Effect of Pedal Deformity on Gait in a Patient With Total Knee Arthroplasty

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abstract

The authors present the case of an 81-year-old man who, despite an anatomically aligned total knee arthroplasty, continued to have knee pain. The patient’s ipsilateral rigid flatfoot caused by an earlier partial pedal amputation resulted in a valgus moment during gait, thus creating clinical symptoms in the total knee arthroplasty. Because of the deformity and scarring within the flatfoot, this valgus deformity was corrected through a varus distal femoral osteotomy. The result was normalization of the mechanical axis of the lower limb and a pain-free total knee arthroplasty with an excellent clinical outcome. This case shows the importance of comprehensive lower-extremity clinical and radiographic examination as well as gait analysis to understand the biomechanical effect on total knee arthroplasty. Recognition of pedal deformities and lower limb malalignment is paramount for achieving optimal outcomes and long-term success of total knee arthroplasty. The authors show that a rigid or nonflexible pedal deformity can have negative biomechanical effects on total knee arthroplasty. [Orthopedics. 2016; 39(1):e159-e161.]

Total knee arthroplasty (TKA) is an effective surgical option for the treatment of irreversible knee osteoarthritis. The potential effect of hindfoot deformity on knee alignment after TKA is not fully understood, and there is no true consensus on whether patients should undergo pedal reconstruction before or after TKA. To determine when pedal deformity affects the results of TKA, the authors report a patient with an acquired posttraumatic pedal hindfoot valgus deformity who underwent adjuncive femoral osteotomy to correct a painful, but anatomically aligned TKA.

CASE REPORT

An 81-year-old man who had end-stage osteoarthritis of the knee underwent left primary TKA that did not reduce his pain. The patient underwent revision TKA 1 year later because of continued pain on ambulation, located mostly in the lateral compartment. Neither the revision TKA nor subsequent intra-articular corticosteroid injections provided symptomatic relief. On presentation to the authors’ institution, the patient had continued knee pain highly concentrated in the lateral compartment (Knee Society Score, 73) and profound ipsilateral posttraumatic pedal deformity. The patient had a land mine injury that necessitated partial foot amputation of the lateral 3 rays, a rigid
flatfoot, and a stiff subtalar joint (5° inversion, 10° inversion), with scarring and atrophic skin. Additionally, physical examination of the knee showed no ligamentous instability. Standard goniometric evaluation was used to assess range of motion, and the patient had full active and passive range of motion (0°-120°). The patient had no effusion, no infection, and no pathology of the hip or knee.

The patient underwent long-leg static radiographic evaluation. The mechanical lateral distal femoral angle measured 88°, and the anatomic lateral distal femoral angle measured 80°. Both of these values were within normal limits. However, mechanical axis deviation of the lower extremity was greater than normal, measuring 3 cm lateral to the center of the knee, indicating valgus (Figure 1). Axial hindfoot radiograph showed a valgus calcaneus.

Gait evaluation showed ambulation with a substantial degree of valgus thrust, as evidenced by a lateral ground reaction force vector that was created by the patient’s rigid hindfoot valgus. Because the foot was not safely operable as a result of previous trauma, planning for the new alignment was based on the location of the ground reaction force vector, not on the standard mechanical axis. With the use of SIMM modeling software version 7 (MusculoGraphics, Inc, Motion Analysis Corp, Santa Rosa, California), the amount of correction at the osteotomy was mapped, based on moving the ground reaction force vector to the normal location, which is through the medial collateral ligament. A varus-producing distal femoral osteotomy with fixator-assisted nailing was performed to medialize the ground reaction force vector (postoperative mechanical lateral distal femoral angle, 91°; anatomic lateral distal femoral angle, 86°). This software is used to locate ground reaction force vectors and their relationship to the center of the knee joint. If the software is unavailable, planning for osteotomy may be based on anteroposterior erect leg films using a standard mechanical axis planning method. The degree of correction is based on the location of the mechanical axis, with a goal of 3 to 6 mm medial to the center of the knee joint (planned varus).

At 7 years of follow-up, the patient had active range of motion of the knee spanning 105° flexion to 5° extension. The patient also had neutral knee position in static stance; a 1-cm limb length discrepancy, with a longer left lower extremity; and mechanical axis deviation of 2.1 cm medial to the center of the knee. Gait analysis showed a normalized ground reaction force vector without pain (Knee Society Score, 90) (Figures 2-3).

**DISCUSSION**

Providing optimal patient outcomes, including decreasing pain and promoting longevity of TKA, requires accurate surgical anatomic alignment. \(^3\) Static radiographic measurements have long been used as the standard to assess and predict abnormal joint and TKA loading patterns. \(^4\) On a long-leg standing radiograph (anteroposterior view, with the patella forward to include the pelvis, bilateral knees, and bilateral ankles), the normal mechanical axis of the lower extrem-
ity is defined by a line from the center of the femoral head to the center of the ankle and passing through the center of the knee.\(^5\)\(^6\) Lee and Jeong\(^7\) reported 142 cases of TKA and noted that an altered mechanical axis precipitated new-onset ankle arthritis in 31 (21.8%) patients who did not have adequate hindfoot motion to compensate.

Studies show that TKA exerts an effect on hindfoot alignment.\(^7\)\(^-\)\(^9\) In a prospective study of 100 patients who underwent TKA, Chandler and Mosakal\(^8\) found that varus deformities of the hindfoot remained in varus after TKA and that valgus deformities of the hindfoot remained in valgus after TKA.\(^8\) Thus, alignment of the TKA has a direct influence on hindfoot motion, but at a smaller magnitude (50%). However, the current patient’s hindfoot was stiff and therefore produced a negative influence on the knee.

Few studies have reported the effect of pedal alignment on TKA.\(^2\)\(^-\)\(^7\)\(^,\)\(^10\) The knee has little ability to compensate for varus or valgus of the foot and ankle.\(^11\) However, knee flexion or extension compensates for sagittal plane foot and ankle deformities, such as equinus or calcaneus.\(^12\) In contrast, the influence of rigid preoperative pedal deformity on the mechanical axis of the lower extremity has been described, with persistent hindfoot valgus causing knee valgus in 29% of 169 TKA procedures performed in 128 patients.\(^10\) A rigid valgus hindfoot deformity, as in the current case, leads to lateral deviation of the mechanical axis at the knee.

During gait, the ground reaction force vector of the limb projects from the ground through the lateral heel and up to the pelvis and spine (T10). Knee malalignment can be surgically corrected with TKA or with either a distal femoral or proximal tibial osteotomy, depending on the degree and level of deformity. In the current case, normalization of the ground reaction force vector in gait was achieved with a varus femoral osteotomy. The patient could not undergo pedal reconstruction because the soft tissue envelope was tenuous as a result of previous trauma. As in other published reports, presurgical planning with kinematic assessment of gait provided useful information on the prognosis of TKA.\(^13\)

Options are available for nonoperative treatment of pedal deformity, including ankle-foot orthosis and orthotics. These devices tend to be less successful as the deformity becomes greater and more rigid, as in this case. If a patient presents with rigid pes planus and foot pain but no knee pain, the first choice is supramalleolar osteotomy. In a patient with lateral knee pain, the first choice of treatment is suprapatellar osteotomy. Greater translation and angulation may be obtained if osteotomy is performed at the supramalleolar level. A smaller degree of translation and angulation is required to correct the same deformity in suprapatellar osteotomy.

**CONCLUSION**

The current case shows the importance of understanding the biomechanical influences of the foot on the lower extremity and the success of TKA. Before TKA, it may be helpful to clinically evaluate range of motion of the subtalar and ankle joints and foot deformity. In specialized cases, formal gait analysis may be necessary. If a question of alignment is raised by clinical examination in postoperative patients with pain of uncertain etiology, static radiographic assessment and/or gait analysis may be helpful.

**REFERENCES**