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A contoured locking plate for distal fibular fractures in osteoporotic bone: A biomechanical cadaver study

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ABSTRACT

Objective: Fixation of ankle fractures in elderly patients is associated with reduced stability conditioned by osteoporotic bone. Therefore, fixation with implants providing improved biomechanical features could allow a more functional treatment, diminish implant failure and avoid consequences of immobilisation.
Materials and methods: In the actual study, we evaluated a lateral conventional contoured plate with a locking contoured plate stabilising experimentally induced distal fibular fractures in human cadavers from elderly. Ankle fractures were induced by the supination-external rotation mechanism according to Lauge-Hansen. Stage II fractures (AO 44-B1) were fixed with the 2 contoured plates and a torque to failure test was performed. Bone mineral density (BMD) was measured by quantitative computed tomography to correlate the parameters of the biomechanical experiments with bone quality.
Results: The locking plate showed a higher torque to failure, angle at failure, and maximal torque compared to the conventional plate. In contrast to the nonlocking system, fixation with the locking plate was independent of BMD.
Conclusion: Fixation of distal fibular fractures in osteoporotic bone with the contoured locking plate may be advantageous as compared to the nonlocking contoured plate. The locking plate with improved biomechanical attributes may allow a more functional treatment, reduce complications and consequences of immobilisation.

Introduction

Ankle fractures belong to the most common injuries of human skeleton with an increasing incidence in the elderly.[22] Lauge-Hansen classified these fractures respecting the pathomechanism, which conditions the exact morphology of the injury. Knowledge of bony and ligamentous lesions of ankle injuries is essential for adequate therapy and success of treatment.

The most frequent lesion within ankle fractures results from talus' external rotation in supination (supination-external rotation, SER).[9,10,12] At stage I of this injury, the anterior inferior tibiofibular syndesmosis ruptures. Stage II with lesion of the syndesmosis and the characteristic oblique fibular fracture at the level of the syndesmosis respectively the tibial plafond is the most common lesion within SER type injuries. At stage III, dorsal progressive forces result in a fracture of the posterior edge of the tibia before the medial malleolus fractures at stage IV. Ligamentous lesions are equivalents of fractures of the posterior edge and medial malleolus.

The recommended treatment after internal fixation of (isolated) distal fibular fractures – without complete lesion of the syndesmosis – includes partial weight bearing.[15,24] In patients with severe osteoporosis even partial weight bearing is critical due to the reduced bone quality or impracticable because of additional handicaps in the elderly. Facing uncontrolled full weight bearing, complete non-weight bearing and (cast-) immobilisation remain questionable alternatives. Therefore, fixation with an implant providing improved biomechanical stability could be advantageous in the treatment of ankle fractures in the elderly.

The purpose of this study was to compare the biomechanical properties of a lateral nonlocking with a lateral locking contoured plate for fixation of distal fibular fractures in osteoporotic bone. The locking plate focuses the distal fibular fragment – which is the predisposed place of implant failure – by providing angular

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stability at the distal part.[8] We evaluated the 2 implants fixing experimentally induced distal fibular fractures in human cadavers at stage II of the SER type injury. Specimens were lower legs of elderly donors with reduced bone quality, as measurement of bone mineral density (BMD) revealed. After fixation, a torque to failure test was employed to register the torque to failure, maximal torque, and stiffness of the fixation. Parameters of biomechanical experiments were correlated to BMD.

Materials and methods

At the knee disarticulated 33 non-fixed human cadaver specimens were used in this study (age 62–100 years, mean 85 years, 3 specimens of male donors). Used specimens had no deformities, ankle fractures or signs of previous ankle surgery. Specimens were stored at −20 °C until thawing at room temperature for 24 h prior to testing.

Soft tissue was removed from the proximal 10 cm of the lower leg. Skin and subcutaneous tissue were carefully removed over the lateral and medial malleolus to expose the malleoli as ligaments and later to visualise the lesions and permit fixation of fractures. Ligaments and tendons were maintained.

All specimens were evaluated with quantitative computed tomography (pQCT; Stratec Inc., XCT2000, Pforzheim, Germany) to measure BMD with 85 mg/cm^3 threshold.[6] We measured the total BMD of the distal metaphyseal tibia and fibula and the distal diaphyseal fibula. BMD was measured 1 cm proximal to the tibia plafond and 5 mm distal of the tibiotalar joint line respectively the syndesmosis. Beside total BMD, cancellous BMD was calculated.[26]

Biomechanical experiments by applying axial load and torsional moment were performed with a Zwick/Roell testing machine (Z020, Zwick/Roell, Ulm, Germany; Fig. 1). Specimens were fixed rigidly in the upper part of the testing apparatus with self-made holders. The holder for the proximal part of the lower leg was a box (height 10 cm with a quadratic plane of 15 cm length) allowing the insertion of up to 16 pins of 5 mm diameter; 4–6 Steinmann pins were inserted to fix the tibia and fibula. The foot was fixed on a different apparatus allowing linear 2-dimensional shifting on a plane and angulation in an axis corresponding to supination–pronation and dorsiflexion–plantarflexion. 1 Steinmann pin fixed the calcaneus; 2 screws fixed the hind foot and 4 screws were inserted to fix the forefoot, 2 of these screws could be inserted through a plate, which pressed the dorsum of the foot on the plate. The longitudinal axis of the lower leg and the ankle joint were adjusted at the rotation axis – plum line – of the testing machine with supination of 25° and dorsiflexion of 15°. The angle between the transmalleolar axis and the second metatarsal was used to

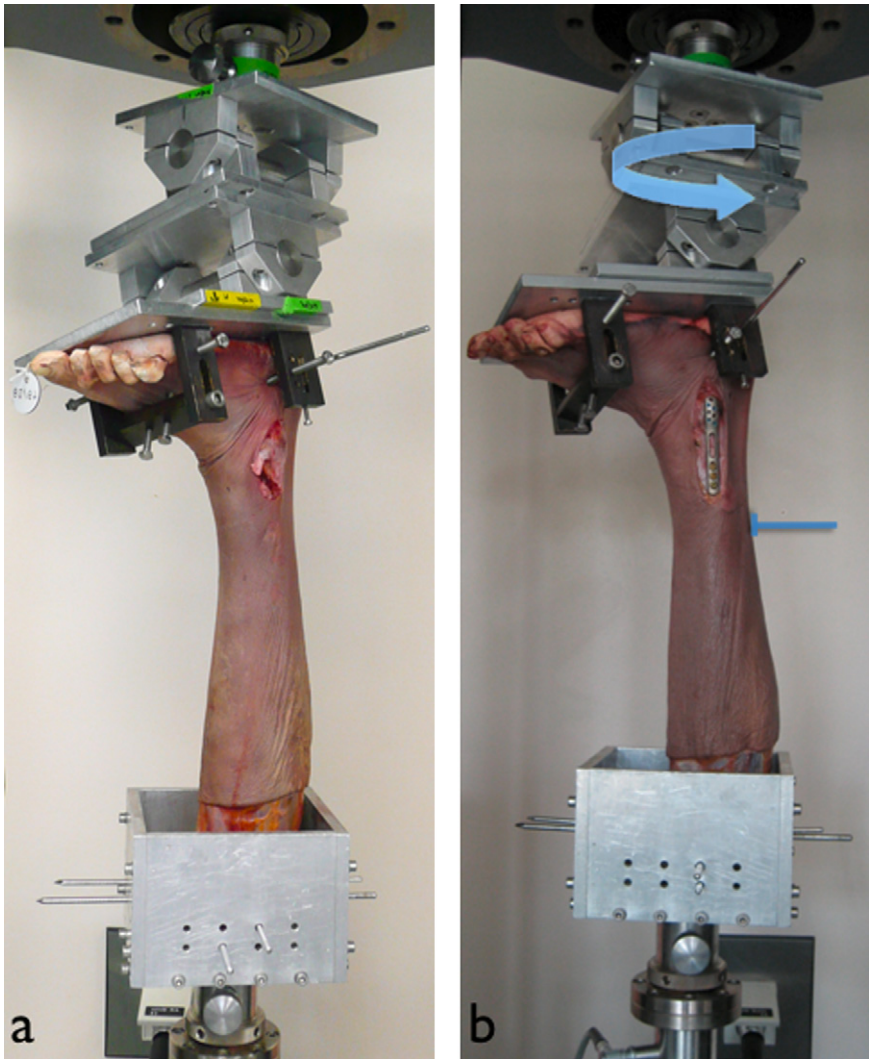

Fig. 1. The experimental setting. (a) Shows the induction of the fibular fracture at the level of the tibial plafond respectively the anterior inferior tibiofibular syndesmosis at stage II of the SER injury. (b) Shows fixation of the reduced fracture with the locking contoured plate. The additional lateral force is illustrated schematically and prevented a lateral shift of the construct.