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Case Report

Fatigue Failure of Semiconstrained Total Knee Replacement: Magnetic Resonance Imaging Diagnosis With Tips and Tricks for Extraction and Reconstruction

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ABSTRACT

Modular components allow for the precise adjustment of sizing and balancing in knee replacement and are widely used in revision total knee arthroplasty. While they have a significant advantage over monoblock implants, these components may be associated with fretting and corrosion at modular junctions. We report the case of a fracture of a morse taper adapter bolt in a 65-year-old female with a history of multiple revision knee arthroplasties. Only a few cases of fracture of the taper adapter bolt have been previously reported. We reinforce 2 learning points in this report: the utility of magnetic resonance imaging as an aid in diagnosing total knee failure when initial radiographs are unremarkable and the use of techniques such as anterior quadrangular femoral osteotomy when an implant is unable to be removed via conventional techniques.

Introduction

Revision total knee arthroplasty (TKA) surgeries present additional difficulties when compared with primary TKA, often requiring orthopedic surgeons to focus on maintaining joint kinematics, managing the loss of bone and soft tissue, and addressing ligamentous instability [1]. Modular components are widely used in TKA procedures and help surgeons overcome the challenges of performing revision TKA by allowing for intraoperative augmentation. As such, by having different sizing and constraint options, modularity can help stabilize the knee joint, enhance kinematic function, and improve implant fixation [2,3]. Despite these benefits, the use of constrained implants can increase the stresses on the modular components which can make them prone to aseptic loosening and mechanical failure, requiring further revision [1,4]. Therefore, the benefit of modularity must be weighed against the possibility of failure at the modular junction site. A general principle when performing a revision TKA is to use the least amount of constraint necessary to restore the original anatomy, restore function, and provide a stable joint [5].

The P.F.C. SIGMA TC3 constrained Knee system (DePuy Johnson & Johnson, Warsaw, IN) is a nonhinged semi-constrained total knee replacement system. The femoral stem is connected to the femoral condylar component via a morse taper junction which is further connected by an adaptor bolt. We report a case of catastrophic failure due to a fracture at the morse taper junction in a knee with this implant, detail interesting challenges faced when diagnosing the fracture, and provide practical suggestions for removing elements of the prosthetic joint.

Case history

Written consent was obtained from the patient described herein for the publication of this case report. The patient is a 65-year-old female who arrived at the clinic with a history of chronic right knee pain with acute worsening over the past 2 months. Her presentation was further complicated by an inability to ambulate without crutches. At the time of this visit, the patient was 5′3” and weighed 213.4 pounds (body mass index = 37.8 kg/m^2). She had an extensive history of 9 knee surgeries from outside hospitals from 2012 to

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2015, including arthroscopic debridement of the meniscus, TKA, and multiple revision arthroplasties due to prosthetic joint infection with *Staphylococcus aureus* and *Streptococcus agalactiae*. Prior to this clinic visit, X-rays and MRI were performed at an outside hospital. The radiographs (image unavailable) were negative for any signs of TKA failure; however, the MRI scan displayed a fracture at the stem-taper junction (Fig. 1).

Upon presentation to our clinic, the patient demonstrated significant ligamentous laxity, especially at the medial aspect of the knee, with a range of motion from 0° to 90°. Interestingly, while radiographs (Fig. 2) obtained at our institution showed a loose adaptor bolt in the knee joint, they did not demonstrate any clear evidence of a stem fracture. The overall component alignment appeared acceptable.

The patient was subsequently diagnosed with a catastrophic failure of her right TKA with a broken morse taper and was taken to the operating room for another revision TKA. This was the tenth surgery on her right knee. We did a preoperative infection workup including knee aspiration as well as routine labs that included Erythrocyte sedimentation rate and C- reactive protein which were normal. The total nucleated cell count was 28/mm^3 with 33% polymorphonuclear leukocyte white blood cells, and the cultures were negative for infection.

Intraoperatively, the femoral component was found to be grossly unstable. We identified the loose adapter bolt, and the femoral component was removed without difficulty. However, part of the adaptor bolt remained within the broken morse taper (Fig. 3a and b). We could not remove the broken part of the adaptor bolt and attempted a standard technique to remove the very well-fixed metaphyseal sleeve without success. Consequently, an anterior quadrangular femoral osteotomy was performed to remove the entire femoral stem, which contained the loose threads in the socket. A prophylactic cerclage wire was first placed proximal to the osteotomy line to prevent further propagation of the osteotomy. An oscillating saw was used to perform the vertical limb of the osteotomy, which was on the medial side, and a pencil-tip burr was then used to carve the proximal end as well as perforate the lateral side to complete the osteotomy. The osteotomy fragment was progressively freed up from the sleeve and elevated off the anterior surface of the sleeve which allowed access to the well-fixed sleeve. The attachment of suprapatellar tissue on the lateral side of the osteotomized anterior surface was preserved to keep vascularity, which is different from the technique described by Merz and Farid [6]. Once it was free, a trough was made in the sleeve using a metal cutting burr. This gave us a tether point to use a bone tamp, and we were able to mallet the femoral component out without difficulty (Fig. 4a and b).

The osteotomy was repaired using a cerclage wire. We found that when the cerclage wire was placed distally, it tended to slip proximally due to the conical nature of the distal femur. We developed a technique to hold the wire, similar to that illustrated by Appleton et al. [7]. We placed cortical screws on either side of the femoral shaft anteriorly which prevented the wire from migrating proximally to the screw. Once the cerclage wire was tightened and able to stay in place, we removed the screw. We also placed a figure-of-8 wire to hold the condyles for any inadvertent split that might have occurred during osteotomy. This was done by inserting 2 cortical screws in the condyles anteriorly and placing a doubled 18-gauge wire in a figure-of-8 pattern with the screws as anchor points. This was progressively tightened until there was no slack. We have previously found success with this technique both for prophylaxis as well as for fixing condyle fractures. Since the femoral stem bypasses the screws, the screws do not produce a stress-riser effect. The femur was then prepared to accept a DePuy Synthes S-ROM rotating hinged knee (S-ROM; DePuy Synthes, Warsaw, IN), including a femoral stem connected to the condylar component via a morse taper junction. A hinged knee component was selected due to the absence of a medial collateral ligament. The polyethylene component was exchanged as well. The knee was able to achieve full extension and 110° of flexion. Final radiographs revealed a well-placed revision TKA (Fig. 5).

On the first postoperative day, the patient remarked that her knee has not felt this good in years and was in good spirits. She was evaluated by physical therapy and cleared for discharge home. She was given information regarding follow-up appointments, posthospital care instructions, and education materials in writing, as well as a prescription for aspirin 81 mg twice a day for

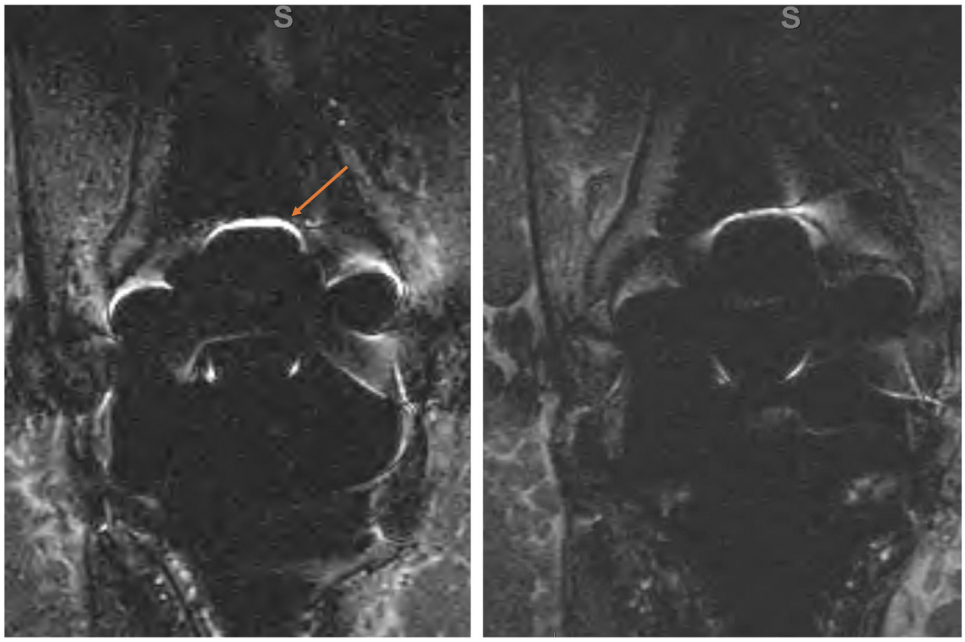

Figure 1. MRI Showing Fractured Morse taper.

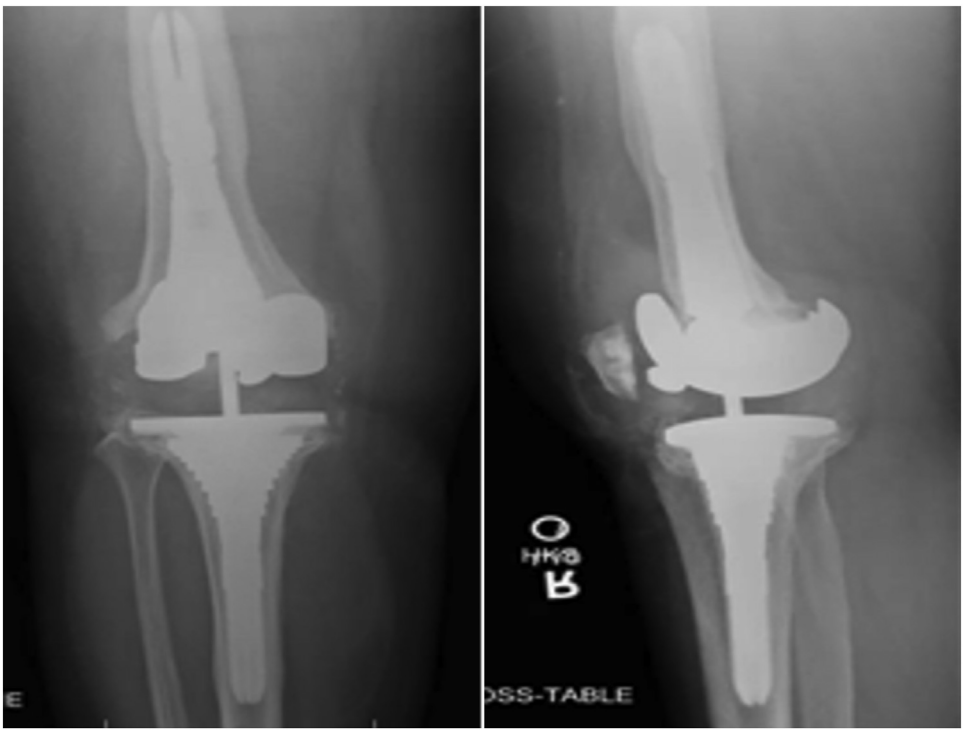

Figure 2. Pre operative x rayshowing loose bolt.

30 days for deep vein thrombosis prophylaxis. She was also referred for physical therapy, focusing on her lower extremity range of motion, strengthening exercises, home exercise programs, and gait training. The patient was discharged on the second postoperative day. At the 12-week follow-up visit, the patient was doing well with minimal pain. She was able to ambulate without assistance. Her knee was stable to varus and valgus stress and demonstrated an improved range of motion from 0° to 110°. The patient has not followed up since then due to distance; however, 2 years after the operation, she is doing well per our last telephonic discussion and confirms that she has not had further knee surgery.

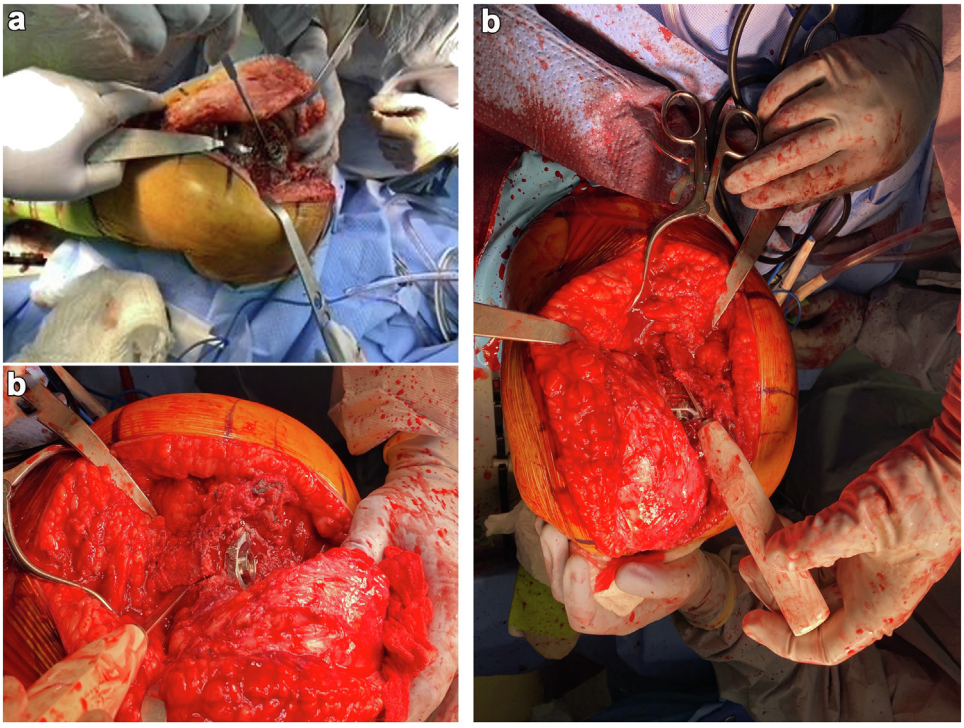

Figure 3. Intra operative x ray showing anterior quadrangular osteotomy.

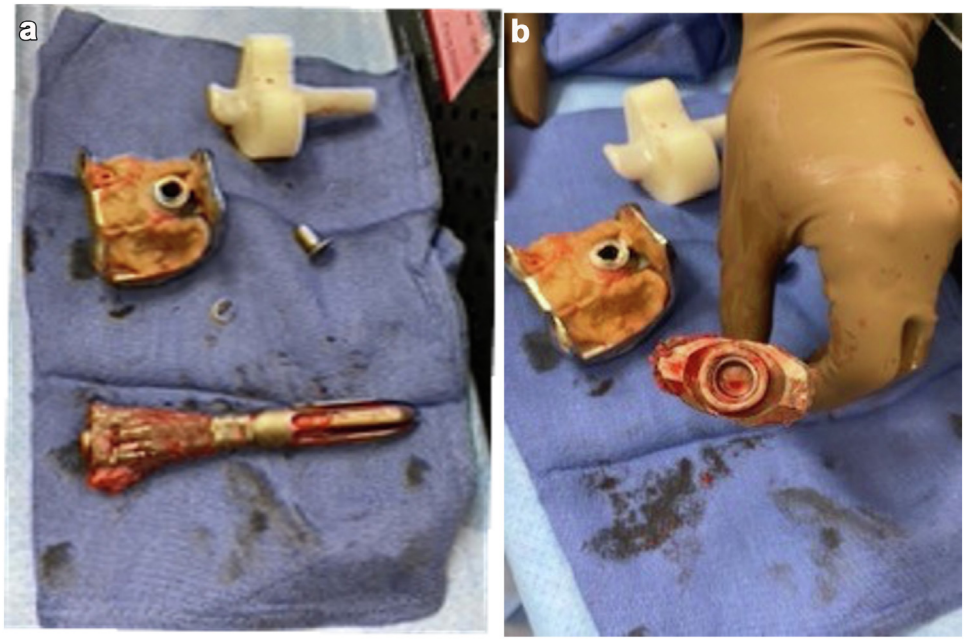

Figure 4. Extracted implant showing fractured morse.

Discussion

Revision TKA failures have been previously reported at the femoral stem-condylar junction as well as at morse taper locks [1,3,8,9]. However, most of these failures were due to component dissociation or loosening of the junction. Fracture at the morse taper junction in a revision TKA has rarely been reported. Baral et al. reported a fracture of a morse taper in a similar DePuy SIGMA TC3 Rotating Platform implant [10]. The reported fracture was in an uncemented revision arthroplasty. While the implant in their case is recommended for use with cement, this material was not used due to their patient's reported allergy. This led to improper distribution of load throughout the femoral metaphyseal sleeve, resulting in a fatigue fracture. The authors advise that in the setting of a

Figure 5. 3 months post operative x ray.

cement allergy, this implant should not be used, and they instead recommend utilizing either a custom implant designed with biologic fixation or an implant with a monolithic design although the sacrifice in modularity may make a revision TKA more difficult. Of note, this case reported by Baral et al. describes a common challenge in revision TKA, which is obtaining sturdy primary fixation of implants into the host bone [10]. Morgan-Jones et al. have previously described a zonal classification framework for preoperative planning, with zones 1, 2, and 3 consisting of the epiphysis, metaphysis, and diaphysis, respectively [11]. They suggest that solid fixation should be obtained in at least 2 of the 3 zones and that while fixation in zone 2 allows for the use of shorter diaphyseal stems, failure to gain adequate fixation here can lead to unsupported epiphyseal fixation, resulting in instability in zone 1 and early failure of the revision, as in the case of the patient described above. This case is very similar to ours; however, while they managed to remove the broken adaptor using a standard extraction technique, we could not.

Intraoperatively, we were presented with the great challenge of removing the fractured adapter bolt connecting the femoral stem to the condylar component. None of our surgical instruments were capable of grabbing and removing the loose bushing threads sitting in the socket. Therefore, we had to perform an anterior quadrangular femoral osteotomy to remove the entire femoral stem with the sleeve containing the loose threads. As the osteotomy increased the risk of a condylar fracture, we used 2 cortical screws and 2 prophylactic cerclage wires to reinforce the distal femur while repairing the osteotomy site. This surgical technique allowed us to successfully disengage the morse taper and remove the femoral implant. As the implant stem bypassed the taper area significantly higher up and because the screws were inserted in the cancellous bone, we believe that the stress from these screws should be distributed and will likely not predispose to later fracture. In our patient, the tibial component was retained as it was well-fixed and appropriately aligned, while the femoral component was replaced with a rotating hinged implant. Primary indications for using a hinged arthroplasty are severe distal femoral bone loss, severe flexion gap instability which cannot be matched by the extension gap, and the presence of a totally disrupted medial collateral ligament, as in our patient [12]. Although hinged knee implants have been associated with excessive strain at the fixation interface, the rotating bearing design in the implant we used can act to diminish the stress. Issack et al. previously reported 2 cases of fracture at the taper lock at the femoral stem-condylar junction in cemented revision arthroplasties [13]. One of these patients had a well-fixed tibia component and only had the femoral component revised, similar to our patient. However, the fractures described were found in Optetrak constrained condylar knee arthroplasty implants (Exactech, Gainesville, FL) [13]. Given the significant differences in biomechanical load distribution in a constrained condylar knee implant vs a rotating platform implant, we felt the particular fracture found in our patient was worth reporting [14].

Of note, we reiterate the importance of diagnostic imaging in evaluating a patient with a complex surgical history. The initial radiographs did not reveal a fracture of the morse taper nor the loose bushing; however, the MRI revealed the loose bushing and fluid within the component space, which aided in our diagnosis of catastrophic TKA failure. One recent study assessing the diagnostic performance of MRI for component loosening in patients with TKA concluded that an MRI examination should be considered for all problematic TKAs and, in some instances, may outperform standard X-ray imaging due to its superior performance in depicting soft-tissue synovial abnormalities and in evaluating the implant-bone interface [15]. To the best of our knowledge, MRI has not been previously used to diagnose implant fractures.

We would like to caution readers that while the P.F.C. SIGMA TC3 implant is indicated in cases in which the collateral ligaments are deficient, it should not be used in the instance that there is gross ligamentous instability.

Our case has some significant learning points for readers, including MRI as a tool for diagnosing implant fracture, as well as the use of variation in anterior quadrangular osteotomy and some suggestions for fixing potential condylar instability. To our knowledge, this is one of few cases of a morse taper failure in a DePuy SIGMA TC3 cemented rotating platform revision knee arthroplasty. While such a case is rare, we would like to reiterate that similar failures have been previously reported by Lim et al. in 2001 who described 5 cases of failure at the stem-condyle junction of modular femoral components of knee implants [3]. All the patients had well-fixed cemented femoral stems with distal loosening of the femoral component. The stem-component junction in these patients, however, was “flat on flat” with no morse taper. As such, the area of maximal stress concentration was at the stem-component junction. The authors state that using a morse taper at the junction site may help avoid the failures observed in their series.

Summary

An increase in the use of modular implants has resulted in increased success in revision TKA; however, it can also lead to a catastrophic TKA failure, as we reported. We would like to reiterate our 2 learning points from this case: An MRI can aid in the diagnosis of a catastrophic TKA failure when initial radiographs are unremarkable although further research would be necessary to truly establish if MRIs are more sensitive than X-rays and that a surgeon should be prepared to utilize additional techniques such as anterior quadrangular osteotomies to disengage implants if they cannot be removed with conventional measures. Morse taper failure is rare, but when it occurs, the diagnosis often requires a high degree of suspicion. Furthermore, it will likely be a difficult explant, and the surgeon should be prepared to perform additional osteotomies.

Conflicts of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.09.011.

Informed patient consent

The authors confirm that informed consent has been obtained from the involved patient or, if appropriate, from the parent, guardian, power of attorney of the involved patient and that they have given approval for this information to be published in this article.

References

[1] Kahan M, Estes C. Failure at the femoral stem extension-condylar interface in a rotating hinge knee without radiographic evidence of loosening. Arthroplast Today 2020;6:36–40.
[2] Durig N, Pace T, Broome B, Osuji O, Harman MK. Clinical outcomes of tibial components with modular stems used in primary TKA. Adv Orthop 2014;2014:651279.
[3] Lim LA, Trousdale RT, Berry DJ, Hanssen AD. Failure of the stem-condyle junction of a modular femoral stem in revision total knee arthroplasty: a report of five cases. J Arthroplasty 2001;16:128–32.
[4] Limberg AK, Wyles CC, Taunton MJ, Hanssen AD, Pagnano MW, Abdel MP. Varus-valgus constrained insert with posterior-stabilized femoral components in complex primary total knee arthroplasties. Bone Jt Open 2021;2:921–5.
[5] Scuderi GR. Revision total knee arthroplasty: how much constraint is enough? Clin Orthop Relat Res 2001;392:300–5.

[6] Merz MK, Farid YR. Anterior distal femoral osteotomy for removal of long femoral stems in revision knee arthroplasty. J Arthroplasty 2014;29:1423–5.
[7] Appleton AT, Mantz GA, Golden-Appleton A, Debenham CT, Sandoval TN, Wang Q, et al. Manual of wiring techniques for orthopedic surgery. Tech Orthop 2020;35:137–44.
[8] Boe CC, Fehring KA, Trousdale RT. Failure of the stem-condyle junction of a modular femoral stem in revision total knee arthroplasty. Am J Orthop (Belle Mead NJ) 2015;44:E401–3.
[9] Kennedy JG, Kearns SR, Quinlan WB. Dissociation of a Morse-Taper stemmed tibial component following revision total knee arthroplasty. A case report. J Bone Joint Surg Am 2003;85:536–8.
[10] Baral EC, McLawhorn AS, Wright TM, Su EP. Fracture of the femoral adapter bolt and taper adapter in a modern rotating platform knee arthroplasty. Arthroplast Today 2017;3:229–33.
[11] Morgan-Jones R, Oussedik SI, Graichen H, Haddad FS. Zonal fixation in revision total knee arthroplasty. Bone Joint J 2015;97-B:147–9.
[12] Indelli PF, Giori N, Maloney W. Level of constraint in revision knee arthroplasty. Curr Rev Musculoskelet Med 2015;8:390–7.
[13] Issack PS, Cottrell JM, Delgado S, Wright TM, Sculco TP, Su EP. Failure at the taper lock of a modular stemmed femoral implant in revision knee arthroplasty. A report of two cases and a retrieval analysis. J Bone Joint Surg Am 2007;89:2271–4.
[14] Malinzak RA, Small SR, Rogge RD, Archer DB, Oja JW, Berend ME, et al. The effect of rotating platform TKA on strain distribution and torque transmission on the proximal tibia. J Arthroplasty 2014;29:541–7.
[15] Endo Y, Burge AJ, Koff MF, Lin B, Westrich GH, Boettner F, et al. Diagnostic performance of MRI for component loosening in total knee arthroplasty compared with radiography. Radiology 2022;304:128–36.