Development of an air-driven, MR-compatible and x-ray transparent bone drill

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Figure 2: *Prototype of the developed MR-compatible and x-ray transparent bone drill.*

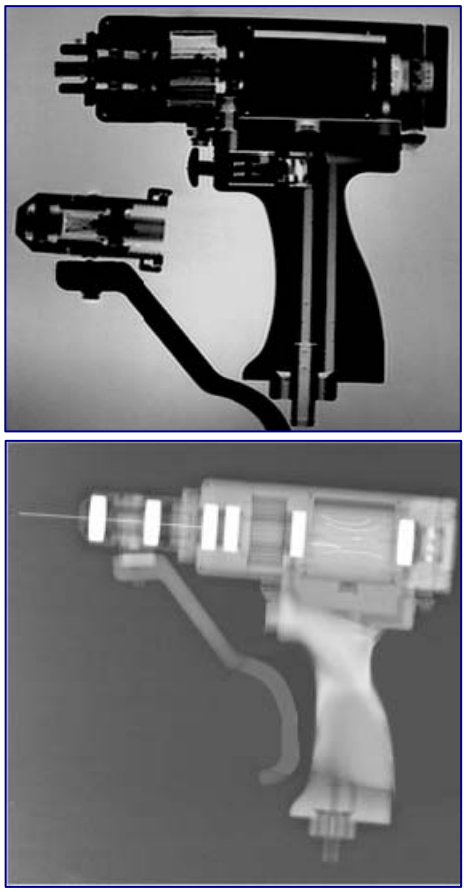

Figure 3: *The prototype shows no susceptibility artifacts on the MR-image (above) and also on the CT-image (below) the material is almost x-ray transparent.*

Introduction:

The precise drilling of bones is a common procedure in orthopaedic surgery of diagnostic and therapeutic areas [1-3]. Image-guided bone bores were usually performed under computed tomography (CT) control. The bone drills are manufactured by metallic components because of their high mechanic load during a bone bore. Due to their radiodensity, the metallic components lead to a limited image quality, and thus hinder the control of surgery. Moreover, those devices are not adequate for MRI due to their typically ferromagnetic components. The purpose of this study was to develop a bone drill for real-time interventions in MRI and CT that does not influence the imaging, is able to bore through dense structures, and enables the laying of Kirschner wires.

Material and Methods:

The construction (see Figure 1) was realized with the aid of orthopaedic requirements for standard (non MR-suitable) bore drills. A special designed, pneumatically controlled drive system of ferrite-free components was developed. After prototype fabrication, the speed, weight, air consumption, operating pressure, perforation and noise level were measured. The evaluation of the manufactured prototype occurred under MR-navigation. During the phantom experiment (n=10), a Kirschner wire was driven into compact bone. Furthermore, the sterilizability in an autoclave, the MR-compatibility and the practical handling of the bore were tested.

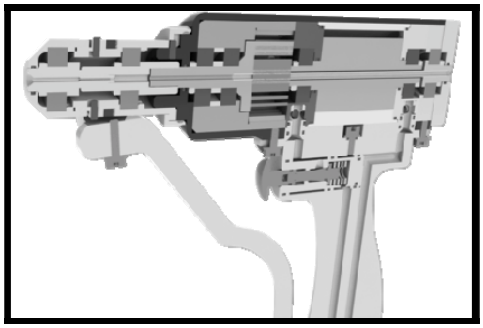

Figure 1: *Computer-aided design of the bone drill.*

Results:

The designed bone drilling (see Figure 2) offers an air-driven, ferrite-free drive system that is MR-compatible according to ASTM and almost completely transparent to x-ray (see Figure 3). The prototype proved in practice to be „comparable“ to other conventional orthopaedic drills and could be used intuitively in all part-functions as feed and clamping systems. The technical data of the prototype were calculated as follows: rotation speed 0–1000 pro min, weight ca. 800 g, air consumption ca. 250 l/min, operating pressure 6–7 bar (max. 10 bar), perforation 3.2 mm, noise level (operator position) ca. 50 dB(A). The placement of Kirschner wire in compact bone was performed without difficulty. The autoclave of the drill at 134°C and 2 bar proceeded without any impairment of the future function.

Conclusions:

The manufacture of an MR-compatible bore drill, comparable to the power of a commercial MR non-compatible system, is in principle possible. Such a device could open new options in CT- and MRI-navigated surgery.

References:

[1] *Ohe, T., K. Nakamura, et al. (1997). Stereo fluoroscopy-assisted distal interlocking of intramedullary nails. Journal of orthopaedic trauma 11(4): 300.*
[2] *Gautier, E., R. Bächler, et al. (2001). Accuracy of computer-guided screw fixation of the sacroiliac joint. Clinical orthopaedics and related research 393: 310.*
[3] *Schnieders, M. J., S. B. Dave, et al. (1997). Assessing the accuracy of a prototype drill guide for fibular graft placement in femoral head necrosis. The Iowa Orthopaedic Journal 17: 58.*