Histomorphometric, CT arthrographic, and biomechanical mapping of the human ankle

BACKGROUND: The specific morphological and biomechanical characteristics of the osteochondral unit of the ankle joint are not yet fully understood. This anatomical study aimed to map regional thickness of the articular hyaline uncalcified cartilage and its adjacent layers of mineralized cartilage and subchondral bone as well as to measure the regional indentation stiffness of human ankle joint cartilage.

MATERIALS AND METHODS: A total of 20 pairs of human cadaver ankle joints (median age: 78 years) were evaluated by histomorphometry and multidetector row double-contrast CT arthrography for cartilage thickness in 17 distinct anatomical regions. In addition, regional distribution of the subchondral bone plate and of the mineralized cartilage was scrutinized histologically. Cartilage indentation stiffness was measured using an arthroscopic handheld device (Artscan200), especially validated for use in thin cartilage. The correlation between the thickness of different components of the osteochondral unit and the cartilage indentation stiffness was evaluated. RESULTS: The thinnest uncalcified cartilage was measured at the anterior talar dome and the distal fibula. The thickest uncalcified cartilage was found in the mid and posterior talar dome, as well as in the tibial plafond. Mineralized cartilage and subchondral bone showed highest values at the anteromedial talar dome. Cartilage indentation stiffness showed a bicentric distribution pattern in 14/20 ankle pairs and was highest in regions with thin cartilage. Positive correlation between the thickness of the mineralized cartilage and the subchondral bone plate was found. No correlation between the thickness of the uncalcified and the mineralized cartilage could be identified. CONCLUSION: This anatomical study provides a comprehensive mapping of the osteochondral unit of the human ankle joint in elderly people. Articular hyaline uncalcified cartilage and the subchondral bone plate showed clear regional differences and were reciprocally distributed. Cartilage indentation stiffness was inversely correlated to cartilage thickness in elderly people. CLINICAL RELEVANCE: Thorough understanding of the osteochondral unit of the ankle joint could be helpful for clinicians and researchers in the development of improved operative repair techniques for osteochondral defects in the ankle joint, for example, in constructing specific tissue-engineered osteochondral plugs.
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