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Case report

Patellar osteolysis after total knee arthroplasty with patellar resurfacing: a potentially underappreciated problem

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ABSTRACT

Osteolysis of the patella following total knee arthroplasty is both uncommon and poorly described in the literature. We describe 3 cases of total knee arthroplasty with patella resurfacing that later presented with anterior knee pain with patellar osteolysis without evidence of patellar implant failure: 2 males and 1 female patient, all with bilateral knee osteoarthritis. Osteolysis of the patella was identified radiographically between 2 and 16 years from the index procedure. We theorize that high pressures across the patella-femoral joint, in obese or muscular patients, may play a role in the formation of these patellar osteolytic lesions. We suspect that the prevalence of this phenomenon is under-recognized in the literature and may increase with longer term follow-up and awareness.

Introduction

In the United States, patellar resurfacing is performed in more than 80% of patients undergoing a total knee arthroplasty (TKA) [1]. Internationally, resurfacing rates are much lower ranging between 4% and 77% [1]. There is considerable controversy regarding the decision to resurface and to date, the literature presents no clear direction as to what is best, with choices ranging from routinely resurfacing, routinely not resurfacing, or selective resurfacing [2,3]. Proponents of resurfacing cite decreased incidences of anterior knee pain, decreased reoperation rates, and increased patient satisfaction with surgery [4-6]. Despite these data, patella resurfacing has been associated with numerous complications including patellar fracture, osteonecrosis, patellar polyethylene (PE) wear, aseptic loosening, instability, dislocation, overstuffing, rupture of the extensor mechanism, and patellar clunk syndrome [7,8].

Although PE wear–induced osteolysis of the femur and tibia has been well-described in the literature, there is a paucity of information on patellar osteolysis [9,10]. A single report in the literature described a gradual, asymptomatic disappearance of a patella in a 74-year-old female after primary TKA with patellar resurfacing [11]. One proposed mechanism for this phenomenon is an increase in PE wear debris in the patellofemoral joint [12]. Although PE wear debris may contribute to osteolysis of the patella, we propose alternative etiologies of patellar osteolysis related to increased patellar pressure leading to findings that will be discussed in the following section [13]. This mechanism of patellar osteolysis may explain the occurrence of this problem in patients who develop this complication relatively early postoperatively before any significant amount of PE wear would have occurred, or in the absence of any evidence of obvious PE wear elsewhere in the joint.

Case histories

This case report describes 3 cases of TKA with patella resurfacing that later presented with anterior knee pain and patellar osteolysis. All PEs used were conventional, with the exception of the left knee in Case 2, which was highly cross-linked. After review by our institution's Institutional Review Board, an exemption was obtained for this case series. However, patients were contacted and all gave

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verbal consent for use of their deidentifed information for this case report (including the patient who had not returned for additional follow-up, Case 1). All patient demographic information is presented in Table 1.

Case 1

A 57-year-old male with a body mass index (BMI) of 29 kg/m^2 and no pertinent past medical history presented with long-standing, advanced bilateral knee osteoarthritis (OA). He underwent bilateral TKAs without complications. At his initial follow-up appointments, he was progressing well. At 1 year, he complained of mild non-restricting intermittent activity-related anterior knee pain. One-year post-op radiographs are demonstrated in Figure 1a-d. He returned at 2 years post-operatively with ongoing anterior knee symptoms. Despite the pain, he continued to exercise actively, avoiding squatting type of activities. However, on further questioning, it was elucidated that he would perform open-chain leg extensions with 190 pounds but reduced this to 110 pounds because of pain. His physical examination was unremarkable with no effusion, normal alignment, good stability, painless range of motion, and normal patellar tracking. Prior imaging had been unremarkable; however, updated radiographs demonstrated a new radiolucency involving the left patella (Fig. 2). A computed tomography (CT) scan was obtained to further evaluate the patellae, as well as implant rotation, which demonstrated several areas of osteolysis adjacent to the patellar implants bilaterally, without evidence of loosening. Femoral and tibial implant rotation was appropriate. There was no obvious osteolysis of the tibiofemoral joint. He was instructed to discontinue leg extensions, squats, and lunges, with concern for patellar implant survival. His CT was repeated 6 months later and revealed similar findings to his prior CT. (Figs. 3 and 4). The patient failed to return for additional follow-up.

Case 2

A 58-year-old otherwise healthy female with a BMI of 40 kg/m^2 presented with intermittent sharp pain on the anterolateral aspect of both knees over the preceding year. She had undergone bilateral cemented TKA with patellar resurfacing for symptomatic OA 9 and 10 years prior on the left and right knee, respectively. Both knee implants were posterior stabilized total knee systems using symmetric patellar implants. Only her left knee utilized highly cross-linked PE as part of a research trial. Radiographs obtained at 2 years following surgery demonstrated well-fixed, well-positioned implants bilaterally (Fig. 5a-d). Physical examination revealed normal alignment and gait, well healed incisions with no tenderness to palpation, or effusions bilaterally. Both knees had 0°-120° of painless motion with normal appearing patellar tracking.

Follow-up radiographs demonstrated bilateral, cemented, posterior stabilized total knee replacements with implants that were well-fixed with no obvious evidence of femoral or tibial osteolysis. The patellae were well positioned; however, there were questionable areas of patellar osteolysis, right greater than left (Fig. 6).

A CT scan of both knees was obtained to further evaluate osteolysis surrounding the implants. The CT demonstrated several areas of patellar osteolysis bilaterally, with the right patella being more affected than the left. There were no signs of implant loosening (Figs. 7 and 8). The CT scan did not demonstrate any femoral or tibial osteolysis. The patient continues to undergo observation without intervention.

Case 3

A 61-year-old male with a BMI of 41 kg/m^2 and previous bilateral TKAs presented with bilateral knee pain. He originally underwent bilateral TKAs with patellar resurfacing 16 and 17 years prior. Four years following his right index procedure, he underwent a right proximal tibial tubercle transposition for patella baja, complicated by nonunion requiring bone grafting. At 10 years following the index left total knee replacement, he underwent revision of his left TKA for tibial loosening. Tibial osteolysis was noted, likely secondary to the loose implant. Three years prior to his current presentation, he was diagnosed with bilateral acute hematogenous periprosthetic knee infections, managed with debridement, irrigation, and exchange of PE inserts. Both PE patellar components were retained. Follow-up inflammatory markers normalized post-operatively with an erythrocyte sedimentation rate of 0 and a C-reactive protein <3 mg/L. Over the next few years he continued to have anterior knee pain with activities and recurrent non-infectious effusions.

Follow-up radiographs at 16 and 17 years from the index procedures showed well-fixed components bilaterally. However, his patellae demonstrated marked areas of osteolysis that was now more evident than on previous imaging. In retrospect, the previous radiographs had demonstrated areas of focal patellar osteolysis. The patellar components looked solidly fixed despite the areas of osteolysis. A CT revealed diffuse patellar osteolysis (Fig. 9).

Radiographs taken 1 year later were unchanged from prior imaging (Fig. 10a-e). No intervention has been recommended and we continue to observe the patient with future follow-up.

Discussion

Patellar osteolysis is a rare complication following total knee replacement with patellar resurfacing. This small case series of 3 patients with patellar osteolysis is the largest to date [11]. All 3 patients, who underwent patellar resurfacing at the time of TKA, presented with anterior knee pain between 2 and 16 years post-

Table 1
Patient demographics and components.

Age[a]	Sex	BMI (kg/m^2)	TKA date	TKA components	Femoral size	Tibial size	Tibial insert	Patellar button
57	M	29	June 2012[b]	Stryker Triathlon PS	6	5	11 mm	31 mm × 9 mm symmetric dome
49	F	40	R: 2008 L: 2009	Stryker Triathlon PS	NA	NA	NA	29 mm × 8 mm symmetric dome
53	M	41	L: 1999 R: 2000	Zimmer NexGen PS	L: G R: F	L: 5 R: 7	L: 14 mm R: 14 mm	38 mm × 9.5 mm symmetric dome

F, female; L, left; M, male; NA, records not available; R, right.
[a] Age at the time of procedure preceding osteolysis of the patella.
[b] Bilateral TKAs.

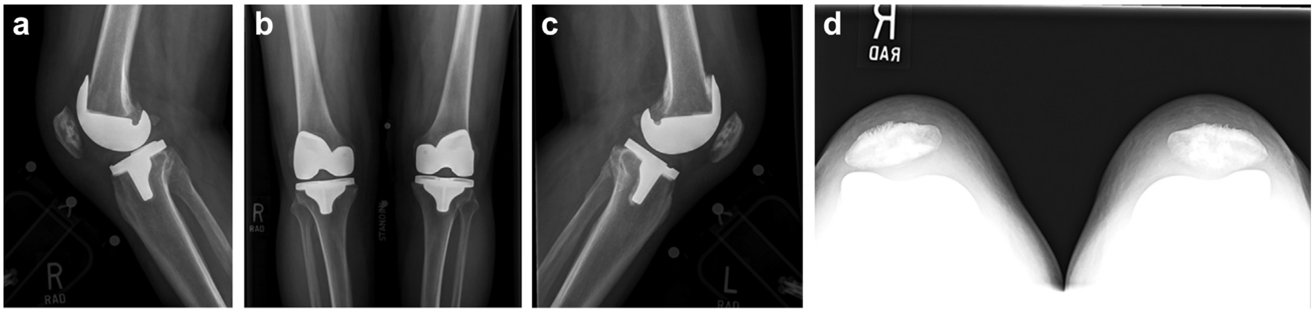

Figure 1. Radiographs of bilateral knees: (a) lateral view of the right knee; (b) standing, both knees; (c) lateral view of the left knee; and (d) Merchant view, both knees. Follow-up radiographs 1-year status post bilateral TKAs. Well-fixed, well-positioned implants bilaterally.

operatively. Radiographic evaluation of all patients revealed multiple lucencies throughout the patella consistent with osteolysis, but without implant loosening.

PE wear debris has been shown to increase the potential for osteolysis in the patella following resurfacing [12]. Ellison et al [12] found the biological activity of PE debris in the patellofemoral joint to be similar to the tibiofemoral joint after TKA with patellar resurfacing. PE wear is a multifactorial process related to the type of PE used, component positioning, and underlying patient activity level. Although further research is warranted before definitive conclusions can be made, a systematic review in 2012 also implicated several genetic components that may contribute to an increased immune response to wear debris and aseptic loosening [14]. Although this may have played a role in the development of osteolysis in our patient samples, the absence of osteolysis elsewhere in the joint (with the exception of Case 3 left knee tibia) suggests that an alternative mechanism may be responsible for patellar osteolysis. The bilateral nature of involvement further supports the possibility of an alternative etiology. We postulate 2 alternative mechanisms, both related to high patella-femoral forces, for the development of this finding, separate from the classic thinking of PE wear from the tibiofemoral joint causing wear-related osteolysis: (1) geode-like formation via synovial fluid extrusion or (2) local particle-induced osteolysis secondary to differences in modulus of elasticity among PE, cement, and bone in the patella exposed to high forces.

The term geode has been used to describe formation of cysts and pseudocysts occurring on high-pressure segments of bone [13]. Geode formation has been observed in OA, rheumatoid arthritis, osteonecrosis, and calcium pyrophosphate dihydrate deposition disease [15]. The pathogenesis of geode formation in OA is hypothesized to be a combined mechanism of bone contusion and synovial fluid extrusion into the bone secondary to elevated intra-articular pressure.

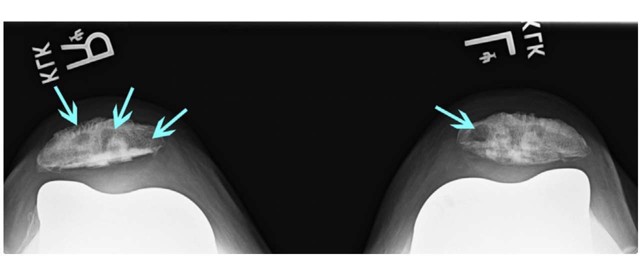

Figure 2. Merchant view of bilateral knees. This radiograph demonstrates left patellar lucencies consistent with patellar osteolysis at 2 years post-op. Blue arrows pointing to areas of osteolysis within the patella.

Of the 3 patients presented in this case, 2 patients were morbidly obese (BMI $\geq$ 40) and the third was extremely muscular and performed repetitive open-chain leg extension exercises. In these patients undergoing TKA with patella resurfacing, patellar pressures can be elevated, as a result of increased forces placed on the knee secondary to increased overall body mass or during weight lifting activities. This increased patellar pressure could cause pressurized synovial fluid extrusion into the space between the patellar prosthetic dome and surrounding bone leading to geode formation in the patella without implant loosening. This geode formation is then visualized as a radiolucency on radiographs. This concept of effective joint space is highlighted by the article from Schmalzried et al in JBJS in 1992. They demonstrated that joint fluid penetrates beyond the joint itself and into the bone and prosthesis interface. This allows particulate debris and perhaps pressure from the joint to extend into this interface, propagating osteolysis and geode formation [16]. Although 2 of our patients had their index procedures greater than 10 years prior to the identification of patellar osteolysis, the first patient presented early after his knee replacements. Consequently, in this latter setting, it is very unlikely that PE wear particles from the tibiofemoral joint would be responsible for the development of osteolysis.

A second alternative mechanism, in which increased patellar pressures secondary to obesity or muscular force may also contribute to osteolysis in resurfaced patellae, may be due to micro-

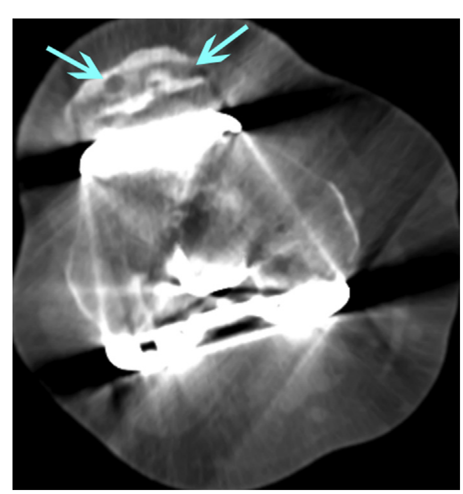

Figure 3. CT of the right knee without contrast (axial view). Total knee arthroplasty at 2.5 years post-op. Note small lucency (3.2 mm) consistent with osteolysis adjacent to bone cement interface of the patellar component. Blue arrows pointing to areas of osteolysis within the patella.

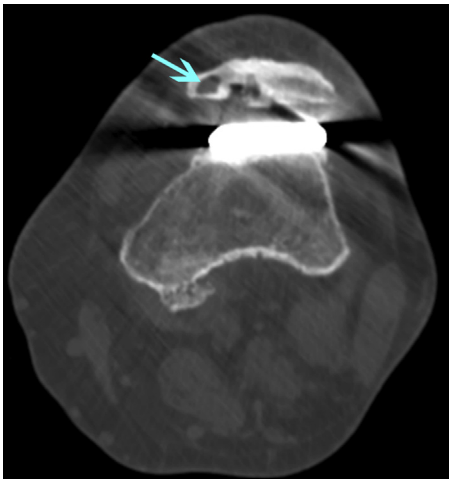

Figure 4. CT of the left knee without contrast (axial view). Total knee arthroplasty at 2.5 years post-op. Note small lucency consistent with osteolysis adjacent to bone cement interface of the patellar component. Blue arrows pointing to areas of osteolysis within the patella.

motion at the bone-cement and cement-PE interface due to differences in their elastic moduli [17,18]. Cortical bone tissue has an elastic modulus of about 17 GPa, whereas bone cement has an elastic modulus of about 2.5 GPa [18,19]. Ultra-high-molecular-weight PE has non-linear elastoplastic deformable properties [19]. Given these differences in modulus of elasticity, micro-motion at these junctions could conceivably produce localized wear particles, contributing to localized patellar osteolysis prior to implant failure. Given the localized areas of bilateral involvement in our cases, an alternative mechanism, apart from tibial insert wear debris causing isolated patellar osteolysis, is plausible.

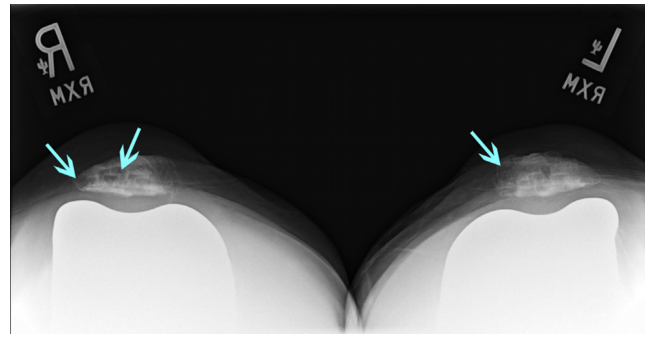

Figure 6. Merchant view bilateral knees. Radiograph demonstrating possible bilateral patellar osteolysis at 9 years post-op, right greater than left. Note the osteolysis surrounding the right lateral peg. Blue arrows pointing to areas of osteolysis within the patella.

Femoral component positioning may impact the patellar contact force and tracking. However, this concept may only apply more in substantial malpositioning of the femoral component. Marra et al [20] demonstrated that femoral component flexion up to 9° increases the knee extensor moment arm in extension, reduces the patellofemoral contact forces in flexion, and provides stable kinematics throughout the range of motion. In addition, Kang et al performed a biomechanical analysis of sagittal plane kinematics with the femoral component flexed up to 7°. They also observed that patellofemoral force decreased with deep flexion, and concluded that femoral component flexion does not appear detrimental to knee joint kinematics [21]. Similarly, Heegaard et al [22] evaluated patellar tracking and peak patellar pressure with rotational variations of 5° of internal and external rotation, and noted minimal change in peak pressures. Rotational changes primarily

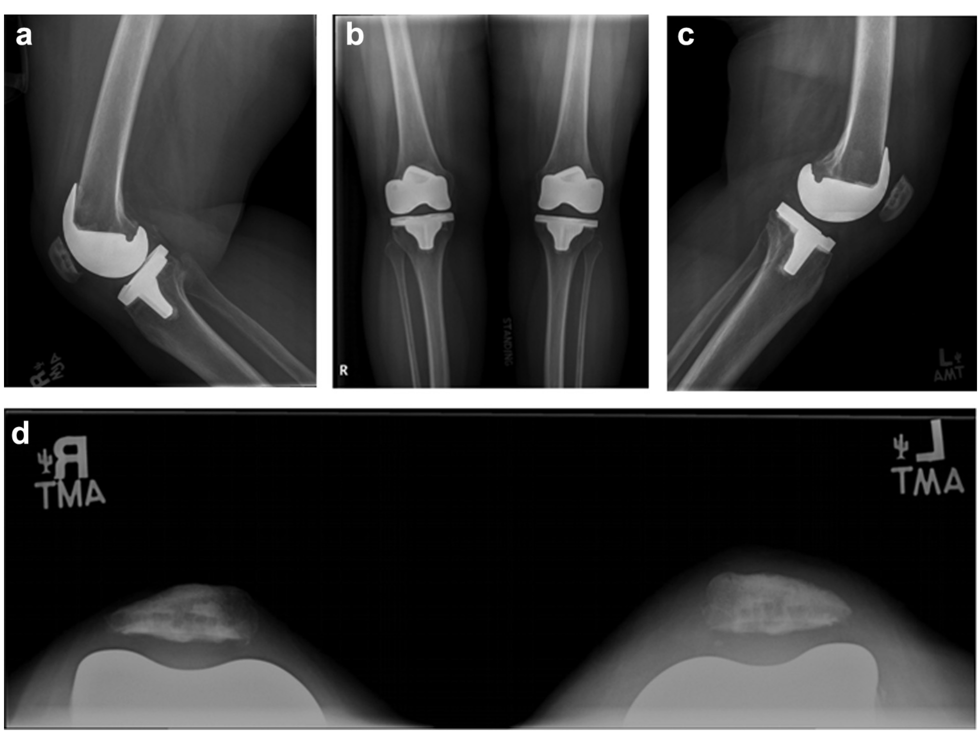

Figure 5. Radiographs of bilateral knees: (a) lateral view of the right knee; (b) standing, both knees; (c) lateral view of the left knee; and (d) Merchant view, both knees. Follow-up radiographs approximately 2 years status post bilateral TKAs. Well-fixed, well-positioned implants bilaterally.

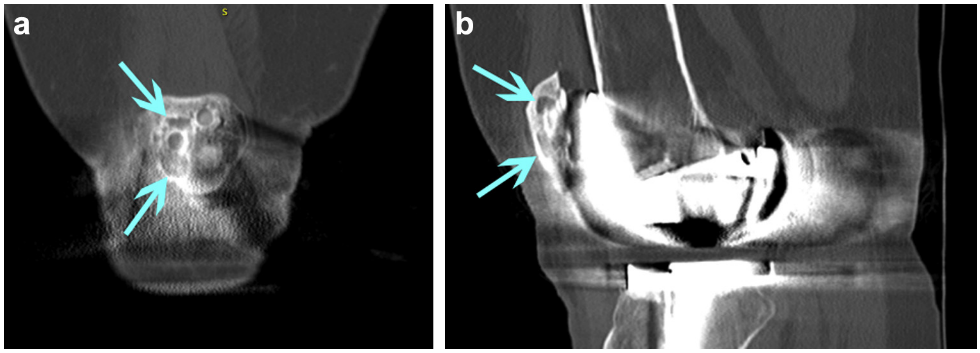

Figure 7. CT of the right knee without contrast: (a) coronal view and (b) sagittal view. Note osteolysis surrounding the lateral patellar peg, measuring 14 mm × 20 mm. CT was obtained at approximately 9 years post-op. Blue arrows pointing to areas of osteolysis within the patella.

affected patellar tracking, potentially affecting risk of patellar subluxation or dislocation. Therefore, slight rotation of the femoral component would be less likely to significantly contribute to osteolysis. Brar et al evaluated the reach of the patella with femoral component flexion. With 15° of flexion, the proximal patella reach decreased by 12 mm, and lateral reach decreased by only 1 mm [23]. They also demonstrated a decrease patellar force with femoral component flexion. The 3 patients presented here did not have any implant malrotation as assessed by CT. Slight femoral implant flexion is noted in Case 1; however, based on the above studies, it is unlikely that femoral component flexion would contribute to patellar osteolysis.

Selective patellar resurfacing has been shown to provide similar outcomes to routine resurfacing [24]. Historically, selective patellar resurfacing has been indicated for patients with anterior knee pain, inflammatory arthritis, isolated patellofemoral arthritis, history of patellar subluxation or maltracking, obesity, or elderly patients [2]. Some surgeons forego resurfacing if the patient is younger, the patellar articular surface is intact without exposed bone, there is proper patellofemoral tracking, and the patient has no history of crystalline or inflammatory arthritis [25-27]. Historically, obese patients have a higher rate of complications following TKA compared with non-obese patients [28-30]. Additionally, patients with a BMI >30 have been shown to have a 6.3-fold and 1.7-fold increase in the risk of loosening and fracture, respectively [31]. Combined with these risks, the potential for osteolysis of the patella following resurfacing should be considered when deciding whether or not to resurface the patella in this population. Similarly, a potentially higher risk for patellar osteolysis should be considered when deciding on resurfacing in muscular patients who similarly place increased load on their patellae. Overall, there is a paucity of patellar osteolysis data in the literature. As such, we hope that these case presentations and the proposal of a novel pathogenesis of isolated patellar osteolysis will encourage further inquiry into the etiology of this phenomenon.

We do not know enough about the natural history of isolated patellar osteolysis to make broad recommendations for the frequency of follow-up or when to recommend surgical intervention. For these 3 patients, we have recommended annual follow-up with plain radiographs. Follow-up CT is recommended if the patient becomes more symptomatic or obvious progression is noted on plain radiographs. Surgical intervention may be considered if there is symptomatic loosing of the patellar implant or if catastrophic failure is likely. Remaining patellar bone stock would be most likely insufficient for further resurfacing and surgical intervention would consist of removal of the implant and debridement of the osteolytic areas.

Summary

Osteolysis of the patella following TKA with resurfacing is rare. We propose that the pathogenesis of these lesions is pressure related and may be similar to the mechanism of geode formation seen in other arthritic or inflammatory conditions. Alternatively, osteolysis may be related to localized particles secondary to modulus mismatch between the implant and cement or between

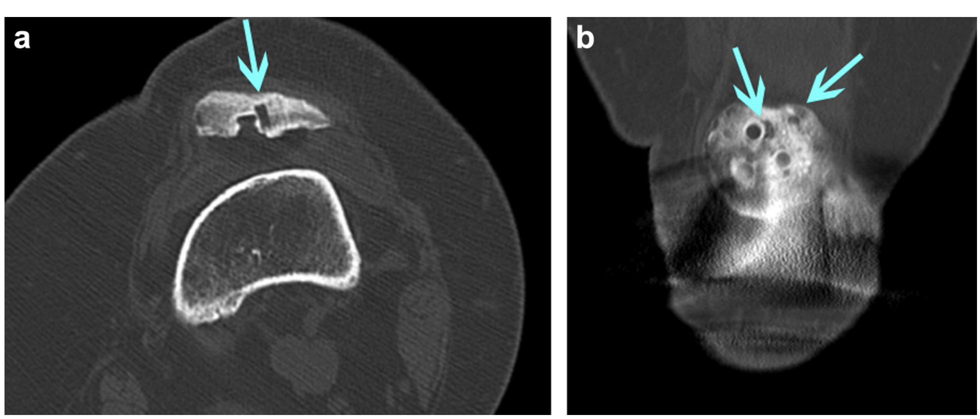

Figure 8. CT of the left knee without contrast: (a) axial view and (b) coronal view. Left total knee arthroplasty, well fixed at approximately 8 years post-op. Note the osteolysis at the lateral aspect of superior patellar peg (7 mm). Additionally, multiple other small lucencies consistent with osteolysis in the patella are evident. Blue arrows pointing to areas of osteolysis within the patella.

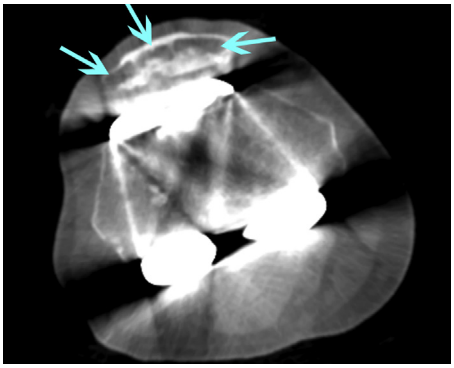

Figure 9. CT of the right knee without contrast (axial view). Right total knee arthroplasty with well-fixed patellar component with evidence of diffuse patellar osteolysis 16 years status post index procedure. Blue arrows pointing to areas of osteolysis within the patella.

the cement and bone. Finally, body habitus may play a role in the development of patellar osteolysis following patellar resurfacing in the muscular or obese patient. Although we cannot state with certainly that high forces through the patellar femoral joint are responsible for the osteolysis observed in these patients, it stands to reason that this may be a contributing factor. Hence we believe that activities that place high forces through the patellofemoral joint should be avoided, particularly in obese or very muscular individuals and counsel patients to avoid such activities. We hope that this series will raise awareness of this phenomenon and promote further research into understanding the pathogenesis of patellar osteolysis.

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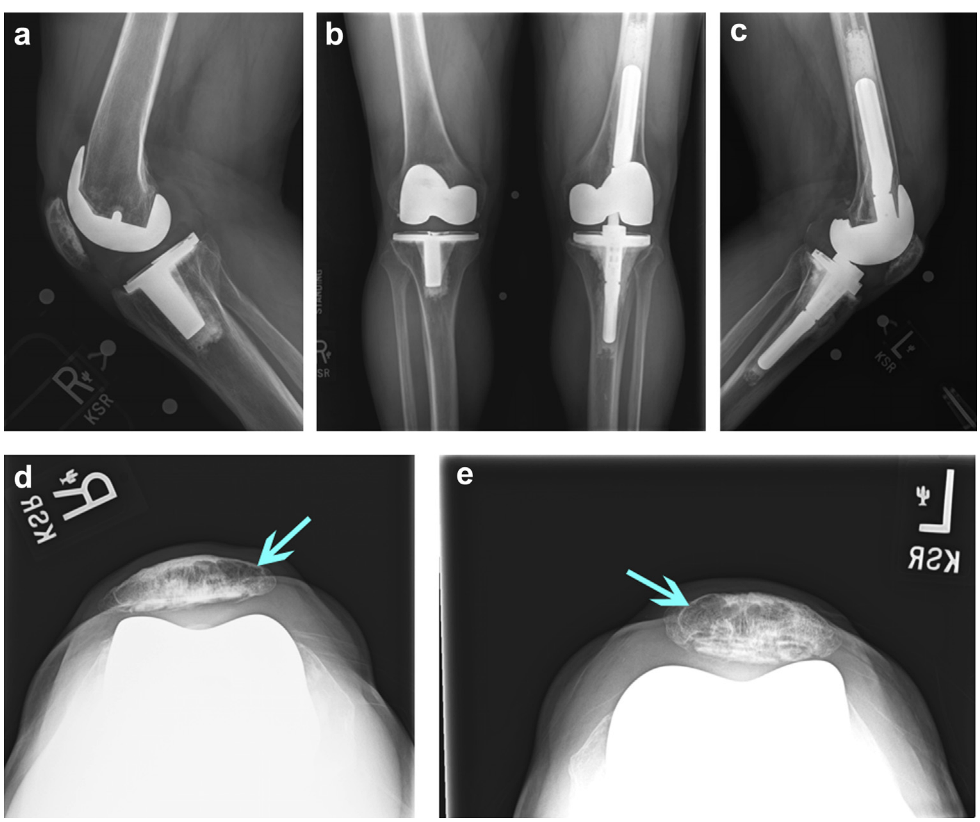

Figure 10. Radiographs of bilateral knees: (a) lateral view of the right knee; (b) standing, both knees; (c) lateral view of the left knee; (d) Merchant view, right knee; and (e) Merchant view, left knee. Well-fixed, bilateral total knee arthroplasties with evidence of patellar osteolysis seen bilaterally on Merchant views. Imaging taken 17 years status post index procedure. Blue arrows pointing to areas of osteolysis within the patella.

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