Arthroplasty Today 16 (2022) 57–62

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Case Report

# Avulsion Fracture of Bicruciate Ligament and Patellar Tendon in Bicruciate-Retaining Total Knee Arthroplasty

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ARTICLE INFO

*Article history:*
Received 24 March 2022
Received in revised form
26 April 2022
Accepted 26 April 2022
Available online xxx

*Keywords:*
Bicruciate retaining total knee arthroplasty
Tibial intercondylar fracture
Posterior cruciate ligament avulsion
Anterior cruciate ligament avulsion

ABSTRACT

Tibial intercondylar fracture with anterior cruciate ligament avulsion is a unique but rare complication of bicruciate-retaining total knee arthroplasty. Here, we describe an even rarer condition that the tibial intercondylar fracture involved bicruciate ligament and partial patellar tendon avulsion fracture resulting in significant clinical instability in a 70-year-old woman, a combination not yet reported in the literature. Dual-energy computed tomography helped characterize the fracture. During revision surgery, the bicruciate retaining total knee arthroplasty was revised to posterior-stabilized total knee arthroplasty and the patellar tendon was repaired with a suture anchor. She recovered well progressively, and at 6 months, she could walk with the use of an assisted walking device.



## Introduction

Total knee arthroplasty (TKA) is commonly performed in patients with severe knee arthritis reducing pain and improving quality of life. Up to 19% of patients, however, are not entirely satisfied with the results of their TKA [1]. Impairment of physiological knee movement may be one of the main reasons for this dissatisfaction as most TKA procedures remove the native anterior cruciate ligament (ACL) and in some designs remove the posterior cruciate ligament (PCL) as well. Bicruciate-retaining total knee arthroplasty (BCR-TKA) attempts to recreate normal knee kinematics by preserving both the ACL and PCL. Patients following BCR-TKA have reduced joint awareness, as measured by the Forgotten Joint Score (FJS), compared to patients with posterior-stabilized total knee arthroplasty (PS-TKA) [2,3]. However, BCR-TKA is also associated with unique complications, like intercondylar fracture, which results in loss of ACL tension as the ACL inserts onto the intercondylar area [4]. Here, we report a patient with a fracture of the intercondylar area that included the ACL footprint and extended anteroinferiorly to include the tibial tuberosity (with partial patellar tendon avulsion) and posteriorly to include the PCL insertional area.

## Case history

Written informed consent for publication of this report was obtained from the patient. Ethics approval was received from the institutional ethics review committee (ethics approval number: 2021.327). The study was performed in accordance with the Declaration of Helsinki. A 70-year-old woman presented with bilateral osteoarthritic knee pain for the past 10 years. She has received physiotherapy for her knee pain without previous knee injections. Past medical history was otherwise unremarkable except for chronic hypertension and a post-traumatic bipolar hemiarthroplasty of the right hip 2 years earlier. She was able to ambulate with the use of an assisted walking device for 30 minutes, being limited by knee pain. There was localized tenderness over both medial knee joint lines, range of motion was 0 to 110° (right side) and 0 to 125° (left side), and they were in 5 degrees of varus. Radiographs showed Kellgren-Lawrence grade 4 medial tibiofemoral osteoarthritis bilaterally (Fig. 1). Her body mass

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https://doi.org/10.1016/j.artd.2022.04.013

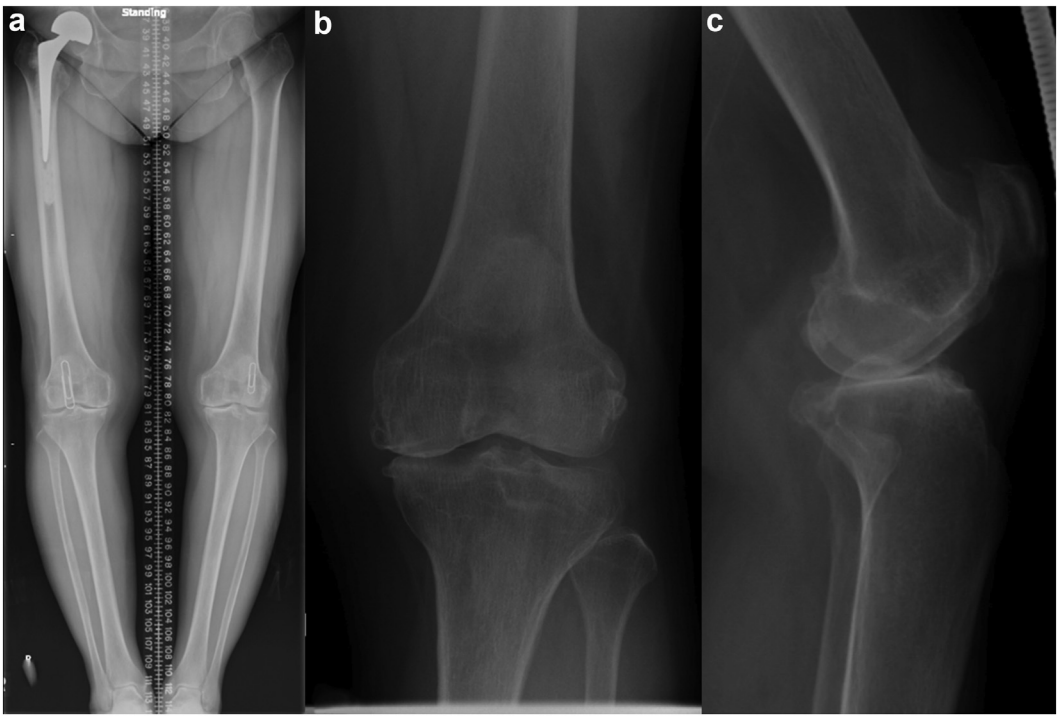


**Figure 1.** (a) Preoperative scanogram showing there is a right hip bipolar arthroplasty with severe knee osteoarthritis bilaterally. (b) Frontal and (c) lateral radiographs left knee joint. There is severe medial tibiofemoral osteoarthritis. Bone density is reasonable.

index was 29.3 kilograms per meter squared ($kg/m^2$). As conservative management was not successful, bilateral TKA was offered.

An uneventful single-stage bilateral knee primary BCR-TKA (Journey II XR, Smith & Nephew, Memphis, TN; left side: femur size 4, tibia size 2, medial and lateral insert 10 mm; right side: femur size 3, tibia size 2, medial and lateral insert 9 mm) was performed using a medial parapatellar approach and an imageless robot-assisted surgical system (CORI system, Smith & Nephew, Memphis, TN) with general anesthesia without any peripheral nerve block. Postoperative radiographs were unremarkable (Fig. 2). She could walk well with a walker on postoperative day 3 and was ultimately discharged to a rehabilitation hospital.

On follow-up 6 weeks after the operation, she reported left knee instability. Instability-type symptoms started during physiotherapy training in the rehabilitation hospital 3 weeks after the procedure when she became unsteady while standing up from the sitting position. She was unable to stand due to muscle weakness, resulting in sudden flexion of her knee into a semisquat position. An extension knee brace was applied due to knee extension lag. In the subsequent 3 weeks, she had 2 more similar episodes of near fall with the knee being flexed to a semisquat position. She did not have any direct knee injury or fall.

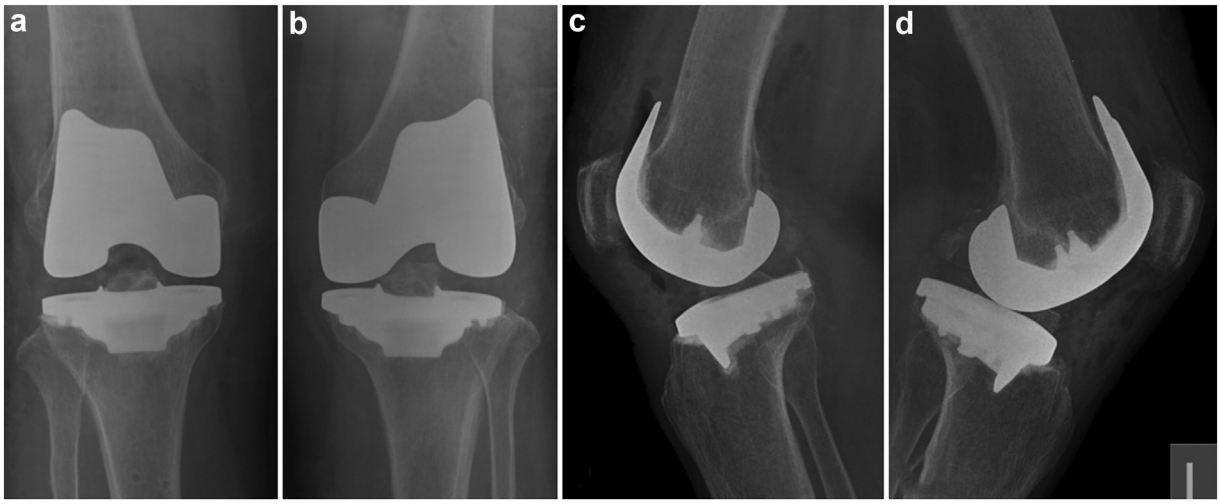


**Figure 2.** Post-operative (a) anteroposterior (right), (b) anteroposterior (left), (c) lateral (right), (d) lateral (left) views showed bilateral bicruciate-retaining total knee arthroplasty performed.

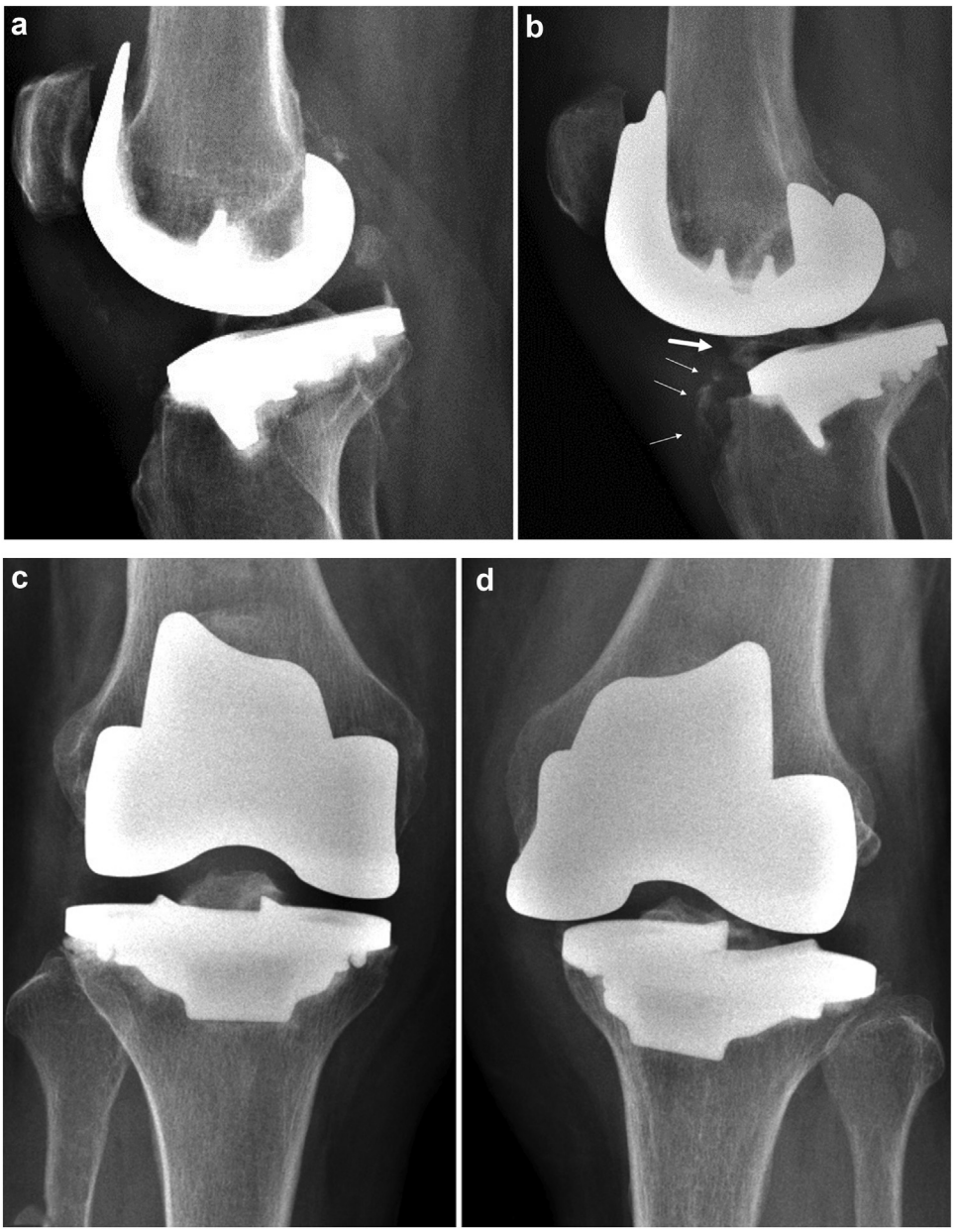


**Figure 3.** Lateral radiographs of (a) right and (b) left knees and frontal radiographs of (c) right and (d) left knees postoperatively. The femur appeared partially subluxated on the tibia in the frontal radiograph (d). On the lateral radiograph over the left knee (b), there is a thin avulsion fracture of the anterior tibial tuberosity (small thin arrows) with a larger anteriorly displaced fracture fragment projected over the anterior aspect of the knee (thick arrow). Moderate posterior translation of the proximal tibia is present relative to the distal femur. The right knee is unremarkable.

Physical examination revealed posterior sagging of the left knee without erythema or effusion. Active range of motion was 10 to 90° with 5 degrees of flexion contracture and 5 degrees of extension lag. Active knee extension could be initiated and sustained. Localized tenderness over the tibial tubercle was present with grade 3 laxity on anterior and posterior drawer testing and grade 1 laxity on varus and valgus stress testing at 30° flexion. External recurvatum test and dial test were negative. The contralateral right knee was asymptomatic with an active range of motion 0 to 110° and no demonstrable laxity. Radiographs revealed posterior tibial translation of the left knee with suspected partial patellar tendon avulsion and tibial intercondylar fracture (Fig. 3). Ultrasound revealed a partial nondisplaced avulsion fracture of the patellar tendon. Dual-energy computed tomography (DECT) showed a fracture of the intercondylar area that included the ACL insertional area, extending posteriorly to include the PCL insertional area and anteroinferiorly with concomitant partial patellar tendon avulsion fracture (Figs. 4 and 5).

A revision of the left knee BCR-TKA was performed. At operation, a partial tear of the medial one-third of the patellar tendon was found with fibrous healing and elongation. There was a complete avulsion of the intercondylar area of the proximal tibia which extended posteriorly such that the ACL and PCL are completely avulsed. The BCR-TKA was revised to a PS-TKA with cemented short stem and medial 5-mm tibial augment to compensate for medial tibial bone loss, which is resulted during the removal of tibial baseplate. Revision arthroplasty system (Legion Revision System, Smith & Nephew, Memphis, TN) (Fig. 6) was used. The patellar tendon avulsion was repaired with one 2.8-mm, double-loaded, all-suture anchors (Q-FIX⋄, Smith & Nephew, Memphis, TN) with the

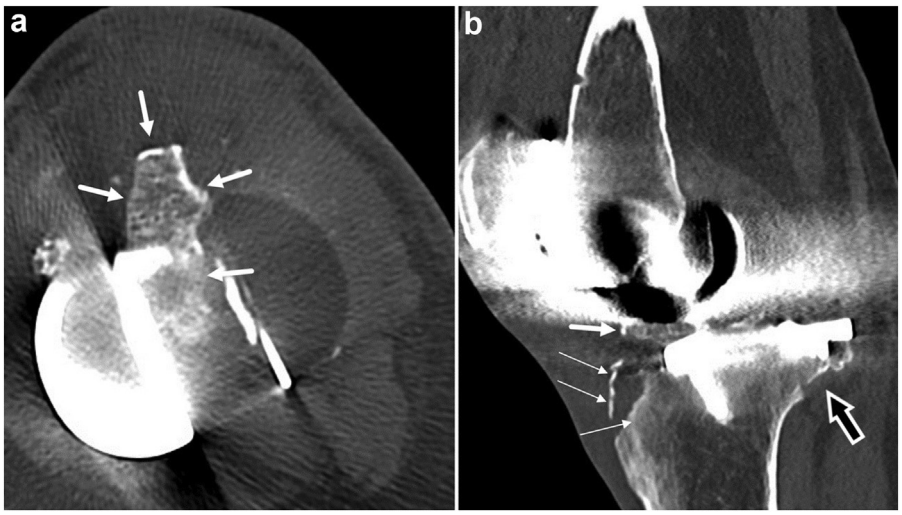


**Figure 4.** (a) Transverse reconstructed CT image left knee with bone window settings. There is a large bone fragment displaced anteriorly from the intercondylar region of the knee (arrows). (b) Sagittal reconstructed CT image left knee with bone window settings. There is a thin avulsion fracture of the anterior tibial tuberosity (small thin arrows) with a larger anteriorly displaced fracture fragment projected over the anterior aspect of the knee (thick arrow). Moderate posterior translation of the proximal tibia is present relative to the distal femur. Arrow with white border and black filling: fracture extended posteriorly and below the baseplate, including the PCL insertion site.

patellar tendon sutured with a Krackow whip stitch method. Postoperatively, the knee was supported with a hinged brace with gradual increase in flexion range to protect the patellar tendon repair. She recovered well progressively, and at the recent follow-up (6 months after initial operation), she could walk with the use of an assisted walking device for more than 30 minutes. The Knee Society Knee Score was 97 (right) and 87 (left), while the Knee Society Function Score was 50.

The range of motion was 0 to 110° (right side) and 5 to 90° (left side). The right knee was painless, while the left knee had mild nonspecific discomfort. She is continuing physiotherapy to further strengthen her lower limb muscle power.

## Discussion

The patient underwent same stage bilateral BCR-TKA procedures in an effort to achieve pain-free knees with good proprioception and physiological knee kinematics to enable her to return to normal function as soon as possible [2,5]. Case selection concurred with the selection criteria of the BCR-TKA surgical technique manual (Journey II XR, Smith & Nephew, Memphis, TN) and recent literature which indicates that pre-existing inflammatory arthritis, age over 80 years, body mass index above 34.9 kg/m$^2$, a varus or valgus deformity of more than 10°, and flexion contractures of more than 10° should be relative contraindications for BCR-TKA [6]. These recommendations do not consider quadriceps weakness, possibly due to generalized sarcopenia as a mitigating factor for BCR-TKA [7]. Such quadriceps muscle weakness may have contribution to periprosthetic fracture in the case presented.

During rehabilitation, the patient had experienced repeated episodes of sudden quadricep weakness resulting in abrupt flexion of her left knee. Such a situation led on one occasion to fracture of the intercondylar area and anterior tibia. This is an unusual fracture occurring in a BCR-TKA patient. Measures to alleviate sarcopenia and quadricep muscle strengthening may potentially lessen the risks of similar fracture and enhance the recovery of BCR-TKA patients. Conceptually, this is not unlike a post-ACL reconstruction (ACLR) knee where, although the knee joint has been stabilized and protected by passive restraints (ligaments), active training of dynamic restraints (quadriceps and hamstring muscles) is necessary to minimize the likelihood of a subsequent ACL graft injury [8–13]. In the post-BCR-TKA knee, although both the ACL and PCL (passive restraints) are stable, additional quadriceps and hamstring muscles (active restraint) should be strengthened to protect the ACL, PCL, and their bony attachments [8,10–13]. It is worth noting that our previously reported cohort of patients with sarcopenia undergoing TKA using PS-TKA did not have this rare complication and thus usage of conventional PS-TKA in someone with pre-existing risk factors for sarcopenia/deconditioning and low bone mineral density might have a role to mitigate risk of this rare complication [7].

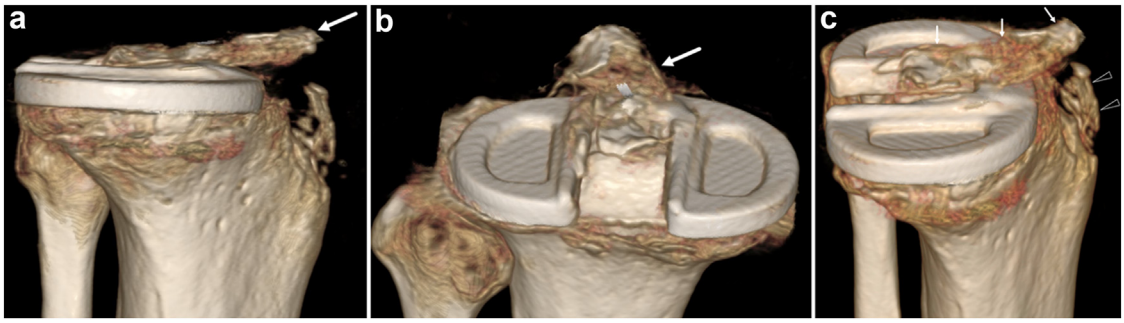


**Figure 5.** (a) Lateral, (b) superior, and (c) superior-oblique 3D CT views of the proximal tibia. The femur has been removed. There is a large anteriorly displaced intercondylar fracture (thick arrows). This fracture fragment includes all of the anteroposterior length of the intercondylar region. The avulsed anterior tibial fragment is also visible (thin arrows).

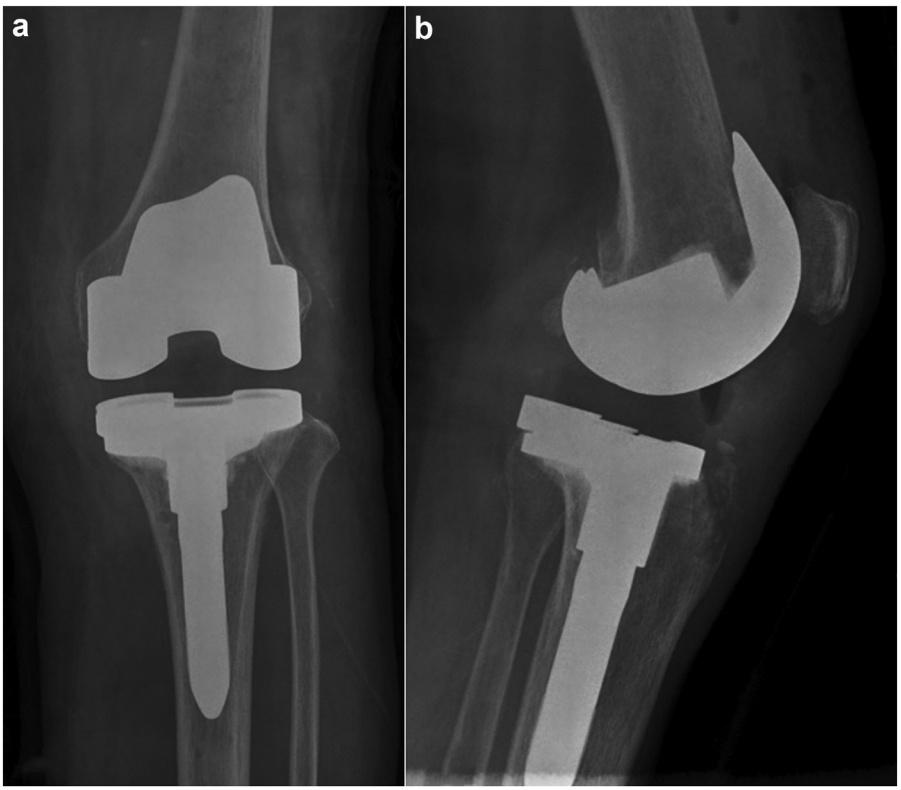


**Figure 6.** (a) Frontal and (b) lateral radiographs following revision surgery. The BCR-TKA was revised to a posterior-stabilized TKA with cemented short stem and medial 5-mm tibial augment to compensate for medial tibial bone loss using revision arthroplasty system (Legion Revision System, Smith & Nephew, Memphis, TN).

The imageless robot-assisted surgical system (CORI system, Smith & Nephew, Memphis, TN) was used in the BCR-TKA surgery to reduce the risk of fracture due to an inappropriate bone cut or a stress riser from cutting jig pinholes [14]. In this regard, we believe we had optimized the bony surgical component of TKA using robot-assisted surgery. The soft tissue component may be further improved with a preoperative and postoperative muscle strengthening program or intraoperatively with the use of alternative quadricep-sparing approaches [15]. A coexisting osteoporosis could be another target to treat preoperatively to reduce fracture risk [16].

Magnetic resonance imaging was not appropriate in this case as the degree of metallic artifact would have been likely to be excessive despite the use of metallic artifact reduction techniques. DECT with metallic artifact reduction was therefore performed. This enabled the anterior displaced fracture fragment of the intercondylar region to be quite well seen. The location of the fracture fragments enabled one to surmise that the ACL and PCL insertional areas were involved (Fig. 5). Other relevant details such as the status of polyethylene insert and the integrity of the ACL and PCL could not be evaluated with DECT, though other upcoming imaging modalities such as multienergy spectral photon-counting computed tomography (MARS CT) may be helpful in identifying these failures due to a superior material composition differentiating power [17].

In the contralateral knee, BCR-TKA had a satisfactory outcome with a high Knee Society Knee Score [3]. With further screening and management of sarcopenia and osteoporosis, preoperative and postoperative muscle strengthening program and the use of robotic surgical system, the benefits of BCR-TKA can be further maximized. The current case highlights an unusual fracture occurring following BCR-TKA. Recognition of this unusual sequela and an understanding as to how it may have occurred should help improve the outcome of BCR-TKA.

## Summary

A rare case with bicruciate ligament and patellar tendon avulsion fracture resulting in significant instability in a 70-year-old woman was reported. DECT was used to diagnose and characterize the fracture and the BCR-TKA was revised to PS-TKA. Improvement in muscle and bone health may play a potential role in BCR-TKA to optimize outcome.

## Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Kevin Ki-Wai Ho receives research support from Smith and Nephew as a principal investigator; Michael Tim-Yun Ong receives research support from Smith and Nephew as a principal investigator; all other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.04.013.

## Informed patient consent

The author(s) confirm that informed consent has been obtained from the involved patient(s) or if appropriate from the parent, guardian, power of attorney of the involved patient(s); and, they have given approval for this information to be published in this case report (series).

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