

Failure of tibial polyethylene insert locking mechanism in posterior stabilized arthroplasty

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Abstract Tibial insert locking mechanisms are intended to limit interface motion and to prevent backside wear in contemporary modular knee designs. The author describes a case of failure of the polyethylene insert locking mechanism in one design of primary total knee arthroplasty. Loosening of the locking clip was observed within 6 weeks of the index operation without any trauma. The possible mechanism of disengagement is discussed. This rare cause for knee failure has to be recognized because it leads to early revision.

Level of evidence IV.

Keywords Knee arthroplasty · Polyethylene insert · Failure · Locking mechanism · Revision

Introduction

Modular components have been introduced for their intra-operative flexibility and interchangeability of sizes, easy liner removal for irrigation and synovectomy in case of early infection, poly exchange in case of wear in well-fixed implants and reduced inventory [2, 6]. With modularity came the problem of ‘backside wear’ due to micromotion with an increased risk of osteolysis [6]. Modularity in total knee arthroplasty (TKA) mandated the development of locking mechanisms to capture the polyethylene into the metal baseplate [1, 5].

The intrinsic complications induced by modularity are disengagement or failure of the locking mechanism,

polyethylene subluxation or dissociation of the bearing [3, 7, 11]. These events all lead to early re-intervention and at least partial revision of components [3, 10, 12].

In general, this type of complication is very rare. The reported complaint rate for locking mechanism failure of this tongue and groove design in the Vanguard primary knee is 0.008% (Data on file with Biomet, Warsaw, USA).

Case report

A 69-year-old woman underwent right total knee arthroplasty (Vanguard PS, Biomet, Warsaw, US) for degenerative arthritis through a subvastus approach in 2011. She had a left total knee arthroplasty 1 year before with the same implant design that was well functioning. The right side procedure was successful and she was able to leave the hospital after 3 days. Rehabilitation was going well and full extension and 135° of flexion were reached after 5 weeks. At 6 weeks, she felt a sudden onset of pain on the anteromedial side of the knee and a limitation of her range of motion to 100°. Just around that time she was scheduled for routine follow-up at the clinic. There was no history of trauma. A subcutaneous swelling and foreign body was palpated on the anteromedial side of the knee. An antero-posterior (AP) radiograph showed migration of the locking clip of the polyethylene insert towards the medial side (Fig. 1). Blood tests were normal. Surgical error was excluded during the complaint procedure with Biomet. The immediate postoperative radiographs were analysed by the company and confirmed the correct initial position of the locking clip. The patient was scheduled for an arthrotomy of the knee with removal and exchange of the locking clip. Intra-operatively, it was observed to have migrated through the medial capsule under the skin (Fig. 2). A quadsparring

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parapatellar incision was performed. The position of the polyethylene was visually confirmed to be normal, without rotational malalignment, soft tissue or post impingement. The implant was well balanced in flexion and extension. A new locking clip was inserted and fixation of the polyethylene was confirmed. Standard postoperative closing was performed. Peroperative cultures were sterile. Her postoperative course was uneventful. Control radiographs 1 year postoperatively confirmed good position of the new locking clip. The patient was informed that her case was submitted for publication and she consented.

Discussion

The most important finding of this report is that fixed bearing locking mechanisms can disengage after surgery. This leads to functional impairment and early diagnosis is necessary to avoid polyethylene dislocation or wear [7, 12]. A locking system that allows easy radiograph recognition allows easy diagnosis and treatment [3, 4].

The introduction of modularity came with its advantages and disadvantages [2, 6]. By definition, modularity in the tibial component requires some amount of clearance at the interface of the insert and the baseplate to allow assembly and disassembly at the time of surgery. Looseness or laxity, as evidenced by relative motion between the insert and the baseplate in the unloaded condition may occur [6]. This problem of micromotion and possible backside wear asks for a solution requiring a capturing mechanism [2, 5].

Three types of locking mechanism are regularly used in total knee arthroplasty to capture the polyethylene insert within the metal baseplate. They can be categorized as linear, peripheral, or central capture mechanisms. The linear locking mechanisms use a tongue and groove, with tracks that run either anterior to posterior or medial to lateral, and are augmented with a locking pin to prevent motion. Peripheral capture mechanisms use a snap fit with bevelled edges along either the entire periphery or a segment of the periphery. Finally, central mechanisms use a mushroom-shaped pin with a peripheral flange for rotational stability or a central locking screw [2, 5].

Disengagement of the locking mechanism of the polyethylene insert has especially been reported in revision total knee arthroplasty [3, 10, 11]. All the published cases in primary TKA until now, to the best of our knowledge, reported on screw loosening, probably, due to repeated motion during the screw home mechanism of the knee. Micromotion between the screw and the polyethylene is certainly a factor leading to possible disengagement [3, 4, 11]. Small internal/external rotation moments of 10 Nm are observed during walking [1]. In the cases where the locking mechanism was a screw, more right cases were published

than left ones because of the pattern of micromotion in the knee, which is counterclockwise [11]. This is, however, not relevant in a tongue and groove mechanism like in our case.

The magnitude and direction of relative motion between the insert and the tibial tray during in vivo use is a complex function of the multi-axial dynamic loading of the components and the design of the capture mechanism. Another contributing factor could be the expansion of the insert in the transverse plane in response to axial compression. This deformation is a function of the points of application of the joint load determined by the design of the articular surfaces and the kinematics of joint motion [6].

During the stance phase of gait, transverse plane translation and rotation can be measured [6]. Adduction moments are present due to the medial offset of the body centre of mass. For this reason, most of the compressive load across the knee is on the medial compartment. During walking, this creates an asymmetry of loading between the medial and lateral compartments [1]. This load can increase due to malalignment or unequal soft tissue balancing [1, 13]. This biomechanical mechanism explains why a locking bar would displace medially like in this case.

Risk factors are malpositioning of the tibial component with anterior slope or varus, flexion–extension mismatch, deficiency of the extensor mechanism or extensive posterolateral release [3, 13]. These conditions are more often observed in revision knee arthroplasty than in primary TKA [3].

In most published cases, patients were of female gender, but this probably only represents the male–female ratio of knee arthritis, since our female patient has a well-functioning implant on the other side [3, 4].

Highly cross-linked polyethylene has been suggested as a risk factor for locking mechanism failure [8]. In our case, compression moulded polyethylene was used.

Since almost all published cases, as in ours, were in PS or CCK implants, constraint may play a role in the disengagement mechanism inducing more micromotion of the bearing during post engagement [3, 11].

Locking mechanism failure can lead to subluxation or dissociation of the polyethylene [3, 7, 9]. Two mechanisms are described: anterior lift-off of the bearing in flexion, resulting in an anterior displacement and posterior lift-off in extension, with a posterior dislocation of the polyethylene [3].

The problems with locking mechanism failure are the possible consequences. Removal of the screw or clip and not replacing it, increases certainly the amount of micromotion and back side wear and can lead to early polyethylene wear and osteolysis [3, 5]. Not only wear will lead to osteolysis. Sathappan et al. [12] published a case where the locking screw was responsible for osteolysis of the femur.



Fig. 1 AP radiograph showing medial displacement of locking bar

The need for retrieval of the locking mechanism device leads to early revision with either arthroscopic removal or arthrotomy of the knee. The locking mechanism device can be simply replaced by a new one or eventually the bearing can be changed if it appears necessary [3]. This decision will depend on the macroscopic damage of the polyethylene and the locking mechanism and lies with the surgeon at the moment of revision surgery.

As preventive measures, we advise surgeons to clear all soft tissues before positioning the bearing and to make sure nothing interferes with the locking pin or the bearing; not to force the pin in case of resistance to avoid fretting of the metal; and to wet the locking pin with human fluids prior to introduction, to facilitate the sliding; finally, to retract the medial soft tissues in obese patients posteriorly, to allow correct placement of the introduction device.

The limitation of this report, as in other cases, is that the surgeon did not remove the polyethylene component so that no real retrieval analysis was possible to see whether there was a manufacturing problem or a subtle design problem [3]. The surgeon was an experienced Vanguard user having implanted more than thousand implants of this brand and did not change the balancing of the knee at revision, reducing the possibility of surgical error but not eliminating it [13]. The correct position of the locking bar



Fig. 2 Locking bar in medial soft tissues during arthrotomy

was confirmed on the immediate postoperative radiographs by the Biomet engineers during the process of the official failure complaint.

At 1 year follow-up, no recurrence of the problem was observed at radiological and clinical control.

Conclusion

Locking mechanisms introduced to reduce backside wear in modular total knee arthroplasty can disengage and be responsible for early revision. Early revision is necessary to limit the possible consequences of this mechanical failure.

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