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CASE REPORT

Total knee arthroplasty associated with tibial tubercle and simultaneous femoral and tibial osteotomies for severe extra-articular deformity: a case report

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Abstract: The restoration of the lower extremity mechanical axis in patients with osteoarthritis in knee and extra-articular deformity requires careful pre-operative planning. An extra-articular deformity may be corrected inside the knee by arthroplasty with intra-articular correction or outside of the knee by osteotomy alone or by arthroplasty combined with extra-articular corrective osteotomy. In this study, we described a unique case of simultaneous femoral and tibial osteotomies at the time of primary total knee arthroplasty in a 45-year-old woman. To prevent unnecessary bone loss, the intra-articular bone resections were made parallelly to the preexisting joint obliquity prior to the corrective tibial and femoral osteotomies. After restoration of the mechanical axis and healing of all osteotomies, a successful clinical and radiological outcome was achieved during the mid-term 5-year follow-up. The preoperative analysis of patients with an extra-articular deformity is invaluable and should include long-standing radiographs from the center of the femoral head to the center of the ankle. Although different osteotomy principles (opening wedge vs closing wedge) and fixation methods (stemmed revision prosthesis, intramedullary nail, locking plates) have been reported in the literature, the use of a tapered fluted long stem offers several benefits, including ease of application, rotational control, and possible early weight bearing. Total knee arthroplasty in combination with simultaneous extra-articular osteotomy is technically difficult but effective. This technique helps to preserve bone stock and ligament stability. A single intervention leads to less recovery time, reduced risk to the patients by avoiding two separate applications of anesthesia, and reduced costs. Based on the literature search, this is the first report describing the detailed surgical technique of simultaneous femoral and tibial osteotomies at the time of primary total knee arthroplasty associated with tibial tubercle osteotomy, achieving a comprehensive correction.

Keywords: osteoarthritis, extra-articular deformity, total knee arthroplasty, femoral osteotomy, tibial osteotomy

Introduction

Restoration of the mechanical axis of a lower extremity in patients with osteoarthritis of the knee and an extra-articular deformity requires careful pre-operative planning. A one-stage procedure, in which an extra-articular deformity is corrected during total knee arthroplasty with intra-articular bone resections and soft tissue balancing, avoids potential complications like nonunion, delayed union, infection, and fixation failure.[1]

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However, an extra-articular corrective osteotomy performed in a staged fashion or simultaneously during total knee arthroplasty should be considered if the line of planned resection is adjacent to the collateral ligament origins on the femoral epicondyles.[2]

There are few available reports of one-stage procedure in which an extra-articular, either femoral or tibial, osteotomy was performed during total knee arthroplasty.[1,3,4] However, a case of total knee arthroplasty with combined femoral and tibial osteotomies has been reported in a post-polio patient.[5] In this study, we present a unique case of simultaneous femoral and tibial osteotomies at the time of primary total knee arthroplasty associated with tibial tubercle osteotomy in a 45-year-old patient. The technique makes fragment fixation more difficult; regardless, the performed correction is more comprehensive than in cases of femoral and tibial corrective osteotomies during total knee arthroplasty reported in the literature. However, after restoration of the mechanical axis and healing of all osteotomies, a favorable clinical and radiological outcome was achieved nonetheless.

Report of the case

A 45-year-old woman with a history of tarsal resection performed to correct a congenital club foot deformity that primarily affected the development of her right lower extremity leading to lymphedema and leg length inequality. She underwent a left distal femur stapling epiphysiodesis at age 7; however, asymmetric physeal closure led to bowing deformity in her left knee after removal of the staples. At age 11 and 17, a valgus femoral osteotomy was performed for genu varum and the patient did well for approximately 25 years. However, symptoms of progressive degenerative arthritis developed at age 45. She finally attended our clinic with severe left knee tri-compartmental osteoarthritis along with significant extra-articular femoral and tibial deformity.

Further examination disclosed moderate valgus laxity in flexion, but otherwise intact medial and lateral collateral ligaments with certain endpoints. She had a decreased range of knee joint flexion (5–85°); regardless, she was able to actively extend and flex her knee against resistance, and peripheral pulses were intact. Radiograph, CT scan, and 3D-CT assessments revealed varus deformity in her supracondylar femur as well as a valgus deformity in her proximal tibial diaphysis and patella baja (Figure 1). A long-standing anteroposterior radiograph confirmed 17° of varus femoral deformity and 14° of valgus tibial deformity, with the mechanical axis passing just medial to her tibial plateau (Figure 2). The patient was obese, with a body mass index of 32 kg/m^2. She did not suffer from any other comorbid diseases, she did not smoke tobacco.

The surgery was performed without tourniquet inflation through midline incision with a medial parapatellar approach and with osteotomy of the tibial tubercle to expose the knee. The deep medial collateral ligament was dissected off the tibia; the superficial medial collateral ligament, and lateral ligamentous structures were preserved. Prior to the corrective osteotomies, the intra-articular bone resections were made parallelly to the pre-existing joint obliquity to prevent unnecessary bone loss. We used the Columbus revision total knee system (Aesculap AG, Tuttlingen, Germany).

Conventional navigation with only a short intramedullary rod placed just anterior to the intercondylar notch was used to perform a 9-mm distal femoral resection. Once the distal femur cut was made parallel to the pre-existing joint line obliquity, the extension gap first technique was continued by cutting the tibia. The extramedullary rod served as an approximate guide showing the needed angle to further correct the mechanical axis during the closing wedge tibial osteotomy. To confirm the correction degree, this intra-operative feedback was compared to pre-operative planning. The extension gap was checked with spreaders.

After drawing the rotational landmarks on the distal femur, the sizing of the same was performed with anterior referencing instruments and a femoral cutting block was fixed parallel to the surgical epicondylar line. Before performing the anterior, posterior and chamfer cuts, a control of the proper rotational alignment and sizing of the 4-in-1 cutting block was made. After the femur resections were completed, reamers were used to prepare the proximal tibia. Next, the midline incision was extended distally; the closing wedge osteotomy was made medially based at the apex of the tibial deformity under C-arm guidance (Figure 3). The tibial osteotomy was closed with contemporary bending of the gracile fibula, and the tibial canal distal to the closing wedge osteotomy was reamed. A stemmed trial was then provisionally inserted to fix the osteotomy site. The femoral osteotomy was approached through the midline incision. After distal femoral reaming, a laterally based closing wedge osteotomy was performed at the apex of the femoral deformity under the guidance of a C-arm. The femoral osteotomy was reduced, and the femoral canal proximal to the closing wedge osteotomy was reamed, followed by

Figure 1 Preoperative 3D-CT.
Abbreviations: 3D-CT, three-dimensional computed tomography.

stabilizing the femoral osteotomy site using the provisional stemmed component. The flexion and extension gaps were evaluated using the articular surface provisionals. The patella was not resurfaced because of its gracility. The stemmed tibial and femoral components were assembled and tried prior to cement mixing. The tibia and femur were then cemented at the joint surfaces only, allowing a tapered fluted long stem to fix the osteotomy sites when impacting the stemmed tibial and femoral component. After wire fixation of the tibial tuberosity, local autologous bone grafts were placed at the osteotomy sites, a drain was placed and closure was routine.

Antibiotic prophylaxis lasted 24 hrs; low-molecular-weight heparin was used to prevent thromboembolic disease for 5 weeks after surgery. Post-operative physiotherapy started at the first post-op day, partial weight-bearing was allowed after 6 weeks.

At 5 years of operation, the patient required no support and ambulated without pain. The pre-operative Hospital for Special Surgery knee score improved from 44 points and increased to final follow-up of 96 points. The pre-operative knee range of motion of 80° increased to a final follow-up of 100°. All osteotomy sites were radiographically healed (Figure 4); limb alignment (weight-bearing full-length

Figure 2 Preoperative full-length, weight-bearing lower extremity anteroposterior view.

X-ray measurements) was corrected from a combined 17° of femoral varus and 14° of tibial valgus deformity preoperatively to 6° of femoral varus postoperatively.

The patient was asked if the data concerning her case could be submitted for publication and she consented.

Discussion

Knee deformity may be caused by a variety of reasons. Most deformities, such as severe varus or valgus osteoarthritis and posttraumatic degenerative disease, are caused by intra-articular bone loss and are always corrected intra-articularly. An extra-articular deformity can come from various sources, including congenital diseases (osteogenesis imperfecta, skeletal dysplasia, etc.), fracture malunion, metabolic diseases (rickets), and iatrogenic causes (overcorrection or undercorrection during high tibial or distal femoral osteotomies). Although extra-articular malalignment may pose significant challenges during total knee arthroplasty, the exact amount of deformity that can be accepted is questionable.[6,7] The magnitude of the deformity, the distance from the knee, the location of the deformity in the femur or tibia, and the direction of the deformity (varus, valgus, flexion, extension, and rotation) should be considered when choosing between intra- and extra-articular corrections.[4] Mechanical axis corrections through a large intra-articular resection that jeopardize the collateral ligaments should be avoided.[5] A deformity closer to the knee causes greater malalignment at the joint line, whereas the deformities that are farther from the knee require smaller intra-articular resections to correct the mechanical axis.[8] Large intra-articular resections, both femoral or tibial, and lateral (in varus deformity) or medial (in valgus deformity), affect the stability of the knee joint in a different manner. The pre-operative analysis of the patients presenting extra-articular deformity is invaluable and should include long-standing radiographs from the center of the femoral head to the center of the ankle.[9]

Bone deformities may be corrected inside the knee by arthroplasty with intra-articular correction or outside of the knee by osteotomy alone or by arthroplasty combined with extra-articular corrective osteotomy. Promising results of total knee arthroplasty in combination with intra-articular resection and soft-tissue release have been reported in patients with knee joint osteoarthritis associated with extra-articular deformity of less than 20° in the coronal plane of the femur or tibia and up to 15° of recurvatum or 16° of pro-curvatum in the sagittal plane.[10] The approach of the axis correction through intra-articular resection and soft tissue release has certain

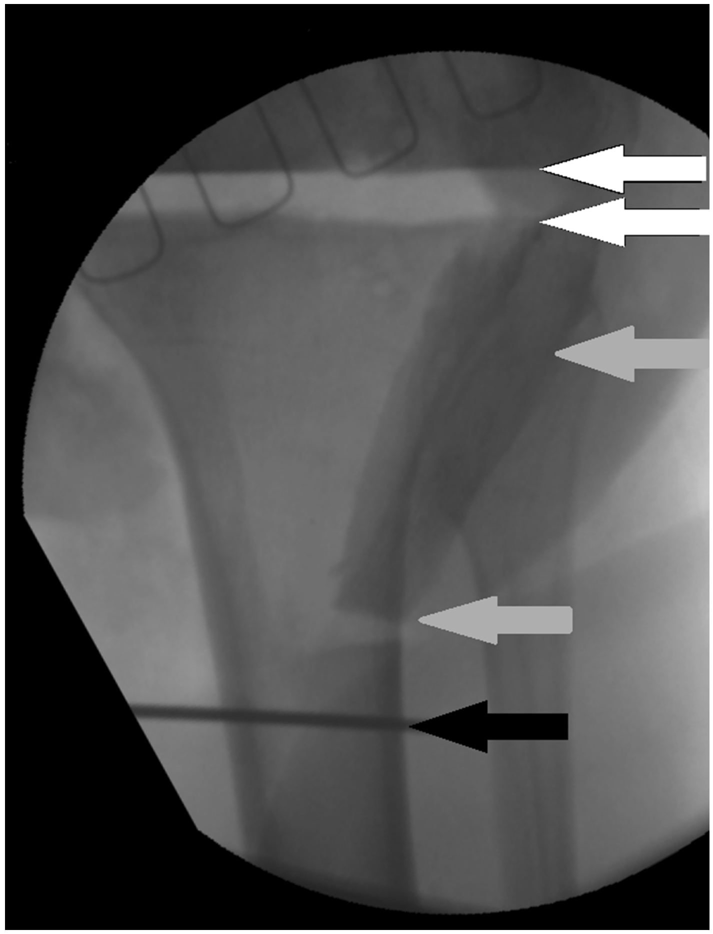

Figure 3 Intraoperative radiograph showing the intra-articular bone resections made parallelly to the preexisting joint obliquity (white arrows), osteotomized tibial tubercle (gray arrows), and insertion of Kirschner wire in the area of the planned tibial osteotomy (black arrow).

advantages, as it requires only a single surgery, allows standard rehabilitation, and avoids potential osteotomy complications such as delayed union, nonunion, infection or hardware failure.[2] However, intra-articular correction is not possible without large soft-tissue release in cases of severe extra-articular deformity. Regarding femoral deformity, a large release can balance the knee in extension but will, unavoidably, cause laxity on the released side in flexion. This will cause instability or internal rotational mal-positioning of the femoral component using a balanced gap technique.[11] The intra-articular correction of a tibial deformity does not cause gap problems and can be achieved by a larger release of the collateral ligaments because it acts in both flexion and extension. Regardless, hinged-type prosthesis or constrained bearing prosthesis may be required to stabilize the knee.[11] However, increasing component constraint can cause increased forces to be transmitted to implant-bone interfaces, which may lead to premature aseptic loosening.[12]

Whether to perform a corrective osteotomy and total knee arthroplasty as a single-stage or as a two-stage procedure remains a controversial topic.[13] Careful evaluation of the extent of osteoarthritis is important because mild to moderate cases (Ahlbäck grade 2 and 3) can be treated by osteotomy alone; therefore, a two-stage procedure may postpone the need of a second procedure, especially in younger patients.[14] On the other hand, single-stage surgery is an attractive option since it revokes the need for a second anesthesia application and operation, it is cost-effective, and requires less hospitalization time. However, the available literature is limited to only a few case series of either femoral or tibial deformity managed by concomitant single osteotomy.[3,7,15]

Different osteotomy principles (opening wedge vs closing wedge) and fixation methods (stemmed revision prosthesis, intramedullary nail, locking plates) have been recently published.[11,13,16] During total knee arthroplasty, the closing wedge osteotomy is more stable than opening wedge

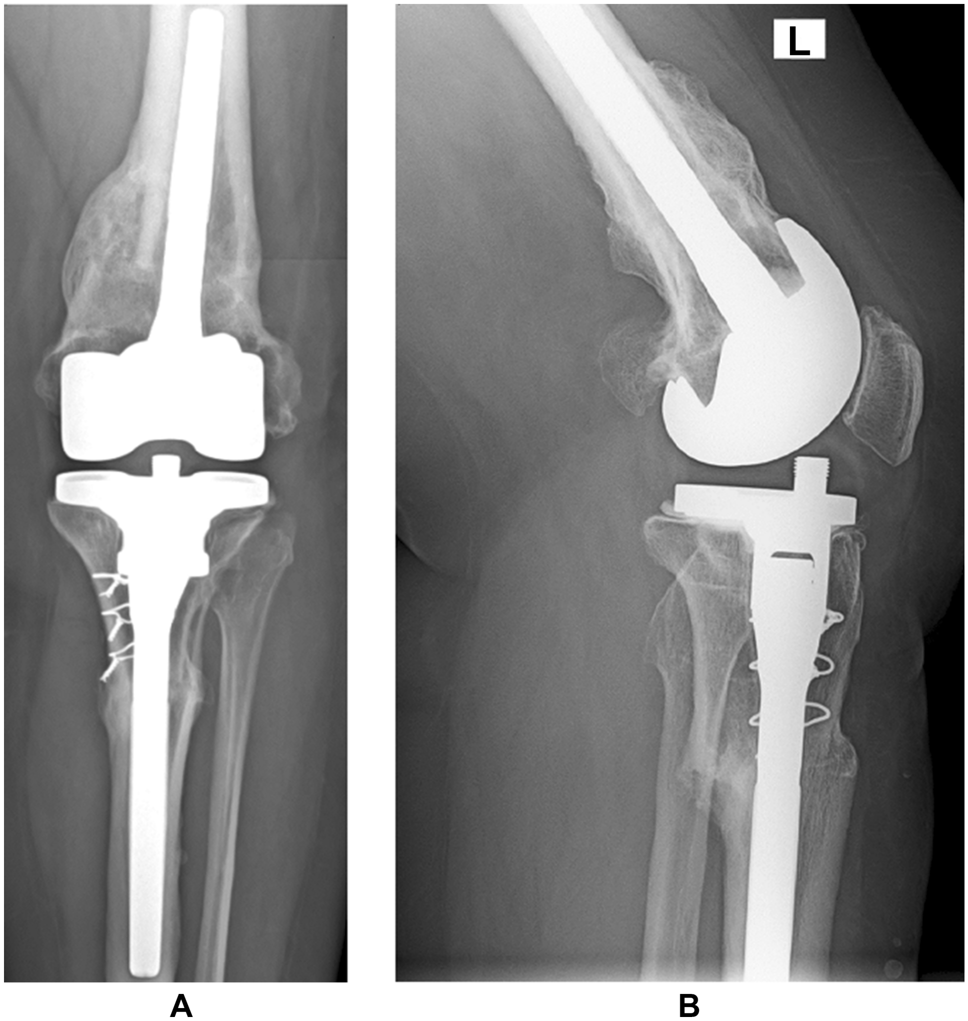

Figure 4 Postoperative radiograph taken at 5-year follow-up. (**A**) Anteroposterior view and (**B**) lateral view.

technique. The use of a tapered fluted long stem offers several benefits over other fixation methods, such as blade plates. These advantages include ease of application, rotational control, and possible early weight bearing.[5] Furthermore, delayed bone healing has been observed in plate application during total knee arthroplasty because it requires a larger incision and greater disruption of the soft tissue envelope.[16]

Total knee arthroplasty in combination with simultaneous extra-articular osteotomy is technically difficult but effective. This technique helps to preserve bone stock and ligament stability. A single intervention leads to less recovery time, reduced risks to patients by avoiding two separate applications of anesthesia, and reduced costs. However, performing a corrective extra-articular osteotomy in addition to total knee arthroplasty contributes to the complexity and risks of the procedure.[5,17] Therefore, the surgeon should be familiar with the techniques involved in revision knee arthroplasty, which should never be attempted without careful pre-operative planning. Ultimately, this decision should be based on the careful evaluation of the individual case and consultation with the patient concerning the risk versus benefit of each approach.

Ethics statement

Written informed consent was obtained from the patient. The review and approval of the institutional review board were not required. The patient agreed for his images and information to be applied to this work and allowed them to be published in this journal.

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Disclosure

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