Joints

Opening-wedge high tibial osteotomy: a seven- to twelve-year study

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Abstract

Purpose: medial opening-wedge osteotomy is a widely performed procedure used to treat moderate isolated medial knee osteoarthritis. Historically, the literature has contained reports showing satisfactory mid-term results when accurate patient selection and precise surgical techniques were applied. This study was conducted to investigate the clinical and radiographic seven- to twelve-year results of opening-wedge high tibial osteotomy in a consecutive series of patients affected by varus knee malalignment with isolated medial compartment degenerative joint disease.
Methods: we reviewed a case series of 147 medial opening-wedge high tibial osteotomies at an average follow-up of 9.5 years. Endpoints for evaluation included the reporting of adverse effects, radiographic evidence of bone union, radiographic changes in the correction angle during union, and clinical and functional final outcomes.
Results: good or excellent results were obtained in 94% of the cases: the patients reported no major complications related to the opening-wedge high tibial osteotomy surgical technique, bone graft resorption, implant choice or postoperative rehabilitation protocol. At final follow-up, the average hip-knee angle was 4° of valgus without major loss of correction during the healing process. A statistically significant change in the patellar height was detected postoperatively, with a trend towards patella infera.
Conclusions: medial opening-wedge high tibial osteotomy is still a reliable method for correcting varus deformity while producing stable fixation, thus allowing satisfactory stability, adequate bone healing and satisfactory mid- to long-term results.
Level of evidence: Level IV, therapeutic cases series.

Keywords: knee, osteotomy, high tibial osteotomy, opening-wedge osteotomy, osteoarthritis.

Introduction

Proximal tibial osteotomy has been proven to be an effective pain-relieving procedure for mild to moderate medial unicompartmental knee osteoarthritis (OA) associated with varus deformity. The objective of high tibial osteotomy (HTO) in patients with medial knee OA associated with varus deformity is to transfer the weight-bearing load to the lateral compartment of the knee, thereby slowing the progression of the chondral pathology in the medial compartment.
In this setting, appropriate patient selection is crucial. Today, the most common indication for HTO is still varus malalignment with isolated medial compartment OA in patients aged ≤ 65 years, with a good range of motion (ROM) and no major ligamentous instability (1). Indeed, poor prognostic factors include severe joint destruction, age > 65 years, presence of patellofemoral OA, poor active knee ROM (<90°), ≥ 15° flexion contracture, joint instability associated with lateral thrust, varus deformity ≥ 20°, and associated inflammatory arthritis (2).

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Multiple surgical techniques for medial compartment unloading have been described; these include dome osteotomy (3), lateral closing-wedge high osteotomy (CWHTO) (4), and medial opening-wedge osteotomy (OWHTO) (5).

Medial OWHTO has the theoretical advantage of allowing accurate correction in both the coronal plane and the sagittal plane, as well as preservation of the proximal bone stock for future total knee arthroplasty (TKA). Potential disadvantages of this technique include the increased risk (compared with other techniques) of a postoperative *patella baja* (or *patella infera*), postoperative knee stability issues, and the need for a period of protected weight-bearing.

This study was conducted to investigate the clinical and radiographic seven- to twelve-year results of OWHTO procedures performed in a consecutive series of patients affected by varus knee malalignment with isolated medial compartment degenerative joint disease. Various aspects were considered (non-union, loss of correction, osteotomy healing and pain relief) and it was hypothesized that no differences would be found between these patients, who were allowed immediate partial weight-bearing for the first three postoperative weeks and full weight-bearing thereafter, and patients (treated with previous surgical techniques, utilizing similar fixation devices) who were not allowed weight-bearing for at least six weeks postoperatively.

Methods

Participants

This study involved retrospective baseline data collection and prospective outcome assessment of a single-center case series of patients affected by isolated medial compartment degenerative knee joint disease who underwent OWHTO. Approval was obtained by the local ethic committee.

From January 2003 to January 2008, 147 OWHTOs were performed in 113 patients (34 cases were bilateral). The main inclusion criteria were age ≥ 18 years, an intact lateral joint compartment prior to surgery, and informed consent to participate in the study. The severity of the medial OA was evaluated in the standard weight-bearing anteroposterior (AP) view and graded using the Alhbäck classification (6): only patients with grade I-III underwent HTO. Other patient selection criteria included varus deformity ≤ 20°, flexion contracture ≤15°, total active ROM ≥ 90°, absence of moderate to severe patellofemoral OA, and body mass index ≤32. The study group comprised 63 males (55.7%) and 50 females (44.3%), with an average age of 34 years (range, 26-47 years). The right knee was involved in 55% of the cases. All the patients reported spontaneous and stimulated pain only at the medial side of the knee joint. Thirty-seven patients (32.7%) had previously undergone arthroscopic knee surgery. In all the patients, preoperative radiographic assessment was extensive, consisting of bilateral weight-bearing pangonogram, standard AP and lateral weight-bearing knee views, Rosenberg views of the affected knee, patellar evaluation according to Merchant (7), and standard magnetic resonance imaging (MRI) of the affected knee. Since a pangonogram can allow simultaneous visualization of the hip, knee and ankle joints, this technique was used to assess lower limb alignment. MRI was helpful in detecting possible intraosseous lesions, meniscal tears, ligamentous lesions, osteochondral defects, osteonecrosis or severe subchondral edema. The extent of varus malalignment detected on bilateral pangonogram was, on average, 9° (range, 3-15°). Fifty-six knees (38%) were classified as grade I, 71 (49%) as grade II, and 20 (13%) as grade III.

Intervention

Preoperative calculation of the degrees of correction was performed according to Jakob et al. (8), who suggested that correction of the mechanical axis should depend on the thickness of the remaining medial compartment cartilage: if 1/3 of medial cartilage is lost, the mechanical axis should pass 10-15% lateral from the center of the tibial plateau; if 2/3 of the cartilage is lost, the axis should pass 20-25% lateral, and if almost all the cartilage is lost, it should pass 30-35% lateral. Correction was always planned and carried out with extreme care because undercorrection may result in recurrence of the varus deformity and overcorrection may cause poor cosmetic and functional outcomes. The proximal osteotomy line was drawn preoperatively on a standard AP knee X-ray from a point 4 cm below the medial knee joint line to the tip of the fibular head (**Fig. 1**); particular care should be taken to maintain the preoperative anatomical posterior tibial

Fig. 1. Right knee. Proximal osteotomy line drawn preoperatively on a standard AP knee X-ray from a point 4 cm below the medial knee joint line to the tip of the fibular head.

slope. The patient was placed in the supine position on a radiolucent operating table and a tourniquet was applied. In all the cases, a diagnostic arthroscopic evaluation was performed prior to the HTO to evaluate the integrity of the lateral compartment of the knee. A 6-cm vertical incision was made over the center of the knee between the medial aspect of the tibial tuberosity and the posteromedial aspect of the tibia, just below the joint line. From the medial border of the patellar tendon, subperiosteal dissection was carried out towards the posteromedial aspect of the tibia, taking care to preserve the distal insertion of the superficial medial collateral ligament. Two guide wires were inserted in the standard fashion at a point 3.5-4 cm below the medial joint line and passed obliquely 1 cm below the lateral articular margin of the tibia towards the tip of the fibular head. Under fluoroscopic guidance, a tibial osteotomy was performed immediately below the guide wires using an osteotome. The surgeon always ensured that the osteotomy line extended to 1 cm medial to the lateral tibial cortex and was parallel to the posterior tibial slope on the sagittal plane. The mobility of the osteotomy site was checked with a slight valgus force and then the osteotomy line was opened according to the preoperative planning using a jack opener device consisting of two scalpels connected by a long screw. Subsequently, a calibrated wedge was inserted until the osteotomy was opened to the desired extent. Once the desired degree of correction had been achieved, internal fixation was obtained using a titanium T-plate (Citieffe, Italy) with three proximal and two distal holes. The proximal fixation screws were placed under fluoroscopic guidance and the defect was always grafted with bone substitute or iliac crest autograft. Before final plate fixation, limb alignment was checked fluoroscopically with a long extramedullary rod centered over the hip and ankle joints.

The postoperative protocol included immediate passive and active assisted ROM using a standard continuous passive motion device: the goal of the immediate postoperative rehabilitation protocol was to achieve 90° of knee flexion before hospital discharge. Partial weight bearing was allowed for the first three postoperative weeks while full weight bearing as tolerated was allowed as from six weeks postoperatively. All patients used one or two crutches during the first six postoperative weeks.

Outcome measurements

The patients underwent clinical evaluation, performed using the Functional Knee Society Scoring (KSS) system (9), preoperatively, annually and at final follow-up: the average follow-up was 9.5 years (range, 7-12 years). Radiological evaluation included standard AP and lateral X-rays at six weeks and three, six and twelve months postoperatively; a repeat pangonogram was performed at final follow-up in all the patients: in order to evaluate correction maintenance and bone healing, particular attention was paid to the measurement of the corrected mechanical axis on the pangonogram and to the progression of the degenerative joint disease according to the Ahlbäck classification (6). Union at the osteotomy site follows the same process as normal bone healing, as shown by Brosset et al. (10). Thus, on the lateral side of the osteotomy, the periosteal callus forms as a fibrous sleeve because the periosteum is continuous. On the medial side, healing occurs mainly through the medullary callus, due to the presence of an inter-fragment space created by the opening technique. Healing of the osteotomy was measured by the progression of the bone filling at the osteotomy site from the lateral cortex.

Radiographic evidence of delayed union or non-union included complications such as resorption within the osteotomy or collapse of the osteotomy. The mechanical angle was measured as the hip-knee-ankle (HKA) angle formed by lines drawn from the midpoint between the tibial spines to the center of the femoral head proximally and to the center of the talocrural joint distally. The postoperative height of the patella was measured and compared to the preoperative status according to the Caton-Deschamps index (11).

Data analysis

Statistical analyses were performed using SPSS 11.0 for Windows (SPSS Inc., Chicago, IL). For statistical evaluation, the non-parametric Mann-Whitney rank sum test was used. A value of $p<0.05$ was considered significant. The preoperative Functional KSS system score was compared with the Functional KSS system score at final follow-up. Individual factor categories (e.g. preoperative OA grade) were significantly associated with the Functional KSS system outcome at final follow-up when $p<0.05$. Complication risks with their binomial exact 95% confidence intervals were estimated by calculating the cumulative number of reported events during the follow-up period divided by the number of patients at baseline.

Results

All the patients were available for the clinical and radiological evaluation (according to the Functional KSS system) at final follow-up. The average final follow-up duration was 9.5 years (range, 7-12 years).

Clinical outcome

The mean Functional KSS system score increased from 65 points preoperatively to 89 points at final follow-up ($p< 0.01$). Good or excellent results were obtained in 106 patients (94%). Seven patients (6%) gave fair results, while none had a poor result. In addition, the 113 patients were found to differ significantly according to their OA grade; a higher grade was associated with a lower Functional KSS system score ($p< 0.0001$). In fact, in the grade I group (56 knees), 45 knees were rated excellent, 10 good and one fair; in the grade II group (71 knees), 51 knees were rated excellent, 17 good and 3 fair; in the grade III group (20 knees), 3 knees were rated excellent, 14 good and 3 fair.

Radiographic evaluation

At the final follow-up, all the knees showed complete bone filling at the osteotomy site. As all the patients underwent radiological evaluation at six weeks, and at three, six and twelve months postoperatively, it was possible to stage the osteotomy site healing process: radiological union took an average of 4.5 months, ranging from a minimum of six weeks to a maximum of six months.

The preoperative average HKA angle was 171° (range, 177-165°) versus 184° (range, 182-187°) at final follow-up. At final follow-up, the target correction of 183-186° was not achieved only in 5 knees (**Fig. 2**). The average preoperative tibial slope was 6.2 *versus* 6.7° at final follow-up: this difference was not statistically significant. The patella was statistically significantly lower postoperatively (*patella infera* or *baja*): the average Caton-Deschamps index dropped from 0.86 before the surgery to 0.74 at the last follow-up.

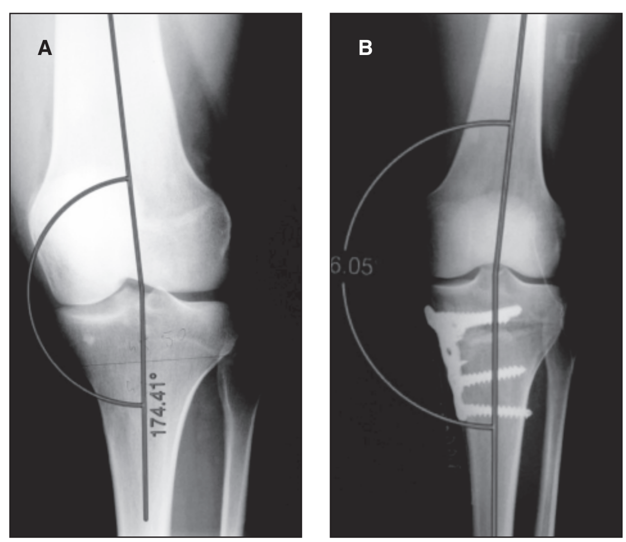

Fig. 2. Left knee affected by varus deformity. A. Preoperative varus alignment: 174°. B. Postoperative alignment: 186°.

Complications

Evaluation of intraoperative and postoperative complications revealed one intraoperative iatrogenic lesion of the popliteal artery, which was treated by the vascular surgeon with an autologous vascular graft. No infections, implant breakage, bone non-union or malunion, fracture of bone substitute or major loss of correction were detected in this consecutive series of OWHTOs.

Discussion

Medial OWHTO is an excellent option for treating varus deformity in patients with medial knee degenerative joint disease. Appropriate patient selection, a precise surgical technique and accurate rehabilitation protocols are all essential to the success of HTO. Classically, both CWHTO and OWHTO are the preferred surgical techniques in the English language literature. Historically, a drawback of OWHTO was delayed weight bearing due to the longer bone healing process. A recent meta-analysis by Smith et al. (12) showed no significant differences in clinical outcomes or complication rates between OWHTO and CWHTO. There was, however, a significantly greater posterior tibial slope and mean angle of correction, increased incidence of patellar *baja*, and reduced HKA angle following OWHTO. The findings of our study suggest that OWHTO is also associated with a statistically significant reduction in patellar height. In fact, during the OWHTO procedure, the tibial tubercle is usually lowered by elongating the proximal tibia, thereby reducing the patellar height. Parvizi et al. (13) showed that primary TKA following HTO resulting in patella *baja* has a higher risk of failure when compared to primary TKA.

Medial OWHTOs have been linked to an increase in posterior tibial slope: our study demonstrated an increase in the postoperative tibial slope, but the difference was not statistically significant when compared to the preoperative slope. In opening wedge osteotomies, in fact, the slope increases because the surgical technique and biomechanics make it difficult to maintain the posterior gap open to the same extent as the anterior gap. LaPrade et al. (14) found that placing the plate posteromedially might reduce the postoperative slope increment.

In their meta-analysis, Smith et al. (12) found that superior anatomical correction following OWHTO was associated with a statistically significant difference in HKA angles. In our study, the average HKA angle at final follow-up was 184° and the target correction of 183-186° was achieved in 97% of the knees. This might be attributed to the fact that OWHTO might be advantageous over the closing wedge method as it permits continuous radiological evaluation under fluoroscopic control.

OWHTOs have been reported to be safer than CWHTOs by many Authors (15). In our series, we recorded only one intraoperative complication and no major postoperative complications. Other studies (10, 16) have emphasized the safety of the opening wedge technique in terms of intraoperative complications. Maintaining an intact lateral cortex with 5-10 mm of bone, releasing soft tissues, opening the osteotomy slowly, making liberal use of fluoroscopy, and using modern fixation devices can all decrease the complication rate of this procedure (17).

The clinical outcomes after HTO performed using modern fixation devices (spacer plate, C-plate, position plate, staple) are promising, even in the long term, resulting in good improvement of knee function (18). With regard to fixation devices, most of the recent literature has focused on the Tomofix plate (Synthes, West Chester, PA, USA) and the Puddu plate (Arthrex, Naples, FL, USA) (19, 20), reporting mid-term survivorship up to 90%. Recently, less rigid implants allowing immediate full weight bearing have been introduced for clinical use: the early results are promising (21). Our results, obtained utilizing a titanium T-plate (Citieffe, Italy), are similar to those reported in the current literature: none of the implants have been removed and none of the patients underwent secondary total knee replacement before final follow-up.

The current study revealed a significant correlation between functional outcome, age and disease severity. Our patient population was young (average age 34 years) and the majority of the patients (87%) were classified as Alhbäck I or II. This is because we followed existing international guidelines which give age limitations for HTO (15). The Authors recognize that the same satisfactory results might not have been obtained had the selection criteria been extended to older patients and more severely affected knees. In the Authors' experience, OWHTO should be used to treat grade III OA only in younger patients without comorbidities like obesity, diabetes and inflammatory arthritis.

This study has a number of limitations. It presents a consecutive series without a comparison with matched controls, like a CWHTO group (22); the rate of complications was low, but the senior Authors (GP, PFI, DT) have long and extensive academic experience with the opening wedge osteotomy technique; radiographs were used to detect bone healing but computed tomography might have constituted a more accurate measure of bone healing.

In conclusion, this study reveals favorable mid- to long-term results after OWHTO in varus OA. The rate of implant-related complications was low using an improved surgical technique and a specific plate fixator: reliable correction with satisfactory stability and bone healing was obtained in the vast majority of the cases. However, OWHTO increases the risk of a greater posterior slope angle and patella *baja* during the postoperative period, making a secondary TKA theoretically more challenging.

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