3D VISUALISATION OF THE TOOTH CARIES - POTENTIAL NEW AREA FOR BIOMEDICAL APPLICATION OF MRI

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Introduction

X-ray based visualization techniques were for many years the only way to asses structure and state of the human teeth. However, during last decade MRI has been used in the research of the healthy and decayed teeth. Several papers were presented showing usefulness of Spin Echo and Gradient Echo imaging, SPI/SPRITE and STRAFI techniques for visualization of the dental surface geometry as well as for distinction between soft tissue (pulp) and mineralized tissue (enamel, dentine and root cement) in the extracted teeth [1-4]. Recently, MRI was used for estimation of the facial bone structure, in preparation to implantation, localization of the tumor in the facial bone tissue, and in detection of the osteoporosis.

The aim of this work was to asses applicability of different MRI techniques for detection and estimation of the teeth caries *in vitro*, on the level of laboratory pre-clinical tests. This work was done within the project to investigate potential and limitations of MRI as a diagnostic technique for dentistry needs.

Materials and Methods

Five extracted human teeth (impossible conservative therapy- for example see Fig 1a), with different level of decay were obtained at Dept. of Dental Surgery MUS. 3D Spin Echo (SE) and Fast Spin Echo (FSE) MR images were done in MR Tomography Lab INP, Krakow, Poland, using 4.7 T research MRI system, equipped with Maran DRX console and dedicated home-built probehead. Prior to the experiment, teeth immersed in water were degassed to minimize magnetic susceptibility artifacts. 3D (512x128x128) images of the teeth with corresponding resolution of 30x120x180 μm^3 were obtained. Silent Single Point Imaging (SPI) [5] were performed using 11.7 T, vertical bore Bruker MRI system, in IBD, Winnipeg, Canada. SPI experiment were done without prior preparation of teeth. In this case lower resolution of 315x315x940 μm^3 was achieved.

Additionally, CT was performed on the most decayed tooth. CT measurements were done as OrbiSinus Topogram 1.0 T20s, with in plane resolution 512x512 (FOV 165x165 mm) for 281/0.1mm slices.

MR data were visualized and analyzed using home developed IDL based software and ImageJ software.

Results

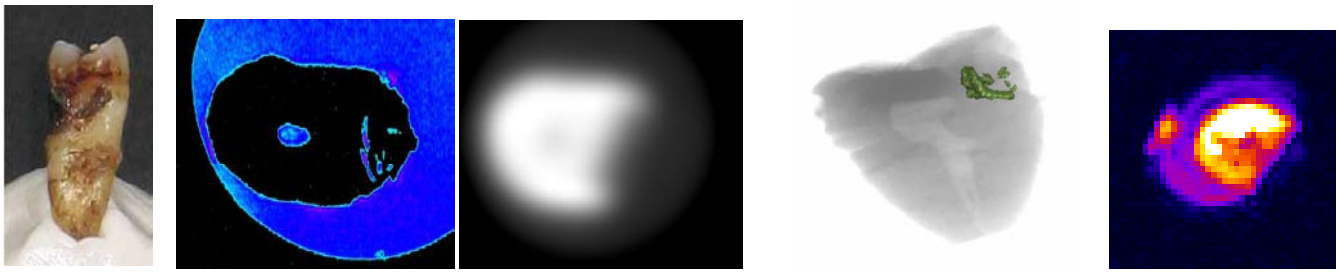
Fig. 1b and 1c show comparison of the corresponding cross-sections of the 3D SE MRI and CT data. In MR image high intensity signal from water penetrated into the porous decayed regions of tooth, contrasted with lack of signal from mineralized tooth tissue, allow for high resolution visualization of the presence and pores within decayed tooth's tissue. FSE MR imaging gives results in somewhat worse quality, however in significantly reduced experimental time. In CT image, decreasing of the signal correlated with decreasing of the tooth tissue density in the area of decay (the right side of image) is visible. Reconstruction of the shape and position of the pores within tooth, based on the MR image is shown in Fig. 1d. The cross-section through the 3D SPI image of the tooth with decay comparable with that for the SE/FSE images is shown in Fig 1e.

Discussion

Spin-echo based MR imaging methods allow for high resolution visualization of the moisture entering into heavily decayed tooth, which are paths for microorganisms causing further damage of the tissue. SE method which gives the highest quality images is relatively slow, and typically require more than 1h time for data collection. With FSE method reasonable quality image is possible to obtain in less than 10 minutes time, which in principle can be considered as applicable *in vivo*. With these methods it is not possible to see any details in mineralized tooth's tissue, especially gradual decrease in tissue density in early stages of the caries development, as it can be seen from CT image. With this respect, the SPI method which allow for visualization of the mineralized tissue is more promising. Its limitations in obtaining high resolution images are long data collection and substantial rf deposition which has to be seriously considered in case of *in vivo* imaging. The potential solution is to compromise resolution. The silent version of the method used in this work overcome another typical disadvantage of SPI, i.e. high level of acoustic noise.

Conclusions

3D SE/FSE MRI measuring methods are capable to visualize water filled pores within carious teeth. As such they gives possibility to investigate extent of the pores through which moisture can penetrate within decayed tooth's tissue. However, this particular method do not allows for visualization of the mineralized tooth tissue and thus do not allow for estimation of its density, which decreases in early stage of the development of the caries. In this respect CT method seems to be better suited. SPI, which is considered to be the "solid" MRI method, allows for visualization of more rigid materials and thus gives possibility to see more details in mineralized tooth tissue. The challenges in transferring these MR techniques to *in vivo* conditions in present stage is lack of dedicated hardware, as well as safety considerations in case of SPI.



a **b** **c** **d** **e**

Fig.1 The photo image (a), corresponding cross-sections through 3D SE MR (b) and 3D CT (c) images and the pseudo 3D reconstruction (d) of the decayed tooth, obtained from 3D SE MR data. In fig (e) 2D cross-section from 3D SPI data of tooth with decay comparable to that for SE images is shown.

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