Case report

MR Imaging with T2*- mapping for improved acetabular cartilage assessment in FAI—a case report with arthroscopic correlation

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Articular cartilage assessment in femoroacetabular impingement (FAI) is challenging. Recent studies on T2* relaxation time mapping suggest the technique may be useful in diagnosing cartilage damage. The purpose of this case report is to describe how quantitative T2*- mapping may improve cartilage assessment of the acetabulum in patients with FAI. MR arthrography was performed at 3 Tesla (T) using intra-articular Gadolinium and a T2* mapping protocol. Data from the acetabular cartilage was separated from femoral head cartilage data and then superimposed on a flattened, map projection representation of the patient’s acetabulum. The areas of unhealthy cartilage observed at the time of arthroscopy – including debonding and delamination – were seen preoperatively at the same anatomic locations as areas of decreased T2* values. T2* mapping values provided a non-invasive assessment of the acetabular articular cartilage. A flattened acetabular map projection allowed for anatomic visualization of areas of unhealthy cartilage.

Level of evidence: Level IV.

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1. Introduction

Femoroacetabular impingement (FAI) is the name given to a common, heterogeneous group of bony hip abnormalities which result in abutment between the proximal femur and acetabular rim and can cause pain and intra-articular hip damage. FAI is a significant risk factor for hip osteoarthritis (OA) [1]. An improved understanding of FAI has led to the successful development of surgical options for the condition, an important selection criteria for which is the state of the patient’s articular cartilage [2]. While the post-operative results of hip arthroscopy are clearly multi-factorial recent data supports that there is a strong correlation between cartilage quality/quantity and failure of arthroscopy and conversions to total hip arthroplasty [3,4]. Patients with significant articular cartilage damage frequently do poorly with surgery while those with more normal cartilage can benefit significantly [5]. Unfortunately, the current gold standard for identifying cartilage damage—Tönnis grading via plain films—has poor inter-observer reliability [6].

Routine, clinical MR imaging has evolved as a reliable tool in diagnosing some aspects of FAI such as labral tears. Its efficacy in diagnosing cartilage problems, however, remains poor [7]. As a result, quantitative MR-methods such as dGEMRIC, spin lock T1-rho, T2- or T2*-relaxation time mapping have been developed to evaluate the biochemical properties of articular cartilage [8–10].

The purpose of this report is to illustrate the use of quantitative T2*-mapping to diagnose articular cartilage damage in a patient with femoroacetabular impingement. Further, we demonstrate how T2* data can be superimposed on a patient-specific, flattened acetabulum so that the exact location of cartilage damage can be seen preoperatively.

2. Observation

A 34-year-old male with a multiple year history of severe groin pain was evaluated after failing a comprehensive non-operative management. Physical examination of the hip revealed limited flexion and internal rotation in flexion and provocative testing was notable for a positive anterior impingement test. Routine, standardized hip radiographs showed an elevated alpha angle of 80 degrees,
At the time of arthroscopy, the joint was found to have substantial synovitis, a torn acetabular labrum from 11:30 to 3 o'clock, a large cam lesion with cartilage changes along the head-neck junction, and significant acetabular cartilage damage (Fig. 2B, C). The intra-operative assessment of the anterior-superior acetabular cartilage revealed cartilage grades 4 and 5 according to the modified Beck's scale, in the same regions identified with decreased T2*-data values (Table 2). Surgical treatment included a labral repair with suture anchors and cam resection (Fig. 3). Areas with complete loss of acetabular cartilage loss were treated with microfracture requiring an additional 6 weeks of protected weight bearing beyond the typical two weeks.

### Table 1
Modified Beck's scale.

<table>
<thead>
<tr>
<th>Score</th>
<th>Notation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal</td>
<td>Macroscopically sound cartilage</td>
</tr>
<tr>
<td>2</td>
<td>Early changes</td>
<td>Softening, fibrillation, cartilage remains adherent to underlying bone</td>
</tr>
<tr>
<td>3</td>
<td>Debonding</td>
<td>Loss of fixation to the subchondral bone, carpet phenomenon</td>
</tr>
<tr>
<td>4</td>
<td>Cleavage</td>
<td>Loss of fixation to the subchondral bone; frayed edges; thinning of the cartilage; flap</td>
</tr>
<tr>
<td>5</td>
<td>Defect, fibrous base</td>
<td>Full thickness loss of articular cartilage with a thin fibrous-tissue covered base</td>
</tr>
<tr>
<td>6</td>
<td>Defect, eburnated base</td>
<td>Full thickness cartilage loss with a base of eburnated bone</td>
</tr>
</tbody>
</table>

lateral center edge angle of 25 degrees, Tönnis angle of 8 degrees, and a mildly retroverted superior acetabulum with a crossover sign several millimeters from the sourcil (Fig. 1C). The Tönnis-grade of the hip was 1 [11].

A standard MR arthrogram (MRA) was performed using a 3T system (Siemens Medical Solutions, Erlangen, Germany) with add on T2*-mapping for cartilage evaluation as described previously [12].

A complete diagnostic arthroscopy was performed and a modified Beck scale was used for intra-operative cartilage assessment [13] (Table 1). Intra-articular pathology was surgically addressed.

Routine MRA findings included the presence of a labral tear with contrast understarking the antero-superior labrum at the chondro-labral junction (Fig. 1B). Decreased offset of the femoral head-neck junction was noted with adjacent sclerosis (Fig. 1A) and subchondral cyst formation.

T2*-maps in the sagittal plane along anterior-superior acetabular cartilage were significantly decreased when compared to areas of normal appearing femoral head and acetabular cartilage (Fig. 2A and Table 2). Probability of disease of the entire cup based on a threshold of T2* being less than 28 ms is shown in Fig. 2D.

#### 3. Discussion

The purpose of this report is to show that in cases of FAI, T2*-mapping can provide the clinician with an accurate, non-invasive quantification of acetabular cartilage quality and to demonstrate that the anatomic location of these findings can be visualized using a patient-specific, two-dimensional acetabular projection. The limitation of this report is the anecdotal nature of a case report; large cohort studies are underway. In addition, this technique requires measuring the reproducibility of the manual procedure.

T2-relaxation time is an indirect indicator of structural changes within articular cartilage; it is sensitive to alterations in the interaction between water molecules and the collagen fiber network [14]. In this report, we found markedly decreased T2*-relaxation time values in the same anatomic regions where articular cartilage damage was subsequently seen during surgery. In cases such as the one presented here–in which the patient required microfracture and a significant increase in post-operative recovery time–preoperative knowledge of the likelihood of microfracture is a particular benefit.

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**Fig. 1.** MR arthrogram: PD-TSE (left); FS T1-weighted TSE (center) depicting a labral tear. AP radiograph (right) with preserved joint space, subchondral sclerosis, small crossover–sign and reduced femoral head-neck-offset.

**Fig. 2.** Flattened acetabular cartilage T2*-map; note preserved cartilage values bright green = 28 ms and above (A) aligned with intra-operative findings (B). Left hip acetabulum: the labrum is separated from the acetabular rim which is denuded of cartilage C. Superior femoral head at the head-neck junction: the point of impingement between the femoral neck and acetabular rim is distinguished by an abrupt transition from normal medial femoral head to lateral cartilage destruction. D. Estimated spatial disease probability map of the entire cup.
4. Conclusion

This case study demonstrates the viability of T2*-mapping as a means of identifying articular cartilage lesions and describes a data visualization protocol that anatomically locates these lesions on the acetabulum.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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