3D MRI impression of metal implant scan abutment in dental implantology

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Introduction: Artifacts induced from dental alloys are potential pitfall in dental MRT. Depending on the imaging sequence and the material used, susceptibility as well as eddy current artifacts are more or less distinct [1],[2]. In dental implantology, a titanium implant (fig. 1) is inserted into the jaw bone. For virtual modeling of a fixed partial denture (bridge or crown), the orientation of the in situ implant must be recorded along with the neighboring teeth, enabling the dental technician to model a well-fitting restoration. This is achieved by affixing a scan abutment with a defined shape that can be detected by pattern-recognition in the scan results. State-of-the-art technologies make use of optical model or situation scans. This being a multi-step process, it is prone to error. In addition, a second impression with gingiva cut-off has to be made to fit the crown into the surrounding. The proposed method comprises all of that in a single scan.

Figure 1 Dental implant. From top to bottom: non-precious metal temporary screw, abutment and titanium implant.

Figure 2 Phantom dentition with mounted implant. The head is recessed in the bone and the scan abutment fixed with MR compatible material.

Subjects and Methods: A titanium dental implant with magnetic susceptibility of 182×10^{-6} was mounted into a phantom (fig. 2). A scan abutment consisting of PEEK (polyetheretherketone) with magnetic susceptibility of -9.3×10^{-6} (human tissue ~ $(-11 \ldots -7) \times 10^{-6}$) was mounted prior to MRI with a 3D TSE sequence similar to [2] with parameters TE=11ms, TR=400ms, echo-train length 7, band-width 390 Hz/pixel, isotropic resolution of 300µm with a total scan time of 5min on a clinical 1.5T MRT scanner. Two 4x4-channel multifunctional array coil array were used for the measurement. For an optimal contrast-to-noise ratio the phantom was surrounded by an enteral contrast agent, which can also be applied in the mouth. The partition direction of the imaging volume was chosen along the implant axis. The acquired dataset's resolution was enhanced by zero-filling [3].

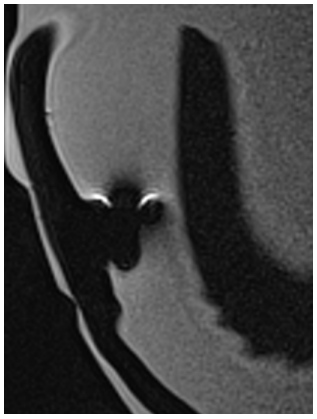

Figure 3 Distortion caused by metal artifacts inside the artificial gingiva in a plane perpendicular to the implant axis.

Results: The measurement data shows that an impression from the scan abutment is possible, when the non-precious metal screw is replaced by a MR compatible screw (fig. 4). The artifacts of the implant head caused by the titanium body of the implant are only visible in-plane within the gingiva (fig. 3) and do not affect the slices that do not contain metal. The TSE sequence is not as sensitive to metal artifacts as a gradient echo sequence is. Strong gradient fields implying high bandwidth and high resolution as well as a short echo time also contribute to less distinct susceptibility artifacts. The scan abutment itself is depicted free of artifacts (fig. 4).

Conclusion: Despite the presence of a metal body in immediate vicinity, the unit consisting of PEEK screw, scan abutment and implant can be measured in MRI and yield a dataset containing the required information for further modeling of a fixed partial denture by a dental technician. Additional metal artifact correction methods like MARS or 3D-PLACE are not needed in this case. For CNR enhancement, the abutment can be scanned intra-orally using an intra-oral coil.

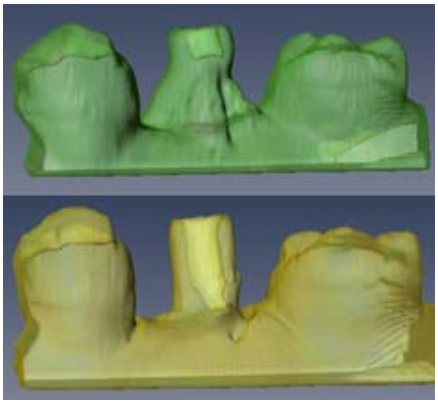

Figure 4 Segmented 3D dataset with (top) and w/o non-precious metal screw (bottom). In the upper image artifacts of the metal screw distort the depiction of the abutment. In the lower image, scan abutment and neighbored teeth are artifact-free with minor distortion in the marginal gingiva.

References: [1] Taniyama, Tomohide et al., Dental Materials Journal 29:297-302 (2010). [2] Tymofiyeva et al., Proc. ISMRM 2010 [3] Tymofiyeva et al., Magma (2010).