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Long-term clinical and radiological outcomes of hybrid total knee arthroplasty

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Objectives: The purpose of this study was to evaluate the clinical effectiveness and radiological results of hybrid total knee arthroplasty (TKA).

Methods: This study recruited 105 patients (169 cases) who underwent hybrid TKA for osteoarthritis and rheumatoid arthritis from 1999 to 2002. Maxim (Biomet Inc., Warsaw, IN, USA) prosthesis was used, and average follow-up was 8.6 years. Radiologically, femorotibial angle was measured in a standing anteroposterior (AP) view, and a femoral flexion angle and a tibial angle were measured using the Knee Society roentgenographic evaluation and scoring system. Radiolucent lines were detected at the last follow-up. Clinically, range of joint motion and the Knee Society clinical rating system scores were evaluated.

Results: The femorotibial angle was improved from varus 4.5° to 6.4° at the last follow-up. The femoral flexion in an AP view at the postoperative and last follow-up was 96.5° and 95.7°, respectively, and the tibial angle was 89.1° and 88.7°, respectively. In lateral view, the femoral flexion was 2.6° and 2.7°, respectively, and the tibial angle was 88.4° and 87.8°, respectively. Total scores of radiolucencies were 4 points or less in all cases, and the average width was 1.1 mm. Flexion contracture was improved from 10.0° to 3.5°, and further flexion was increased from 110.5° to 130.4°. Knee score and function score were also enhanced from 47.6 and 46.8 preoperatively to 89.7 and 88.4 after the operation, respectively.

Conclusion: Hybrid technique for TKA can be effective clinically and radiologically on long-term follow-up.

Key words: Hybrid; follow-up study; total knee arthroplasty.

Prosthetic fixation with polymethylmethacrylate in total knee arthroplasty (TKA) has been widely used since 1970s; however, for implants fixed with cement, loosening has occurred with time around the implant and cement, thus raising questions about long-term stability of the fixation.[1,2] In order to address this problem, the tendency of bone to grow into porous surfaces (bony ingrowth) has been exploited, initially in total hip arthroplasty, and subsequently in TKA, and the cementless technique has been developed. Unfortunately, long-term follow-up of cementless TKA also has revealed that aseptic loosening was occurring frequently around tibial and patellar components. The expected bony ingrowth around the tibial component has been poor, with resultant problems in fixation of the component.[3-7] To resolve these disadvantages of the cementless technique, a hybrid technique has been employed, applying cement to the tibia and patella, but not to the femur. This technique has resulted in relatively good bone ingrowth, and most reports have shown excellent results in the short-term and

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mid-term follow-up;[8-11] however others have noted higher rates of failure with hybrid TKA compared with cemented TKA.[12,13] We have been performing hybrid TKAs for several years, and herein report the radiological and clinical long-term results of this technique.

Patients and methods

This study identified 105 patients with osteoarthritis (169 cases) underwent hybrid TKA performed by one surgeon at St. Mary's hospital from January 1999 to December 2002. The patients were 11 men (16 cases) and 94 women (153 cases). The mean age was 72.6 years (range 56-85 years), and weight was 67.8 kg (range 56-82 kg). The mean follow-up period was 8.6 years (range 6 years 6 months-10 years 6 months). No patient had had any previous surgical procedures (Table 1).

A cruciate-retaining type of Maxim prosthesis (Biomet Inc, Warsaw, IN, USA) was used in all patients, each of whom had the tibial component cemented and the femoral component inserted without cement. The patella was resurfaced with a cemented 3-pegged all-polyethylene component. The decision to use a cementless femoral component was at the discretion of the surgeon, based on bone quality of the femur. Cases that had poor bone quality or showed large bone defect were excluded from this study. A small bone defect (<5 mm) and type I defects by the Anderson Orthopedic Research Institute (AORI) classification[14] were included, and were treated with cement or morselized autogenous bone graft.[15] Either posterior cruciate ligament release or lateral retinacular release was performed if necessary, at the discretion of the surgeon. A tourniquet was used for bleeding control during the operation, and a suction drain was also used after hemostasis at the end of the operation. On the second day after the operation, continuous passive motion exercise was started, and on the fourth day, full weight-bearing ambulation was permitted.

We evaluated all patients 6 months after surgery. Radiologically, femorotibial angle was gauged in a standing knee anteroposteior (AP) view before and after the operation and at the last follow-up. The fixation of components was evaluated by measuring component position and radiolucent lines with Knee Society roentgenographic evaluation and scoring system.[16] We measured femoral flexion and tibial angle in an AP view, and flexion angle and tibial angle in a lateral view after the operation and at the last follow-up. In addition, total scores of radiolucent lines of each component gauged with the picture archiving communication system (PACS) were calculated and divided into three groups: 4 or less for no significance; 5 to 9 points for careful observation of clinical course; and 10 or more for possibility of failure.[16]

Clinically, the range of joint motion was measured at the preoperative, postoperative, and final follow-up. Knee score and function score were also evaluated with the Knee Society clinical rating system.[17] A score of 90 points was considered an excellent outcome, 80-89 points was considered a good outcome, 70-79 points was considered a fair outcome, and <70 points was considered a poor outcome.[11]

Prosthesis survival was evaluated using Kaplan-Meier survival analysis of SPSS statistical software. Failure was defined as revision of any component. The statistical significance of the change according to the passage of time was analyzed by paired t-test, and a p value <0.05 was considered to be statistically significant for each method.

Table 1

Number of patients with unilateral vs. bilateral total knee arthroplasty (TKA) in age groups

	Age groups (years)			
	50-60	60-70	70-80	80-90
Bilateral TKA	-	29	33	2
Unilateral TKA	4	23	14	-

Results

The survival rate was 0.994 at postoperative 1.5 years, 0.988 at 4 years, and 0.978 at 8.5 years. Survival rate changed with time, and was 0.982 at the final evaluation, which was at postoperative 10.5 years (Fig. 1).

In the radiological evaluation, femorotibial angle in the standing AP view was improved on average from 4.5° varus preoperatively, to 6.6° valgus postoperatively. At the final follow-up, it was revised to 6.4°, and was maintained close to the normal range ($p<0.05$). For evaluation of component position, the femoral flexion in an AP view was 96.5° and 95.7° on average at the postoperative and final follow-up, respectively, and the tibial angle was recorded to be 89.1° and 88.7° on average, respectively. The component position in the lateral view was also maintained well, recording 2.6° and 2.7° of femoral flexion on average, and 88.4° and 87.8° of tibial angle on average at postoperative and final follow-up, respectively ($p>0.05$).

In nine cases in which the femoral components were observed at the last follow-up visit (5.3% of 169 knees), radiolucent lines were ≤2 mm. Tibial components were observed in 25 cases (14.8% of 169 knees) of which 19 cases were observed in AP view and six cases in lateral view (Fig. 2, Table 2). Among these, three cases seen in the AP view had radiolucent lines 2 mm wide, but loosening or further progression was not observed in any case. Two cases (1.2% of 169 cases) showed radiolucencies both in the femoral and tibial components. There was no radioluscent line in the patellar components. No case showed a radiolucent score of ≥5 in total at the last follow-up, and the average width of radiolucent lines was 1.1 mm.

Clinically, flexion contracture was improved from preoperative 10.0° on average, to postoperative 3.5° at the last follow-up. Maximum flexion also increased from an average of 110.5° to 130.4° ($p<0.5$). In the evaluation using the Knee Society clinical rating system, knee score increased from an average of 47.6 preoperatively to an average of 89.7 at the final follow-up, showing good or excellent results in 94.7% (160 of 169 cases). Function score also improved from an average of 46.8 to 88.4, showing good or excellent results in 94.1% (159 of 169 cases) ($p<0.05$, Fig. 3, Table 3).

During the follow-up period, there were two revisions of the femoral component. There were no tibial or patellar component failures. One femoral failure was observed in a 78-year-old woman who was

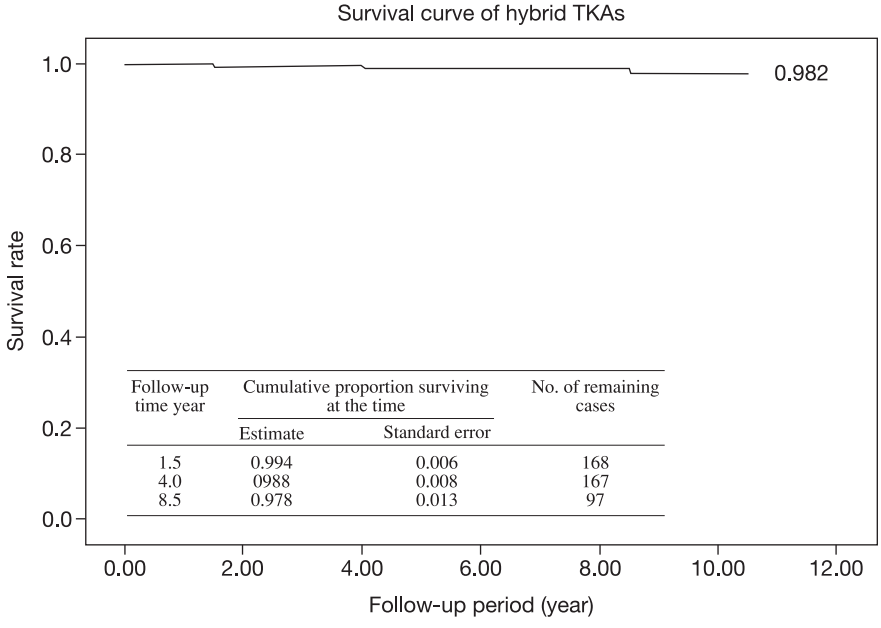

Fig. 1. Kaplan-Meier survival analysis and curve demonstrating 98.2% survival at postoperative 10.5 years follow-up.

Fig. 2. Radiolucent line at the bone-cement interface on the **(a)** medial side and **(b)** anterior side of the tibial component in knee radiograph.

treated primarily for osteoarthritis. She complained of continuous pain and discomfort after the operation, but there was no sign of infection, or radiographic signs of loosening of the component. We suspected failure of bony ingrowth on the femoral component, and performed an additional operation 18 months after the primary surgical procedure. The failure was confirmed at the time of surgery. The other was due to infection 4 years postoperatively in a 74-year-old woman. She was treated with 2-stage revision surgery and appropriate intravenous antibiotics. Wear of the polyethylene component of the tibial insert was observed in one case at postoperative 8.5 years. Polyethylene exchange and debridement were performed. At 5 years 3 months postoperatively, a post-traumatic periprosthetic fracture occurred above the femoral component in one case. Bony union was achieved by conducting open reduction and internal fixation, and the prosthesis was well maintained. As an early complication, superficial infection of the operative wound was observed in one case at postoperative one week. We did not perform any operative procedure, and the infection resolved completely with antibiotic treatment. There was no specific complications such as deep vein thrombosis or other soft tissue involvement.

Discussion

Both the experience of the surgeon and the condition of the patient influence the decision of whether to use cement during TKA. Although the cement technique has had good results, it raises questions regarding long-term maintenance due to brittleness of methylmethacrylate, abnormal reaction of tissue caused by cement, the possibility of third-body wear following polyethylene wear due to cement particles, and a risk of loosening as evidenced by radiolucent lines around components.[1,2,4]

With this background, the cementless technique was developed, and was expected to resolve the disadvantages of cement, to maintain bone integrity in case surgical revision should become necessary, to reduce operative time, and to eliminate loosening by

Table 2

Radiolucent line of each component

Prosthesis	Mean thickness (mm)	Areas of implant (section around the component)						
		1	2	3	4	5	6	7
Femur	1.0	3	2	1	3	-	-	-
Tibia (anteroposterior view)	1.2	14	3	2	-	-	-	-
Tibia (lateral view)	1.0	5	1		-	-	-	-

inducing bone ingrowth with an initially close connection between bone and porous coated components.[18,19] However, this technique also resulted in aseptic loosening on the tibial and patellar components as noted on radiological and histological examination during long-term follow-up. The expected bone ingrowth on tibial components was especially poor, suggesting the possibility of problems of component fixation.[3,20] Reasons proposed for poor bone ingrowth include relatively poor tibial bone matrix; technical problems or micromotion at the initial fixation, which requires a close connection between components and bone; differences in component design; and differences in types of loads.[3,5,21]

In order to avoid the aforementioned disadvantages of the cementless technique, and to induce biologic fixation in the femur, the hybrid technique was introduced. This technique fixes components with cement on the tibia and patella, but does not use cement on the femur. The potential benefits of cementless femoral fixation include durable biologic fixation via bone ingrowth, decreased risk of third-body wear due to cement debris, bone preservation, ease of revision, and possibly decreased operative time.[22] This hybrid TKA has shown good results, comparable to those of the cement technique, with good outcome. Some authors have asserted that the hybrid technique would be the optimal method for TKA in the future;[8-11,23] however others have reported that the results of the hybrid fixation were inferior to those of cemented TKAs because of an unacceptably high failure rate of the femoral component. There were no significant differences to recommend one method of fixation over another.[12,13,24,25]

We have been performing TKAs by using the hybrid technique in most cases for several years except when revision arthroplasty was conducted, or when there were problems related to bone quality. Results of these procedures have shown that although early walking and joint motion were permitted after the surgery, 91.7% of total cases had a clinical result of "good" or "excellent" at the final follow-up, and the survival rate of the knee replacement was 98.1% at 10.5 years after surgery.

Radiolucent lines observed around components were still open to dispute, but became an important feature in evaluating the results of TKA in most cases.[26,27] It has been reported that there were fewer

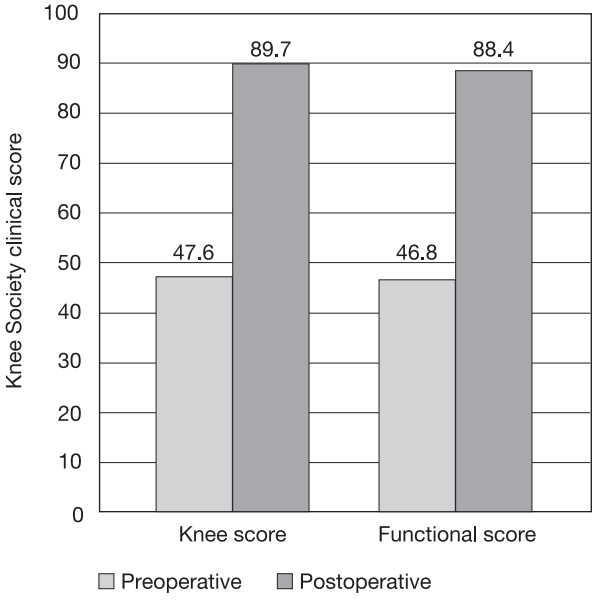

Fig. 3. Preoperative and postoperative mean scores of the Knee Society clinical rating system.

Table 3

Number of cases according to the Knee Society clinical rating system scores at the last follow-up

		Knee score	Functional score
Excellent	≥90	68	60
Good	80-89	92	99
Fair	70-79	9	10
Poor	≤70	-	-

radiolucent lines on femoral components than on tibial components.[4,28] Ecker et al.[26] reported that there was no statistically significant correlation between the occurrence of thin radiolucent lines in any location and the eventual postoperative clinical result, and that radiolucent lines greater than 2 mm were associated with poor results. Radiolucent lines shown after performing the hybrid technique were reported before; however, the lines were meaningless and non-progressive in all studies.[8,10,23] This study demonstrated that there was no radiolucent line around patellar components, and that the radiolucent lines found in 6.1% of femoral components and 19.2% of tibial components were meaningless and non-progressive in all cases. There was also no significant correlation of radiolucent lines with clinical results.

In conclusion, hybrid TKA has shown satisfactory clinical and radiological results without serious complications; however, those were only mid-term results, and long-term follow-up is necessary for a minimum of 10 years.

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