TOPOGRAPHICAL VARIATION OF COMPOSITION AND MECHANICAL PROPERTIES OF ARTICULAR CARTILAGE IN HEALTHY AND DEGENERATED HUMAN PATELLAE

INTRODUCTION Currently, diagnosis of osteoarthritis (OA) is primarily based on patients' symptoms and conventional radiological imaging, such as the narrowing of joint space. Changes in radiographs represent the late stage of OA. At this stage, there is no true means to improve anymore cartilage status. Novel quantitative diagnostic methods, based on the measurement of cartilage mechanical properties [1, 2], acoustic and magnetic resonance assessment of the integrity and structure of cartilage surface [2, 3] or amount of macromolecules within cartilage tissue [4] are under development. The measured properties are gradually impaired as the progression of OA. On the other hand these tissue properties show topographical variations among different cartilage surfaces and joints. As some of the novel methods employ highly local, point-like measurements, we should know what is the normal variation of the measured parameters within one cartilage surface. In the present study we evaluate topographical variation of collagen and proteoglycan content and mechanical parameters in human patella, and locally discern the differences between healthy and degenerated cartilage.

MATERIALS AND METHODS 14 patellae with healthy and spontaneously degenerated articular cartilage were collected from human cadavers (12 males, 2 females, age 55±18 years) with permission from National Authority for Medicolegal Affairs in Finland. In each patella, 6 measurement sites were selected (Fig.1). Articular cartilage was detached from underlying bone with a biopsy punch (ø=4 mm) and a razor blade. Compressive equilibrium (E) and dynamic modulus (E_dyn) of the samples were tested using a high precision material testing device in unconfined geometry [5]. Subsequently, the samples were processed for microscopic analyses of matrix proteoglycans (assessed with optical density measurements [6]) and collagen contents (assessed with Fourier transform infrared spectral imaging [7]). The Mankin score [8] of the samples was evaluated by three of the authors independently from blind-coded sections. As the samples were detached from subchondral bone, the integrity of the tidemark could not be evaluated.

RESULTS Altogether 76 individual samples were successfully measured using all methods. The samples were divided into three categories based on their Mankin score: Healthy cartilage (Mankin score <3.2, n=29), Early degeneration (Mankin scores 3.3-5.0, n=23) and Advanced degeneration (Mankin score >5.0, n=24). All measured parameters, i.e. E, E_dyn, PG and collagen content, showed statistically significant variation between different categories (Table 1). There was a statistically significant site-dependent variation in E, PG and collagen content within the healthy samples (p<0.05, Kruskal-Wallis test, data not shown). In early degeneration group, there was statistically significant site-dependent variation in E, E_dyn and collagen content (p<0.05). For advanced degeneration, no statistically significant site dependent variation was found for any parameter. Topographical variation in E for healthy samples, as well as that for samples with degeneration is summarized in Fig. 2. Structural parameters were found to be related to the mechanical properties of cartilage (Table 2).

DISCUSSION The healthy human patellar samples showed significant topographical variation in collagen and PG content as well as in E and E_dyn. This variation was dependent on the stage of degeneration. The results confirm that collagen and proteoglycan content and compressive moduli of cartilage are decreased in parallel during the degenerative process. The present results highlight the importance to use site-matched control samples in comparisons. Also, all in vivo (e.g. arthroscopic) measurements must be accurately located as significant topographical variation may exist within small areas of articular surfaces. As shown in Fig. 2, the site-dependent variation is significant and the parameter values of healthy and degenerated samples from adjacent sites overlap. As histologically intact samples showed significant topographical variation in equilibrium compressive modulus, the results suggest that the healthy tissue is functionally adapted to local mechanical forces that act locally. We believe that the present results can be important when establishing guidelines for in vivo assessment of cartilage structure and integrity.