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*ORIGINAL STUDY*

# MRI following UKA : The component-bone interface

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***Introduction :*** **Loosening is one of the major long-term failure modes in unicondylar knee arthroplasty (UKA). The aim of the study is to describe and characterize implant-bone interface of femoral and tibial components after UKA by means of magnet resonance imaging (MRI).**

***Material and Methods :*** **MRI tailored to reduce metallic artefact of the knee after medial UKA was performed in 10 patients as a pilot study. The component-bone interface at femoral and tibial components was evaluated by two independent investigators. They gave degree of confidence to their evaluation of each parameter on a five-point scale. Inter-observer reliability was determined.**

***Results :*** **Artefacts provoked by the implants were rare. Inter-observer reliability and confidence were excellent for the femoral interface. They were lower at the tibial interface but results were still satisfactory.**

***Conclusion :*** **Tailored MRI allows reproducible analysis of the component-bone interface after UKA. It is helpful in assessment of suspected loosening after UKA.**

**Keywords :** UKA ; MRI ; Knee ; Unicompartmental Knee Arthroplasty ; Magnet Resonance Imaging ; component-bone interface.

## INTRODUCTION

Although first inaugurated in the seventies of the last century, the value of UKA in osteoarthritis (OA) of the knee is still matter of intense discussion (*2,3, 7,8,17,19,20,22,27,28*). Total knee arthroplasty (TKA) remains the most popular procedure in the management of advanced OA. With appropriate patient selection survivorship at 10 years greater than 95% has been reported (*1,4,21*). Compared to TKA, UKA offers reduced invasiveness and morbidity as well as preservation of bone stock, less blood loss and a lower risk of infection. Presuming that both, medial and patellofemoral compartments are preserved, UKA may be a valuable alternative to total knee arthroplasty for young and active patients with unicompartmental knee pain (*1,7,14,26*).

Experience with UKA seems to be key for successful outcome (*25*). In comparison with highly specialized centers, less favorable survival rates were achieved in low-volume centers, as shown by registry data (*4,15*). Essential for longevity of the implant is mainly the stable fixation with a reasonable penetration of cement into the underlying bone

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in UKA. The most common revisions are due to implant related problems, such as loosening or malposition (*15,16*). Tibial loosening seems to be far more common than femoral component loosening.

X-rays play a prominent role in the evaluation of UKA. Radiographs are the most important diagnostic means for the detection of component loosening, but their sensitivity is limited and exposes the patient to radiation. Bone scans are very sensitive for detection of component loosening, but are usually non-diagnostic in the first two years after implantation (*6,13*). Magnetic resonance imaging (MRI) is generally approved as the most important tool in evaluation of symptomatic native knees. However, because of significant metal artefact, MRI has been traditionally considered being of little diagnostic value following arthroplasty (*29*). Lately, MRI tailored to reduce metallic susceptibility artefact, has been proven clinically useful when added to traditional imaging techniques in evaluation of patients with painful TKA (*23,29*). A recent study reported on the interface between arthroplasty components and bone following TKA as an indicator for loosening and osteolysis (*10*).

The aim of this pilot study was to assess the reproducibility of analysis of the component-bone interface after UKA by means of MRI. It was hypothesized, that the evaluation would be reproducible in terms of intra- and inter-observer reliability.

## MATERIAL AND METHODS

MRI of the knee after medial UKA was performed in 10 patients including seven women and three men with an average age of 64.6 ± 7.2 years (range 52-74 years) at index UKA (seven left, three right knees). All patients underwent UKA for degenerative joint disease to the medial compartment of the knee. MRI was done at a mean interval of 9.8 ± 2.5 months (range 7-14 months) after index procedure. The study protocol follows the principles as stated in the declaration of Helsinki. It was reviewed by the local ethics committee and approved.

All patients received the Accuris UKA system using cemented femoral Zirconium components (Smith & Nephew, Memphis, TN, USA). On the tibial side, cemented full-poly (n = 5) as well as cemented modular metal-backed components (n = 5) were applied. The metal-backed tibial components come with a titanium/aluminum/vanadium alloy base plate (TiAlV). The implants were positioned following the manufacturer's instructions in a minimally invasive surgical technique. For femoral preparation with the Accuris system, the alternate reamers were used instead of the range of motion reaming system.

For MRI, the patient was placed a feet first supine on the scanning table with the extremity in full extension. The MRI examinations were performed on a clinical MRI scanner (Magnetom Espree, Siemens Medical Systems, Erlangen, Germany) with a superconducting coil and field strength of 1.5T. The knee was placed in transmit-receive extremity coil (CP Extremity, Siemens Medical Systems, Erlangen, Germany). Using the perpendicular localizer views the scans were performed.

Sagittal, axial and coronal Turbo-Spinecho-Sequences were acquired with a repetition time (TR) of 7000 ms, an Echo Time (TE) of 10 ms, a flip angle of 150°, a slice thickness of 3 mm and 6 mm intersection gap, a 20 cm-field of view, a 512 × 384 pixel-matrix, a pixel-bandwidth of 465 kHz, a 25-echo-train-length, 400 phase encoding steps and 2 averages. Patient cohort, implants and MRI settings have been described in earlier publications that worked up a different set of scientific questions (*11,12*).

The component-bone interface of femoral and tibial components was evaluated by applying a relatively new score (*10*) (Table I) : "0" applied, when the interface was not evaluable due to metallic artifacts. "1" applied whenever there was no evident gap between component and underlying bone. Whenever there was a gap < 2 mm, "2" was noted. "3" applied for gaps > 2 mm and osteolyses. The reproducibility of this score was shown in a previous publication (*10*). The interface was separated in different quadrants following the cuts usually performed in UKA. On the femoral side it was differentiated between the anterior, middle and posterior third of the interface recording two localizations (lateral and medial) on each expanse. Thus, 6 zones were evaluated for each femoral component (Fig. 1). For the tibial component, the plateau

Table I. — A new scoring method was established to assess the interface between UKA components and bone (*10*).

| Interface Classification | Gap at interface |
|---|---|
| 0 | Artefacts |
| 1. | No gap |
| 2. | Gap < 2mm |
| 3. | Gap > 2 mm |

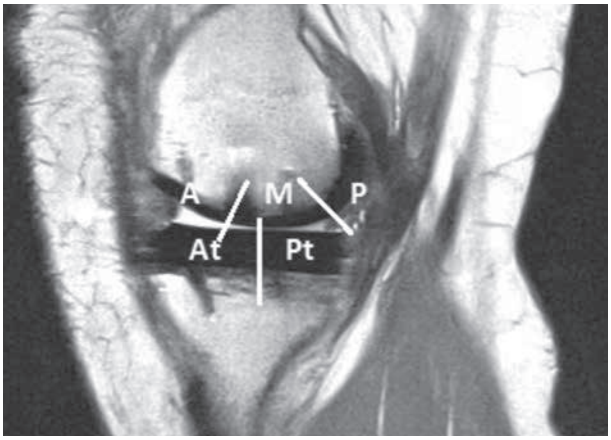


***Fig. 1.*** — Assessment zones on the femoral and tibial components : On the femoral side it was differentiated between the anterior (A), the medial (M) and the posterior (P) surface recording two localizations (lateral and medial) on each expanse. For the tibial component, the plateau was anterior (At) and posterior (Pt) scored separately on medial and lateral sides. In total 10 interface zones were evaluated for each knee.

was anterior and posterior scored separately on medial and lateral sides equaling 4 zones. In total 10 interface zones were evaluated for each knee.

Continuous variables were shown as mean and SD. Categorical data were given in absolute figures. For analysis of data, $p < 0.05$ was considered as statistically significant. After verifying equal distribution, values were analysed by student's t-test. The MRIs were evaluated by two independent investigators (T. H. and T. E.) who were blinded to the clinical information. The mean values of analysis results and confidence were used as basis for calculation of the Cohen's Kappas to determine the inter-observer reliability. Guidelines characterize Kappas over 0.75 as excellent, 0.40 to 0.75 as fair, and below 0.40 as poor. Statistical analysis was supported by using Microsoft Excel (Microsoft Corporation, Seattle, USA) and IBM SPSS Statistics 18 (PASW 18, SPSS Inc., Chicago, IL, USA).

## RESULTS

All results are displayed in Table II. For almost all structures that were assessed there was excellent inter-observer reliability as expressed by Cohen's Kappas > 0.75 (Table II). Only for the metal back tibia there was only fare inter-observer reliability at an inter-observer agreement of 70 % (Table II).

At the femoral interface there were hardly problems related to artefacts resulting in high confidence levels for evaluation (Fig. 2). Artefacts were more an issue on the tibial side. Especially with metal back components, confidence levels were lower. With all-poly inlays some scattering was

Table II. — Inter-observer reliability as expressed by Cohen's Kappa, inter-observer-agreement and the level of confidence for all evaluated zones in MRI after UKA. Tibial zones were not further analysed in the all poly group as there was perfect agreement between observers. The metal back (MB) group was sub analysed for the two medial and lateral zones to have a sufficient number for Cohen's Kappa statistics.

| Structure | | Cohen's Kappa | Inter-observer agreement (%) | Confidence |
|---|---|---|---|---|
| Femur | | | | |
| Femur all | | 0.877 | 93.3 | 3.95 ± 0.22 |
| Lateral | anterior | 0.857 | 90 | 3.95 ± 0.22 |
| | middle | 1.0 | 100 | 3.95 ± 0.22 |
| | posterior | 0.721 | 80 | 3.95 ± 0.22 |
| Medial | anterior | 1.0 | 100 | 3.95 ± 0.22 |
| | middle | 1.0 | 100 | 3.95 ± 0.22 |
| | posterior | 0.864 | 90 | 3.95 ± 0.22 |
| Tibia | | | | |
| Tibia All poly | | 1.0 | 100 | 3 ± 1.70 |
| Tibia Metal back | | 0.722 | 70 | 2.2 ± 1.81 |
| MB lateral | | 0.751 | 80 | 2.2 ± 1.81 |
| MB medial | | 0.603 | 60 | 2.2 ± 1.81 |

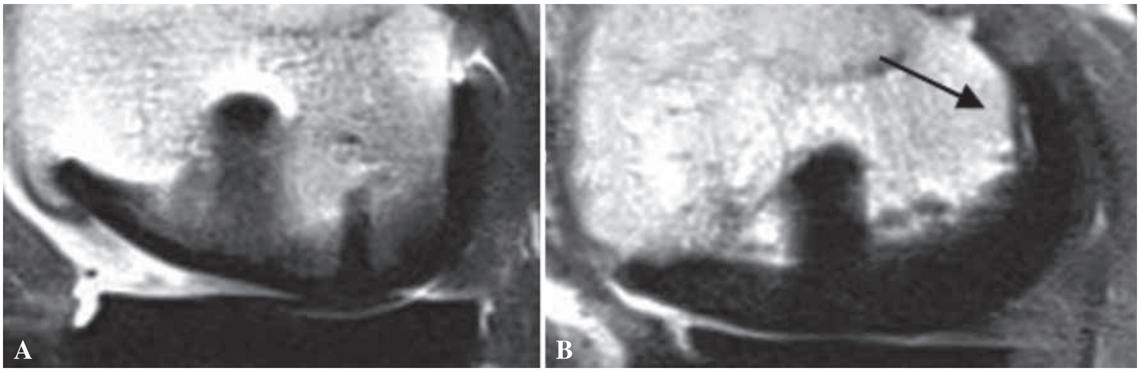


***Fig. 2.*** — Interface at the femoral component : A : No gap, B : Gap < 2 mm (arrow). There were no gaps > 2 mm recorded at the femoral interface.

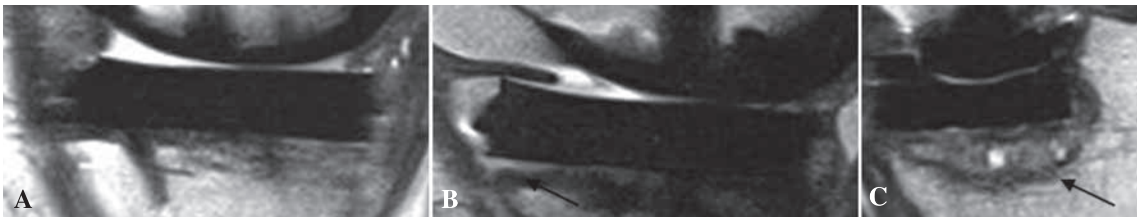


***Fig. 3.*** — Interface at the all-poly tibial component : A : No gap, B : Gap < 2 mm. C. gap > 2 mm.

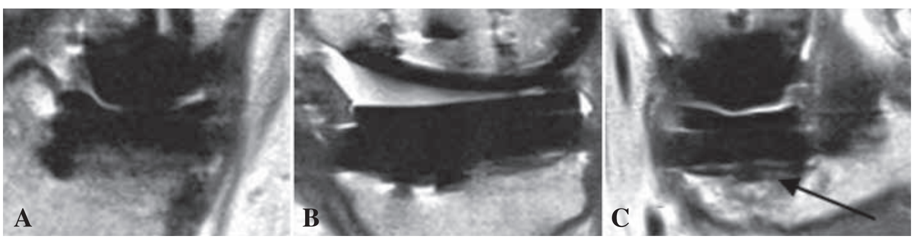


***Fig. 4.*** — Interface at the metal-back tibial component : A and B : No gap, C : Gap < 2 mm. There were no gaps > 2 mm recorded at the interface of metal-back tibia.

caused by the marking wire. All-poly inlays were easier to assess as metal back inlays resulting in higher inter-observer reliability, inter-observer agreement and confidence levels.

On the femoral side, only 3.3% of all assessed regions were not evaluable due to artifact and 3.3% of the areas showed gaps < 2 mm. There were no areas of larger gaps (Fig. 2).

On the tibial side (Figs. 3 and 4), 20% (all-poly) and 40% (metal back) of the zones were not evaluable due to artifact. In 10% of the regions, there were gaps < 2 mm. In one patient, there was significant osteolysis under the tibia (Fig. 4). The patient had complained about ongoing pain over the medial side of the proximal tibia. As there was no evidence for infection the implant was changed to TKA in a one-stage procedure. The other findings did not lead to clinical consequences as the knees did not show clinically related problems.

## DISCUSSION

The data presented in this study show a good reproducibility of analysis of bone-component interface applying a new score after UKA by means of MRI by high Cohen's Kappa for the inter-observer reliability. Zirconium facilitated the analysis of femoral components and a high percentage of interface zones at the femur were evaluable.

Tibial implants caused more artefacts, which made application of the score more difficult. Especially with metal-back implants, there was lower inter-observer agreement and confidence of evaluation, but inter-observer reliability in terms of Cohen's Kappas was still satisfactory.

As described earlier there are some limitations to MRI studies like these (*10,11*). As the patients included do not represent a specific cohort, findings in terms of gaps or osteolyses at the interface might not be representative. Group size is an issue of this pilot study, but since MRI is an expensive examination and given the fact that this is a pilot study to report on MRI following UKA, patient numbers seem to be sufficient to work on the hypotheses as aroused in the introduction. The presented data was obtained from the pilot series of MRI after joint arthroplasty. It might reflect some of the learning curve of establishing the MR technique at the authors' center.

The study was conducted with zirconium femoral components, which are known to facilitate MR imaging due to a lower magnetic moment of this alloy (*23,24*). CoCr components may interfere with MRI to some extent (*10*), but newer MRI protocols seem to be promising with better imaging even of CoCr components (*5,9*).

It is hard to relate findings in terms of gaps or osteolyses at the interface to the clinical problem. In the presented series, some gaps at the interface were found in knees that were clinically unremarkable. Moreover, it is hard to declare a component being loose, based on the findings made by application of the new score. In one case the finding of significant osteolysis at the tibial interface led to revision of the implant to TKA. Thus, MRI findings may facilitate the complex diagnosis of loosening and possible life changing consequences. MRI might especially help in the first two years after TKA, when bone scans are often non-diagnostic (*6,13*). However, till now it is also not clear how far bone scans could be useful in the diagnosis of loosening after UKA implantation, as most studies evaluating this problem refer to TKA.

A number of applications for MRI after TKA have been described and special MRI protocols are available on most commercial MRI units (*29*). Publications in this field are still scarce, but indications and understanding of images are evolving. (*18,23,30*).

MRI could be a useful device for evaluation of patients with painful UKA and suspicions for component loosening. Our data present a reproducible analysis of component-bone interface with a new scoring method that can be done without exposing the patient to radiation. It might add important information for assessment of suspected loosening of a UKA.

## CONCLUSION

MRI performed with a special protocol allows good reproducibility of analysis of implant-bone interface after UKA with femoral components made of zirconium applying a new score method. Artefacts hardly interfered with evaluation of the component-bone interface at the femur but were more of an issue at the tibial interface. MRI tailored to reduce metallic artefacts may be helpful in the diagnosis of loosening after UKA.

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