Morphological analysis of the Distal Femur for optimal Biplane Distal Femoral Osteotomy

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INTRODUCTION: Distal femoral osteotomy (DFO) is a surgical procedure used alone or in combination with proximal tibial osteotomy to treat patients with lower limb mal-alignment[1-3]. Medial closing wedge DFO (MCWDFO) is performed in patients with valgus knee osteoarthritis (OA)[3-5], while lateral closing wedge DFO (LCWDFO) may be performed with high tibial osteotomy (HTO) in patients with severe medial compartment osteoarthritis of the varus knee and is called double-level osteotomy (DLO)[6]. It has been reported in the past that bone union after MCWDFO was significantly slower than that after LCWDFO with HTO, and a higher incidence of hinge fractures was observed after MCWDFO[7]. In distal femoral biplane osteotomies, the determination of the osteotomy angle and thickness when creating the anterior flange requires careful attention. We assumed that the thickness of the anterior flange may be associated to hinge fractures. The purpose of this study was to compare the morphological characteristics of the distal femoral cortex in valgus and varus knees.

METHODS: A total of 97 patients (100 knees) were included, 50 valgus knees in49 patients and 50 varus knees in 48 patients who underwent DFO or total knee arthroplasty. The axial slice 65 mm proximal to the joint line on computed tomography (CT), which corresponds to the average starting level of the transverse osteotomy in DFO previously performed in our hospital, was used for analysis. Measurements were determined as follows: 1) Draw a straight line along the posterior margin of the femur. (Line 1) 2) Draw a line parallel to line 1 tangent to the anterior tip of the femur. (Line 2) 3) Draw a line parallel to and at the midpoint of line 1 and line 2 (Line3). The point where line 3 intersects the medial and lateral cortex are points A and B, respectively. 4) Lines tangent to the medial and lateral cortex, which pass through points A and B are drawn (line 4 and 5). 5) The angle between line 1 and line 4 was defined as the medial cortex line angle (MCLA) and between line 1 and line 5 as the lateral cortex line angle (LCLA) (**Figure 1**). 6) The tangential lines to the posterior cortex (Line 6) and the anterior cortex (Line 7) are drawn. 7) Lines vertical to line 6 are drawn where it meets the medial and lateral intersections of line 7 and the anterior cortex (point M and L) 8) The vertical distance between line 6 and point M was defined as the medial cortex height (MCH) and between line 7 and point L was defined as the lateral cortex height (LCH) (**Figure 2**). The Shapiro–Wilk test was used for the normality test. Due to the normality of the data, the Mann-Whitney U test or Student's t test was used to compare continuous values between the two groups. This retrospective study was approved by our Institutional Review Board.

RESULTS: [Comparison of MCLA and LCLA in valgus and varus knees] In the valgus knee, there was a significant difference between MCLA (68.1±8.5°) and LCLA (78.4±4.3°) with a larger angle in LCLA (P<0.01). The varus knee also showed a significant difference between MCLA (74.8±5.9°) and LCLA (80.4±4.7°), with LCLA having a larger angle(P<0.01). [Comparison of MCH and LCH in valgus and varus knees] LCH (27.3±3.8 mm) was significantly higher than MCH (21.3±3.5 mm) in the valgus knee with a significant difference between MCH and LCH (P<0.01). The LCH (30.3±3.3 mm) was also significantly higher than the MCH (24.7±3.1 mm) for varus knee between the MCH and LCH (P<0.01). [Comparison of valgus and varus knees in MCLA, LCLA, MCH, and LCH] MCLA was significantly smaller in the valgus knee (68.1±8.5°) compared to the varus knee (74.8±5.9°) (P<0.01). The LCLA was similarly significantly smaller in valgus knee (78.4±4.3°) compared to the varus knee (80.4±4.7°) (P=0.015). MCH was significantly lower for the valgus knee (21.3±3.5 mm) compared to the varus knee (24.7±3.1 mm,) (P<0.01). LCH was also significantly lower for the valgus knee (27.3±3.8 mm) compared to the varus knee (30.3±3.3 mm) (P<0.01).

DISCUSSION: The main finding of this study was that the medial distal femur had a significantly smaller MCLA in the valgus knee compared to varus knees. In addition, MCH was lower than LCH for valgus and varus knees. There are several reports on the height and length of osteotomy during the creation of the anterior flange, but there are no reports specifically addressing the angle of osteotomy. The results of this study suggest that if the surgeon aims the ascending cut too posteriorly, the remaining cortex at the hinge point will be narrow, presumably subjecting it to higher risk of hinge fracture. In conclusion, the medial cortical angle and height was smaller and lower than the lateral cortex at the osteotomy site, particularly in patients with valgus knees.

SIGNIFICANCE/CLINICAL RELEVANCE: When performing DFO on valgus knees, surgeons should be careful not to aim the bone saw posteriorly as it may cause risk of hinge fractures.

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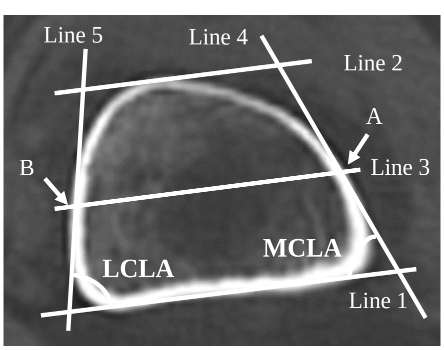
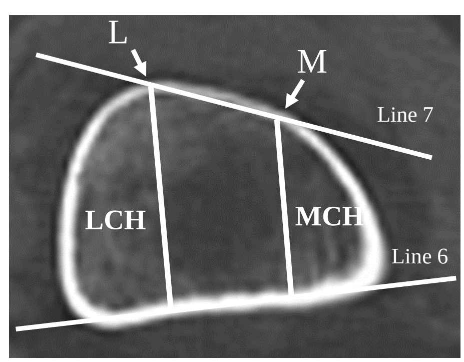
Figure 1. Method of measuring the angle of the femoral cortex.



MCLA: medial cortex line angle
LCLA: lateral cortex line angle

Figure 2. Method of measuring the height of femur.



MCH: medial cortex height
LCH: lateral cortex height