



# Importance of a Dynamic Evaluation of Tibial Osteotomy for Medial Knee Osteoarthritis

Eiichi Nakamura\*

Department of Orthopaedic Surgery, Kumamoto University, Japan

## Abstract

High Tibial Osteotomy (HTO) is a reliable procedure with proper patient selection and a precise surgical technique for patients who had the medial compartment osteoarthritis of the knee with a varus deformity. HTO has the major advantages in the preservation of bone stock and intra-articular structures. In addition to the coronal alignment of the lower limb following HTO, however, various anatomical elements including the morphology of the proximal tibia, the relative patellar height, the tension of surrounding soft tissues and the whole leg length are changed. These alterations can adversely affect both tibiofemoral and patellofemoral kinematics or the dynamic loading of the knee, which cannot be assessed using conventional radiology. It is necessary, therefore, to evaluate those changes following HTO from many aspects. Identifying and understanding these relationships may lead to further improvement in the clinical success of HTO in the future.

## Introduction

High Tibial Osteotomy (HTO) is a well-established procedure for treating the Medial Compartment Osteoarthritis (MOA) of the knee with a varus deformity. Many techniques have been developed, and among them, lateral Closing-Wedge Osteotomy (CWO) and Medial Opening-Wedge Osteotomy (MWO) are the most commonly used. During the last decade, medial open-wedge osteotomy has gained popularity. The goal of these osteotomies is to reduce excessive loading of the medial compartment of the knee by shifting the load-bearing axis of the lower leg laterally, which HTO may decrease pain, improve function, slow knee deterioration and earn the time to arthroplasty.

On the other hand, HTO alters various anatomical elements including the morphology of the proximal tibia, the relative patellar height, the tension of surrounding soft tissues and the whole leg length, in addition to the coronal alignment of the lower limb. These alterations can adversely affect both tibiofemoral and patellofemoral kinematics or the dynamic loading of the knee, which cannot be assessed using conventional radiology. In this mini-review, the results of HTO using contemporary techniques are reviewed, and some of the areas that would benefit from further development and understanding will be discussed.

## Outcomes Based on the Clinical Evaluation and Conventional Radiological Examination

CWO has been considered for a long time as the gold standard. There is a broad consensus that the outcomes during the five to 10 years after CWO are good, but that they deteriorate with time. Rates of survival, using either conversion to total knee arthroplasty or failure in the clinical score as the endpoints, of between 75% and 90% at 10 years and between 50% and 70% at 15 years, recently have been reported [1-5]. Only two Japanese studies and one French study had higher rates of survival of approximately 90% after 15 years [6-8]. As for MWO, the outcomes during the five to 10 years are also good [9-12]. Further research is needed, however, to evaluate longer-term outcomes in MWO. At the present time, no conclusion can be drawn on which technique is more suitable [13] and the choice remains a matter of preference of the surgeon.

## Morphology of the Proximal Tibia

There has recently been an increasing awareness of the importance of the tibial posterior inclination in the sagittal plane. An unintended change in the tibial posterior inclination can occur after either CWO or MWO. Alteration of tibial inclination may lead to instability and excessive anteroposterior tibial translation, which can exacerbate the progression of MOA. In contrast, a

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### \*Correspondence:

Eiichi Nakamura, Chairman,  
Department of Orthopaedic Surgery,  
Kumamoto University, 1-1-1 Honjo,  
Chuo-ku, Kumamoto-City, Kumamoto  
860-8556, Japan, Tel: +81-96-373-  
5226; Fax: +81-96-373-5228;  
E-mail: h@kumamoto-u.ac.jp

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carefully controlled, planned, alteration of the inclination may be available to compensate for the cruciate ligamentous instability. This issue will be discussed later.

## Relative Patellar Height

It has also been shown to alter the anatomical relationship between the patella and the tibial tubercle after HTO. The incidence of patella alta increased after CWO while those of patella infera was found to increase after MWO [14]. The alteration in the relative height of the patella following HTO, especially patella infera could have a negative effect on the patellofemoral kinematics. Considering the osteotomy site, the osteotomy below the tibial tubercle is a more advantageous option than that above the tubercle in order to avoid patella infera [15]. Indeed, the patellar relative positions were maintained one year after hemicallotaxis with the low tibial osteotomy [16].

## Tension in the Surrounding Soft Tissues

Recently, there has been increasing biomechanical and clinical interest in the indication of HTO for the treatment of ligamentous deficiencies of the knee joint. HTO can effects on the abduction-adduction laxity of the knee because of changes of tension in the surrounding soft tissues. These depend on the level of the osteotomy in relation to the tibial attachments of soft tissue structures that cross the knee joint. Generally, in the coronal plane, CWO will tend to slacken the lateral soft tissue structures, and MWO will lengthen the superficial MCL fibers attached to the distal fragment. In addition, MWO has been reported to have a secondary advantage of tightening the lateral capsuloligamentous structures [17]. In the sagittal plane, on the other hand, both osteotomies can reduce to some extent the anteroposterior subluxation of the tibia relative to the femur by alteration of the posterior tibial inclination in the cruciate-ligament deficient knee. However, it is technically difficult to treat the cruciate ligamentous instability by those osteotomies alone. HTO has been often reported in combination with the reconstructive surgery to chronic ACL-deficient knees with varus deformity.

## Whole Leg Length

The postoperative leg length, indeed, decreased by an average of 1.3 mm to 4.1 mm after CWO and increased by an average of 5.5 mm to 9.6 mm after MWO [18-20]. While the awareness of postoperative leg-length change is an important issue, the amount of leg-length discrepancy is more important clinically. In any case, an additional consideration should be the presence of a preexisting leg-length discrepancy before surgery [20]. Those anatomical alterations surrounding knee joint can adversely affect both tibiofemoral and patellofemoral kinematics or the dynamic loading of the knee, which cannot be assessed using conventional radiology. Deie et al. [21] performed a 3-D gait analysis comparing CWO and MWO. They described the lateral thrust reduced at 3 months. In MWO, the reduction was remained at 12 months, but in CWO, the reduction was loss at 12 months. In addition, Kawakami et al. [22] examined the locus of dynamic loading axis on the proximal tibia joint surface during walking by using 4-D gait analysis system. The locus of loading axis in CWO was remained on the medial surface postoperatively, while in MWO was shifted laterally. At present, however, the reason for those different phenomenons between two surgical procedures is not known.

## Summary

Even if there is no scientific evidence, it appears common

experience that HTO is a reliable procedure with proper patient selection and a precise surgical technique. However, the effects of HTO on the proximal tibia and the surrounding soft tissues in both coronal and sagittal planes must be kept in mind; particularly an unintended change in the tibial posterior inclination and the relative position of the patella may be undesirable. This can adversely affect both tibiofemoral and patellofemoral kinematics or the dynamic loading of the knee, which cannot be assessed using conventional radiology. It is necessary, therefore, to evaluate those changes following HTO from many aspects. Identifying and understanding these relationships may lead to further improvement in the clinical success of HTO in the future.

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