Tibiofemoral Instability After Primary Total Knee Arthroplasty: Posterior-Stabilized Implants for Obese Patients

ATA CAN, MD; FAHRI ERDOGAN, MD; AYSER EVUL ERDOGAN, MD

Abstract

Tibiofemoral instability is a common complication after total knee arthroplasty (TKA), accounting for up to 22% of all revision procedures. Instability is the second most common cause of revision in the first 5 years after primary TKA. In this study, 13 knees with tibiofemoral instability after TKA were identified among 693 consecutive primary TKA procedures. Patient demographics, body mass index, clinical symptoms, previous deformity, previous knee surgery, complications, interval between index TKA and first tibiofemoral instability, causes of instability, and interval between index TKA and revision TKA were retrospectively reviewed. Clinical outcomes were assessed with the Lysholm Knee Scoring Scale. All patients were women, and mean body mass index was 37.7 kg/m² (range, 27.2-52.6 kg/m²). Mean interval between index TKA and first tibiofemoral instability was 23.4 months (range, 9-45 months), and mean interval between index TKA and revision TKA was 25.6 months (range, 14-48 months). All patients had posterior cruciate ligament-retaining implants. Of the 13 knees, 11 had flexion instability and 2 had global instability. In all patients, instability was caused by incompetence of the posterior cruciate ligament; additionally, 1 patient had undersized and malpositioned implants. In 4 knees, the polyethylene insert was broken as well. All patients underwent revision TKA. Lysholm Knee Scoring Scale score had improved from a mean of 35.8 (range, 30-46) to a mean of 68.3 (range, 66-76). All patients included in this study were female and obese. The main cause of instability was secondary posterior cruciate ligament rupture and incompetence. The use of posterior-stabilized implants for primary TKA may prevent secondary instability in obese patients. [Orthopedics. 201x; xx(x):xx-xx.]

Total knee arthroplasty (TKA), which is one of the most common orthopedic surgical procedures, is a proven treatment option for end-stage osteoarthritis of the knee. However, instability is an increasingly frequent complication of primary and revision TKA, and it accounts for up to 22% of all knee revision procedures. Instability has been reported as the second most common reason for revision TKA in the first 5 years after primary TKA, after periprosthetic infection. However, clinically apparent and radiographically obvious overt instability is rare, and dislocation is even rarer.

Tibiofemoral instability may occur in the sagittal or coronal plane. Posterior cruciate ligament (PCL) rupture with cruciate-retaining prostheses, implant malposition, polyethylene insert fracture, flexion-extension gap mismatch, excessive soft tissue release among patients with preoperative severe valgus deformity, or infection has been blamed for tibiofemoral instability. Tibiofemoral instability after TKA has been described with unicompartmental prostheses in the past, and the use of posterior-stabilized implants has been advocated to prevent this complication.

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mental, mobile-bearing, cruciate-retaining, posterior-stabilized, and semiconstrained designs.\textsuperscript{10} Published data on tibiofemoral instability are insufficient and complicated in the orthopedic literature, making evaluation of the causes and treatment of tibiofemoral instability difficult.

This study describes 13 knees in 12 patients who had atraumatic tibiofemoral instability after primary TKA and analyzes the factors related to instability.

**Materials and Methods**

Between January 2011 and May 2015, 466 patients underwent a total of 693 primary TKA procedures (including 227 bilateral procedures) with the same total knee implant system (Vanguard Complete Knee System; Biomet, Warsaw, Indiana). Of the 693 treated knees, 530 had implantation of cruciate-retaining prostheses, 163 had implantation with posterior-stabilized prostheses, and 62 had patellar resurfacing added to the TKA procedure. In all cases, cemented TKA was used. The authors identified 13 knees (12 patients) without tibiofemoral instability after TKA. Of the 693 treated knees, 530 had implantation of cruciate-retaining prostheses, 163 had implantation with posterior-stabilized prostheses, and 62 had patellar resurfacing.

Patient age, sex, body mass index, clinical symptoms, original indication for surgery, previous deformity, previous knee surgery, wound complications, interval between index TKA and first tibiofemoral instability, causes of instability, interval between index TKA and revision TKA, and complications were retrospectively reviewed. Comorbidities and patient neurologic status also were considered. Patients who had patellofemoral instability without tibiofemoral instability were not included in this study.

Clinical assessment of the knees included physical examination and observation of the patient while walking and while climbing and descending stairs. Any sign of giving way of the knee or pain on walking was noted. Hip and ankle deformities and clinical evidence of neurovascular compromise were evaluated. Effusions were noted. Sagittal plane instability was evaluated with anterior and posterior drawer tests. Recurvatum was evaluated as hyperextension in the sagittal plane in extension. Frontal plane instability was evaluated with varus-valgus testing of the knee in full extension, at 30° flexion, and at 90° flexion. Patellar tracking was checked, and competence of the extensor mechanism was evaluated with resisted knee extension. Clinical outcomes were assessed with the Lysholm Knee Scoring Scale.

Standing anteroposterior and lateral radiographs and full-length lower limb radiographs were obtained. Radiographs were examined for axial alignment of the knee, radiolucency associated with prosthetic loosening, component positioning, and joint line level. Component malposition was defined as coronal plane malalignment of greater than 5°, sagittal plane tibial component alignment of less than 0° (anterior slope) or greater than 10° (excessive posterior slope), or axial malalignment of the femoral component of greater than 5° internal rotation.\textsuperscript{10}

Data were analyzed with SPSS version 22 software (SPSS Inc, Chicago, Illinois). Statistical analysis was performed with Student’s t test. Significance was set at $P<.05$. The study was approved by the institutional review board.

**Results**

Patient data are summarized in the Table. All 12 patients were women. Mean patient age at the time of index TKA was 62.6 years (range, 52-73 years). Mean body mass index at the time of tibiofemoral instability was 37.7 kg/m$^2$ (range, 27.2-52.6 kg/m$^2$). For all patients, the original indication for surgery was end-stage osteoarthritis of the knee, and no patient had previous knee surgery. Mean interval between index TKA and first tibiofemoral instability was 23.4 months (range, 9-45 months), and mean interval between index TKA and revision TKA was 25.6 months (range, 14-48 months). Of the 12 patients, 8 had simultaneous bilateral TKA and 4 had unilateral TKA. One patient who had bilateral TKA also had bilateral tibiofemoral instability. All patients who had instability had cruciate-retaining implants, and 1 also had patellar resurfacing.

The main symptoms were occasional giving way of the knee, pain on walking, difficulty climbing and descending stairs, effusion, and anxiety. Reportedly, none of the patients had overt trauma or total dislocation. None of the patients had a preoperative valgus deformity, and mean preoperative varus deformity was 5° (range, 3°-11°). Review of the operative notes in each case showed that none of the patients had extensive soft tissue release. All patients had an uneventful postoperative period, with no wound or systemic complications. Comorbidities occurred in 7 patients, with some having more than 1: 7 had high blood pressure, 3 had diabetes mellitus, 1 had glaucoma, and 1 had coronary artery disease. None of the patients had a neurologic disorder. Of the 5 patients who had previous surgery, 3 had musculoskeletal procedures, including surgery to treat forearm fracture, osteoporotic spine fracture, and lumbar disk herniation, and 2 had gynecologic surgery.

All patients had anxiety when walking and when climbing and descending stairs. None of the patients had hip or ankle deformity or clinical evidence of neurovascular compromise. Physical examination of the knee showed sagittal plane instability in all patients who had positive anterior and posterior drawer test results. All patients had hyperextension in the sagittal plane in extension, with recurvatum as the clinical manifestation. Varus-valgus testing of the knee in full extension, at 30° flexion, and at 90° flexion showed stability for all patients except 1 who had a global pattern of instability. Patellar tracking and competence of the extensor mechanism were normal for all patients. Mean active range of motion was -20° to 90° (range, -30° to 100°), and mean passive range of motion was -20° to 100° (range, -30° to 110°). Of the 13 knees, 11 had flexion...
### Table

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**Abbreviations:** PCL, posterior cruciate ligament; TKA, total knee arthroplasty.
instability and 2 had global instability. Mean Lysholm Knee Scoring Scale score was 35.8 (range, 30-46).

Radiographs revealed anterior translation of the tibial component and recurvatum in extension for all knees, and additionally, 2 knees had coronal plane instability. For 1 patient who had coronal and sagittal instability, the femoral component was undersized, and excessive tibial slope greater than 10° was noted. No radiolucency was associated with prosthetic loosening, osteolysis, or component migration. All implants were well fixed. Joint line levels were normally positioned for all patients except for the patient who had coronal and sagittal instability.

No patient had clinically suspected infection. Laboratory tests, including erythrocyte sedimentation rate and C-reactive protein level, were conducted to exclude periprosthetic joint infection. All results were within normal limits. All patients underwent arthrocentesis to evaluate the articular fluid. Synovial white blood cell count and differential were normal, and culture findings were negative for all patients.

All patients had revision TKA. Except for 1 patient who had global instability with a posterior tibial slope of greater than 10°, none of the patients had malpositioning of the femoral or tibial component or imbalance of the flexion-extension gap. At surgery, 12 knees had total rupture of the PCL and posterior capsular stretch. For 1 knee, the PCL and posterior capsule were grossly stretched, elongated, and nonfunctional, although the ligament was intact. For all patients, the PCL showed insufficient competence. For 4 knees, the polyethylene insert was broken as well (Figure 1). For 11 knees, the femoral component and the polyethylene insert were revised with posterior-stabilized components (Figure 2). For all patients, the PS Plus polyethylene insert (Vanguard Complete Knee System) was used. For 1 patient who had a broken polyethylene insert, only the polyethylene insert was exchanged with an insert that was 2 mm thicker. For the patient who had global instability with an undersized femoral component and excessive posterior tibial slope revision, TKA of both femoral and tibial components was performed with posterior-stabilized components (Figure 3). For the second patient who had global instability, revision TKA of the femoral component and polyethylene insert was performed with posterior-stabilized components (Figure 4). Soft tissue balancing of the knee was assessed intraoperatively. For all patients, the knee was believed to be stable on completion of revision TKA.

No patient was lost to follow-up. No complications occurred at a mean follow-up of 20.1 months (range, 15-28 months) for the 12 knees that underwent revision TKA with posterior-stabilized components. However, the patient who underwent isolated polyethylene insert exchange had recurrent instability 8 months postoperatively. A second revision TKA was performed with a posterior-stabilized femoral component and polyethylene insert. No complications were noted at 12-month follow-up.

During the study period, the percentage of revision TKA procedures performed for tibiofemoral instability at the study institution was 1.88%. None of the patients had further instability. At the last follow-up, none of the patients had symptoms of recurrent effusion. Physical examination at 90° flexion showed no anterior tibial translation in any of the knees. At the last follow-up, the Lysholm Knee Scoring Scale score had improved to a mean of 68.3 (range, 66-76). This improvement was statistically significant (P<.05).

**DISCUSSION**

Instability after TKA is an increasingly frequent complication, accounting for up to 22% of all knee revision procedures.1-5,7,10 This is the second most common cause of revision in the first 5 years after primary TKA.1,5,7 Instability-related
revisions are performed an average of 4 years after primary surgery.\textsuperscript{3} One study found that instability was the second most common cause of revision in the first year as well.\textsuperscript{10} Another study found that instability was the leading cause of failure less than 2 years after primary TKA.\textsuperscript{6} In the current series, the interval between index TKA and first tibiofemoral instability was 23.4 months (range, 9–45 months). Mean interval between index TKA and revision TKA was 25.6 months (range, 14–48 months). Of the current patients, 8 had tibiofemoral instability in the first 2 years, and all had instability in the first 5 years. Likewise, 7 patients underwent revision TKA in the first 2 years after index TKA. These figures reflect the characteristics of patients who undergo revision TKA for tibiofemoral instability. Although a definite incidence is not known, in the current series, the percentage of revision TKA procedures performed for tibiofemoral instability was 1.88% (13 of 693 procedures).

The main causes of tibiofemoral instability are inappropriate implant selection and surgical error, and these are mostly preventable.\textsuperscript{3,4,6} Ligamentous balancing and equal flexion-extension gaps are extremely important for stability in both the coronal and sagittal planes. Determining the underlying cause of instability is imperative for appropriate treatment. Tibiofemoral instability is broadly classified as flexion instability, extension instability, genu recurvatum, and global instability.\textsuperscript{1,4,5}

Flexion instability occurs when the flexion gap exceeds the extension gap and causes flexion-extension gap mismatch. Laxity is caused by either inadequate filling of the flexion space with the implant or PCL disruption. Causes of flexion instability are use of an undersized femoral component and/or excessive tibial slope, secondary PCL incompetence with cruciate-retaining designs, overresection of posterior femoral condyles, and internal rotation and/or inadequate size of the femoral component.\textsuperscript{1,5,6}

Genu recurvatum, or hyperextension instability, arises mostly as a result of bone deformity or insufficient quadriceps strength. Genu recurvatum usually is seen in patients with rheumatoid arthritis, poliomyelitis, or Charcot arthropathy as well as in patients with severe valgus deformity.\textsuperscript{1,5}
There are 2 forms of extension instability, symmetrical and asymmetrical. Symmetrical extension instability occurs as a result of excessive distal femoral or proximal tibial resection that leads to flexion-extension gap mismatch. Asymmetrical extension instability occurs as a result of ligamentous asymmetry or misalignment in the coronal plane.1,5

Global instability is combined mediolateral and flexion-extension instability. Global instability occurs in patients with multiligamentous insufficiency, undersized implants, and wear or fracture of the polyethylene insert. Global instability may lead to recurvatum deformity. Severe global instability may cause tibiofemoral dislocation.11

The authors hypothesized that the cause of instability in the current case series was late PCL incompetence. Rupture or insufficiency of the PCL occurred in all patients, and simultaneous polyethylene insert damage was present in 4 knees. The authors believe that PCL incompetence leads to flexion instability, which in turn leads to damage of the polyethylene insert at the posteromedial border. Polyethylene wear or ligament rupture has been reported to cause tibiofemoral dislocation as well.9,12,13 Further, a loose flexion gap, evidenced by an undersized femoral component and excessive tibial slope in addition to PCL incompetence in the patient who had global instability, probably contributed to instability. All patients had hyperextension deformity, but none of them had bone deformity or insufficient quadriceps strength.

Patients with tibiofemoral instability require thorough evaluation. The clinical picture may include subtle instability with symptoms of recurrent effusion, giving way, soft tissue tenderness, pain over the pes anserine bursa, and overt dislocation. Frank dislocation is very rare,9 but varus-valgus or genu recurvatum deformity may be evident when walking. Patients with flexion instability describe difficulty rising from a chair.3 All of the current patients had hyperextension in the sagittal plane in extension, with recurvatum as the clinical manifestation. Patients who had global instability also had varus deformity in the coronal plane.

Flexion instability is a clinical diagnosis, with no objective diagnostic criteria. Many symptoms are inconsistent with clinical findings, which makes diagnosis difficult. On the other hand, flexion instability occurs not only in patients with cruciate-retaining designs but also in those with posterior-stabilized designs.5 Usually, the jump distance provided by the cam and post mechanism in posterior-stabilized designs prevents frank dislocation. However, excessive flexion gap can lead to instability as a result of anterior tibial translation.12 The finding of varus malalignment of the tibial component, inadequate distal femoral resection, an undersized femoral component, excessive posterior tibial slope, and internal rotation of the femoral or tibial component on radiographs suggests flexion instability.5,7,14

Management of tibiofemoral instability depends on the underlying cause. The pattern of instability must be determined because treatment should be tailored to the specific cause of instability. Increasing constraint during revision TKA is essential. As was noted for 1 patient in the current series, isolated polyethylene insert exchange usually is not successful and leads to a second revision with a more constrained implant. However, some authors reported that isolated polyethylene insert exchange was comparable to revision of components in selected patients.11 Naturally, axial malalignment and flexion-extension gaps should be restored if necessary. The femoral component may be revised with a larger component to decrease the flexion gap. Excessive tibial slope must be reduced, and rotational malalignment must be corrected. Joint line elevation may be needed as well.5

Component design may affect clinical outcomes and survival rates for primary TKA. However, the total knee implant system used in this series has reliable features, and no implant-related adverse outcomes occurred.15,16 Revision of all components instead of partial component revision for failed TKA as a result of mechanical problems is advocated.5,17,18 However, in the current case series, all 11 knees in which only the femoral component and polyethylene insert were revised with posterior-stabilized components did well after revision TKA. The authors believe that this was because of the use of the PS Plus polyethylene insert. The standard Vanguard PS post geometry is rounded to minimize the effect of femoral rotation. The standard PS bearing does not constrain the femur in rotation or varus-valgus lift-off. The PS Plus post geometry is rectangular and has a prominent anterior lip that resists anterior femoral slide during gait. With the standard PS bearing, 15° internal-external rotation is possible without varus-valgus constraint. However, the PS Plus bearing is more constrained than the standard PS bearing and provides more stability and initial constraint. It resists rotation and varus-valgus lift-off, limiting rotation to ±2° and varus-valgus lift-off to 2°. The improvement in the Lysholm Knee Scoring Scale score confirmed that stability improved after revision TKA for all patients.

The patient who had recurrent instability 8 months after isolated polyethylene insert exchange underwent a second revision TKA with a posterior-stabilized femoral component and polyethylene insert without tibial component change. There were no complications 12 months postoperatively.

Obesity, female sex, and neuromuscular comorbidity increase instability.9 Obesity is also a significant risk factor for osteoarthritis. The number of obese people has increased exponentially, and obesity is a worldwide problem of epidemic proportions.19 The prevalence of arthritis is increased by 38%, 200%, and 400% in overweight, obese, and morbidly obese patients, respectively.20 Thus, overweight and obese people are more likely than
nonobese people to undergo joint arthroplasty, and obese patients have increased complication rates compared with patients with normal body mass index. Further, one study found that patients who underwent total hip and knee arthroplasty actually gained weight postoperatively. Another study found that approximately 70% of patients undergoing TKA remained at the preoperative weight. Either way, obesity is a risk factor for subsequent revision. In the current case series, mean body mass index at the time of tibiofemoral instability was 37.7 kg/m² (range, 27.2–52.6 kg/m²). Of patients included in the current study, 3 were overweight, 2 had class I obesity, 3 had class II obesity, and 4 had class III obesity, according to the World Health Organization classification, and no patients were of normal weight.

As the average age of patients undergoing TKA has been decreasing, the prevalence of obesity in relatively young patients has been increasing. Patients younger than 64 years old who undergo TKA are 4 times more likely to be obese than older patients. A projection study estimated that patients younger than 65 years old are expected to account for 55% of all patients undergoing primary TKA and 62% of all patients undergoing revision TKA by 2030, and the fastest-growing age category for patients undergoing primary TKA is 45 to 54 years. It is widely accepted that young patients are more demanding than older patients because of their greater need for mobility and higher level of mobility. Young patients have higher expectations, and there is a higher prevalence of obesity in this age group. Their anticipated lifespan is longer than that of the implants. Age is a major factor in the outcome of primary TKA, and revision rates are higher in younger patients. The demand for TKA for younger patients has increased as obesity has become more common.

In the current study, mean patient age at index TKA was 62.6 years (range, 52–73 years). These patients were not exceptionally young, but 10 of them were 64 years old or younger, making them more demanding and more likely to have complications.

Limitations
This study had several limitations. The study was retrospective and included a relatively small number of patients, which limited the statistical power. However, the patient group was homogeneous in terms of pattern of instability, etiologic factors causing instability, and treatment modalities. One strength of the study was lack of follow-up loss.

Conclusion
In the current study, patients who had tibiofemoral instability after primary TKA were female, obese, and at high risk for complications. With use of a cruciate-retaining design, in the absence of the anterior cruciate ligament, the PCL may not be able to withstand the immense moments of the knees of overweight or obese patients and ultimately may rupture. None of the current patients had a neurologic comorbidity, implying that obesity was likely the triggering cause of instability. Especially in young, obese women, the use of posterior-stabilized implants in primary TKA may prevent secondary tibiofemoral instability.

References


