MR-assisted Retrograde Drilling of Osteochondral Lesions of the Talus – A feasibility study

C.Seebauer[1], F.Wichlas[1], J.Rump[2], J.Pinkernelle[2], I.Papanikolaou[3], T.Jung[1], S.Chopra[4], U.Teichgräber[2] and H.J.Bail[1]

[1]Center for Muskuloskeletal Surgery, Charité, Berlin, Germany, [2]Department of Radiology, Charité, Berlin, Germany,
[3]Central Interdisciplinary Endoscopy Unit, Charité, Berlin, Germany, [4]Department of Surgery, Charité, Berlin, Germany

Introduction:

Retrograde drilling techniques are clinically established. However, the poor visualization under X-ray control can lead to damage of bone and cartilage. MRI is ideal for the evaluation of the osteocartilaginous components of talus lesions. We present an innovative method using a MR-compatible drilling guide for the minimal-invasive treatment of OD under MR-control.

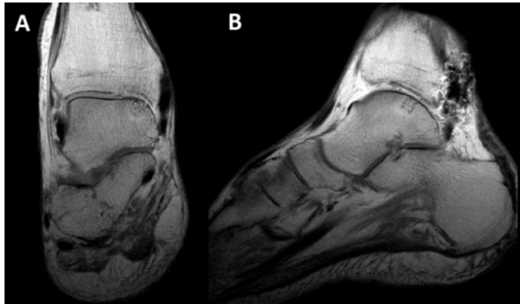

Figure 1
T1W TSE image of the artificial osteochondral lesion
A: coronal; B: sagital; Measurement: diameter of the OD lesion 4.5mm

Figure 2
Custom made drilling guide;
3.4mm titanium spiral drill is put through the drilling capsule and is bent on the tubule marker

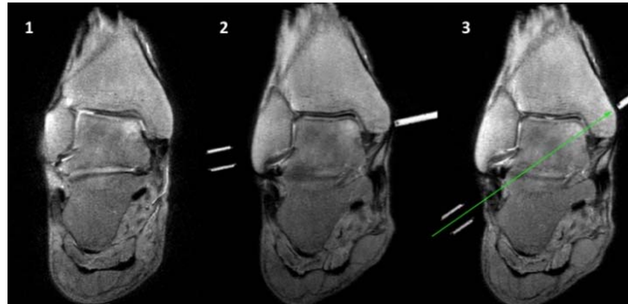

Figure 3
3 step orientation;
1: plane determination of the definitive drilling direction;
2: in plane orientation of the markers of the drilling guide;
3: drilling orientation of the markers thus marker - OD - marker are in line

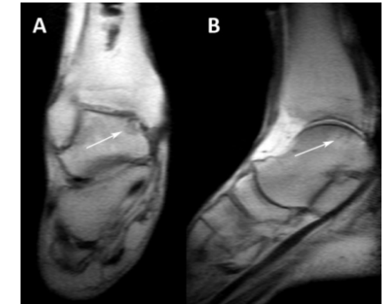

Figure 4
Visualization of the artificial OD lesion with interactive PDW TSE sequences marked by arrows; A:coronal; B:sagital

Material and Methods:

Artificial osteochondral defects were simulated in human cadaveric specimens at the medial talar dome using a 6 mm diamond bonecutting system (Fig.1A and B; Fig. 4A and B). For drilling we used a custom-made MR-compatible c-shaped drilling guide (Fig.2). For visualization it was marked with liquid filled tubule on its opposite ends (Fig. 2, 3.2, 3.3 and 5). According to the used weighting (PDW (Fig. 4), T1W and T2W (not shown)), the markers can be filled with common water or Gadolinium. The upper cylindrical marker had a 3.5mm drilling-port. All experiments were performed in a closed 1.5T Gyroscan ACS-NT and a 1.0T open MRI PANORAMA (Philips Medical Systems, Best, NL). The first step was to orientate the image plane in order to achieve the desired direction for the drilling (Fig.3.1-3.3). Under near real-time TSE image acquisition (Fig. 4 and 5), the drilling guide was aligned with the selected plane using the markers as a reference (Fig. 3 and 5). The two markers of the drilling guide were positioned in the direction of the osteochondral lesion of the talus (Fig.3.3 (green arrow) and 5). Drilling was performed under near real-time PDW TSE (TR:400 TE:8; 1.6s/image), T1W TSE (TR:100 TE:20; 2.0s/image), T2W TSE (TR:1600 TE:90; 1.6s/image) and T1 GRE control by a MR-compatible drilling machine (INVIVO, Schwerin, D) with a 3.4mm titanium spiral drill. In histological specimens the distance of the drilling canal and the artificial OD lesion was measured.

Results:

The drilling guide alignment was easy to handle. Histological specimens showed that the artificial lesion was hit with an accuracy of 1.2mm to the middle without perforating the overlying cartilage (Fig. 7 and 8). Due to the use of a low artifact titanium spiral drill and spin echo sequences metal-related susceptibility artifacts were minimal and allowed an exact assessment of anatomical structures and a safe drilling. Interactive T1W TSE, T2W TSE as well as PDW TSE were eligible for near real-time image acquisition and intervention. PDW TSE was proven to be the best. Due to the artifacts FFE sequences are unsuited. The MR-navigated retrograde drilling of OD using a passive drilling guide enabled precise drilling into the lesion without damaging the normal cartilage.

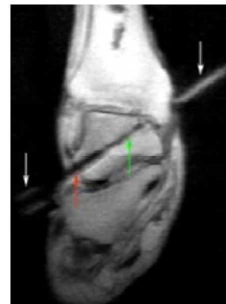

Figure 5
Interactive PDW TSE;
white: Gd filled markers;
green: drilling canal;
red: artifact of the drill

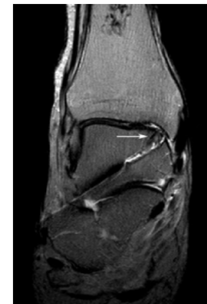

Figure 6
T2W TSE; drilling canal after drilling;
OD lesion is marked by white arrow

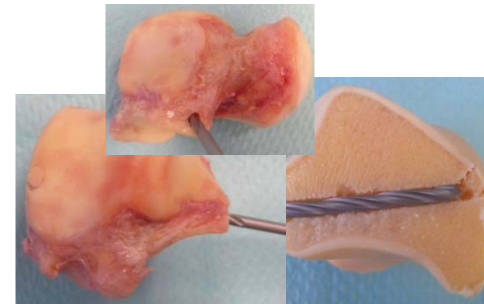

Figure 7
Talus of the cadaveric ankle;
artificial OD-lesion and the 3.4mm drill in the drilling canal

Figure 8
Saw cut through the drilling canal;
artificial lesion was hit

Conclusion:

MRI provides the best available information on the condition of the bone surrounding the lesion and the overlying cartilage. MR-navigated drilling in combination with a non-invasive and MR-compatible drilling guide provides a superior approach, compared to conventional methods. It allows percutaneous drilling under a local anesthetic without opening the joint capsule and thereby reducing the risk of articular infection significantly.

References:

1. Kumai T et al.; **Arthroscopic Drilling for the Treatment of Osteochondral Lesion of the Talus;** Journal of Bone and Joint Surgery; 1999;81-A:1229-1235
2. Bale RJ et al.; **Osteochondral Lesion of the Talus:Computer-assisted Retrograde Drilling-Feasibility and Accuracy in Initial Experiences;** Radiology; 2001;218:278-282
3. Schumann L et al.; **Arthroscopic treatment for osteochondral defects of the talus;** Journal of Bone and Joint Surgery; 2002;84-B:364-8
4. Schibany N et al.; **Impact of high field (3.0T) magnetic resonance imaging on diagnosis of osteochondral defects in the ankle joint;** European Journal of Radiology; 2005;55:283-288
5. Ohnsorge JAK et al.; **Computer-assistierte retrograde Anbohrung der OD tali mittels fluoroskopischer Navigation;** Z Orthop; 2003;141:452-458
6. Berndt AL, Harty M; **Transchondral fractures (osteochondritis dissecans) of the talus;** J Bone and Joint Surg; 1959;41-A:988-1020
7. Rosenberger RE et al.; **Computer-Assisted Minimal Treatment of Osteochondrosis Dissecans of the Talus;** oper Orthop Traumatol;2006;18:30016
8. Yulish BS et al.; **MR imaging of osteochondral lesions of talus;** J Comput Assist Tomogr; 1987;11(2):296-301