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Medial cortical fractures in computer-assisted closing-wedge high tibial osteotomy

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ABSTRACT

Background: We evaluated the incidence of medial cortical fracture and influence on the loss of the correction angle in computer-assisted closing-wedge high tibial osteotomy.
Methods: Using a navigation system, 200 closing-wedge high tibial osteotomies were performed. The correction angle was defined as the difference between the pre- and postoperative medial proximal tibial angles. The change in the medial proximal tibial angle was calculated as the difference between the medial proximal tibial angles two weeks and one year postoperatively. The medial cortical fractures of the osteotomy site were evaluated. Their incidence, risk factors, and influence on the loss of correction angle were analyzed.
Results: The incidence of non-displaced cortical breakage and displaced cortical fracture was 28.0% and 6.5%, respectively. Medial cortical fracture was more frequent in younger patients and patients with severe preoperative varus deformity. The average correction angle was significantly larger in the displaced cortical fracture group (9.6° vs. 12.7°, $p < 0.001$). The average change in the medial proximal tibial angle in the no fracture, non-displaced cortical breakage, and displaced cortical fracture groups was 0.7°, 1.8°, and 4.4°, respectively ($p < 0.001$).
Conclusions: Medial cortical fracture could not be prevented in all knees, even using the navigation system. The risk of medial cortical fracture and loss of the correction angle was increased, particularly when a greater correction angle is required in young patients.
Level of evidence: IV

1. Introduction

High tibial osteotomy (HTO) is an effective surgical treatment option for unicompartmental osteoarthritis of the knee with varus deformity [1,2]. The achievement and maintenance of an adequate correction angle are essential for a successful HTO [1,3,4]. For these purposes, surgeons try the medial cortical hinge to be intact in a closed-wedge HTO [5]. A medial cortical fracture may result in displacement of the osteotomy fragments and contribute to loss of the correction angle and recurrent varus deformity [6]. However, it can be difficult to avoid a hinge fracture, particularly when a large correction angle and wedge size is required [5,7]. A cadaveric study reported that the maximum angles of the wedge were 6.5° and 6.7° in closing- and opening-wedge HTOs, respectively, before fracture of the opposite cortex occurred [5].

There are only a few reports on the incidence of medial cortical fracture and its influence on loss of the correction angle after closing-wedge HTO [7,8]. Navigation systems are used to increase the accuracy, precision, and reproducibility of surgery in many orthopedic procedures [9]. The software can calculate the length of the osteotomy, and the medial cortical hinge can be tailored to avoid cortical disruption in computer-assisted closed-wedge HTO [9]. To our knowledge, no study has analyzed medial cortical fractures in computer-assisted closing-wedge HTO.

Therefore, this study evaluated the incidence of medial cortical fracture and its influence on loss of the correction angle in computer-assisted closing-wedge HTO. We hypothesized that medial cortical fractures could occur in patients undergoing closing-wedge HTOs, and this might influence the loss of the correction angle and recurrent varus deformity.

2. Patients and methods

2.1. Patients

Between 2005 and 2014, 200 closing-wedge HTOs were performed in 190 patients using a computed tomography (CT)-free navigation system (Vector Vision® ver. 1.1; Brainlab, Heimstetten, Germany) for medial compartment osteoarthritis of the knee and genu varum deformity (Kellgren and Lawrence grades 3 to 4) (Feucht's classification, group 3)[10]. A miniplate staple (U&I®; Uijeongbu-si, Korea) [11] was used

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to fix the osteotomy site. The exclusion criteria were opening-wedge HTO, double level femoral and tibial osteotomies, conventional HTO, HTO for non-osteoarthritic patients, and closing-wedge HTO with fixation other than miniplate staples. The HTO was also contraindicated if it expects to lead to joint line obliquity of more than 5° [12]. The study was approved by the institutional review board of our hospital (KMC IRB 1508-09, Kyung Hee University Hospital).

The patients had an average age of 59.0 ± 7.2 years and comprised 175 females and 15 males. There were 112 right knees and 88 left knees. The average body mass index was 25.2 ± 2.6 (range 17.3 to 32.8) kg/m^2. The average follow-up period was 4.1 ± 2.5 (range 2.0 to 9.1) years.

2.2. Radiographic evaluation of medial cortical fractures

Standing anteroposterior radiographs obtained preoperatively and two weeks and one year postoperatively were reviewed, including full-length, weight-bearing, and anteroposterior radiographs of the leg, including the hip, knee, and ankle (an orthoroentgenogram). The images were transferred digitally and manipulated using a picture-acquiring communication system (PACS). Two independent investigators evaluated medial cortical fractures at the osteotomy sites on anteroposterior radiographs in the supine position on the day of surgery and in the standing position two weeks postoperatively. When cortical breakage and disruption were seen in the medial cortex, displacement was also checked. A non-displaced fracture was defined as cortical breakage without displacement between the proximal and distal fragments (Fig. 1B). A displaced fracture was defined as a fracture with more than two millimeters between the disrupted fragments of the medial cortex (Fig. 1C). To reduce any observation bias, two independent investigators performed all radiographic determinations of the fracture, and were blinded to the 1-year postoperative radiographic result. Each knee classified differently by the two investigators was re-evaluated, using the PACS stored multiple digital images with the magnification tool until they agreed the categorization of the fracture classification.

2.3. Measurements using the navigation system

Under navigational guidance, the mechanical axis (MA) and mechanical axis percent (MA%) were measured before and after the osteotomy. The MA% was measured navigationally as the percentage by which the mechanical axis bisects the total width of the tibia [1,9]. In this study, the navigational data were measured and recorded to one decimal place in the navigation system.

2.4. Incidence of medial cortical fractures according to age and severity of preoperative varus deformity

To assess the risk factors of medial cortical hinge fracture, we compared the incidence of hinge fracture according to patient age and the severity of the preoperative varus deformity. The age categories were <50, 50 to 60, 60 to 70, and >70 years at the time of surgery. According to the preoperative varus deformity, the knees were categorized into six groups: varus <4°, 4 to 6°, 6 to 8°, 8 to 10°, 10 to 12°, and >12° on the navigational measurement of the MA.

2.5. Radiographic evaluation for the correction angle and loss of correction angle

The mechanical axis (MA), MA%, and medial proximal tibial angle (MPTA, joint obliquity) were measured from standing anteroposterior radiographs and an orthoroentgenogram preoperatively, and two weeks and one year postoperatively [9,13,14]. The correction angle was defined as the difference between the pre- and two-weeks postoperative MPTA because the MA and MA% could be altered by soft tissue laxity. Patients were categorized into high (correction angle ≥10°) and low (correction angle <10°) correction groups. The loss of correction angle was defined as the difference between the MPTA two weeks and one year postoperatively, considering the bone healing time and possibility of change in the soft tissue tension with long-term follow-up.

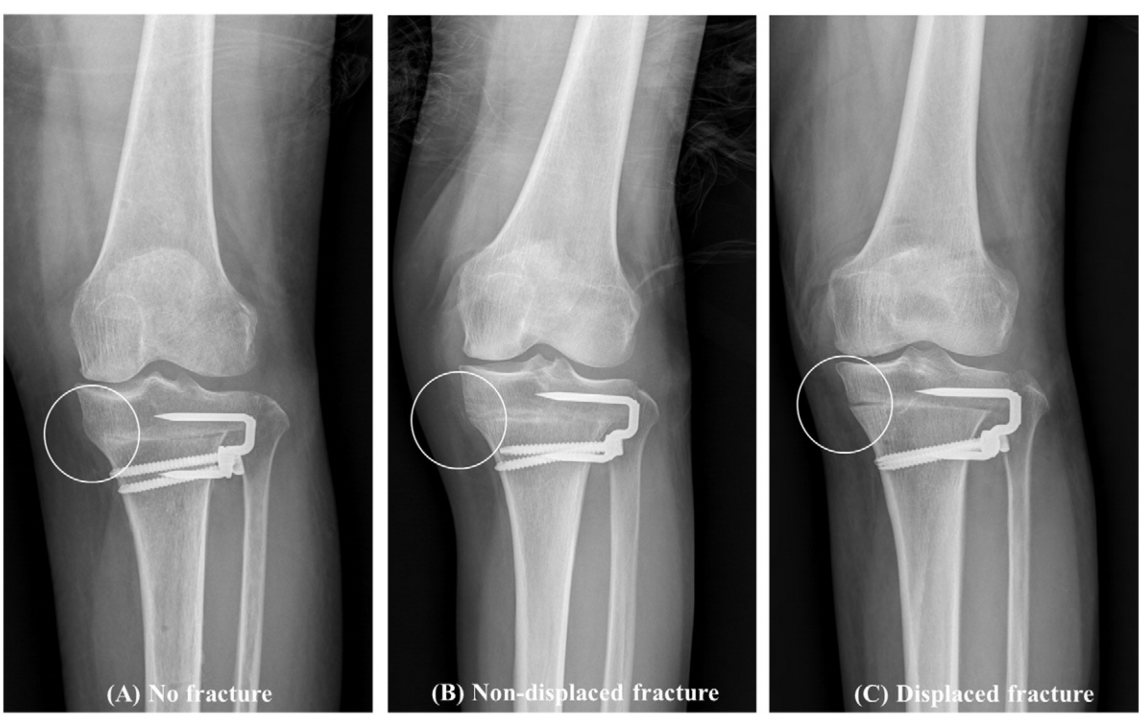

Fig. 1. Categorization according to the status of the medial cortical hinge: (A) intact medial cortex without fracture; (B) medial cortical breakage without displacement; and (C) displaced medial cortical fracture with a gap >2 mm.