# Dental MRI: Compatibility of Dental Materials

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**Introduction.** Recently, new approaches for application of MRI in various branches of dentistry have been proposed: in endodontics [1], prosthodontics [2], orthodontics [3] and diagnosis of dental caries [4]. Dental materials present in the subject's mouth pose a major concern for dental applications of MRI. Magnetic susceptibility information is not readily available for many materials used in dentistry, especially those containing several components. Partly contradictory results have been reported regarding the severity of image artifacts caused by different dental materials [5,6], often without consideration of dental applications of MRI. The purpose of this paper was to study compatibility of standard dental materials and classify them from the standpoint of dental MRI (dMRI).

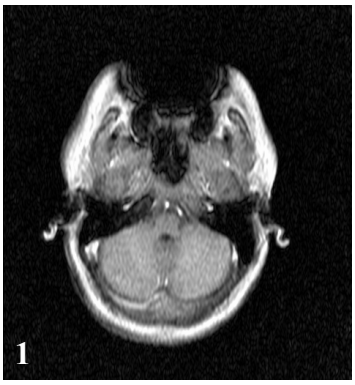
**Subjects and Methods.** A series of standard dental materials listed in Table 1 was studied on a 1.5 T MRI scanner using a 4 cm diameter RF surface coil. Materials were placed on PEEK cylinders and immersed in water doped with a Gd-based contrast agent. Spin echo and gradient echo images were acquired. Image distortions were analyzed and for cylindrically shaped materials the magnetic susceptibility was estimated according to [7]. The materials were classified according to their compatibility solely from the standpoint of dMRI. High-resolution MRI-based digitization of the tooth surface [1] (the most demanding dMRI application with an isotropic resolution of 300 µm) served as the criteria. Depending on the severity of distortions, the dental materials were classified according to four groups:

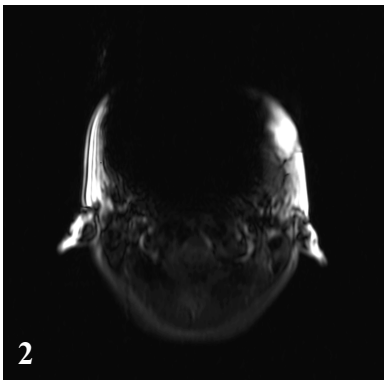
- ***compatible*** material can be present in the tooth of interest
- ***non-compatible I*** material should not be present in the tooth of interest OR its direct neighbors
- ***non-compatible II*** material should not be present in two to five neighbor teeth (depending on the amount of the material)
- ***non-compatible III*** material should not be present in the mouth

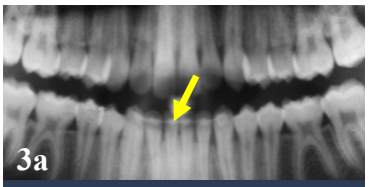
| Material | Manufacturer | dMRI-Compatibility |
|---|---|---|
| "AH Plus" resin | ***Dentsply*** | ***compatible*** |
| Amalgam | ***Degussa*** | ***non-compatible I*** |
| CoCr alloy | ***Amann Girrbach*** | ***non-compatible II*** |
| Composites | ***3M ESPE*** <br> ***Ivoclar Vivadent*** | ***compatible*** <br> ***non-compatible II*** |
| Glass ionomer cement | ***3M ESPE*** | ***compatible*** |
| Gold alloy | ***DeguDent*** | ***non-compatible I*** |
| Gold-ceramic crown | ***DeguDent*** | ***non-compatible I*** |
| Gutta-percha | ***Demedi-Dent*** | ***compatible*** |
| Titanium alloy | ***Friadent*** | ***non-compatible II*** |
| Zircon dioxide (ZrO2) | ***Metoxit*** | ***compatible*** |
| **Orthodontic appliances** | | |
| NiTi alloy wire | ***Dentaurum*** | ***non-compatible II*** |
| Stainless steel wire | ***Dentaurum*** | ***non-compatible III*** |
| Stainless steel brackets | ***Dentaurum*** | ***non-compatible III*** |

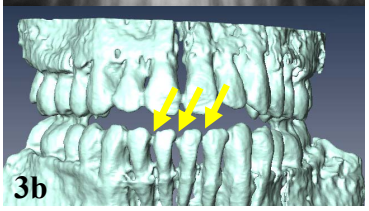
**Results.** The results are summarized in Table 1. As expected, the stainless steel orthodontic appliances showed the strongest distortions, making dMRI impossible in most cases (*non-compatible III*). *In vivo* examples of a stainless steel retainer and braces are shown in Figs. 1 and 2 respectively. NiTi wires caused smaller artifacts, which in 3D reconstructions became apparent as slight distortions of the tooth surface (Fig. 3b). Relatively strong distortions (*non-compatible II*) were caused by composite materials from some manufacturers, probably due to the use of iron oxide pigments [8]. An *in vivo* example of a composite filling is shown in Fig. 4b. No detectable artifacts (*compatible*) were caused by zirconium dioxide, glass ionomer cement, resin-based sealer "AH Plus", and gutta-percha.

**Discussion and Conclusion.** Development of MRI applications in dentistry sets new requirements for the compatibility of dental materials. Although solutions for artifact correction are being sought [9], foreign materials in the body still remain an issue. Influence of dental materials on MRI in general has been studied previously (e.g. [6]), however, dental applications of MRI are more sensitive to the presence of dental materials. This paper provides classification of some standard dental materials solely from the standpoint of dMRI applications, and can serve as a guideline in future dMRI research.



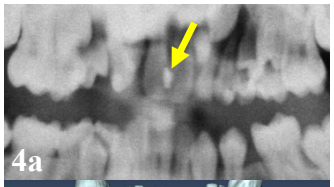





**Fig. 1** MRI scout scan of a volunteer with a stainless steel retainer. Signal void is seen in the region of the teeth. **Fig. 2** MRI scout scan of a volunteer with braces. **Fig. 3** X-ray image (a) and a 3D MRI reconstruction (b) of the teeth of a volunteer with a NiTi retainer (marked with arrows). **Fig. 4** X-ray image (a) and a 3D MRI reconstruction (b) of the teeth of a volunteer with a composite filling (Ivoclar Vivadent) in the front teeth (marked with arrows).

**References** [1] B. Kress et al, Dentomaxillofac Radiol 2004, 33(4):241-244. [2] O. Tymofiyeva et al, Concept Magn Reson B: Magn Reson Eng 2008, 33B: 244-251. [3] O. Tymofiyeva et al, Clin Oral Invest 2009 (in print). [4] O. Tymofiyeva et al, MAGMA (accepted). [5] G. Eggers et al, MAGMA 2005, 18(2):103-111. [6] F. Shafiei et al, J Dent Res 2003, 82(8):602-606. [7] J.F. Schenck. Proc. SMRM, 1993, p. 350. [8] O. Tymofiyeva et al, Proc. ESMRMB 2008 (abstract 843). [9] M.N. Hoff, Q-S. Xiang. Proc. ISMRM, Hawaii, USA (abstract 571).