In-vivo high-resolution MRI of the Jaw Bone

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Introduction: For planning of dental implants a high-resolution survey radiograph of the jaw bone is an important tool. It provides information about the localization of the mandibular nerve canal and the position of the foramen mentale, assisting the surgeon in avoiding these structures when planning the position and direction of the dental implant. Furthermore, the thickness and a measure of the quality of the bone helps in deciding for implant dimensions and the possible need of bone grafts. Some of this information is currently obtained by dental X-ray, especially by cone beam tomography. The latter method does provide 3D images of the jaw bone but in order to maintain the lowest level of X-ray exposure, the tradeoff between resolution and dose limits the accuracy of this method e.g. in localizing the mandibular nerve. To overcome this limitation, this work investigated the possibility to use high-resolution MRI methods. So far only work concerning the jaw bone ex-vivo were published [1]. They show that the distinction of cancellous and cortical bone is indeed possible.

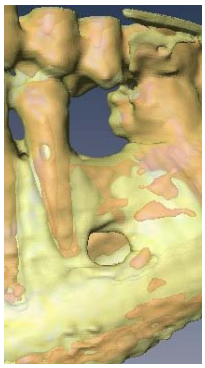

Fig. 1: Segmentation of the high-resolution image allows clear localization of the foramen mentale.

Subjects and Methods: For high-resolution imaging, which shows an overview of the jaw, a standard T_1-weighted TSE sequence was employed on a 3T scanner (TE=12ms, TR=1000ms, TF=12, 0.4x0.4x1mm³, TA=5:30min, 4-channel array extra oral dental coil [2]).
For the ultra-high-resolution bone depiction, a standard T_1-weighted TSE sequence was employed (TE=20ms, TR=500ms, TF=8, 0.2x0.2x0.5mm³, TA=14min, 4-channel array multi-function coils). To minimize motion artifacts one coil was placed on each side of the patient's jaw and tightly hold in place using a mechanical fixture.

Results: Figure 1 shows the teeth and jaw bone from a segmented high resolution dataset. The second premolar tooth 45 is missing. The foramen mentale is clearly depicted and the length of the roots can be assessed. Figure 2 shows a cross-sectional view of the 3D ultra-high-resolution dataset of both sides of a volunteer's jaw bone. Between the roots, the bone matrix is visible. In the lower image the gap and the foramen mentale (white arrow) as well as the nerve canal in the bone (black arrow) is clearly visible. The implant must not be placed too close to the nerve canal and the images show that in this case there is not enough bone to place an implant long and wide enough and still safely avoid any risk.
Furthermore the trabecular network in the maxilla can be visualized with ultra-high-resolution imaging the as seen in figure 3. This allows a qualitative rating of bone strength and thus can be used to check, whether the bone can hold an implant tight in place or if additional treatment for bone regeneration is needed.

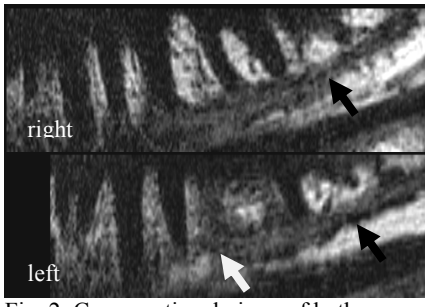

Fig. 2: Cross sectional views of both sides of a jaw bone. The position of the roots and the nerve canal (black arrow) can be seen on both images. In the lower image, the gap with the missing tooth and the foramen mentale is indicated by the white arrow

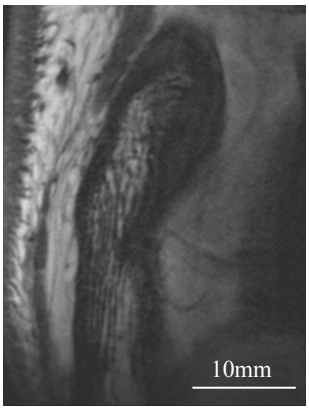

Fig. 3: Ultra-high resolution MR image allows visualization of trabecular bone in the maxilla.

Conclusion: It was shown that high resolution MRI can be used in-vivo to assess the three dimensional bone structures and the localization of the mandibular nerve. The measurement time is short enough to be tolerated by the patients and motion artifacts are found to be small enough. The image quality apepars to be sufficient to aid the placement of dental implants and help the surgeon to decide on the need for bone grafts. The suitability of the MRI-data for fabrication of surgical trays will have to be shown but the absence of x-ray irradiation makes MRI a promising method for dental imaging in the longer term.

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References: [1] L. Choël et al., "Trabecular alveolar bone microarchitecture in the human mandible using high resolution magnetic resonance imaging.," *Dento maxillo facial radiology*, vol. 33, no. 3, pp. 177-82, May. 2004. [2] Düring et al. Proc ISMRM 2009 [3] R. Jacobs et al., "Neurovascularization of the anterior jaw bones revisited using high-resolution magnetic resonance imaging.," *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics*, vol. 103, no. 5, pp. 683-93, May. 2007.