Novel Arthroscopic Technique for Measurement of Speed of Sound in Articular Cartilage

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INTRODUCTION

Speed of sound (SOS) in articular cartilage is strongly related to the degenerative state of the tissue1,2. Thus, techniques enabling accurate SOS measurement during arthroscopy could have high diagnostic value. In the present study, a novel multimodal technique for SOS measurement is introduced and evaluated.

MATERIAL AND METHODS

• Ultrasound (US) time-of-flight (TOF) in cartilage and cartilage thickness were simultaneously measured using high frequency US and optical coherence tomography (OCT), respectively (Fig 1).

Validation
• The SOS in six phantoms were measured using the multimodal technique and compared with SOS obtained using an acoustic microscope.
• SOS in intact osteochondral samples (n = 25) prepared from equine fetlock joints was measured in vitro with the multimodal technique.
• The propagation of measurement error was investigated by systematically varying the US and OCT related measurement error in tissues with varying thickness values.

RESULTS

• SOS values measured with the multimodality technique correlated significantly (r = 0.99, p < 0.01) with values measured with the reference technique (Fig 2A). However, some uncertainty was detected (Fig 2B).
• Mean thickness and SOS in equine cartilage samples were 0.66 mm and 1618 ± 142 m/s, respectively.
• With thin equine cartilage resolution of both US and OCT measurements are crucial for the accuracy of the SOS measurement (Fig 3).

DISCUSSION AND CONCLUSIONS

• The multimodal technique enabled measurement of SOS in articular cartilage.

• Consistent SOS values were obtained with the multimodal and the reference techniques.

• The SOS values measured for the equine cartilage agreed with those found in literature3.

• The resolutions of TOF and thickness measurements were observed to limit the accuracy of the technique when measuring thin equine cartilage.

• Optimization of image processing and choices for US frequency and light intensity could improve the measurement accuracy.

SIGNIFICANCE

The proposed technique could be applied arthroscopically to measure SOS which could provide insight into the degenerative state of cartilage.

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REFERENCES

1Joiner et al., Ultrason Imaging 2001.
2Töyräs et al., Ultrasound in Med and Bio 2002.

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