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Clinical Results Associated with Changes of Posterior Tibial Slope in Total Knee Arthroplasty

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Purpose: The purpose of this retrospective study is to investigate the effect of posterior tibial slope (PTS) on clinical results in total knee replacement arthroplasty (TKA).
Materials and Methods: We analyzed 801 knees in 768 patients who underwent TKA using a cruciate-retaining prosthesis for osteoarthritis from July 2003 to July 2009. PTS was measured on simple X-ray films and patients were divided into 5 groups, according to the change in PTS that was calculated by subtracting the preoperative from the postoperative PTS: group 1, >3°; group 2, 3° to 1°; group 3, 1° to -1°; group 4, -1° to -3°; and group 5, <-3°. We analyzed the correlations between the change in PTS and clinical results, such as Knee Society knee score, Knee Society functional score, Feller patella score, Kujala score, visual analog scale score, range of motion, and complications.
Results: There was no statistically significant intergroup difference; however, Feller patella score and Kujala score were significantly different in groups 2 and 3. There were no complications, such as progressive loosening of implants, fractures of polyethylene inserts and wears.
Conclusions: Clinically meaningful improvement was observed in all patients after TKA. Groups 2 and 3 (3° to -1°) showed significant improvement compared to the other groups.

Keywords: **Total knee replacement, Arthroplasty, Knee, Posterior tibial slope**

Introduction

Studies have suggested that posterior tibial slope (PTS) is associated with biomechanics of the knee joint and posterior cruciate ligament (PCL) tension and stability, and facilitates femoral rollback. Thus, it has a profound influence on the clinical outcomes of total knee arthroplasty (TKA)[1-3]. Several biomechanical studies have shown that PTS is positively correlated with the range of flexion and inhibits excessive tension in the PCL during knee flexion, resulting in fewer instances of tibial component loosening[4]. However, excessive PTS can lead to anterior dislocation of the tibia and biomechanical changes of the knee, compromising the longevity of TKA[5]. On the other hand, the type of knee prosthesis (PCL-retaining vs. PCL-sacrificing) is an important factor that should be considered in evaluating the relationship between PTS and TKA outcomes. A majority of studies have reported that the influence of PTS on the range of motion (ROM) was notable in PCL-retaining TKA, whereas insignificant in PCL-sacrificing TKA[6,7].

The normal PTS was reported as 7° by Hofmann et al.[8], 8°–10° by Laskin and Reiger[9], and 14.8° by Chiu et al.[10]. However, there is no consensus on the proper PTS for normal biomechanics of the knee joint in the absence of clinical studies.

Patellar fracture, wear or loosening, and anterior knee pain develop in approximately 50% of TKA patients[11,12]. These complications are associated with patellofemoral contact forces that are affected by the device design[12], patellar thickness[13], and femoral rollback in flexion. A relationship between the complications and PTS has never been investigated in clinical

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studies.

The purpose of this study is to assess the influence of intra-operative changes in PTS on clinical results under the hypotheses that 1) compared to excessive postoperative PTS, insufficient PTS after PCL-retaining TKA relatively increases anterior dislocation of the femur, which results in a higher femorotibial contact pressure and development of patellofemoral pain, and 2) PTS is positively correlated with stress on the posterior compartment of the tibia in flexion, which results in component loosening. In the absence of established intraoperative measurement methods, PTS measured from the preoperative and postoperative radiographs were used to assess the relationship between PTS change and clinical outcome and ROM.

Materials and Methods

1. Patients

A total of 1,028 TKAs were performed at our institution between July 2003 and July 2009. Of those, 801 cases with a minimum follow-up of 12 months were enrolled in this retrospective study. The exclusion criteria were <90° preoperative ROM, rheumatoid arthritis, traumatic or infectious arthritis, patellar resurfacing, and ≥Outerbridge grade III lesion in more than 50% of the patellofemoral joint. The mean age of the enrollees was 68.4±8.1. The surgery was performed on the right knee in 436 cases and on the left knee in 465 cases. There were 134 males and 677 females. Surgery was performed using the E-motion (Aesculap, B-Braun, Tuttlingen, Germany) PCL-retaining prosthesis in all cases. The mean follow-up period was 51.2±20.2 months.

2. Operative Technique

All the operations were performed by the same surgeon using a medial parapatellar approach. Proximal tibial osteotomy was performed with care to maintain the original slope of the articular surface by taking 3° of posterior slope of the tibial implant into consideration. The tibial cut was followed by distal femoral osteotomy. Rotation of the femoral component was determined as 3°–5° of external rotation with respect to the posterior condylar axis based on the preoperative computed tomography (CT) scan. Taking care to avoid more than one size smaller or larger prosthesis, a femoral component that was identical as much as possible to the anteroposterior diameter of the femoral condyle was chosen using a posterior reference method. Femoral osteotomy was carried out when femoral component size was determined. The PCL was retained in TKA. If severe flexion contracture and soft tissue contracture were present, posterior osteophyte removal and partial PCL release were done to achieve flexion-extension gap balance. Patella was not resurfaced in all cases. Electrocautery and sensitization were performed for the parapatellar soft tissue structures. Normal patellar tracking was confirmed using the no thumb technique[14].

3. Assessment and Analysis

The mean values of PTS measured by two observers using a picture archiving and communicating system (Maroview 5.4, Marotech, Seoul, Korea) were used for analysis. The anatomical axis and mechanical axis were measured on the weight-bearing radiographs preoperatively and at the last follow-up. PTS was defined as the angle between a line perpendicular to the proximal tibial anterior cortex and a line parallel to the tibial medial plateau

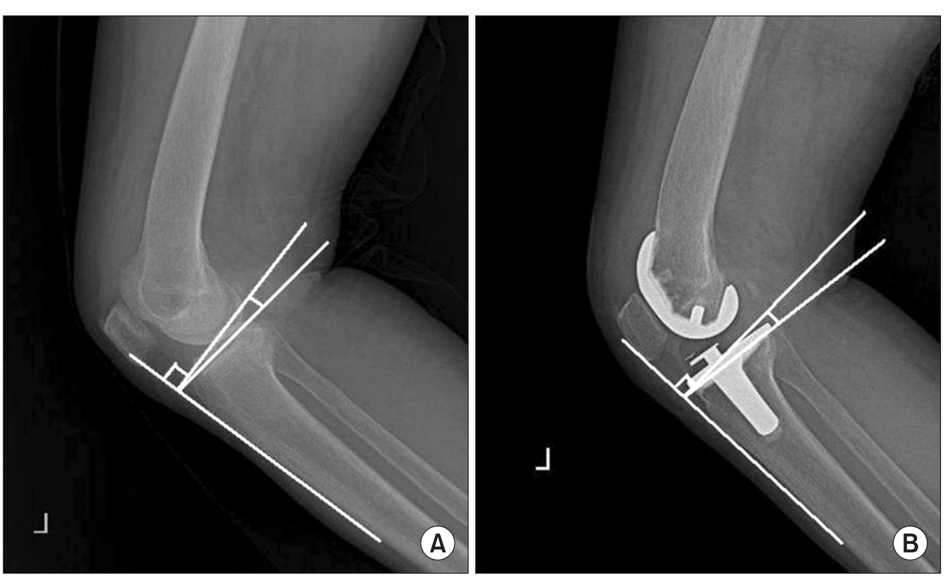

Fig. 1. (A) Preoperative tibial posterior slope line was measured by perpendicular line of proximal tibia anterior cortex and tibial medial plateau line. (B) Postoperative tibial posterior slope line was measured by perpendicular line of proximal tibia anterior cortex and tibial medial plateau line.

on the 30° flexion lateral view (Fig. 1). Patients were divided into 5 groups, according to the change in PTS that was calculated by subtracting the preoperative value from the postoperative value. If the postoperative value was greater than the preoperative value, a plus sign (+) was placed in front of a numeric value, whereas a minus sign (-) was used in the opposite case: group 1, >3° (129 patients); group 2, 3° to 1° (113 patients); group 3, 1° to -1° (312 patients), group 4, -1° to -3° (163 patients); and group 5, <-3° (84 patients). ROM was measured preoperatively and at the last follow-up. Knee function was assessed using the visual analog scale (VAS) score, Feller patella score[15], Kujala score[16], functional score, and Knee Society knee score (KSS)[17] preoperatively and at the last follow-up. Intergroup differences in knee function score changes between the preoperative and last follow-up examinations were analyzed using the SPSS ver. 10 (SPSS Inc., Chicago, IL, USA). The ANOVA test was performed to compare the differences in parameters among the groups and Scheffe test was conducted additionally to confirm statistical significance of the differences. The pre- and postoperative parameters in each group were assessed using paired t-tests with a 95% confidence interval.

Results

There was no statistically significant intergroup difference in the parameters that can affect the postoperative ROM and knee function including the preoperative body mass index (BMI) and ROM, VAS score, functional score, KSS, Feller patella score, and Kujala score (Table 1).

The mean preoperative anatomical axis and mechanical axis of the lower limb measured by two observers was 3.6°±4.2° of varus and 7.8°±5.3° of varus, respectively. The interobserver reliability of the measurements assessed with intraclass correlation coefficient (ICC) proposed by Shrout and Fleiss[18] was high with an ICC of 0.813 and 0.799, respectively. The preoperative values were not significantly different among the groups. The mean anatomical axis and mechanical axis at the last follow-up was 8.7°±3.3° of valgus and 2.4°±2.2° of valgus, respectively, indicating a correction of varus deformity. The ICC for interobserver reliability was 0.803 and 0.815, respectively. There was no significant difference among the groups in the last follow-up measurements and the amount of increase (p=0.143). The mean preoperative PTS was 7.1°±5.4° with an ICC of 0.823 and no notable difference was found among the groups (p=0.211). The mean PTS at the last follow-up was 7.2°±2.8° with an ICC of 0.812.

The VAS score, functional score, and KSS were improved postoperatively in all groups and the level of improvement was not significantly different among the groups. The Feller patella score was improved postoperatively in all the groups; however, especially significant improvement was observed in group 2 (26.3, p=0.022) and group 3 (27.8, p=0.034). The Kujala score was increased postoperatively in all groups, and especially significantly in group 2 (76.5, p=0.041) and group 3 (77.4, p=0.029) (Table 2).

The ROM was improved postoperatively in all groups, but the level of improvement was not significantly different among the groups (p=0.241). There were no clinically significant complications during the follow-up, such as aseptic loosening,

Table 1. Preoperative Clinical and Radiological Scores of Each Group and p-value

	Group I (>3°)	Group II (3° to 1°)	Group III (1° to -1°)	Group IV (-1° to -3°)	Group V (<-3°)	p-value[a]
No.	129	113	312	163	84	-
Age (yr)	68.6±8.0	68.3±7.7	68.5±8.5	68.3±8.2	68.4±7.9	0.357
Body mass index (kg/m²)	24.7±1.1	24.8±1.3	24.6±0.9	24.7±1.2	24.9±1.2	0.436
Preoperative range of motion	114.1±5.8	117.3±6.2	113.9±5.4	118.1±5.9	114.6±5.2	0.234
Anatomical axis (°)	Varus 3.6±4.1	Varus 3.7±3.9	Varus 3.4±3.5	Varus 3.8±4.3	Varus 3.6±3.8	0.189
Mechanical axis (°)	Varus 7.6±5.1	Varus 7.7±4.9	Varus 7.8±4.8	Varus 7.9±5.2	Varus 7.9±4.7	0.341
Posterior tibial slope angle (°)	7.0±5.3	7.2±4.9	6.9±5.1	7.3±4.8	7.1±5.2	0.245
Visual analog scale	7.8±1.5	8.2±1.4	8.1±1.3	7.4±1.6	8.0±1.4	0.267
Knee Society functional score	53.4±14.2	55.5±13.6	53.1±14.7	54.7±13.9	53.9±13.4	0.169
Knee Society knee score	55.8±21.2	56.2±20.4	56.3±20.2	55.4±20.8	55.1±20.7	0.214
Feller patella score	18.1±7.8	18.3±7.5	17.8±8.2	18.2±7.7	18.0±7.9	0.374
Kujala score	51.1±6.1	51.5±6.6	51.4±5.8	50.8±5.9	51.3±6.5	0.219

[a]A p-value is results of ANOVA test.

Table 2. Postoperative Clinical and Radiological Scores of Each Group and p-value

	Group I (>3°)	Group II (3° to 1°)	Group III (1° to -1°)	Group IV (-1° to -3°)	Group V (<-3°)	p-value[a]
No.	129	113	312	163	84	-
Preoperative range of motion	130.2±3.8	129.5±4.2	131.9±4.9	128.9±4.7	130.6±4.4	0.241
Anatomical axis (°)	Valgus 8.6±3.4	Valgus 8.8±3.6	Valgus 8.5±2.9	Valgus 8.8±3.1	Valgus 8.8±3.2	0.231
Mechanical axis (°)	Valgus 2.4±2.1	Valgus 2.3±2.3	Valgus 2.5±2.4	Valgus 2.5±2.1	Valgus 2.3±1.9	0.254
Posterior tibial slope angle (°)	11.7±3.1	9.1±2.2	7.1±2.0	5.2±2.3	3.5±2.2	<0.001
Visual analog scale	2.6±0.8	3.1±0.7	3.2±1.0	2.8±0.6	2.9±0.7	0.179
Knee Society functional score	82.4±7.5	83.5±8.6	83.1±7.7	82.7±8.9	83.4±7.4	0.215
Knee Society knee score	86.3±8.2	86.2±8.4	86.3±7.2	85.9±7.8	86.1±7.7	0.304
Feller patella score	22.4±3.8	26.3±2.6[b]	27.8±2.1[b]	23.2±3.7	23.7±2.9	0.014
Kujala score	72.2±6.9	76.5±6.1[b]	77.4±5.7[b]	71.8±6.5	71.3±6.1	0.021

[a]A p-value is results of ANOVA test. [b]Statistically significant results.

increased radiolucency, and fracture of the polyethylene insert.

Discussion

There was no statistically significant difference in the pre- and postoperative changes in the VAS score, functional score, and KSS among the 5 groups that were divided according to the changes in the pre- and postoperative PTS. We attributed this to the fact that most of the patients had degenerative arthritis and PTS is not the only factor that influences postoperative pain, ROM limitation, and knee function. However, Feller patella score and Kujala score appeared correlated with PTS as in groups 2 and 3. It is our understanding that PTS is negatively correlated with anterior dislocation of the tibia, which results in reduced patellofemoral contact surface and stress, and eventually improvement in the Feller patella score and Kujala score. However, significant improvement was not observed in group 1 with >3° increase in PTS. We thought that the poor clinical results in this group were attributable to posterior translation of the femur, relative to the tibia, resulting in excessive traction forces on the quadriceps femoris tendon or patellar tendon or impingement of the patellar tendon during joint movement. Further, contrary to our hypothesis that PTS is correlated with the incidence of tibial component loosening due to increased pressure on the posterior compartment during flexion, there was no case of loosening in this study.

PTS increase and PCL release in TKA contribute to the improvement of flexion tightness. The latter corrects anteroposterior tightness, whereas the former enhances varus and valgus, anteroposterior, and rotational laxity in knees that are too tight in flexion. Therefore, PTS increase can be more effective than PCL release in the knees with abnormal collateral ligament tightness and flexion tightness[19]. Walker and Garg[20] reported that 30° increase in flexion was observed in the knees with 10° PTS compared to those with 0° PTS after PCL-retaining TKA. In a cadaver study by Bellemans et al.[21], flexion improved by 1.7° for every 1° extra PTS. However, we could not find a correlation between PTS and ROM in this study.

One of the limitations of our study is that factors, such as posterior condylar offset, that can affect the postoperative ROM were not taken into consideration in patient selection. Therefore, we think that our study results should be confirmed by future clinical and biomechanical studies with prospective design and tighter control on possible confounding variables.

Conclusions

Significant clinical improvement was observed in all the knees after PCL-retaining TKA. The improvement was especially notable in groups 2 and 3 with 3 to -1° increase in PTS compared to the other groups.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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