Arthroplasty Today 5 (2019) 284–287

Contents lists available at ScienceDirect

Arthroplasty Today

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

Case report

Nontraumatic fracture of the polyethylene tibial post in a bi-cruciate stabilized total knee prosthesis

Daan Renson, MD [a, *], Wouter Lenaerts, MD [b], Johan Feyen, MD [c]

[a] Department of Orthopaedics and Traumatology, University of Antwerp (UA), AZ St-Dimpna, Geel, Belgium
[b] University of Leuven (K.U.L), Leuven, Belgium
[c] Department of Orthopaedics and Traumatology, AZ St-Dimpna, Geel, Belgium

ARTICLE INFO

Article history:
Received 2 January 2019
Received in revised form
22 May 2019
Accepted 3 June 2019
Available online 23 July 2019

Keywords:
Tibial post fracture
TKA
Bi-Cruciate Stabilized (BCS) journey total knee

ABSTRACT

Tibial post fracture in total knee arthroplasty is a rare but disabling complication. The authors report a case of a nontraumatic fracture of the polyethylene tibial post in a patient with a bi-cruciate stabilized Journey total knee arthroplasty system with subsequent episodes of knee subluxation. Early revision is required to resolve this particular problem.

Introduction

The history of total knee arthroplasty shows a wide range of approaches, both with and without attempting to reconstruct native anatomy. The use of bi-cruciate stabilized (BCS) designs has been promoted to compensate for the shortcomings in normal knee kinematics of posterior-stabilized total knee arthroplasty (TKA) designs, which include post wear and instability. Polyethylene wear is often seen in revision arthroplasty and is a risk factor for (nontraumatic) breakage of the tibial post, an uncommon disabling complication that needs operative treatment [1-3]. Previous reports have presented polyethylene post fractures in NexGen (Zimmer Biomet, Warsaw, IN) and Scorpio (Stryker Corp., Mahwah, NJ) posterior-stabilized prostheses, but to our knowledge, this is the first report of a tibial post fracture in a BCS Journey (Smith & Nephew, Memphis, TN) TKA system [4-8].

Case history

In August 2017, an 81-year-old man was referred to the emergency department with a problem of recurrent “dislocation” of the right knee. There was no history of recent trauma or prosthesis malfunction after the replacement of his right arthritic knee joint in 2008 with a BCS knee prosthesis (BCS Journey; Smith & Nephew) was performed at our institution. The left knee had already been replaced with a posterior-stabilized (PS)-type prosthesis 1 year earlier and remained free of complications at presentation. Symptoms had appeared 3 days earlier after crouching on his right knee while working in his garden. He was unable to get up and extend his right leg, but after gentle insistence, the prosthesis popped back into place. Pain developed during the following days with recurrent subluxation and reduction of his knee prosthesis, particularly at night when he would unknowingly flex his knee to the point when the TKA system would subluxate in a locked position and wake him up.

Clinical examination of the patient showed laxity in the coronal plane in both knee joints and an increased anterior drawer test grade on the right joint. There were no posttraumatic signs of ecchymosis or swelling. Flexion of the right knee beyond 100° caused a posterior subluxation of the tibia in relation to the femur which reduced with a painful clicking sensation on active extension (video, Appendix A). Walking with his right leg in extension was possible. Radiographs obtained routinely showed no signs of

No author associated with this paper has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work. For full disclosure statements refer to https://doi.org/10.1016/j.artd.2019.06.001.

* Corresponding author. J.-B. Stessensstraat 2, 2440 Geel, Belgium. Tel.: +32 3 821 32 48.
E-mail address: daanrenson@hotmail.com

https://doi.org/10.1016/j.artd.2019.06.001

loosening of the femoral or tibial component, whereas imaging in 90° of flexion and in 115° of flexion showed a posterior translation of the tibia during hyperflexion (Fig. 1).

Two weeks after the first presentation, a revision was performed. In the meantime, the right leg was immobilized using a knee brace in extension, which prevented subluxation and further damage of the TKA system. During the operation, a transverse breakage of the posterior tibial post could be seen, without excessive wear of the femoral or tibial components (Fig. 2). The broken 9-mm polyethylene tibial insert was replaced with an 11-mm insert and provided adequate flexion and extension of the knee joint as well as mediolateral stability.

Three days after the operation, the patient was able to walk independently, only using a walking aid for long distances. At 18-month follow-up, the patient was able to ambulate normally and showed full extension and 120° of flexion of the right knee. He was free of knee pain and had no complaints of instability. Radiographs showed an unchanged position of the knee prosthesis without signs of loosening.

The patient provided written consent to disclose medical information. Device failure was reported to the Advanced Surgical Devices Division of Smith and Nephew, 1450 Brooks Road, Memphis, TN 38116, USA.

Discussion

The concept of cruciate-substituting TKA dates back to the 1970s. After sacrificing the cruciate ligaments, knee stability is provided by a post-cam mechanism or by an ultracongruent inlay of the TKA. The tibial spine-post femoral-cam mechanism was designed to engage only on the posterior side of the tibial post during flexion to improve femoral rollback and to increase the amount of knee flexion. However, wear and deformation of the tibial post has repeatedly been described [2,9-11]. In a retrieval study of 23 components, 7 patients (30%) exhibited severe wear [2]. Several causes have been suggested for this: (1) excessive slope of the tibial component can cause unintended femoral contact with the post and (2) femoral rotation can cause edge loading on non-rounded posts and cams, which may lead to fissuring and ultimate failure of the tibial post. Post-cam engagement velocity and flexion engagement angle under dynamic physiologic conditions were calculated for different TKA devices by Fitzpatrick et al. [12]. The flexion angle at engagement ranged from 23° to 89° among 8 different designs and correlated with the initial distance between the post and the cam and, to a lesser extent, with the AP position of the posterior surface of the post. This study highlighted the importance of tibiofemoral articulation on post-cam mechanics during dynamic activity. The influence of post design has been described in prior studies. Designs with narrow spacing between the post and femoral box were sensitive to edge loading and high mediolateral force [13].

The Journey BCS TKA system (BCS Journey; Smith & Nephew) was designed to restore normal knee kinematics and increase AP stability throughout knee flexion. It has a unique dual cam-post mechanism which substitutes for the anterior cruciate ligament and posterior cruciate ligament. The 2 femoral cams engage on the anterior and on the posterior aspect of the tibial post. The anterior cam-post mechanism is designed to engage from full extension to 20° of flexion, and the posterior cam-post engages beyond 60° of flexion. The posterior cam is asymmetric to guide the femur into external rotation relative to the tibia during flexion and to guide the femur into internal rotation relative to the tibia during extension. This is known as the screw-home mechanism (Fig. 3). Guided motion has a theoretical advantage because multidirectional sliding is detrimental to the polyethylene. It is not likely that the anterior post contact did contribute to the post fracture in our case because the subluxation occurred in a posterior direction.

The Journey BCS prosthesis (BCS Journey; Smith & Nephew) was introduced in 2005. The highly cross-linked polyethylene in combination with Oxinium (Oxidized Zirconium; Smith and Nephew) showed a highly durable bearing combination with very low wear rates during simulator testing [14].

However, several patients with this particular prosthesis were reported with postoperative symptoms mimicking the iliotibial band friction syndrome. Luyckx et al. reported a 7.2% rate of iliotibial band friction syndrome in a consecutive series of over 1000 Journey BCS knees at a mean follow-up of 2.5 years. This was explained by the fact that the asymmetric cam-post mechanism forced posterior femoral translation and internal tibial rotation during flexion, possibly stretching the iliotibial band [15].

Design changes were introduced to the prosthesis, which resulted in the release of the Journey BCS II (BCS II Journey; Smith & Nephew) in 2012. Besides changes to the flanges and width of the femoral component, changes had been made to the tibial post, which was placed anteriorly and designed to be taller than that in the Journey I prosthesis (BCS Journey; Smith & Nephew) (Fig. 2b).

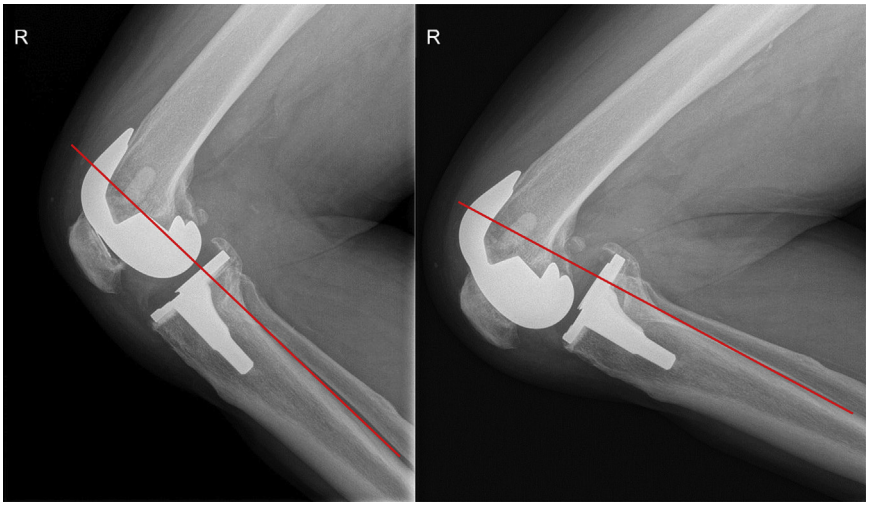

Figure 1. Preoperative imaging of the right knee in 90° flexion (left) and 115° hyperflexion (right). The red line represents the posterior border of the tibia.

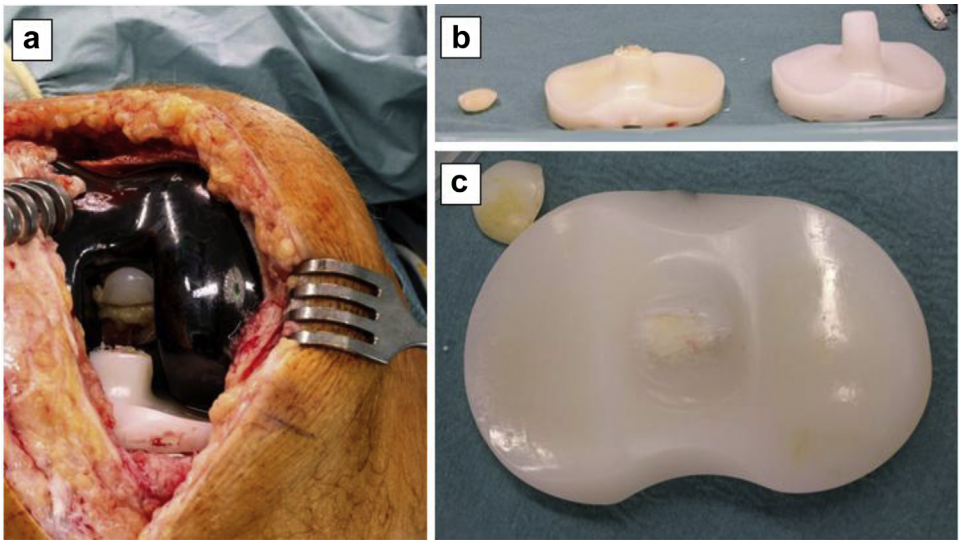

Figure 2. Intraoperative imaging of the tibial insert. The broken fragment of the polyethylene post was found in the intercondylar notch (a). The anterior (b) and top view (c) of the tibial insert show no additional wear patterns on the articulating surfaces.

The kinematic effect of these design changes in vivo has recently been investigated with in vivo fluoroscopy imaging [16]. The results in this study demonstrated that the cam-post mechanism does replicate the role of the anterior cruciate ligament and posterior cruciate ligament for AP motion, but not for axial rotation, and that midflexion cruciate functionality cannot be maintained because of the lack of engagement of neither the anterior nor the posterior cam post. Digennaro et al. found the BCS design to favor posterior femoral rollback and axial rotation compared with the PS design, which resulted in a better clinical outcome (less pain and improved quality of life) [17]. Still, the kinematic profile remains different from the normal knees possibly because of the femur being too far posterior relative to the tibia [18]. In addition, in a prospective randomized controlled trial, no increased maximal flexion was observed compared with a conventional PS system [19]. These abnormal kinematics, however, do not preclude a good clinical outcome as stated by Ward et al. and question the need for a kinematic profile equivalent to similarly aged normal knees [20,21].

In the context of our case, the question arises whether hyperlaxity did contribute to the tibial post failure. The mediolateral and anteroposterior laxity at the end of the surgical procedure eventually is decided by the surgeon's subjective assessment of the joint stability. This may influence the behavior of a mechanically constant-guided motion system of an implant.

The fact that the tibial post eventually broke during squatting may suggest posterior loading during deep flexion. The rather high level of the post fracture is somewhat atypical. It is well known that anteroposterior force is not significantly increased during the gait cycle, but biomechanical studies have shown that a higher anteroposterior shear force is applied at the tibiofemoral joint during deep knee flexion [22]. Late knee prosthesis instability is usually related to polyethylene wear due to malalignment or fatigue of materials by excessive forces during movement of the TKA [23-28].

An actual breakage of the polyethylene post is uncommon but can be diagnosed after proper clinical examination or during arthroscopy of the affected knee.

The use of radiographic examinations provides only indirect evidence, possibly secondary to noted hyperextension of the tibia or increased translation of the tibia compared with the femur, but can be of value nonetheless [4]. When the diagnosis is confirmed, a revision of the TKA is planned. Awaiting the procedure, the knee joint should be immobilized to prevent further damage to the components.

Replacing the polyethylene insert with a thicker component is a valid treatment option as studied in a patient population with PS TKAs [1]. A group of mainly male patients, who were younger and heavier, were reported to have a successful outcome after replacement of the tibial insert. The outcome of this procedure in BCS designs, however, has not yet been studied.

Figure 3. Tibial post mechanism in a conventional TKA (left) and the post-cam mechanism in the BCS design (right).

The exact incidence of tibial post fracture after TKA is difficult to determine, but several studies estimate the incidence to be less than 1% and 1.5% [1]. Hendel et al. found 5 tibial post fractures and 7 excessive wear patterns anterior of the tibial post during a 5-year follow-up period of 332 implants (Insall Burstein II prosthesis) [9]. Another study found an incidence of 12.4% in 564 PS TKAs (Total Condylar Knee System; Encore Orthopedics Inc.), but this was probably due to several design aspects that compromised its structural integrity and long-term performance [29]. The average time between the index procedure and the revision was 40 months (24-83 months range). The combination of highly cross-linked polyethylene with Oxinium may have contributed to the rather late failure in our patient (9 years after implantation).

In general, when a clinician is confronted with acute subluxation or malfunction of a knee implant, the possibility of a tibial post fracture should always be investigated to prevent further damaging of the other components. PS and BCS designs both show evidence of tibial post wear and are at risk of breakage in a nontraumatic situation. BCS prostheses that match the kinematics of similarly aged normal knees can possibly reduce the risk of wear and tibial post fractures, as can be stated by the absence of tibial post fractures of the Journey BCS II prosthesis (BCS Journey; Smith & Nephew) in the present literature.

Long-term effects on wear and revision rates have not yet been studied for this design but could influence our perspective on knee kinematics and failure after TKA.

Summary

Tibial post fracture in posterior-stabilized total knee arthroplasty is a rare but disabling complication.

This case report describes a case of tibial post fracture in a BCS total knee arthroplasty.

By reporting this infrequent complication and providing a short review of literature, we want to emphasize the importance of early recognition because surgical intervention is the appropriate treatment.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.artd.2019.06.001.

References

[1] Lachiewicz PF. How to treat a tibial post fracture in total knee arthroplasty? Clin Orthop Relat Res 2011;469(6):1709.
[2] Puloski SKT, McCalden RW, MacDonald SJ, Rorabeck CH, Bourne RB. Tibial post wear in posterior stabilized total knee arthroplasty: an unrecognized source of polyethylene debris. J Bone Joint Surg Am 2001;83(3):390.
[3] Pang H-N, Razak HRBA, Jamiecson P, Teeter MG, Naudie DD, MacDonald SJ. Factors affecting wear of constrained polyethylene tibial inserts in total knee arthroplasty. J Arthroplasty 2016;31(6):1340.
[4] D'Angelo F, Marcolli D, Bulgheroni P, Murena L, Congiu T, Cherubino P. Two stage fracture of a polyethylene post in a 9-year-old posterior-stabilized knee prosthesis: a case report. J Med case Rep 2010;4(1):65.
[5] Lim HC, Bae JH, Hwang JH, Kim SJ, Yoon JY. Fracture of a polyethylene tibial post in a Scorpio posterior-stabilized knee prosthesis. Clin Orthop Surg 2009;1(2):118.
[6] Chiu Y-S, Chen W-M, Huang C-K, Chiang C-C, Chen T-H. Fracture of the polyethylene tibial post in a NexGen posterior-stabilized knee prosthesis. J Arthroplasty 2004;19(8):1045.
[7] Sands KC, Silver JW. Fracture of the polyethylene tibial post in a posterior stabilized PFC total knee arthroplasty. Orthopedics 2005;28(10):1203.
[8] Lee C-S, Chen W-M, Kou H-C, Lo W-H, Chen C-L. Early nontraumatic fracture of the polyethylene tibial post in a NexGen LPS-Flex posterior stabilized knee prosthesis. J Arthroplasty 2009;24(8):1292.e5.
[9] Hendel D, Garti A, Weisbort M. Fracture of the central polyethylene tibial spine in posterior stabilized total knee arthroplasty1. J Arthroplasty 2003;18(5):672.
[10] Dolan M, Kelly N, LeFloch S, Wright TM, Haas S. Tibial post wear in posterior-stabilized knee replacements: a comparison of three contemporary designs. J Arthroplasty 2010;25(3):e39.
[11] Furman BD, Lipman J, Kligman M, Wright TM, Haas SB. Tibial post wear in posterior-stabilized knee replacements is design-dependent. Clin Orthop Relat Res 2008;466(11):2650.
[12] Fitzpatrick CK, Clary CW, Cyr AJ, Maletsky LP, Rullkoetter PJ. Mechanics of post-cam engagement during simulated dynamic activity. J Orthop Res 2013;31(9):1438.
[13] Nakayama K, Matsuda S, Miura H, Higaki H, Otsuka K, Iwamoto Y. Contact stress at the post-cam mechanism in posterior-stabilised total knee arthroplasty. J Bone Joint Surg Br 2005;87(4):483.
[14] Papannagari R, Hines G, Sprague J, Morrison M. Long-term wear performance of an advanced bearing knee technology. Orthopaedic Proceedings, vol. 94. London, Br: The British Editorial Society of Bone & Joint Surgery; 2012. p. 152.
[15] Luyckx L, Luyckx T, Bellemans J, Victor J. Iliotibial band traction syndrome in guided motion TKA. A new clinical entity after TKA. Acta Orthop Belg 2010;76(4):507.
[16] Grieco TF, Sharma A, Dessinger GM, Cates HE, Komistek RD. In vivo kinematic comparison of a bicruciate stabilized total knee arthroplasty and the normal knee using fluoroscopy. J Arthroplasty 2018;33:565.
[17] Digennaro V, Zambianchi F, Marcovigi A, Mugnai R, Fiacchi F, Catani F. Design and kinematics in total knee arthroplasty. Int Orthop 2014;38(2):227.
[18] Van Duren BH, Pandit H, Price M, et al. Bicruciate substituting total knee replacement: how effective are the added kinematic constraints in vivo? Knee Surg Sports Traumatol Arthrosc 2012;20(10):2002.
[19] Schimmel JJP, Defoort KC, Heesterbeek PJC, Wymenga AB, Jacobs WCH, Van Hellemondt GG. Bicruciate substituting design does not improve maximal flexion in total knee arthroplasty: a randomized controlled trial. J Bone Joint Surg Am 2014;96(10):e81.
[20] Ward TR, Burns AW, Gillespie MJ, Scarvell JM, Smith PN. Bicruciate-stabilised total knee replacements produce more normal sagittal plane kinematics than posterior-stabilised designs. J Bone Joint Surg Br 2011;93(7):907.
[21] Lee TQ. Biomechanics of hyperflexion and kneeling before and after total knee arthroplasty. Clin Orthop Surg 2014;6(2):117.
[22] Nagura T, Dyrby CO, Alexander EJ, Andriacchi TP. Mechanical loads on the knee joint during deep flexion. J Orthop Res 2002;20(4):881–6.
[23] Lachiewicz PF, Geyer MR. The use of highly cross-linked polyethylene in total knee arthroplasty. J Am Acad Orthop Surg 2011;19(3):143.
[24] Vandekerckhove P-JT, Teeter MG, Naudie DD, Howard JL, MacDonald SJ, Lanting BA. The impact of coronal plane alignment on polyethylene wear and damage in total knee arthroplasty: a retrieval study. J Arthroplasty 2017;32(6):2012.
[25] Pang H-N, Jamieson P, Teeter MG, McCalden RW, Naudie DD, MacDonald SJ. Retrieval analysis of posterior stabilized polyethylene tibial inserts and its clinical relevance. J Arthroplasty 2014;29(2):365.
[26] Kuwashima U, Hamai S, Okazaki K, et al. Contact stress analysis of the anterior tibial post in bi-cruciate stabilized and mobile-bearing posterior stabilized total knee arthroplasty designs. J Mech Behav Biomed Mater 2016;60:460.
[27] Sera T, Iwai Y, Yamazaki T, et al. Strain measurements of the tibial insert of a knee prosthesis using a knee motion simulator. J Orthop 2017;14(4):495.
[28] Rodriguez-Merchan EC. Instability following total knee arthroplasty. HSS J 2011;7(3):273.
[29] Bal BS, Greenberg D, Li S, Mauerhan DR, Schultz L, Cherry K. Tibial post failures in a condylar posterior cruciate substituting total knee arthroplasty. J Arthroplasty 2008;23(5):650.