A New Total Knee Arthroplasty Technique for Valgus Knees that preserves the deep layer of the medial collateral ligament

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ABSTRACT

Objective: The aim of this study was to assess the outcomes and complications, such as tibiofemoral instability and recurrence of valgus deformity, of total knee arthroplasty for valgus knees with a new technique preserving the deep layer of the medial collateral ligament.

Methods: In this study, 33 (4 male and 29 female) patients, and a total of 36 (26 knees with osteoarthritis and 10 with rheumatoid arthritis) knees with a standing femorotibial angle (FTA) of $<170^\circ$ were included. Posterior Stabilized (PS) implants were used in 34 knees, rotating hinged knee implants were used in 2 knees. The procedures were carried out by a single surgeon protecting the deep layer of the medial collateral ligament. The patients’ average age at the time of the operation was 67.6 ± 12 years, and the average follow-up period was 9.0 ± 3 years (range, 4-15 years). The Japanese Orthopaedic Association (JOA) knee score, range of motion (ROM) (extension/flexion; measured in degrees), FTA (measured in degrees) and complications were investigated.

Results: The Japanese Orthopaedic Association knee score significantly improved from an average of 51 ± 12 points before the operation to 86 ± 9 points after the operation ($P<0.001$). The extension ROM and flexion ROM improved from -13 ± 2° to a postoperative average of $2^\circ$ ± 4°, and 115 ± 25° to a postoperative average of 125 ± 18° respectively ($P<0.001$). The standing FTA significantly improved from 158 ± 9° to an average of 173 ± 2° after the operation ($P<0.001$). Thirty-four knees with severe valgus deformity were operated on using posterior stabilised implants, while only two knees required constrained implants. During follow-up, no complications, such as tibiofemoral instability, recurrence of valgus deformity, patellar necrosis, deep infection, wound problems, or peroneal nerve paralysis were observed.

Conclusion: This study has shown us that after performing TKA while preserving the d-MCL for valgus knee deformity good clinical results were obtained and no complications were observed.

Level of Evidence: Level IV, Therapeutic Study

Introduction

Total knee arthroplasty (TKA) for valgus knee deformity is considered challenging because of anatomical variations in the bone and soft tissue. Bone tissue variations include lateral cartilage erosion and hypoplasia, metaphyseal femur, and tibial plateau remodeling. Soft tissue variations may present as tightening of the lateral collateral ligament, posterolateral capsule, popliteus tendon, hamstring tendon, lateral head of the gastrocnemius, or iliotibial band. Moreover, major complications (tibiofemoral instability (2-70%) and recurrent valgus deformity (4-30%)) after TKA for valgus knee deformity have been reported. In a valgus knee, the medial soft tissue structures, although they play an important role in knee joint stability during weight bearing, tend to show considerable laxity compared to the lateral soft tissue structures. The most important medial soft tissue structure is the medial collateral ligament (MCL), which is divided into the superficial medial collateral ligament (s-MCL) and deep medial collateral ligament (d-MCL). The d-MCL attaches near the articular surface of the tibia; in many cases of TKA, the d-MCL is removed during the tibial cut. During TKA performed for valgus knees, in particular, removal of the d-MCL can cause valgus deformity progression, resulting in a soft tissue imbalance. Furthermore, aggressive lateral soft tissue release or a constrained implant is required afterward. Therefore, regarding TKA for valgus knee deformity, we believe that preserving the d-MCL is important and may reduce the occurrence of complications and the need for highly constrained implants. However, there have been no reports on the outcomes of d-MCL-preservation procedures during TKA for valgus knees. This study aims to assess the outcomes of TKA with d-MCL preservation for valgus knee deformities.

Materials and Methods

This retrospective cohort study was approved by the Institutional Review Board of the authors’ affiliated institutions (approval number: 2019266). The requirement for informed patient consent was waived because all patient data were fully de-identified.

Between March 2006 and January 2016, 33 patients (4 males and 29 females) underwent TKA in 36 knees (26 knees with osteoarthritis and 10 with rheumatoid arthritis) with valgus deformity showing a standing femorotibial angle (FTA) $<170^\circ$. The patients were followed up for at least 4 years.
The average age of the patients was 67.6 ± 12 years. The mean body mass index was 22.3 ± 4 kg/m² at the time of surgery. The mean follow-up duration was 9.0 ± 3 years (range, 4-15 years). Genesis II Posterior Stabilized (PS) implants with High Flex inserts (Smith & Nephew, Memphis, Tenn, USA) were used in 34 knees, and the rotational and hinge knee joint Endo-Model® SL® prosthesis (GmbH & Co, Hamburg, Germany) in 2 knees. All procedures were performed by 1 orthopaedic surgeon. The Japanese Orthopaedic Association (JOA) knee score, range of motion (ROM) [extension/flexion], measured in degrees indicating flexion contracture, femorotibial angle (FTA), measured in degrees, and complications were investigated. The ROM, especially the maximum passive extension and flexion, was assessed using a goniometer with the arms aligned along the axes of the femur and tibia on the lateral side of the knee joint. Tibiofemoral instability and recurrence of valgus deformity were determined based on the valgus stress test results, and medial joint looseness was judged based on the standing anteroposterior x-ray results. Furthermore, the degree of valgus deformity that could be treated by TKA with a PS implant was investigated. All patients with severe valgus deformities (with an FTA of 170° or less) were included; however, we excluded patients in whom the medial articular surface was elevated above the lateral articular surface (either congenitally or after high tibial osteotomy). Patients with extra-articular bony valgus deformities were also excluded.

Surgical procedure
For all cases of valgus knee deformity, a lateral straight incision and lateral parapatellar approach were employed. With the lateral approach, the lateral retinaculum was incised approximately 5 mm from the patella, and the joint capsule was incised at the level of the patella attachment after releasing the retinaculum and joint capsule. Afterward, only the joint capsule was sutured to the lateral retinaculum of the patella on the incision side.

The anterior fibers of the iliotibial band were released, and osteotomy was performed using the measured resection technique. Although tibial cut was performed while preserving the d-MCL, the gap between the femur and tibia was small because the attachment of the d-MCL was near the medial tibial surface. Therefore, an additional 4 mm of the distal femur was resected, however, because we usually used PS implants, the flexion gap became large. Therefore, we checked the gap using a spacer technique. As a result, the extension and flexion gaps were almost the same in all cases. We usually cut the distal femur at a valgus angle of 6° in knees with varus deformity. However, the medial soft tissue structures tended to show considerable laxity for knees with valgus deformity compared to the lateral soft tissue structures. Therefore, we cut the distal femur at a valgus angle of 7° to achieve a lateral gap between the femur and tibia. An additional 4 mm of the distal femur was resected. Femoral rotational alignment was determined based on the Whiteside line and surgical epicondylar axis. A smaller femoral component was chosen when the femur was between sizes. For tibial cut, the Akagi line was referenced to achieve tibial rotational alignment; in order to preserve the d-MCL, the location of the d-MCL attachment was confirmed, and the cutting level was 1-3 mm from the medial joint surface. Then, the medial meniscus was excised, and care was taken not to damage the d-MCL. Next, if an extension/flexion gap of 9 mm or more could not be obtained, the location of the d-MCL attachment was reconfirmed, and another 1-2 mm tibial cut was performed.

After completing both bone cuts, 5 patients presented with the tightness of the lateral soft tissue, and the posterolateral joint capsule was released. In 2 cases, the popliteus tendon and lateral collateral ligament were further released.

Theory/Calculation
The JOA knee score, ROM, and FTA changes from the preoperative value to the final follow-up value were statistically analyzed using the Mann–Whitney U test. A value of P < 0.05 was considered statistically significant. All statistical analyses were performed using StatView-J (SAS Institute, Cary, NC, USA).

Results
The JOA knee score significantly improved from a preoperative average of 51 ± 12 points to 86 ± 9 points postoperatively (P < 0.001). The extension ROM significantly improved from a preoperative average of −13 ± 13° to a postoperative average of −2 ± 4° (P < 0.001). Additionally, the flexion ROM significantly improved from a preoperative average of 115 ± 25° to a postoperative average of 125 ± 16° (P < 0.001). The knees were divided into 3 groups according to the degree of standing FTA, as follows: 22 knees had a standing FTA of 160°-170°; 11 knees had a standing FTA of 150°-160°; 3 knees had a standing FTA of <150°. The standing FTA significantly improved from an average of 158 ± 9° (range, 124°-167°) preoperatively to an average of 173 ± 2° postoperatively (P < 0.001) (Table 1, Figure 1). In 2 patients with preoperative FTA of 124° and 139°, respectively, even preservation of the d-MCL and additional release of the lateral soft tissue did not improve the soft tissue balance; therefore, it was necessary to perform TKA with a rotating hinge prosthesis.

During the follow-up period of 9.0 ± 3 years (range, 4-15 years), no complications such as tibiofemoral instability, valgus deformity recurrence, patellar necrosis, deep infection, wound issues, and peroneal nerve paralysis were observed. Our representative case 1 was a 63-year-old woman with bilateral osteoarthritis of the knee and valgus deformity (with a preoperative JOA knee score of 50 points on both sides) associated with congenital dysplasia of both hip joints. One year previously, she underwent bilateral total hip arthroplasty and TKA on the same day (Figure 1a). Fifteen years postoperatively (Figure 1b), the JOA knee score was 85 points on both sides. The ROM of the right knee improved from −10/110° preoperatively to 0/125° postoperatively, and that of the left knee improved from −20/120° preoperatively to 0/125° postoperatively. The FTA of the right leg improved from 164° preoperatively to 170° postoperatively, and that of the left leg improved from 152° preoperatively to 168° postoperatively. This was a notable endpoint for the MCL, with no valgus deformity recurrence at the final follow-up.

Table 1. Clinical outcomes of 36 knees with valgus deformity before and after Total Knee Arthroplasty

| Measure                        | Before Surgery | After Surgery | P     |
|-------------------------------|----------------|--------------|-------|
| Mean JOA knee score           | 51 ± 12        | 86 ± 9       | <0.001|
| Mean extension angle (°)       | −13 ± 13       | −2 ± 4       | <0.001|
| Mean flexion angle (°)         | 115 ± 25       | 125 ± 16     | <0.001|
| Mean standing FTA (°)          | 158 ± 9        | 173 ± 2      | <0.001|

JOA, Japanese Orthopaedic Association; FTA, femorotibial angle.
Our representative case 2 was a 44-year-old woman who underwent bilateral TKA for valgus deformity due to rheumatoid arthritis (preoperative JOA knee scores: right knee, 55 points; left knee, 61 points) (Figure 2a). Eight years postoperatively (Figure 2b), the JOA knee score was 97 points on both sides. The ROM of the right knee had improved from $-40/65^\circ$ preoperatively to $0/110^\circ$ postoperatively, and that of the left knee had improved from $-20/115^\circ$ preoperatively to $0/120^\circ$ postoperatively. The FTA of the right leg improved from $163^\circ$ preoperatively to $171^\circ$ postoperatively, and that of the left leg improved from $158^\circ$ preoperatively to $168^\circ$ postoperatively. Similar to case 1, this was a notable endpoint for the MCL, with no valgus deformity recurrence at the final follow-up.

Discussion

With this new TKA technique that involved preserving the d-MCL using the lateral approach for valgus knees, we easily achieved the appropriate bone gap and good clinical outcomes. In the literature, the primary complications following TKA for valgus knees are tibiofemoral instability (2-70%), recurrent valgus deformity (4-38%), poor postoperative ROM (1-20%), wound problems (4-13%), patellar stress fracture and osteonecrosis (1-12%), patellar maltracking (2-10%), and peroneal nerve palsy (0.3-9.5%).\(^1\)\(^2\) We had considered how to reduce the incidence of these complications and speculated that it was important to preserve the d-MCL during TKA for valgus knees.

According to LaPrade\(^6\) the average proximal end of the tibial attachment of the d-MCL (the meniscotibial ligament) is 3.2 mm (range, 1.8-5.9 mm) distal to the medial tibial joint surface (Figure 3). This close attachment of the d-MCL to the joint surface suggests that it is likely to become damaged at the usual level of tibial cut during TKA.

Maes\(^3\) used the tibial cutting guide for TKA to achieve a posterior slope of $3^\circ$ and performed the tibial cut 9 mm distal to the lateral joint surface in 33 cadaver knees. An average of 54% of the tibial attachment area of the d-MCL was injured; furthermore, in 29% of all knees, complete detachment of the d-MCL attachment was reported. We believe that increasing the level of tibial cut increases the frequency of d-MCL injuries. Moreover, Griffith\(^7\) reported no apparent increase in the valgus angle by releasing the s-MCL.
when separating the deep layer and posterior oblique ligament and applying valgus torque in cadaver knees. However, they stated that when the d-MCL was subsequently released, an increase in the valgus angle was noted. In other words, while the s-MCL is relaxed in the valgus knee, it is thought that valgus deformity will be enhanced if the d-MCL is released. In addition to the s-MCL, the d-MCL appears to be an important medial soft tissue stabilizer that is particularly important in the valgus knee.

Few reports have provided detailed information about tibial cutting levels in TKA for valgus knees. Ranawat et al.8 recommended performing tibial cut at a point of 6-8 mm distal to the medial tibial joint surface. However, this is believed to be detrimental to the d-MCL, as exemplified by the study by Griffith et al.7 and further increases the valgus deformity, thus increasing the chance of requiring extensive dissection of the lateral soft tissue and an attenuated valgus cutting angle at the distal femur. Additionally, when it is difficult to obtain soft-tissue balance, the probability of requiring a highly constrained implant increases.

Preserving the d-MCL results in the need for only minimal release of the lateral soft tissue, easier achievement of soft tissue balance, and less frequent use of more constrained prosthesis models. Additionally, it reduces the incidence of common postoperative complications of TKA in the valgus knee.

However, for our 2 patients with standing preoperative FTA of 124° (Figure 4A) and 139°, although an additional lateral soft tissue release was performed, soft tissue balance could not be achieved using the described d-MCL preservation method, and a rotating hinge prosthesis will likely be required by both patients (Figure 4B). Therefore, when the standing FTA is approximately 140°, the surgeon should choose either the usual PS implant or a more constrained prosthesis.

The surgical approach also plays an important role in TKA for valgus knees. In general, TKA is performed using the medial approach for varus knees; however, when performing TKA for valgus knees, it is important to be familiar with the lateral approach as well.

When the medial approach is used for a fixed valgus knee, extensive dissection of the lateral soft tissue, such as the lateral retinaculum, posterolateral joint capsule, iliotibial band, popliteus tendon, and lateral collateral ligament, is inevitably required based on the degree of deformity. As a result, the blood flow to the patella decreases and the possibility of patellar necrosis increases. However, when the lateral approach is employed, blood flow from the medial side of the knee to the patella is preserved. When the lateral approach is used in patients with fixed valgus knees and in those with PF joint tightness, the lateral soft tissue tightness can be released, and soft-tissue balance is easily achieved by preserving the d-MCL without further dissecting the lateral soft tissue. Although we could not achieve soft-tissue balance in the two patients with severe valgus deformity and standing preoperative FTA of 124° and 139°, among the other 34 knees in which d-MCL was preserved, lateral soft tissue release was only required in three cases and limited to the posterolateral joint capsule; soft tissue balance was easily achieved.

One of the limitations of this study is its small sample size. The incidence of valgus deformity in western countries is nearly 10% in patients who undergo TKA.1 However, there are fewer cases of valgus deformity in Japan, where this single-institution study was performed. The second limitation is that the procedure mentioned above cannot be performed when the MCL shows a degree of laxity that does not allow the surgeon to determine its endpoint before surgery. Additionally, this procedure cannot be performed when the medial articular surface is elevated above the lateral articular surface following a high tibial osteotomy. The third limitation is that no comparison could be made with a traditional technique that does not preserve the d-MCL because there were few target cases and ethical concerns. However, we believe that our new procedure resulted in better outcomes with no obvious complications than TKA for valgus knee deformity, which has been associated with complications.2

In conclusion, we obtained good clinical results by performing TKA while preserving the d-MCL for valgus knee deformity. Complications, such as tibiofemoral instability, valgus deformity recurrence, patellar necrosis, deep infection, wound problems, and peroneal nerve paralysis, were not observed. When the standing FTA ranges from 141° to 167°, TKA can be performed using the usual PS implant to preserve the d-MCL.

Ethics Committee Approval: This retrospective cohort study was approved by the Kansai Medical University Institutional Review Board (Approval Number: 2019268).

Informed Consent: The requirement for informed patient consent was waived because all patient data were fully de-identified.

Author Contributions: Concept - H.O.; Design - H.O.; Supervision - T.S.; Materials - H.O., M.M., T.K., H.S.; Data Collection and/or Processing - H.O.; Analysis and/or Interpretation - H.O.; Literature Review - H.O.; Writing - H.O., H.O., M.M., T.K., H.S.; T.S.

Declaration of Interests: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study has received no financial support.

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