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Changes in the syndesmotic reduction after syndesmotic screw fixation for ankle malleolar fractures: One-year longitudinal evaluations using computer tomography

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ABSTRACT

Introduction: To evaluate time-dependent changes in the syndesmotic reduction after syndesmotic screw fixation and one year after screw removal for ankle malleolar fractures, and to assess whether the incidence of syndesmotic malreduction changes depending on the measurement method.
Methods: We assessed twenty patients who underwent syndesmotic screw fixation for ankle fractures. The syndesmotic screws were removed after six weeks of the fracture surgery. Syndesmotic reduction was assessed within two weeks of the fracture surgery and one year after the screw removal using the axial computer tomographic images. Side-to-side differences in the anterior and posterior tibiofibular distances, anteroposterior fibular translation, and fibular rotation were measured.
Results: The mean anterior tibiofibular distance was 0.7 mm after syndesmotic fixation. It increased to 1.9 mm at one year after screw removal ($p = 0.002$). After syndesmotic fixation, four ankles had malreduction of the anterior tibiofibular distance, including three ankles with widening and one with overtightening. At one year, eight ankles had malreduction, all of whom had widening. The other measurement values did not change over time (0.1 mm vs. 0.6 mm for the posterior tibiofibular distance, 0.2 mm vs. 0.3 mm for the anteroposterior fibular translation, and 0.7° vs. 0° for the fibular rotation). The incidences of malreduction were significantly different depending on the definition of malreduction, ranging from 10% to 50% after syndesmotic fixation ($p = 0.01$) and from 20% to 60% at one year after screw removal ($p = 0.02$).
Conclusions: The anterior tibiofibular distance widened after one year of syndesmotic screw removal. The incidence of malreduction varied depending on the measurement method.

Introduction

Injury of the distal tibiofibular ligaments or tibiofibular diastasis occurs in 11–20% of ankle malleolar fractures [1,2]. Anatomical reduction of the tibiofibular syndesmosis is essential for operative treatment of ankle malleolar fractures because syndesmotic malreduction is correlated with worse functional outcome in the short term [3]. Furthermore, widening and chronic instability of the syndesmosis may cause ankle osteoarthritis in the long term [3]. Several operative techniques have been reported to restore the syndesmosis, including suture-button fixation and repair of the syndesmotic ligaments [4], yet tibiofibular screw fixation is still the most common method [4]. The timing, and indeed the necessity, of screw removal after surgery has been controversial. While recent reports have advocated delaying screw removal until at least 12 weeks after surgery [5,6], the majority of surgeons still remove the screw at 6–8 weeks after surgery in clinical practice [5,7]. Furthermore, Bell stated that retaining the syndesmotic screw at the commencement of weight bearing seemed to increase the risk of subsequent screw breakage, and the screw should be removed before weight bearing to avert this [8].

Plain radiographs have limited sensitivity in detecting subtle syndesmotic malalignment [9], and therefore computed tomography (CT) is mandatory for the detailed evaluation of syndesmotic reduction after surgical treatment of ankle fractures [9]. Moreover, comparison between the injured and contralateral ankles is essential because of the large variability among individuals

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[9,10]. A number of studies have evaluated syndesmotic reduction after tibiofibular screw fixation and have shown that the incidence of malreduction ranges from 5% to 52% [11,12]. Data on changes in reduction after screw removal, in contrast, are limited [13]. Song et al. measured syndesmotic reduction both two weeks after tibiofibular screw fixation and 30 days after screw removal using CT [13], but longer follow-up is necessary as the tibiofibular distance will continue to increase for at least three months after screw removal [13].

The other issue affecting CT evaluation of the tibiofibular syndesmosis is that no standard method exists for the assessment of malreduction. More than ten methods have been used, including measurements of mediolateral translation [13], anteroposterior translation [2], and axial rotation of the fibula [14]. The large variability in the incidence of malreduction among studies may be partly due to inconsistent measurement methods and definitions of malreduction [15]. Several studies have compared the repeatability of various measurement methods [10,14], yet the way in which the selection of a measurement method may affect the incidence of malreduction is not well studied.

The purposes of this study were (1) to evaluate time-dependent change in the syndesmotic reduction after syndesmotic screw fixation and one year after removal of the screw for ankle malleolar fractures using CT, and (2) to assess whether the incidence of syndesmotic malreduction changes depending on the measurement method.

Methods

Patients

The ethical committee of our hospital approved the study protocol. Patients were prospectively recruited at our hospital from September 2012 to December 2014. Inclusion criteria were tibiofibular screw fixation for ankle malleolar fracture (AO/OTA 44-B and 44-C) [16] or Maisonneuve fracture with tibiofibular diastasis [16,17], age 20 years or greater, and surgery date within two weeks after injury. Exclusion criteria were history of previous ankle fracture, bilateral ankle fracture, concomitant fracture of the ipsilateral lower extremity, open fracture, tibial plafond fracture (AO/OTA 43-A, B, and C), osteoarthritis of the ankle (Kellgren-Lawrence grade 2 or more) [18] in the preoperative radiographs, and unwillingness to consent to participation in this study. The treating surgeons classified each fracture based on preoperative anteroposterior and lateral radiographs and preoperative CT images, and subsequently confirmed each classification based on intraoperative findings.

Surgical techniques

Open reduction and internal fixation were performed based on the AO principles [19]. Fibular fractures were fixed with a plate either with or without an inter-fragmentary screw. Medial malleolar fractures were fixed with two 3.5–4.5 mm, partially threaded cancellous screws. Posterior malleolar fractures involving more than 25% of the articular surfaces were fixed with one or two partially threaded cancellous screws. Smaller posterior fractures involving less than 25% of the articular surfaces were fixed according to various methods depending on the surgeons' preference. For Maisonneuve fractures, only syndesmosis fixation was performed. Ligament repairs such as deltoid ligament or tibiofibular ligament repair were not performed.

Syndesmotic instability was diagnosed intraoperatively by the treating surgeons after concomitant fractures were fixed. The Cotton test and the external rotation test were performed under fluoroscopy [20]. Syndesmotic instability was defined as a side-to-side difference greater than 2 mm in the tibiofibular and medial clear spaces on the mortise radiograph of the ankle [2]. The tibiofibular syndesmosis was reduced under fluoroscopy and direct visualization of the anterior edge of the syndesmosis, and the reduction was held with a large pointed clamp. The ankle was held in a neutral position during syndesmotic screw insertion [21]. The syndesmosis was then fixed with one or more syndesmotic screws. Since there is no gold standard regarding the number of screws to be used or their optimal length and diameter [5], each surgeon determined these variables based on his or her own experience.

Postoperatively, patients were instructed not to bear weight on the injured ankle for six weeks. The tibiofibular screws were routinely removed six weeks after the initial surgery, and the patients were then allowed to bear full weight on the injured ankle as tolerated. Although recent studies recommend removal of the tibiofibular screws at 12 or more weeks after surgery [22], we decided to continue with removal at six weeks because it is still the standard practice in the majority of hospitals including our own hospital [5].

Patient evaluations

Patient backgrounds including age, sex, and fracture classification were recorded. The number of syndesmotic screws and number of cortices to be engaged by the screws were also documented. Quality of reduction in the articular surface of the ankle was assessed using postoperative CT images. Malreduction of the articular surface was defined as a step-off or gap of 2 mm or more [2]. Furthermore, clinical outcome was assessed at one year after screw removal using the Japanese Society for Surgery of the Foot (JSSF) ankle/hindfoot scale [23]. The JSSF scale is a validated objective evaluation consisting of 40 points for pain, 45 points for function, and 15 points for alignment. Higher scores indicate better outcome.

Evaluation of syndesmotic reduction

All patients underwent CT scanning of the bilateral ankles at two time points: within two weeks after the fracture fixation and one year after the removal of the syndesmotic screw. Images were obtained with the bilateral ankle, knee, and hip joints in a neutral position. CT images were obtained with a slice thickness of 1 mm or less. Imaging data were saved in the Digital Imaging and Communications in Medicine format and loaded into image processing software (ZioTerm 2009, Ziosoft, Inc, Tokyo, Japan). The images were reformatted to produce a standardized axial image for analysis for each ankle, parallel to the long axis of the tibia and 1 cm proximal to the tibial plafond [24]. Several techniques have been described for the evaluation of tibiofibular reduction with variable reproducibility [9,10,15,24]. We used four different measurements which have been reported to be relatively reproducible [9,10,24].

Anterior tibiofibular distance (Fig. 1A): The distance between the most anterior point of the incisura and the most anterior point of the fibula [9]. The difference between the injured and contralateral sides was used for analysis. A positive value indicates widening of the syndesmosis relative to the contralateral ankle, and a negative value indicates overtightening.

Posterior tibiofibular distance (Fig. 1B): The distance between the most posterior point of the incisura and the most posterior point of the fibula [9]. A positive value indicates widening of the syndesmosis, and a negative value indicates overtightening.

Anteroposterior fibular translation (Fig. 1C): A line is drawn perpendicular to the line connecting the anterior and posterior tibial tubercles, passing through the anterior tibial tubercle. The

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