Temporary detrimental effect of a high field 3 Tesla Magnetic Resonance to chondrocyte activity

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Introduction

Today magnetic resonance imaging (MRI) is a highly sensitive method in the diagnosis of cartilage damage; however, the effects of high magnetic flux densities on cartilage metabolism are currently unknown. In this study we investigated the effect of a 3 Tesla MRI device on the biosynthetic activity of articular chondrocytes.

Materials and Methods

Metacarpophalangeal joints were obtained from 15 three month old calves and divided into 3 groups. Group 1 was left untreated and served as control. Group 2 was exposed to a static magnetic field (3 Tesla), while group 3 was subjected to a pulsed magnetic field (constant 3 Tesla, additional 0.0135 Tesla pulsed field, pulse rate 0.5s) for the duration of a standard knee-joint examination. Directly after exposure cartilage was removed from the joints and biosynthesis of extracellular matrix macromolecules was measured by [35S] Sulfate incorporation and values were normalized to hydroxyproline content. In a second step cartilage explants were exposed to the magnetic field as described above and proteoglycan synthesis was measured on days 0, 3 and 6. Furthermore, to investigate a possible differentiation towards osteogenesis, alkaline phosphatase (ALP) activity was determined. Chondrocyte apoptosis was assessed by Annexin V staining and TUNEL-FITC labelling using FACS analysis 24 hours after exposure.

Results

The exposure to the magnetic fields, either static or pulsed, resulted in a significant decrease in cartilage macromolecule synthesis (control (mean±SEM cpm/µg hydroxyproline): 6137.1±446.5 vs static field: 3865.7±415.6, $p< 0.002$; vs pulsed field: 3177.8±256.5, $p< 0.00002$) [Fig.1]. In time response studies cartilage metabolic activity recovered and reached proteoglycan synthesis levels comparable to control cultures after 3 days post exposure [Fig.2]. The release of proteoglycans into the supernatant remained unchanged when compared to controls. Annexin V staining as well as TUNEL labelling revealed no significant increase in the number of apoptotic cells in the static and pulsed magnetic field group. There was no difference in ALP activity between the 3 groups.

Conclusion

Although high-field magnetic resonance provides a better signal-to-noise ratio with the possibility to gain higher spatial resolution, our data demonstrate reduced matrix synthesis by articular chondrocytes under the influence of high magnetic flux densities. The 3 Tesla MRI may mimic mechanical stress and induce an inadequate movement of fluid and electrolytes thereby temporaryly compromising chondrocyte metabolism

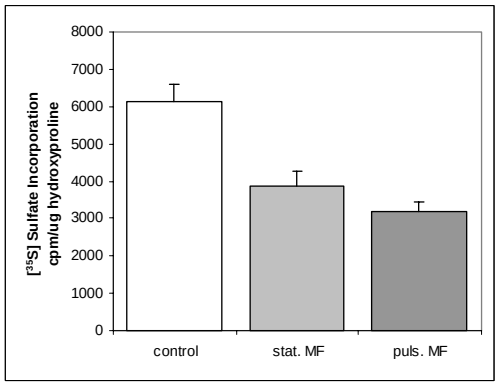

Fig.1 [^{35}S] Sulfat incorporation into newly synthesized matrix molecules

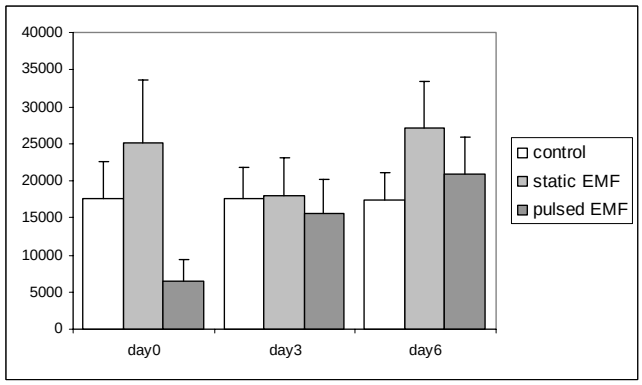

Fig.2 Longterm-experiment (Days post EMF exposition)

Ctrl vs stat. $p>0.002$
Ctrl vs pulsed $p>0.00002$