compartment. This design was proven to emulate normal knee kinematics [6].

As reported by Pritchett [7], the medial-pivot TKA was associated with a greater patient satisfaction. At our institute, more than 250 cases had been performed by July 2008 by a single surgeon. The present study sought to investigate the clinical and radiologic outcomes of the Advance Medial-Pivot TKA (Wright Medical Technology, Arlington, Tenn) at a minimal follow-up of 5 years. The above study was approved by the institutional review board of our institute.

Materials and Methods

Our study enrolled 56 consecutive patients with 59 primary TKAs performed within September 2002 and September 2003 at the authors' institute. All cases were followed up for at least 5 years. The indications for a TKA (the index procedure) included 55 knees with

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Submitted October 28, 2008; accepted May 8, 2009.
No benefits or funds were received in support of the study.
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0883-5403/09/2503-0027$36.00/0
doi:10.1016/j.arth.2009.05.008

degenerative osteoarthritis, 3 with posttraumatic osteoarthritis, and 1 with rheumatoid arthritis. All patients met the criteria for TKA by joint space narrowing of greater than 50% in at least 2 compartments according to the regulations of the National Health Insurance of Taiwan. A preoperative genu vara was presented in 55 patients (range, 0°-16°). One patient refused to receive scheduled follow-up because her knee was well-functioning. Ultimately, 55 patients with 58 TKAs were evaluated, including 42 females and 13 males. The average age at the index procedure was 65.1 years (range, 48-83 years). All procedures were performed by the same surgeon.

Preoperative evaluations included functional assessments with the Knee Society (KS) rating system consisting of an objective knee score and a functional score [8]. The Advance Medial-Pivot TKA was the only type of implant applied to each patient. The surgical procedures were all the same and described as followed. Briefly, after a midline mid-vastus arthrotomy, both the anterior cruciate ligament and posterior cruciate ligament were excised. The femoral alignment chosen was 3° of external rotation and 5° of valgus for all knees. Tibia resection was performed with intramedullary instruments. After well-prepared femoral and tibial surfaces were obtained, the appropriate sizes of femoral and tibial component trials were temporally inserted to test the anteroposterior stability and valgus-varus balance. Detailed soft tissue release was performed until symmetrical opening of the joint space was achieved under valgus and varus stress loading and through extension to flexion. All of the components were then inserted with cement. The patella was resurfaced with a central-peg type prosthesis in 31 knees if evidence of patellofemoral arthrosis was present. The tourniquet cuff was then deflated and bleeders were electrocauterized cautiously. All wounds were closed in an ordinary manner after placing a 1/8-in Wound-Evac drainage tube (Microtek Medical, Columbus, Miss). The intraoperative details recorded included the tourniquet time, blood loss, soft tissue release, and prosthetic sizes. The average insert thickness was 11.6 mm (range, 10-14 mm). Each patient received a prophylactic injection of 1000 mg cefazolin before the procedure and subsequently 1000 mg every 8 hours for 2 days. No procedures against thromboembolism were performed in our patients because of the lower risk of thromboembolism for Asians [9]. The mean tourniquet time was 80.1 minutes (range, 52-115 minutes), and the average blood loss was 170 mL (range, 100-460 mL). All drainage tubes were removed on the second postoperative day.

The rehabilitation protocol including active quadriceps strengthening exercise immediately after the operation and continuous passive motion of the operated knee was commenced after removal of the drainage tube. The average hospital stay was 7.6 days (range, 6-11 days), and all patients were discharged with a stable wound condition. Patients were encouraged to engage in early ambulation with the assistance of a walker for a 2-week period and then discard the walker as tolerance increased.

All patients received scheduled follow-ups with radiographic checkup at 1-month intervals for 3 months, then at intervals of 3 months for 1 year, and then yearly for at least 5 years. The clinical and functional scores were rated with the KS system [8] proposed by Dr Insall and modified in 1993, which were assessed before the operation and at 5 years after the index procedure. The data were analyzed with paired *t* test. *P* values less than .05 were considered to indicate significant improvement. Radiographic analysis was obtained from the standard weight-bearing anterior-posterior, lateral, and 45° Merchant's views of the knee. The alignments of the TKAs and the radiolucent zone categorized with the KS radiographic evaluation system [10] were accessed at the latest follow-up. All clinical and radiographic evaluations were performed by the same surgeon.

Results

After the mean follow-up duration of 64.7 months, all of the implants had been retained without clinical failure. No knee developed prosthetic loosening, radiographic evidence of osteolysis, or severe malalignment necessitating revisional surgery. One case is illustrated in Figs. 1 and 2, and the clinical behaviors after the index procedure are listed in Table 1. All of the 58 knees improved on an objective scale according to the KS rating system at the 5-year follow-up, which showed an improvement from 30.5 (range, 0-73) preoperatively to 91.1 (range, 35-100) after knee arthroplasty. The pain component of the scale showed an amelioration from 5.6 (range, 0-25) to 43.2 (range, 15-50) in these 58 knees. Fifty-seven knees obtained an improvement in the functional score except for one patient who complained about knee dysfunction. The average functional score improved from 36.7 (range, 15-70) to 82.3 (range, 20-100). The patient with poor recovery proved to have

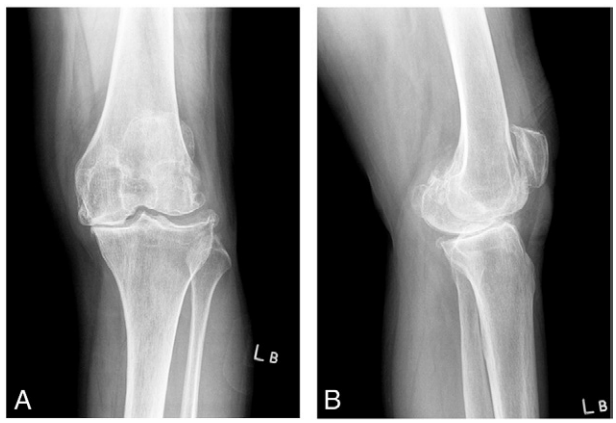

Fig. 1. Weight-bearing anteroposterior (A) and lateral (B) views of a 70-year-old woman with evident osteoarthritis of the left knee.

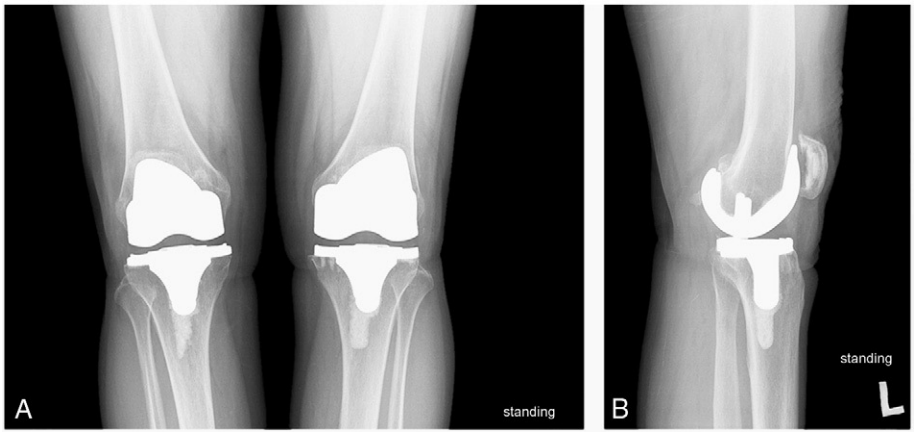

Fig. 2. Seventy months after medial-pivot TKA for the left knee. The prosthesis is in good alignment without radiographic evidence of loosening. (A) Anteroposterior view. (B) Lateral view. The right TKA was performed 22 months later and was not included in this study.

concomitant lumbar spondylolisthesis inducing intermittent claudication. This might have been the aggravating factor in her knee dysfunction. Statistically, the Medial-Pivot TKA showed significant improvement in the postoperative range of motion (ROM), objective KS score, pain scale, and functional score ($P < .05$).

Radiographically, all knees obtained a steady fixation of all implants without evidence of prosthetic loosening between the bone-cement or cement-implant interface. Two patients exhibited radiolucent lines, one over femoral zone I and the other over tibial zone II. The implant positions of these 2 patients showed no migration, which means no attenuated implant stability. Fifty-seven knees were effectively corrected to a valgus alignment (4°-8° of valgus) in anatomic axis. One malalignment with 2° of varus alignment was found in our series.

Surgery-related complications included 2 wound infections that developed 2 and 4 weeks after the operation. Both of the infections were superficial and were successfully eliminated with intravenous antibiotic therapy. Anterior femoral notching was noted in one knee with a depth of 3 mm, but no other sequala was noted for this patient. No other complications related to this surgery were found in our study.

Discussion

Poor outcomes after TKA are multivariable including detrimental implant design, component malpositioning, and improper surgical procedures as possible causes. Many attempts have been made to refine the prosthesis design to achieve normal kinematics and elongate implant survivorship over the past 2 decades. As proposed by some investigators, the PS-type total knee system possesses the advantage of posterior femoral rollback that stores more potential energy for knee extension and can facilitate high flexion through the cam-and-post engagement [11,12]. However, a study by van Duren et al [13] showed that PS-type implants fail to minimize anterior translation during initial flexion, and the cam-and-post mechanism does not express significant rollback. This finding goes against the conclusion from modern kinematic studies, that the medial femoral condyle should exhibit minimal translation throughout extension to flexion and the lateral condyle slides posteriorly [6,14,15].

Medial-pivot concepts have been reported to have many advantages [5,13,16] by many investigators. As mentioned by Blaha [4], the essential factors of the medial-pivot design are as follows. The distal and posterior femoral condyles belong to a uniform radius. The medial aspect of the tibial insert serves as the "pivot," which is highly congruent and provides a ball-in-socket kinematics. Theses features constrict the medial femoral condyle and make the medial joint compartment more stable. Translation, posterior rolling, and sliding can only occur in the lateral condyle during knee motion. This design was proven to effectively diminish paradoxical anterior movement of the medial condyle during knee motion [13] and should be closer to normal human knee kinematics. Furthermore, the contact stress of the femoral component against the tibial polyethelene is reduced. Subsequently smaller and rounder wear

Table 1. Objective and Functional Outcomes of the 58 Advance Medial-Pivot TKAs

	ROM (degrees)	Objective KS Score (Maximum = 100)	Pain Component (Maximum = 50)	Functional Score (Maximum = 100)
Preoperative (mean ± SE)	103.5 ± 2.0	30.5 ± 2.3	5.6 ± 1.0	36.7 ± 1.7
Postoperative (mean ± SE)	115.4 ± 1.8	91.1 ± 1.3	43.2 ± 0.8	82.3 ± 1.7
P	<.0001	<.0001	<.0001	<.0001

particles are generated [16]. This significantly contributes to the enhancement of prosthetic longevity. Moreover, another noticeable advantage of the medial-pivot TKA is that the PS femoral housing resection is not required, which preserve more bony stock. In a review of the literature on medial-pivot TKA, most studies focus on kinematic designs, but few studies on the clinical or functional outcomes after medial-pivot TKA have been published. Our study indicated that the mid-term results after medial-pivot TKA are excellent. Few complications were found, and the functional and clinical knee scores were encouraging.

As reported by Shakespeare et al [17], the average flexion angle obtained after Medial-Pivot knee arthroplasty was 111°. In our study, the average ROM after the Medial-Pivot TKA was 115.4°. Comparing with the results of other type of implants reported from our Asian counterparts to eliminate the influence of knee size, the result of medial-pivot knee arthroplasties seems to achieve a less return of flexion than some high-flex designs, which were reported to have an average flexion angle of about 130° [18,19] and also less than the mobile-bearing design [20]. This less optimal recovery of ROM in our series may result from the more advanced arthritic status in our population comparing with the aforementioned series because the elderly patients in Taiwan are used to seek massage therapy and take herb medication until difficulty in walking developed. As mentioned above, 57 of the 58 knees acquired an average increase of 47.0 points in the functional score, and the average advancement in ROM was 11.9°. The above data all showed significant improvement with *P* value less than .0001. The results implied a conspicuous improvement in the ability to fulfill the need for daily activities. Consequently, no patient required manipulation under anesthesia. Ranawat [21] stated in 2003 that some implant designs achieved high knee flexion at the cost of sacrificing more bone and possible instability and increased patellar and tibial contact stress. Data on long-term results from these implant types are still lacking, and we should not draw conclusions about which implant design is better at this time.

According to a study by Pritchett [7], 77% of the patients preferred the medial-pivot TKA to the PS-TKA. Although the midterm results and functional improvement of our study are also satisfactory and encouraging, an average follow-up period of 64.7 months is relatively short and a longer follow-up is needed for this new implant design before we recognize its success.

Without the cam-and-post mechanism, some may be concerned that the medial-pivot TKA implant design is not sufficiently constrained to achieve valgus-varus balance. Our study enrolled 11 cases of varus deformities greater than 10°. The final medial-lateral stability of these 11 patients showed no laxity and the KS score was proved to be excellent. In our experience, delicate soft tissue balance should be obtained intraoperatively to achieve stability. During insertion of the trial component, the medial and lateral openings should have equal laxity on the valgus and varus loads and through extension to flexion. No postoperative instability was observed in our study. The same result was also documented by Shakespeare et al [22] who mentioned that the stability of the medial-pivot TKA is reliable through proper soft tissue procedures.

Our study demonstrated excellent midterm results with the medial-pivot TKA prosthesis. Nevertheless, we should keep some potential problems in mind. The restriction of anterior translation depends on the constraint of the highly congruent tibial polyethylene insert. The longevity of the insert and tibial component loosening is thus a major possible cause of failure of this implant style. A longer follow-up of this cohort is therefore necessary.

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