

Ninety-one MRIs of patients treated with a cell-free collagen-hydroxyapatite osteochondral scaffold for lesions of the knee articular surface were considered (71 men, 20 women, age at surgery 31.2 ± 11.5 years, defect size 2.8 ± 1.6 cm², 38 affected by degenerative and 14 by traumatic cartilage lesions, and 39 by OCD). All MRIs were performed at 2 years of follow-up. MOCART, the most commonly applied MRI scoring system for cartilage evaluation, was used for developing the osteochondral imaging evaluation tool, by expanding the focus also on the subchondral structure and adapting the scores attributed to each parameter according to their correlation with the clinical outcome.

The MRI analysis showed no correlation between MOCART score and the clinical outcome (IKDC subjective score 75.7 ± 15.4). The results of the multivariate analysis, performed to assess the correlation of each osteochondral score parameter with the clinical outcome, were used to attribute the score to each parameter to develop a 0-100 MRI score. Statistical analysis confirmed the correlation between the MRI results and the clinical outcome, both for the overall group and the patellar lesions ($p=0.008$ and $p=0.038$, respectively). With a few exceptions, patients clinically successful with an IKDC > 80 also had an MRI osteochondral score of at least 70 ($p=0.002$).

In conclusion, after reducing the parameters for cartilage layer evaluation and expanding the focus on the subchondral layer, 7 parameters were selected: degree of filling and integration, surface appearance, signal intensity with DP FAT-SAT, subchondral bone appearance and edema, effusion. The new osteochondral score correlated with the clinical outcome, proving to be an useful tool for the study of tissue maturation after the implantation of scaffolds for osteochondral regeneration.

IMAGING TECHNOLOGIES IN TISSUE ENGINEERING

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Introduction

Monitoring the parameters oxygen, pH or CO₂ is of great interest in many fields in cell biology and medical research. The knowledge on these parameters gives evidence on the metabolic status of cells, spheroids, engineered or native tissue. Ideally, a detection method should be non toxic and non invasive and at the same time the respective analyte should not be consumed during an online measurement. We

addressed these points and developed a new imaging device for online monitoring of metabolic activity.

Methods

The imaging system VisiSens consists of a compact fluorescence microscope and an optical sensor foil. The sensor foil is doped with fluorescent dyes which are sensitive to oxygen, pH or CO₂. The foils are flexible and based on a transparent polyester support, thus they can be cut to any desired size to fit the experimental requirements. A non-transparent optical isolation layer above prevents cross-talk by optical interferences like sample auto-fluorescence or ambient light. The sensor translates concentrations of oxygen, pH or CO₂ into specific light signals. Each dye molecule inside the sensor foil reacts independently and the light signals can be recorded with the digital camera inside the detector unit. One single image contains the information of a whole array of single sensor points. This way the oxygen distribution over a large 2D area can be visualized and analyzed with a high spatial resolution.

Results

We present application examples starting from monitoring cell monolayers over spheroids to engineered and native tissue. The method is simple, fast and reliable and even vasculated tissue may be examined in one step and monitored over time periods up to several days. The spatial resolution of the respective oxygen, pH or CO₂ maps is shown to be as low as 25 μm in optimal case. The system was already applied for investigating microfluidic chips, native and engineered tissue.

Conclusion

The new imaging system VisiSens is compact, mobile, flexible and easy to use and allows imaging of pattern and gradients with high spatial resolution and without analyte consumption. VisiSens proofed to be a new and valuable tool for online monitoring of metabolic activity.