Characterization of grayscale of the MRI Images for articular cartilage

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ABSTRACT – Magnetic resonance imaging (MRI) is a non-invasive potential imaging method to diagnose the cartilage disorder. Degeneration of the articular cartilage has been recognized as the main cause of osteoarthritis (OA). Normally OA refers to the end-stage which is already incurable. Therefore, in this study, a non-invasive method is develop to characterize the grayscale of the MRI images for articular cartilage. To test this, bovine's humeral head cartilage samples (n=7) were selected as models. The primary findings from the results indicated that there was a significant difference in grayscale intensity of the MRI images on the articular cartilage. This could indicate that the composition in the articular cartilage could affect the grayscale of the articular cartilage. This results give a new perspective into the properties of the tissue.

1. INTRODUCTION

Magnetic resonance imaging (MRI) is a non-invasive technique that provides precise imaging visualization on cartilage tissues, bone, synovium and ligaments [1]. Recently, MRI has been known as a tool to characterize the articular cartilage morphology and function [2].

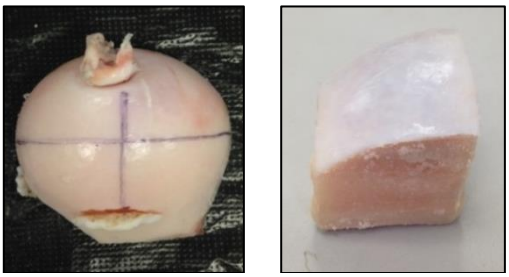
Articular cartilage is a tissue mainly consists of the interstitial water content, collagen and proteoglycan [3]. It comprised of four different layers which can be divided into the superficial zone, middle zone, deep zone and calcified zone.All components in articular cartilage such as proteoglycan, and collagen help in restraining the water content which is very important to remain the unique properties of the articular cartilage [3-4]. Degeneration of the macromolecular constituents in articular cartilage influence the mechanical principle of the tissue [3].

In the present study, a non-invasive method is developed to characterize the grayscale of MRI images on articular cartilage as a potential probe to assess the properties of articular cartilage.

2. METHODOLOGY

2.1 Sample preparation

Articular cartilage from bovine was used in the study as shown in the Figure 1 (a). Humeral head cartilage samples (n=7) were dissected from the 3-4 years old bovine hip joint**.** All humeral heads were sectioned using electric hand saw to yield samples with four quadrants cross-sectional areas of the articular layer and underlying bone as shown in Figure 1 (b). All samples were kept moist in the phosphate buffered saline (PBS) washes and were observed by visual imaging inspection using MRI.



(a) (b)

Figure 1 (a) Cartilage specimen of humeral head, (b) One quadrant of the sample was segmented from the humeral head.

2.2 Magnetic resonance imaging (MRI)

Samples were imaged using a low-field magnetic resonance imaging (MRI) with a magnetic field strength of 0.18 Tesla (Genova, Italy) as shown in Figure 2. Scanning of the MRI images of the cartilage was conducted at room temperature (25o). Gradient echo sequence was selected to scan the cartilage [5- 6]. 2mm axial slices of the cartilage were acquired. Field of view was fixed to 200x200mm and the matrix 256x256.

Figure 2 Samples were scanned using Esaote C-Scan low magnetic field magnetic resonance imaging (MRI) from Genova, Italy.

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2.3 Data processing

Analysis of MRI images was performed using image processing software, MATLAB. The analysis was performed in the search size of 7x14 pixels throughout the region of interest of the articular layer.

3. RESULTS AND DISCUSSION

The grayscale values in pixels of the MRI images on articular cartilage was determined to observe the range for different zone of the articular cartilage.

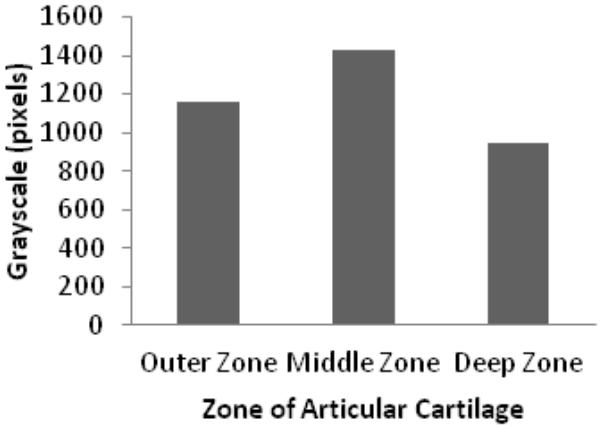

Figure 3 Average grayscale of the MRI images on articular cartilage for different zone.

Figure 3 shows the average grayscale intensity of the MRI images on articular cartilage from one of the samples. Trend for all the samples were the same as it shows a significant difference in grayscale intensity across the different zones of the articular cartilage. Grayscale of the articular cartilage rose gradually from superficial to middle zone until it reach a peak before dropping to the deep zone.

The range of the grayscale intensity for the superficial layer was between 1145.60±10.57 while the middle and the deep zone were between 1411.34±57.50 and 944.48±114.83 respectively. It could be due to the composition in each zone of the articular cartilage that produce a different outcome for the grayscale intensity.

Based on the study, articular cartilage is a complex structure with different composition in each zone that makes the grayscale intensity different across the various zones of the MRI images on articular cartilage [4,6,7]. From superficial to deep subchondral , there is different composition throughout the different layers in regards of the water content, proteoglycan, cellular size and volume and collagen orientation [8].

From the anatomy of the articular cartilage, it shows that water content, proteoglycan and collagen content have an important role in articular cartilage behavior. Deep zone has reduced water content [4, 7]. Subsequently, the grayscale intensity for this zone is the lowest. With this criteria, the water content inherent to the grayscale value among the zones in articular cartilage.

4. CONCLUSION

In this present study, the results of the grayscale intensity of the MRI images on cartilage demonstrated the potential of low-field MRI system to examine the properties of the cartilage. The significant difference in the grayscale intensity across the different zones of the articular cartilage could be reflected mainly based on the composition of the water content, proteoglycan and collagen in different zones. It is also expected that the grayscale intensity could be useful to a new knowledge for further identification of the pre-osteoarthritis and contribute a new insight into the biomechanical environment of the tissues.

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