IN-VIVO CARTILAGE CONTACT OF THE TALOCRURAL JOINT DURING THE STANCE PHASE OF WALKING

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INTRODUCTION

The talocrural (ankle) joint is one of the most important weightbearing articulations in the human body. The ground reaction force transmitted through the talocrural joint can be two to three times the body weight during gait. In-vivo cartilage contact characteristics of musculoskeletal joints during functional activities are important to understand the pathogenesis of joint diseases such as osteoarthritis. This study investigated the articular cartilage contact of the talocrural joint at three positions during the simulated stance phase of walking.

MATERIALS AND METHODS

Five healthy ankles of living subjects (age 32-43, 4 male and 1 female) were scanned using a 1.5 Tesla scanner (GE, Milwaukee, WI) with a surface coil and three-dimensional spoiled gradient-recalled (3D SPGR) sequence while the subject lying supine. Sagittal plane images at 1 mm intervals with a resolution of 512 x 512 pixels were acquired (Fig. 1A). A 3D anatomic model of each talocrural joint, including the tibia, talus and their cartilage layers, was constructed from the MR images (Fig. 1B). The in-vivo ankle positions were then captured at three weightbearing positions (heel strike, mid-stance, toe off) during the simulated stance phase of walking using a dual-orthogonal fluoroscopic imaging technique [1]. In-vivo talocrural motion was then reproduced by manipulating the 3D talocrural joint models in the virtual space until their projected contours matched the two sets of the orthogonal fluoroscopic images concurrently. Once the talocrural joint position was known, the relative position of the cartilage surface was also determined. The overlap area of the tibial plafond and trochlea tali cartilage layers was outlined and defined as the contact area.

A repeated measure ANOVA was used to compare the cartilage contact areas between different foot positions. The statistically significant difference was defined as p<0.05.

RESULTS

The average cartilage coverage area on tibial plafond was 987.88 ± 197.13mm². The average cartilage coverage area on trochlea tali was 1346.11 ± 241.47mm².

The contact area distribution of one subject on both tibial plafond and trochlea tali at predefined foot positions is presented in Figure 2. The average contact area was 287.03 ± 79.69mm² at heel strike, 410.72 ± 35.80 mm² at mid-stance and 325.53 ± 74.08mm² at toe off (Fig. 3). The contact area at mid-stance was significantly larger than those at heel strike and toe off. The contact area at toe off was larger than that at heel strike. This may be indicative of the varying loading conditions throughout the stance phase of walking and the complicated geometry of the joint itself. This quantitative data on talocrural cartilage contact area is important for calculation of in-vivo cartilage contact stress, understanding the biomechanical function of cartilage, and further investigation of cartilage injury mechanism.

DISCUSSION

At heel strike, 28.9 ± 5.5% of the tibial plafond cartilage and 21.2 ± 4.2% of the trochlea tali cartilage saw contact. At mid-stance, 42.4 ± 6.2% of the tibial plafond cartilage and 31.0 ± 4.0% of the trochlea tali cartilage saw contact. At toe off, 32.9 ± 3.7% of the tibial plafond cartilage and 24.1 ± 2.9% of the trochlea tali cartilage saw contact. The contact areas were more lateral at heel strike in four out of five ankles and at mid-stance in all five ankles possibly due to the reason to keep body balance where valgus positioned hindfeet were generally observed. The motion of the talocrural joint will cause dramatic changes of the cartilage contact area distribution. The contact areas at mid-stance was larger than those at heel strike and toe off while the contact area at toe off was larger than that at heel strike. This may be indicative of the varying loading conditions throughout the stance phase of walking and the complicated geometry of the joint itself. This quantitative data on talocrural cartilage contact area is important for calculation of in-vivo cartilage contact stress, understanding the biomechanical function of cartilage, and further investigation of cartilage injury mechanism.

**REFERENCES**


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