In-vitro quantification of dental filling induced artifacts in dental magnetic resonance imaging using ultrashort echo time (UTE) at 3 Tesla

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Introduction

Teeth restoration and placement of dental fillings is mostly monitored using X-ray imaging, which is less frequently complemented by volume CT. Although, X-ray based methods are currently the gold standard, the required ionizing radiation and artifacts caused by metal materials rise the interest in non-invasive imaging alternatives. MRI has not yet entered the field of dental imaging, mainly due to limitations in assessing the hard tissue of the teeth and metal artifacts caused by the dental fillings. However, with the advent of MRI approaches using ultrashort echo time (UTE) with TE=50μs assessment of anatomical and physiological features of teeth have been proven (1). To finally assess the value of MRI as a real alternative to X-ray based imaging, its sensitivity to dental filling materials has to be investigated.

The goal of this paper is to assess the sensitivity of UTE-MRI to artifacts induced by different commercially available filling materials, widely used in dental practice. This contribution compares also the resulting artifact level caused by the dental filling materials using UTE imaging approach to those acquired by conventional spin echo and gradient echo MRI techniques.

Materials and Methods

Samples preparation: 17 different samples of commercially available dental filling materials were separately tested. In order to decrease susceptibility artifacts and mimic the biological conditions, each dental filling material was embedded in agarosa gel, which was carefully degazed to avoid air bubbles in the original solution.

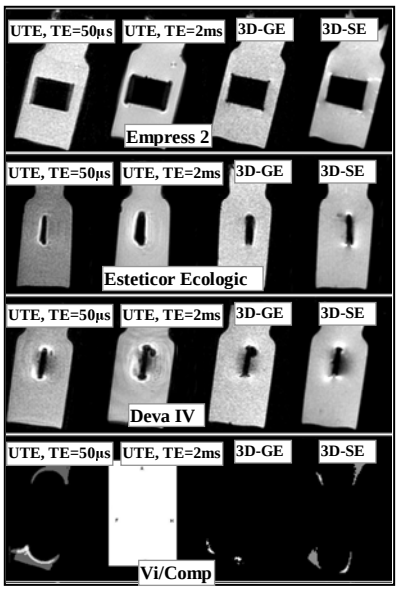
MRI Measurement: All measurements were carried out using 3 Tesla whole body MRI system (Achieva, Philips Medical Systems, Best, The Netherlands) equipped with enhanced gradient hardware (max gradient 40 mT/m) using a maximum slew rate of 200T/m.s. All data were acquired with a two times two-element carotid artery coil sized 120×50 mm overall (Philips Research Europe, Hamburg, Germany). The internal coils measure 65×50 mm.

A non-selective short RF pulse was applied for excitation to ensure minimal echo times, which were only limited by the time required to switch the RF front-end from transmit to receive mode. K-space was encoded along a 3D radial trajectory covering a sphere at homogeneous angular density. The k-space data permit the reconstruction of spherically shaped 3D datasets at isotropic spatial resolution. The scan parameters for the UTE acquisitions were: FOV 80mm^3, α=10°, 3 signal averages, TR=9.4, TE=0.05, 2 and 4 ms at a bandwidth of 357 Hz/voxel, with a total scan time of 37min. Images were reconstructed using an 400^3 matrix, yielding an isotropic resolution of 200μm^3. The 3D gradient echo parameters were FOV 80mm^3, α=10°, 3 signal averages, TR/TE =12.8/5.1ms while 3D spin echo parameters were FOV 80mm^3, α=90°, 3 signal averages, TR/TE =163.9/14.6ms.

Artifacts Quantification and classification: To date, studies of dental and non dental implants and fillings artifacts in MRI was mainly focusing on qualitative assessment including evaluation of the signal enhancement at the interface of filling or implant and tissue of the imaged part of the body. In this in-vitro study, we introduce a quantitative index that is volume ratio index (VR_i), which is simply defined as ratio of volume of the dental filling or implant by the volume of the same implant as evaluated in the 3D MRI images. VR_i evaluates the extension of the volume of filling and implant in the tissue space without considering distortion around. In addition, artifacts were classified according to the severity (2) that sever artifact corresponding to completely blurred and distorted image have a score 5 while image free of artifacts have the score 0. Scores 1, 2, 3 and 4 correspond respectively to images that have very slight, slight, moderate and strong artifacts.

Results

Most amalgam dental materials showed a VR_i close to 1 in images of UTE at TE=50μs with an artifact score varying between 0 and 2, while one material showed VR_i=1.24 and a score of severity of 3. In the mean time higher VR_i and severity of artifacts (2 to 4) were noticed in images of UTE at 2ms, 3D-GE and 3D-SE images. Tree amalgam materials showed a VR_i= ∞ and a severity of artifact of 6. 2 composite materials studied showed a VR_i 1.01 for UTE at 50 μs while it varied between 1.03 and 1.14 for the images acquired with other methods; the score of severity of artifacts didn't exceed 1. A sample of results is shown in the Figure 1.



Discussion and conclusion

The UTE imaging method used at shortest TE= 50μs showed least artifacts for amalgam materials investigated, while more severe artifacts were found when using other imaging methods investigated except 3 materials that showed completely destroyed signal for all techniques. The composite filling is most compatible with all imaging methods investigated. In conclusion, the artifact level in MRI depends on imaging method used and also on the composition of the dental material.

References

(1) Abstracts 143 and 144, ISMRM Conf Proceedings 2009; Honolulu, Hawai'i, USA.

(2) J Jpn Prosthodont Soc Vol. 52 (2008), No. 2 pp.205-210