Osteoarthritis and Cartilage 23 (2015) 232–238

Osteoarthritis and Cartilage

Changes of knee joint and ankle joint orientations after high tibial osteotomy

K.M. Lee †, C.B. Chang ‡ § *, M.S. Park †, S.-B. Kang ‡ §, T.K. Kim † §, C.Y. Chung † §

† Department of Orthopaedic Surgery, Seoul National University Bundang Hospital, Seongnam-si, South Korea
‡ Department of Orthopaedic Surgery, SMG-SNU Boramae Medical Center, Seoul, South Korea
§ Department of Orthopaedic Surgery, Seoul National University College of Medicine, South Korea

ARTICLE INFO

Article history:
Received 1 April 2014
Accepted 2 November 2014

Keywords:
High tibial osteotomy
Tibial plateau inclination
Knee joint line orientation relative to the ground
Ankle joint line orientation relative to the ground

SUMMARY

Objective: We sought to determine (1) whether change in the tibial plateau inclination (TPI) after high tibial osteotomy (HTO) is different from change in the knee joint line orientation (KJLO) relative to the ground; (2) whether, in varus knee OA patients before and after HTO, these radiographic measures are different from those in normal control; and (3) whether the postoperative values of the TPI and KJLO relative to the ground are associated with short term clinical outcome scores after HTO.

Design: Fifty patients who underwent HTO and 75 normal controls were assessed with four radiographic measures. We compared the measures before HTO with those after HTO and with those of the normal controls, then examined associations between the postoperative radiographic measures and clinical outcome scores 1-year after HTO.

Results: After HTO, TPI increased 9.0°, whereas KJLO relative to the ground only increased 4.1°, with a compensatory change of the ankle joint line orientation. However, the postoperative KJLO relative to the ground in the HTO group was significantly different from that of the normal controls (mean difference, 4.9°; $P < 0.001$). In the multiple regression analyses, the postoperative radiographic measures were not associated with outcome clinical scores 1 year after HTO.

Conclusion: After HTO the relative KJLO changed significantly less than did the anatomical geometry of the proximal tibia. Although the KJLO after the HTO was still significantly different from that of normal knees, its value did not adversely affect clinical outcome scores 1 year after HTO.

Introduction

High tibial osteotomy (HTO) is a frequent realignment procedure for patients with symptomatic medial tibiofemoral (TF) osteoarthritis (OA) of the knee with varus malalignment[1–3]. Varus malalignment was reported to accelerate progression of medial compartment OA of the knee and to aggravate symptoms in such patients[4–6], therefore, HTO is considered to be a biomechanically sound joint preserving option for relatively younger patients with varus knee OA.

On the other hand, HTO has a potential biomechanical disadvantage; the procedure can lead to abnormal joint line orientation of the knee. HTO directly changes only the tibial geometry, thus the tibial plateau inclination (TPI) can become abnormally valgus which can eventually lead to abnormal knee joint line orientation (KJLO)[7–9]. Moreover, in a patient with medial TF OA, the traditionally recommended target alignment of the procedure is a few degrees of valgus mechanical alignment, i.e., slight overcorrection of the patient's limb alignment[10]. To the best of our knowledge, there is little information about effects of abnormal knee joint orientation on knee kinematics, functional outcomes, and long-term survivorship[7]. Given that major candidates for HTO are relatively younger and active patients, the potential adverse effects of the abnormal knee joint orientation caused by the procedure may be a concern for knee surgeons.[7–9]

However, changes of the proximal tibial geometry produced by HTO could theoretically influence the orientation of both joints directly connected to the osteotomy site, the knee and the ankle. In fact, we have observed that patients with preoperative varus malalignment frequently had an abnormal ankle joint line

* Address correspondence and reprint requests to: C.B. Chang, Department of Orthopaedic Surgery, Seoul National University College of Medicine, SMG-SNU Boramae Medical Center, 20, Boramae-ro 5-gil, Dongjak-gu, Seoul 156-707, South Korea. Tel: 82-2-870-2316; Fax: 82-2-870-3863.
E-mail addresses: drchuc@chol.com, ccbknee@gmail.com (C.B. Chang).

http://dx.doi.org/10.1016/j.joca.2014.11.001
1063-4584/

orientation (excessive lateral tilt) relative to the ground in the coronal plane; the excessive lateral tilt was reduced after HTO. Based on these theoretical considerations and observations, we speculated that the postoperative change of the KJLO relative to the ground may be diluted by the change of the ankle joint orientation relative to the ground. Consequently, the alteration of the relative KJLO after HTO would be smaller than the change in the TPI.

Therefore, this study sought to determine (1) whether change in the TPI after HTO is different from change in the KJLO relative to the ground; (2) whether, in varus knee OA patients before and after HTO, the TPI, and the knee- and the ankle joint line orientations relative to the ground differ from those of normal controls; and (3) whether the postoperative values of the TPI and KJLO relative to the ground are associated with short term functional outcome scores after HTO.

Method

Study subjects

For this study, we compared two study groups: (1) the HTO group included patients who underwent unilateral open-wedge HTO due to symptomatic varus knee OA and were followed for ≥1-year after HTO and (2) the control group included patients with asymptomatic and stable knees with no or minimal radiographic OA. We excluded patients who underwent bilateral HTO. We reviewed the medical records of 91 patients who underwent a unilateral open-wedge HTO performed by two surgeons in a single center between January 2008 and June 2012.

We excluded 41 patients in whom an HTO was performed due to diseases other than primary OA, such as ligament injuries (posterolateral corner injury of the knee and anterior cruciate ligament injury), developmental deformity of the knee, and malunion of a proximal tibial fracture. Finally, 50 eligible patients (50 knees) remained who underwent unilateral open wedge HTO due to symptomatic primary varus knee OA (Fig. 1). Our usual indications for HTO in patients with varus knee OA were (1) moderate (Kellgren–Lawrence grade 3) radiographic medial TF OA with varus malalignment and with an intact radiographic joint space at the lateral TF compartment; (2) the major component of the varus limb alignment was the proximal tibia not the distal femur; and (3) significant and disabling pain originating from the medial side of the knee that did not respond to >3 months of conservative measures. The HTO group included 38 women and 12 men with a mean age of 53 years (SD, 5.9; range, 33–63) and a mean body mass index (BMI) of 26.8 kg/m^2 (SD, 3.7; range, 20.2–35.0).

We enrolled 75 control subjects, 1.5 controls per HTO patient, matched individually by gender to the HTO group because alignment parameters may be influenced by gender[11]. Additionally, we included only control subjects >30 years of age as to reduce variation by age. From a database of 359 patients who underwent unilateral arthroscopic surgeries due to traumatic meniscal injuries and/or anterior cruciate ligament injuries between July 2010 and June 2012 we selected, in a retrograde order, 75 gender-matched and age-limited patients with contralateral asymptomatic and stable knees with no or minimal radiographic OA (Kellegren–Lawrence grade 0 or 1) as the control group (Fig. 1). The control group included 57 women and 18 men with a mean age of 44 years (SD, 9.0; range, 31–64) and a mean BMI of 24.1 kg/m^2 (SD, 3.4; range,18.6–37.4).

We estimated the sample size required to detect a 2° difference in the mean KJLO relative to the ground (considered to be clinically meaningful) between the controls and the post-HTO patients using an independent *t*-test. Based on the information obtained from a previous study[12], a minimum of 46 HTO patients and 69 control subjects, 1.5 controls per case, were required to detect this difference, with a the type I error of 0.05 and power of 0.8. This result verified the adequacy of the sample size of this study. This study was approved by the institutional review board of our hospital.

Radiographic evaluation

Four radiographic measures including (1) the mechanical TF angle, (2) the TPI, (3) the knee-, and (4) ankle joint line orientation relative to the ground were assessed using preoperative and postoperative 1-year standing full-limb anteroposterior (AP) radiographs in the HTO group and using preoperative standing full-limb AP radiographs in the controls. Standing full-limb AP radiographs were obtained on a 14- × 51-inch (36- × 130-cm) grid cassette at a source-to-image distance of 240 cm using a UT 2000 X-ray machine

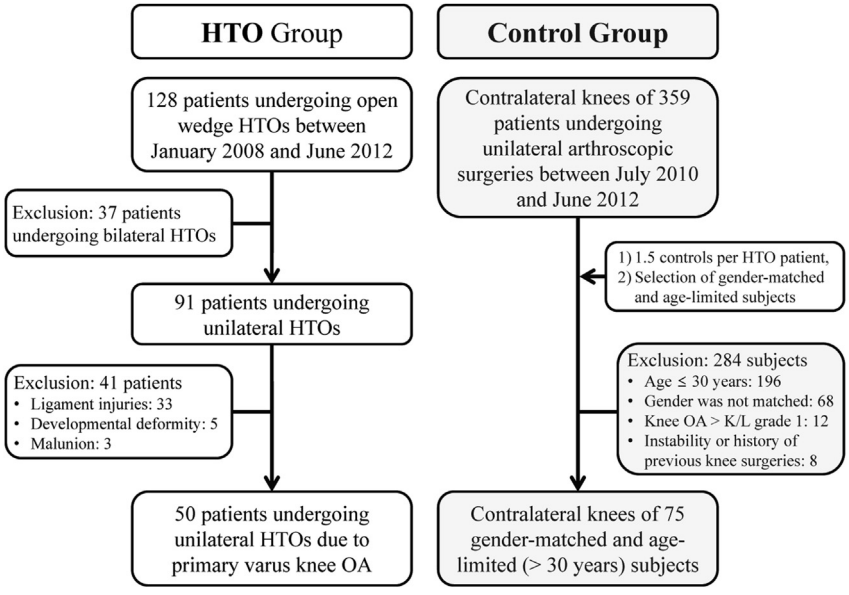

Fig. 1. Study subjects enrollment flowchart. HTO, High Tibial Osteotomy; OA, Osteoarthritis; K/L, Kellgren–Lawrence.