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Differences between opening versus closing high tibial osteotomy on clinical outcomes and gait analysis

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ABSTRACT

Background: High tibial osteotomy (HTO) for medial knee osteoarthritis (OA) is mainly performed via two procedures: closing wedge HTO (CW) and opening wedge HTO (OW). In this study, differences between these procedures were assessed by serial clinical evaluation and gait analysis before and after surgery.
Methods: Twenty-one patients underwent HTO for medial knee OA in 2011 and 2012, with 12 patients undergoing CW and nine undergoing OW. The severity of OA was classified according to the Kellgren–Lawrence classification. The Japanese Orthopedic Association score for assessment of knee OA (JOA score), the Numeric Rating Scale (NRS), and the femoral tibial angle (FTA) on X-ray were evaluated. For gait analysis, gait speed, varus moment, varus angle and lateral thrust were calculated.
Results: The JOA score and NRS were improved significantly one year postoperatively in both groups. The FTA was maintained in both groups at one year. Varus angle and varus moment were significantly improved in both groups at each postoperative follow-up, when compared preoperatively. Lateral thrust was significantly improved at three months postoperatively in both groups. However, the significant improvement in lateral thrust had disappeared in the CW group six months postoperatively, whereas it was maintained for at least one year in the OW group.
Conclusions: This study found that clinical outcomes were well maintained after HTO. OW reduced knee varus moment and lateral thrust, whereas CW had little effect on reducing lateral thrust.
Level of evidence: Level IV

1. Introduction

Japan's population is rapidly aging, and together with this aging, the number of patients with degenerative changes of knee osteoarthritis (OA) is increasing. Yoshimura et al. estimated that 25.3 million people (8.6 million men, 16.7 million women) aged 40 years and older have radiographic findings of knee OA, and that 7.8 million (2.2 million men, 5.6 million women; 42.6% of men and 62.4% of women aged ≥40 years) have symptoms such as pain [1].

Knee OA is a disease associated with joint dysfunction due to degeneration, destruction, and loss of articular cartilage. In Japan, more than 90% of patients with knee OA develop a varus deformity. Varus malalignment overloads the medial tibiofemoral compartment, causing degenerative changes in the articular cartilage, which lead to pain and dysfunction [2].

Treatment of pain and dysfunction in knee OA includes conservative treatment and surgical treatment. Improvement with conservative treatment becomes difficult if symptoms progress and surgical treatment may be indicated. In patients with severe knee OA, surgical treatment may include arthroscopic surgery, a high tibial osteotomy (HTO), or total knee arthroplasty. HTO is generally indicated in relatively young and more active patients [3]. HTO is a load-shifting procedure which transfers the mechanical axis more laterally. As a result, this surgery improves pain and delays the progression of arthritis [4].

HTO is broadly divided into two surgical procedures. The first is a lateral closing wedge HTO (CW) in which a wedge-shaped cut is made in the lateral tibia. The second is a medial opening wedge HTO (OW) in which the medial tibia is cut (Fig. 1A, B). OW has been performed more recently. The difference between CW and OW is that OW does not need a fibula osteotomy. This reduces the incidence of complications such as peroneal nerve palsy, but increases the tibial slope [4,5].

Clinical outcomes and problems associated with CW and OW have been compared in some studies [5,6]. However, these studies often compare subjective symptoms and static data such as radiographic findings. Our literature review found no studies that compared serial

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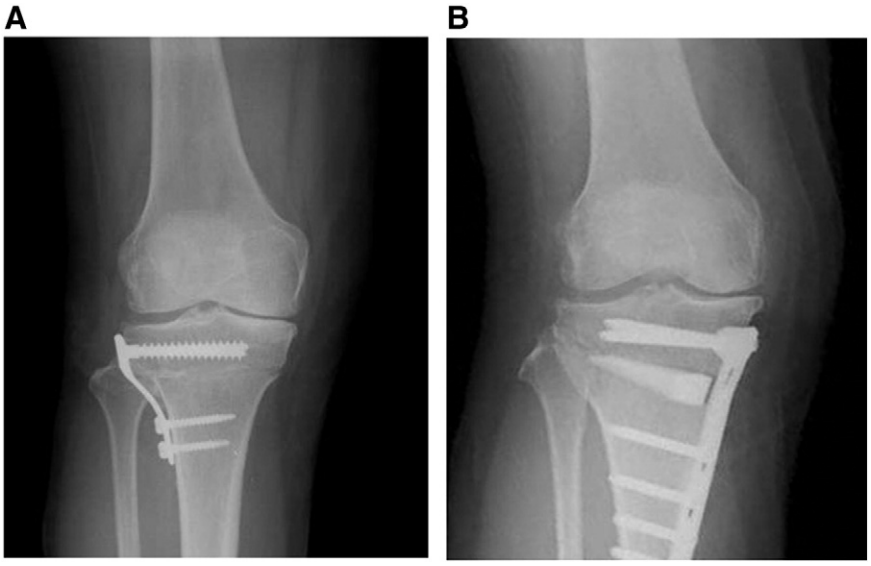

Fig. 1. Anterior–posterior radiographs of high tibial osteotomy (HTO). (A) Radiograph of closed wedge osteotomy procedure. (B) Radiograph of opening wedge osteotomy procedure.

changes from a kinetic and kinematic perspective such as walking in activities of daily living.

Therefore, the present study aimed to investigate serial changes in clinical symptoms and knee joint kinetics and kinematics during free walking in patients who underwent CW and OW. We examined gait analysis using a three-dimensional (3D) motion analysis system (Vicon 612) with 7 infrared cameras and four force plates to find any differences in knee kinetics and kinematics between CW and OW. We hypothesized that there would be no differences found between CW and OW using gait analysis.

2. Materials and methods

2.1. Patients

This study included 21 patients (six men, 15 women) diagnosed with unilateral or bilateral knee OA at the Department of Orthopedic Surgery at Hiroshima University Hospital between 2011 and 2012, and in whom HTO was indicated. Indications for HTO were patients less than 65 years old with medial compartmental osteoarthritis and a femoral tibial angle (FTA) of more than 178°. The measured leg was the operated side, and the contralateral leg did not undergo any surgical procedures for one year following the HTO. A past medical history was taken, and patients with any of the following conditions that might affect gait were excluded: central nervous system disease; trauma or previous surgery of the leg other than the knee joint; sensory deficits, respiratory disease, or cardiovascular disease; and difficulty walking alone.

The day of surgery was Monday for CW and Friday for OW. There were three men and nine women who underwent CW (mean age, 57.8 ± 6.1 years; range, 45–64 years) and three men and six women who underwent OW (mean age, 57.5 ± 6.0 years; range, 46–64 years). Anterior–posterior X-rays of the knees were taken during weight-bearing on both feet, and the severity of knee OA was assessed by an orthopedic surgeon according to the Kellgren–Lawrence (KL) classification [7]. The FTA was also measured from knee X-rays. In the CW group, OA was assessed as KL class II in one patient, class III in five, and class IV in six, and the mean FTA was 183.5 ± 3.9°. In the OW group, OA was assessed as KL class III in six patients, and class IV in three, and the mean FTA was 180.9 ± 1.6° (Table 1). There were no significant differences between the CW and OW groups preoperatively.

This study was approved by the Epidemiology Research Ethical Review Board at Hiroshima University (No. E-204). All participants received an explanation of the purpose and nature of the study, and their written informed consent was obtained.

2.2. Surgical procedures

All surgeries were performed at the same medical facility by two surgeons (MD and NA). Surgery was performed under general or lumbar anesthesia. Arthroscopy was performed before osteotomy to confirm that HTO was indicated for the lateral knee joint.

2.2.1. Closing wedge osteotomy

A three centimeter incision was made in the central part of the leg, and a one and a half to two centimeter central section of the fibula was resected. Next, a six centimeter, inverted-shaped skin incision was made over the lateral tibia, the tibialis anterior muscle was detached, and a wedge-shaped osteotomy of the lateral tibia was made to the angle of correction. After confirming the angle of correction by fluoroscopy, plate fixation was performed.

2.2.2. Opening wedge osteotomy

In preoperative measurement and planning, a FTA of 170° was anticipated in the coronal plane. A five centimeter skin incision was made in the pes anserinus region of the leg to expose the medial tibia, the osteotomy site was confirmed by fluoroscopy, and an osteotomy was performed. The medial tibia was opened to the angle of correction, artificial bone or an autologous bone graft was placed in the opening, and plate fixation was performed. Artificial bone substitute was used

Table 1
Patient characteristics. Values are mean ± standard deviation.

	CW	OW
Number of knees	12	9
Sex (male:female)	3:9	3:6
Age (years)	57.8 ± 6.0	57.5 ± 6.0
Height (cm)	157.0 ± 9.6	159.3 ± 5.5
Weight (kg)	62.3 ± 8.9	71.5 ± 9.1
BMI (kg/m^2)	24.8 ± 3.3	28.2 ± 4.0
Preoperative FTA	183.5 ± 3.9	180.9 ± 1.6
Postoperative FTA	167.4 ± 1.4	168.6 ± 1.8
K/L score	II: 1, III: 5, IV: 6	II: 0, III: 6, IV: 3

Abbreviations: CW, closing wedge high tibial osteotomy; OW, opening wedge high tibial osteotomy; BMI, body mass index; FTA, femoral tibial angle; and K/L score, Kellgren–Lawrence classification score.