INTRODUCTION

Injury of articular cartilage can lead to development of osteoarthritis (OA). Arthroscopic examination of the knee joint is a routine procedure for evaluation of the severity of a cartilage injury. However, the arthroscopy enables only visual evaluation of the cartilage surfaces and subjective palpation of the cartilage stiffness. Novel more sensitive imaging methods are needed for detection of acute cartilage lesions. The aim of this study was to investigate the ability of the arthroscopic ultrasound technique to detect acute injury of articular cartilage after a mechanical impact.

MATERIALS AND METHOD

Intact osteochondral plugs (n=32) were prepared from bovine patellae (n=8). The plugs were injured by dropping an impactor on the cartilage samples from heights of 2.5 cm (n=8), 5.0 cm (n=8), 10.0 cm (n=8) and 15.0 cm (n=8), corresponding the impact energies of 0.12 J, 0.25 J, 0.50 J and 0.74 J, in a custom-made dropping tower.

Clinical high frequency intravascular ultrasound device (ClearView Ultra, Boston Scientific Corporation, San Jose, CA, USA) and catheter (Dia. = 1 mm, 40 MHz, -6 dB bandwidth, 30.1 – 45.3 MHz) were used. Radiofrequency ultrasound signals were recorded and digitized at a sampling frequency of 250 MHz using a digital oscilloscope (LeCroy Corporation, Wave Runner 6051A, Chestnut Ridge, NY, USA). The signals were stored for off-line analysis using a custom-made LabVIEW-software (version 8.2, National Instruments Corporation, Austin, TX, USA). Ultrasound reflection coefficient (R), integrated reflection coefficient (IRC), apparent integrated backscattering (AIB) and ultrasound roughness index (URI) were determined for each measurement site. For determination of the reproducibility all the measurements were repeated for three times. The reproducibility of ultrasound parameters was calculated as a standardized coefficient of variation (sCV (%)).

To determine the integrity of the samples the cartilage surfaces were imaged with a light microscope (LEICA MZ7.5, Leica Microsystems Inc., Bannockburn, IL, USA) before and after the injury. To determine the proteoglycan distribution digital densitometry (Leitz Ortholux II, Leitz Wetzlar, Wetzla, Germany) was conducted for the Safranin-O stained sections and non-stained section were imaged with polarized light microscopy (Leitz Ortholux II POL, Leitz Wetzlar, Wetzlar, Germany) to determine the orientation of the collagen fibers.

RESULTS

Visually non-detectable injuries could be detected by a decrease in the values of the ultrasound reflection parameters (p<0.05, Figure 1). Furthermore, trend for decrease was detected in the values of R and IRC as the impact energy increased. The values of AIB and URI were similar in intact and injured tissue. The histological analysis of the cartilage samples showed that the injured cartilage exhibited depletion of the proteoglycans in superficial tissue but the structure of the collagen network was nearly normal (Figure 2). The reproducibility (sCV) of the ultrasound parameters was 4.3% - 6.4%.

DISCUSSION

Reflection coefficient of the cartilage surface was the most sensitive parameter to detect the injury. Because the surface roughness of injured tissue was similar to that of intact cartilage the diminished reflection coefficient might relate to the increase of cartilage surface water content or decreased tension of collagen fibrils.

To conclude, present results indicate that the acute cartilage injury can be diagnosed with quantitative ultrasound imaging. However, the uncertainties in the positioning of ultrasound catheter in clinical conditions may affect the reproducibility of measurements and, thus, limit the detection of minor cartilage injuries.

SIGNIFICANCE

The present study introduces a novel clinically applicable ultrasound technique for diagnosis of acute cartilage injuries. The early diagnosis of acute cartilage injuries may be beneficial for treatment of the injury.

REFERENCES