Retrograde Drilling of Osteochondral Lesions of the Knee with MRI guidance

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Introduction:
Today, computer assisted surgery is a novel challenge for surgeons and interventional radiologists. Magnetic Resonance guided musculoskeletal procedures are still evolving. In this experimental study, the authors are introducing and assessing an innovative passive navigation method for the MR-guided treatment of Osteochondritis Dissecans (OCD) of the knee.

Material and Methods:
In preliminary tests the interactive PDW FSE (TR: 400ms, TE: 8ms, FOV: 200 x 138, 1.6s/image) was proven to be superior for interactive imaging. Artificial osteochondral defects (Ø = 4.5mm) were simulated in 6 human cadaveric knees at the medial and lateral femoral condyle using a 4.5mm bone cutting system. All tests were performed in a 1.0T open MRI PANORAMA (Philips, Best, NL). For drilling we used a custom-made MR-compatible c-shaped drilling device *(Fig. 1)*. For visualization it was marked with Gd-filled tubules on its opposite ends. The upper marker had a 3.4 mm drilling-port. The first step was to determine a single image plane in order to visualize the desired drilling direction and orientation. Under interactive image acquisition the drilling device was aligned with the selected plane using the filled markers as a reference. The two markers on each end of the drilling device were positioned in line with the osteochondral lesion. Drillings were performed under int. PDW FSE control with a MR-compatible drilling machine (Invivo, Schwerin, Germany) with a 3.4mm titanium spiral drill *(Fig. 2)*. Postoperative diagnostic T1W FSE scans and saw cut specimens were taken and the distances were measured *(Fig. 3)*.

Results:
MRI-navigated retrograde drilling of OCD using a passive drilling guide enabled precise drilling into the lesion. Saw cut specimens showed that all artificial lesions were hit without perforating the overlying cartilage. All 12 artificial lesions were targeted with an accuracy of 1.86 mm ± 0.99 in the coronal plane and 1.4 mm ± 0.87 in the sagittal plane. Due to the use of a low artifact titanium spiral drill and spin echo sequences, artifacts were minimal and allowed exact assessment of anatomic structures and a safe drilling. Int. PDW FSE was feasible for near real-time image acquisition and intervention. The time for predefinition of the coronal drilling plane on the user interface was 3.74 minutes ± 0.47, the time for exact drilling guide alignment was 6.23 minutes ± 1.41, and the time for drilling under MR-guidance was 4.1 minutes ± 0.75.

Conclusion:
Our experiment suggests that MR-navigated drilling in combination with a noninvasive and MR-compatible drilling guide may provide a superior approach, compared to conventional methods. This MR-guided method allows percutaneously drilling under local anesthetic without opening the joint capsule and thereby reduces the risk of articular infection by sparing arthroscopy.

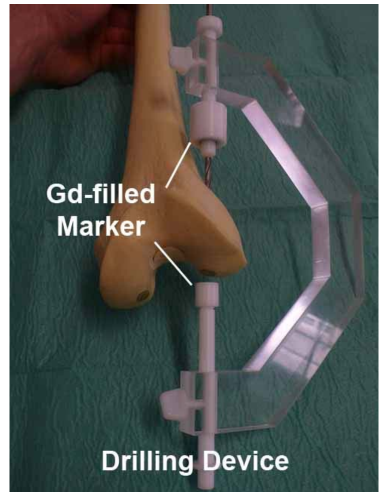

Figure 1:
Photograph shows the adjustment of the navigation device to a Synbone™ model. Both markers which are assembled with the c-shaped main part were aligned with the artificial osteochondral defect .

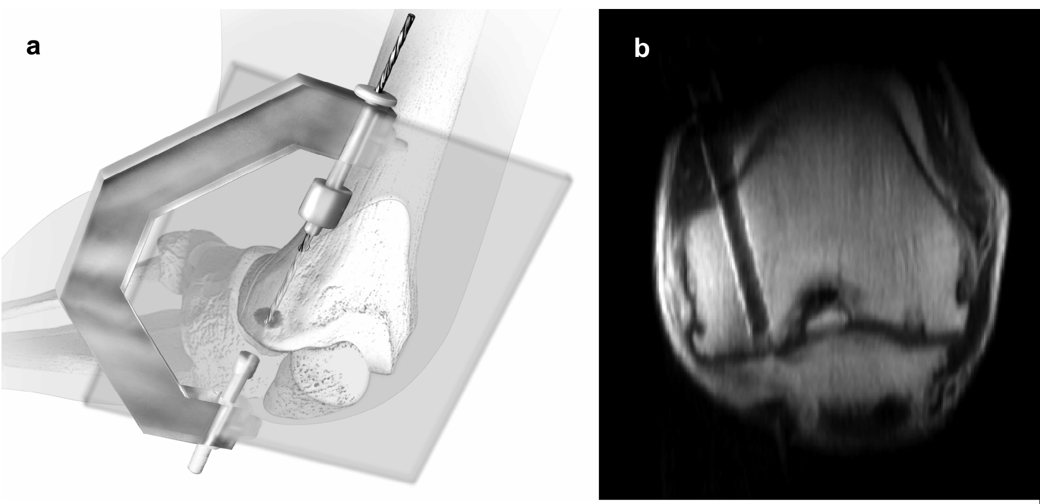

Figure 2:
Schematic drawing (a) and coronal interactive PD-weighted FSE image (b) show the drilling procedure under interactive MR guidance. The drill guide was hand-held throughout the procedure. Minor movements could be corrected immediately. The artificial osteochondral lesion was hit.

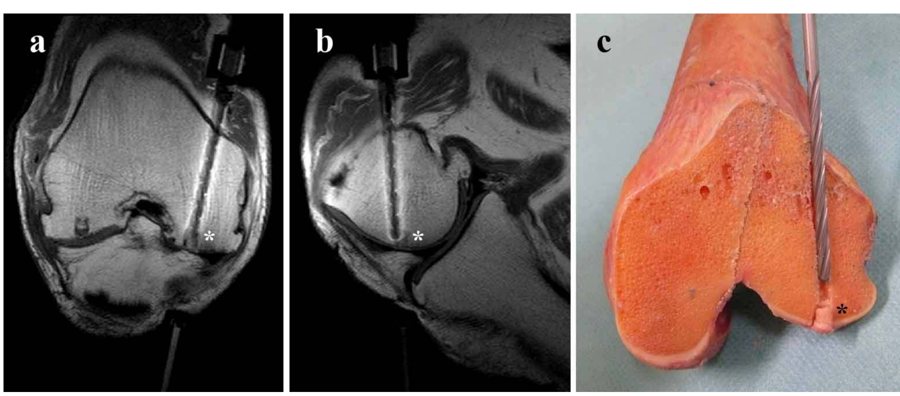

Figure 3: Coronal (a) and sagittal (b) T1-weighted MR images and saw-cut specimen (c) after drilling show the results of the drilling experiments. After each drilling, the femoral condyles were scanned in coronal and sagittal planes parallel to the drilling canal in order to measure possible deviations of the drilling canal from the center of the artificial osteochondral lesion. Finally, every specimen was cut along the drilling canal. The artificial osteochondral lesion(*)was hit.