Early Damage in Articular Cartilage

Osteoarthritis is a disabling and painful disease which commonly prevails with age and overweightness. The diagnosis of this disease normally occurs at a late stage and common treatments include pain relief and physical therapy. These current treatments, however, only provide temporal relief. Eventually a total joint replacement is necessary. Osteoarthritis is linked to the degeneration of articular cartilage, which is a thin layer that covers the ends of the bones in the joints and allows to withstand several times the corporal weight. If articular cartilage degeneration could be detected earlier, the symptoms could be treated in time, and the tissue could return to its normal functioning.

Current diagnosis tools, however, are incapable to detect subtle changes in the articular cartilage. Diverse studies are undertaken to develop tools which can detect the degeneration of articular cartilage in an early stage, but more knowledge about the mechanisms behind the degeneration of articular cartilage is required. The general aim of my research was to achieve a better understanding of the underlying mechanisms involved in the process of early cartilage damage and progression. In the future, this understanding may contribute to creating and developing new tools to predict the initiation and progression of osteoarthritis, therefore making earlier intervention feasible.

To study the degeneration of articular cartilage, we performed a laboratory experiments in which we subjected pieces of bone with cartilage to mechanical overloads. We then observed the effect of the load on the collagen fibers and on proteins called proteoglycans, both present in the extracellular matrix of the articular cartilage.

During the first stage of this research we assessed the location and amount of damage that developed macroscopically in the superficial cartilage layer and microscopically in the internal collagen network, as a function of various combinations of mechanical load (i.e. different magnitudes and speeds). We found that magnitude and speed of load are both linked to the total collagen damage in cartilage.

The above-mentioned finding led to the second stage of this research, where we evaluated the relationship between total proteoglycan loss and the amount and type of collagen damage in the articular cartilage. We determined whether repetitive load further increases the already enhanced loss of proteoglycans in cartilage with collagen damage. An increase in proteoglycan loss was observed in
cartilage samples that had more total collagen damage. Proteoglycan loss was therefore dependent on the presence but not on the amount of internal damage. Furthermore, repeated load alone significantly enhanced proteoglycan loss in cartilage with intact collagen. However, it was shown that once proteoglycan loss is increased because the collagen network is damaged, it is not further enhanced by repetitive load.

In the third stage of this research, we explored whether applying constant load to articular cartilage prior to overload would prevent or reduce the occurrence of collagen damage. In addition, we questioned whether such protective effect would depend on constant load magnitude. The results showed that it is possible to reduce or abolish the amount of collagen damage that develops in the tissue.

Finally, in the fourth stage of our research, we explored the relationship between damage development in cartilage, mechanical load and number of load repetitions, and we evaluated whether the nature of load would make a difference for this relationship. The results showed independence between damage development and number of load repetitions. Furthermore, results clearly showed the stress levels of damage onset decreased depending on the type of load.

Summarizing, this thesis provides insight into specific mechanical load (i.e. magnitudes, speeds, load and number of repetitions) that have an effect on the development of superficial macroscopic or internal microscopic collagen damage, and proteoglycan loss. Additionally, this thesis also shows how constant load prior to overload has a protective effect on articular cartilage. This information together may be useful to develop in the future computational models or tools that could support diagnosis, prevention, and treatment of osteoarthritis.

*Title of PhD-thesis: Strain-induced Initiation and Progression of Articular Cartilage Damage.*

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