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EVALUATION OF TIBIAL COMPONENT ROTATION IN PAINFUL TOTAL KNEE ARTHROPLASTIES BY MRI ENHANCED WITH METAL ARTIFACT REDUCTION TECHNIQUE

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ABSTRACT

Background: Tibial component malrotation is one of the commonest causes of pain and stiffness following total knee arthroplasties, however, the assessment of tibial component malrotation on imaging is not clear-cut. The objective of this study was to assess tibial component rotation in cases with pain following total knee replacement using MRI with metal artifact reduction technique.

Methods: In 15 consecutive patients presented in our clinic — a high-volume arthroplasty institution — between January 2017 and June 2017 with persistent unexplained moderate to severe pain for at least 6 months following total knee arthroplasties, which were ALL done outside our institution, after exclusion of infection and loosening (tibial or femoral), MRI evaluation of tibial component rotation using metal artifact reduction for orthopedic implants (O-MAR) technique — to improve visualization of soft tissue and bone by reducing artifacts caused by metal implants — was

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done according to the technique of Berger *et al.* [Malrotation causing patellofemoral complications after total knee arthroplasty. *Clin Orthop Relat Res* 144–153, 1998].

Results: Eleven cases showed an internal rotation of tibial components (73.3%), four cases showed a neutral or external rotation of tibial components (26.6%), however, with the presence of abnormal intraarticular fibrous bands in two of them.

Conclusions: Two main conclusions are obtained from this study: Firstly, internal rotation of tibial component must be excluded in all cases of persistent pain following total knee replacement. Secondly, magnetic resonance imaging with the newly developed metal artifact reduction techniques is a very useful tool in evaluating cases of unexplained pain following total knee replacement.

Keywords: Total knee arthroplasty; Tibial component; Malrotation; MRI; Metal artifact.

INTRODUCTION

Although total knee arthroplasty (TKA) is a well-established orthopedic procedure, patient dissatisfaction after surgery is still high.[5] Determining the etiology of symptomatic and failed arthroplasty is important for effective and timely revision.[14] Due to its unparalleled soft tissue and bone marrow contrast, magnetic resonance (MR) imaging can contribute important information to the diagnosis of synovitis, periprosthetic bone resorption and osteolysis, implant-associated fractures, arthrofibrosis, extensor mechanism injury, periprosthetic infection, certain types of instability and component fractures.[19]

In the presence of orthopedic implants, conventional MR imaging sequences show severe artifacts which limit the utilization of MR in the follow-up of a patient with orthopedic implants.[7,23] The severity of the MRI artifact induced by an orthopedic implant depends on various factors including the implant material, size, shape and orientation of the implant, as well as the chosen imaging sequence. Signal loss caused by field inhomogeneities around the metal can be reduced to a certain extent, however, often not sufficient to allow for periprosthetic tissue visualization.

Advances in MRI technology provide the imaging necessary to obtain high-resolution images to evaluate knee anatomical and pathological structures that were not easily evaluated in the past. Furthermore, recent advances in MRI techniques allow for improved imaging in the post-operative knee and metal artifact reduction. The objective of this study was to assess tibial component rotation in cases with pain following total knee replacement using MRI with metal artifact reduction technique.

METHODS

In 15 consecutive patients presented in a high-volume arthroplasty institution between January 2017 and April 2017 with persistent unexplained moderate to severe pain for at least 6 months following total knee arthroplasties — ALL done outside our institution — after exclusion of infection and loosening (tibial or femoral), MRI evaluation of tibial component rotation using metal artifact reduction for orthopedic implants (O-MAR) technique — to improve visualization of soft tissue and bone by reducing artifacts caused by metal implants — was done according to the technique of Berger *et al.*[4] (see Figs. 1(a)–1(e)). If tibial component rotation was found normal, further evaluation of femoral component rotation was done (Fig. 2). Only cases with symmetrical tibial components were included in this study. Ten female and five male patients were included in the study with a mean age of 65 years (range from 53 to 74 years).

All images were performed using a closed MRI system 1.5 T (Philips, Ingenia) and dedicated knee coil 16 channels. Multiple sequences in different planes were performed including the following:

(1) Proton density with fat suppression in sagittal and coronal planes with 3 mm slice thickness and 3 mm gap. (Field of view is 160 × 160, TE 30, TR 3000, 24 slice, ETL-21, Matrix 288 × 208, Nex 2).
(2) STIR sequences in axial and coronal planes. (Fov 160 × 160, Slice thickness 3 mm and 3 mm gap, TE 30, TR 4200, slice 30, Matrix-264 × 216, ETL-12, Nex 2).
(3) T2 weighted in axial and sagittal planes. (Fov 160 × 160, TE 100, TR 5400, Slice thickness 3 mm and gap 3 mm, Slice 27, Matrix 324 × 260, ETL 13, Nex 2).

All measurements were done digitally by two physicians, a senior musculoskeletal consultant radiologist and an experienced orthopedic surgeon specializing in knee arthroplasty, using Philips Intellispace Pacs Enterprise software version 4.4. The evaluation was performed on coronal, axial and sagittal views in T2-weighted and PD-weighted VISTA sequences for all patients.

Interobserver variations in interpretation of measurements were recorded, and discrepancies were resolved by consensus. We performed the statistical analysis using statistical package for the social sciences (SPSS) version 16. This study was approved by the institutional review board at our hospital, and informed consent was obtained from all potential candidates before performing the MRI study.

Table 1 Statistical Data.

Serial	Age	Sex	Tibial Component Rotation Angle in Degrees — According to Berger *et al.*[4]
1	59	F	21
2	63	F	24
3	65	M	25
4	68	F	27
5	71	F	29
6	53	F	30
7	56	M	33
8	63	F	35
9	56	F	36
10	72	F	37
11	74	F	38
12	65	M	18
13	66	M	18
14	68	F	15
15	69	M	16

RESULTS

According to the technique of Berger *et al.*, rotation of the tibial component is recorded as the angle subtended by the tibial tubercle axis and the tibial component axis which is normally 18°. Higher values indicate internal rotation of the tibial component relative to the tibial tubercle.[4] Based on the angles measured, patients were classified into two groups, the first group (internal malrotation group) included 11 cases (73.3%) that showed an internal rotation of the tibial component with a mean angle of 30.45° (range from 21° to 38°), the second group without tibial component malrotation included 4 cases (26.6%) (2 cases with neutral rotation of tibial component (18° both) and 2 cases with external rotation of tibial component (15° and 16°)). Femoral component rotation was evaluated in these four cases and was found to be parallel to the surgical transepicondylar axis (Fig. 2). However, the presence of abnormal intraarticular fibrous bands was noticed in two of these cases (Figs. 3(a) and 3(b)) (Table 1).

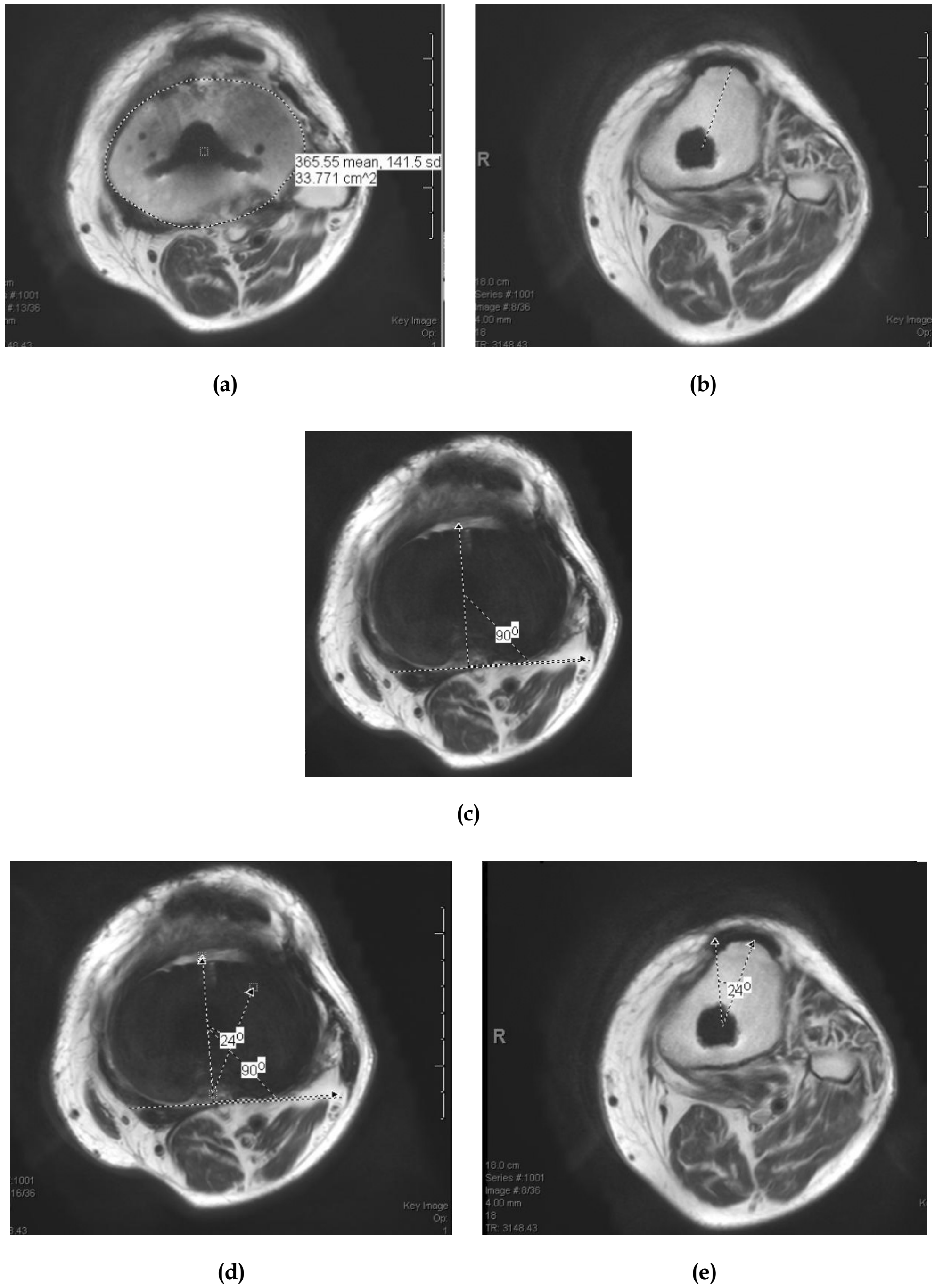


Fig. 1 **(a)** Axial MRI image through the proximal tibial plateau, showing the best-fit circle of the proximal plateau. The center is marked automatically by the computer. **(b)** Axial image through the tip of the tibial tubercle. The geometric center of the tibial plateau was transposed distally to this image. The tibial tubercle orientation is the line connecting the geometric center of the tibial plateau to the tip of the tibial tubercle. **(c)** Axial MRI image through the tibial component polyethylene. The tibial component axis is perpendicular to the transverse axis of the tibial component (posterior margin of the component in symmetrical tibial components). **(d)** Axial image through the tibial component polyethylene. The tibial tubercle orientation is superimposed on the tibial component axis. **(e)** The rotation of the tibial component is recorded as the angle subtended by the tibial tubercle axis and the tibial component axis.

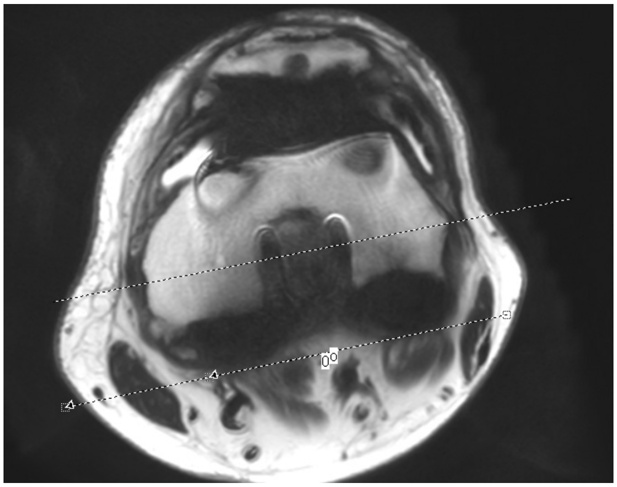
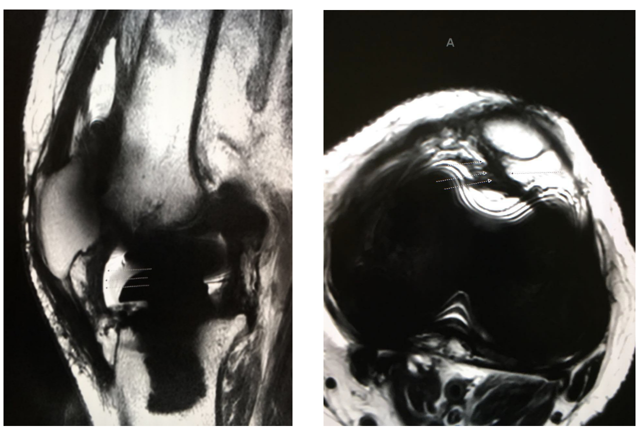


Fig. 2 Axial MRI image of the distal femur showing a femoral component that is parallel to the surgical epicondylar axis (between the lateral epicondylar prominence and the medial sulcus of the medial epicondyle).



(a) **(b)**

Fig. 3 Sagittal **(a)** and axial **(b)** MRI images showing intraarticular fibrous bands (arrows).

DISCUSSION

Persistent pain following a total knee replacement can be due to several causes such as infection, loosening and components malalignment which can be either femoral or tibial. Our study showed that malrotation of tibial component is a common finding in patients with unexplained knee pain posttotal knee replacement (11 out of 15 patients (73.3%)). Four patients out of 15 (26.6%) showed a normal or external rotation of the tibial components, however, postoperative pain in 2 of those patients can be explained by the presence of fibrous bands which was identified clearly in the MRI images, this is considered a big advantage in this imaging modality. However, in the other two remaining patients (13%), the exact cause of knee pain cannot be identified, and further investigations are still required in those patients.

MR imaging with optimized conventional pulse sequences and advanced metal artifact reduction techniques can contribute important information for the diagnosis, prognosis, risk stratification and surgical planning. Afford improved visualization of bone, implant-tissue interfaces and periprosthetic soft tissue for the diagnosis of arthroplasty-related complications including aseptic loosening, polyethylene wear-induced synovitis and osteolysis, periprosthetic joint infections, fracture, patellar clunk syndrome, recurrent hemarthrosis, arthrofibrosis, component malalignment, extensor mechanism injury and instability.[22]

MR imaging is accurate for the identification of the anatomic landmarks and the axes required for the measurement and calculation of the rotational alignment parameters.[10,15] Rotational alignments for tibial components generally demonstrate higher variation, which likely relates to the more complex geometric method used for this measurement rather than to the imaging modality used. As a result, tibial component malrotation occurs more frequently than femoral component malrotation with subsequent unexplained pain, stiffness and patellar complications. Furthermore, the self-positioning or self-adjusting technique after knee flexion extension cycles translates any femoral rotational errors to the tibia. The effect of rotational alignment of the tibial component in total knee replacement on a postoperative range of motion remains not completely understood.

Accurate rotational alignment of implant components is an important factor for satisfactory joint function and implant survival.[18] Figgie *et al.* concluded that tibial component rotation is the most important factor for patellofemoral tracking.[6] Several authors[3,8,12,16] have linked component rotational malalignment with inferior clinical and functional outcomes. Barrack *et al.*[3] found a significant difference between patients with anterior knee pain and an asymptomatic control group in terms of tibial and combined component rotation. Patients with combined component internal rotation have a fivefold increase in the likelihood of experiencing anterior knee pain following TKA compared with those with combined component external rotation. Nicoll and Rowley[16] found that excessive internal rotation of the tibial component is a major cause of pain after TKA, whereas external rotation of the tibial component was well-tolerated by most patients. On the other hand, excessive external rotation was not found to be a factor in pain following TKA. Component rotational malalignment alters patellofemoral and knee flexion extension kinematics from the first day postoperative.[1] This explains the high incidence of early pain and inferior outcome measures when component malrotation is evident.

Advantages of MRI over CT includes no radiation exposure, more clear images, in addition to evaluation of associated soft tissue problems like osteolysis, metallosis, pseudo-tumors, fluid collections, scarring and ligamentous disruption, furthermore, MR imaging may be more accurate than plain radiography or CT in the visualization of bony landmarks such as the medial epicondylar sulcus.[15] Two CT studies identified the medial epicondylar sulcus in only 69–73% of patients.[21,24] Measurement of the rotational angle of the tibial component relative to the tibia requires determination of the tibial tubercle axis and tibial component anteroposterior axis which ideally should measure 18° of internal rotation.[15]

Internally rotated tibial components are with slightly anteriorly displaced posterolateral corner, thus limiting posterior femoral rollback which takes place mainly in the lateral compartment especially with intact posterior cruciate ligament. This will lead to — in addition to patellofemoral mal tracking — decreased flexion. On the other hand, the screw home movement occurring physiologically in normal knees — by external rotation of the tibia on the femur by 15° in the last 20° of extension — will be disturbed in total knees with internally rotated tibial components thus limiting full knee extension with subsequent flexion contractures. One study concluded that internal malrotation of the tibial component limits the ability of the tibia to externally rotate on the femur, thereby limiting full knee extension and leading to flexion contracture in TKA.[2]

Increased internal or external rotation of the femoral component can cause increased tibiofemoral wear, worsen patellar tracking, and contribute to subluxation, dislocation, patellar clunk and eccentric wear.[3] Varying configurations of malrotation exist, including combined component external rotation, tibial component internal mismatch, tibial component external mismatch and combined component internal rotation. Combined femoral and tibial component internal malrotation has been associated with the presence of a painful synovitis and a fivefold increase in the likelihood of experiencing anterior knee pain.[15] Internal rotational errors, involving the femoral, the tibial, or both components, were found in 56.4% of patients with painful TKA.[16]

Mayr *et al.* defined arthrofibrosis as the presence of scar tissue in any compartment of the joint leading to restricted ROM.[13] In our study, the presence of abnormal fibrous bands in two cases indicates the presence of some degree of arthrofibrosis. Arthrofibrosis is diagnosed primarily clinically and confirmed with histopathologic analysis.[11] Such diagnosis can be markedly reinforced with advancements in metal artifact reduction sequences for MRI as identification of nonparticulate densities of low intensity and intraarticular adhesions in patients with stiff knees are highly suggestive for arthrofibrosis.[9,17,20]

This study is, however, limited by the small size of the study group. Nevertheless, with the prevalence of tibial component malrotation in a big number of our sample of painful total knee arthroplasties, it seems unlikely that a larger population would have significantly altered the observation. Another important limitation to this study is that the femoral component rotation should have been correlated in all the cases as well, however, our concern here was mainly on the tibia malrotation being a common finding in revision knee surgery. Finally, the Berger method of measurements is only applicable in patients with symmetrical tibial components, and not applicable in cases being operated with the floating tibia technique.

CONCLUSIONS

Two main conclusions are obtained from this study: Firstly, internal rotation of tibial component must be excluded in all cases of persistent pain following total knee replacement. Secondly, MR imaging with the newly developed metal artifact reduction techniques is a very useful tool in evaluating cases of unexplained pain following total knee replacement.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest. This study has been approved by the Local Institutional Ethical Committee and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. No funding has been received for this study.

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