

MOBILE TIBIAL POLYETHYLENE BEARING IN TOTAL KNEE ARTHROPLASTY

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ABSTRACT

Debris of polyethylene tibial bearings have been recognized as a major cause for the onset of the cascade of biological events leading to osteolysis and loosening of prosthetic components after total knee arthroplasty. Since then, research has been focused on alternative bearing surfaces in order to minimize the amount and rate of polyethylene wear off and, in doing so, increasing the survivorship rate for knee arthroplasties. One such option is to have a mo-

bile tibial bearing allowing more conformity and rotational self-alignment of the components, improving kinetics and kinematics of the prosthesis. The authors present a resumed but throughout and comprehensive review of the rationale, biomechanics fundamentals, indications, pitfalls, outcomes and complications for the use of mobile tibial bearings in total knee replacement.

Keywords – *Knee; Biomechanics; Arthroplasty; Polyethylene*

INTRODUCTION

Recognized as one of the main causes of failure in total knee arthroplasty, tibial polyethylene has been the focus of much research, from new manufacturing methods to the manners in which it is used, aiming to reduce the level of wear of the material and its consequences^(1,2).

One alternative that has been adopted is the use of mobile tibial polyethylene, which are more suitable for decreasing wear of the upper surface that is in direct contact with the femoral component and also the wear observed on the lower fixed polyethylene surface^(2,4).

Another advantage is the possibility of the mobile polyethylene bearings positioning themselves, allowing and accommodating errors in the rotational positioning of the tibial component^(2,4-7).

Currently, all of the major companies that produce and sell the components of total knee arthroplasty have the mobile tibial polyethylene bearing alternative in their portfolio.

However, there are also disadvantages to consider. The cost of total knee arthroplasty with a mobile platform is

higher than that with a fixed polyethylene component. The possibility of rotational dislocation of the mobile polyethylene bearing (spin-out) must be assessed and prevented, as it can lead to the need for revision surgery^(4,8).

BIOMECHANICAL ASPECTS

Mobile tibial polyethylene components are not new, the first to be used was the Oxford-type unicompartmental arthroplasty (Biomet, Bridgend, South Wales) 30 years ago, soon followed by the launch of the LCS (Low Contact Stress) system (DePuy, Warsaw, Indiana)^(2,9).

The concept of mobile tibial polyethylene bearings is attractive and may be the solution for some of the biomechanical problems and dilemmas of knee arthroplasties.

Since rotation occurs between the tibial tray and polyethylene, the need to allow for rotation at the level of the femorotibial joint, as must occur in fixed platforms, is eliminated and the contact area is increased from 200 mm² to 1000 mm² or more, with a consequent reduction of contact stress^(2,5,6,9,10).

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On the other hand, unlike the first fixed polyethylenes that had a flat and straight femoral contact surface to enable rotation of the femur and tibia, leading to increased contact stress, especially point contact stress, the greater conformity of mobile polyethylene increases and maintains the contact area throughout the arc of motion.

Thus, the kinematic conflict (surface/rotation) observed with the fixed platforms can be solved, since a high-conformity articular surface is then able to coexist with rotational motion^(2,6,7,11).

This would ultimately lead to less friction and less wear of the polyethylene, two important tribological variables, with consequent increased durability of the prosthesis.

When mobile tibial polyethylene platforms are paired with metallic components, that is, when the femoral, tibial, and polyethylene components have the same size, they allow for approximately 10° of internal or external rotation with no protrusion of polyethylene over the metal tibial tray. In cases where it is necessary to use a tibial polyethylene component larger than the metal tibial tray, it is still possible to observe around 5° of internal and external rotation of the polyethylene, also without protrusion of polyethylene⁽⁶⁾.

The mobile platforms can be described in relation to their mobility such as pure rotation (for example, the LCS rotating platform) (Figure 1), anteroposterior translation (for example, the Oxford-type unicompartmental prosthesis) (Figure 2), and rotation with anteroposterior translation (for example, the LCS mobile polyethylene meniscus) (Figure 3).

It is important to stress that to have mobility between the polyethylene and the tibial tray, it is necessary that the superior metal surface of the tibial component is completely uniform, smooth, and wrinkle-free, thus

avoiding friction and consequent wear. For this reason, the tibial components are composed of chrome-cobalt, since the elimination of surface wrinkles has not been possible with titanium alloys up to the present time.

INDICATIONS AND SURGICAL TECHNIQUE

The indications for the use of mobile tibial polyethylene components are actually the same for total knee arthroplasty with fixed tibial polyethylene components. However, due to its higher cost and the possibility of greater durability, the tendency is to reserve its use for younger and more active patients⁽⁶⁾. In fact, this choice ends up depending on the surgeon's preference and experience, and also, obviously, the availability of the prosthesis.

The surgical technique is similar to that used for performing total knee arthroplasty with a fixed platform. We must pay special attention in areas of flexion and extension, because if they are uneven, they may cause rotational dislocation of the mobile polyethylene bearings. Another important factor in preventing the rotational dislocation of the mobile polyethylene bearings is the tension of the posterior cruciate ligament, which must be verified by testing posterior displacement, as described by Scott⁽⁶⁾. This verification is performed with the femoral and tibial metallic test components and the tibial polyethylene properly positioned. One should be careful to freely support the tibial polyethylene on metal tibial test tray. The knee is then placed between 80° and 100° of flexion, verifying the displacement of the tibial polyethylene component.

If there is displacement of the tibial polyethylene to the front of the metal tibial tray, besides the tendency to or lifting this metal tibial tray, there will be exaggerated tension of the posterior cruciate ligament.



Figure 1 – Surgical appearance of the mobile tibial polyethylene platform. Note also the mobile patellar component. To the right, profile and AP radiological images. Note the radio-opaque markers in both the patellar and tibial polyethylene.



Figure 2 – Picture of the Oxford-type unicompartmental prosthesis, series 3.

If the tibial polyethylene moves more than 3 mm posteriorly, it is a sign of posterior cruciate ligament laxity.

Ideally, in this situation, the tibial polyethylene is located in a position 2 to 3 mm posterior to the anterior edge of the metal tibial tray, demonstrating proper posterior cruciate ligament tension.

RESULTS

The results of total knee arthroplasties with mobile platforms need to be compared with those obtained with the use of fixed platforms^(2,6,9,12,13). Total knee arthroplasty with a fixed platform offers significant subjective and objective results and a durability index of more than 90% long-term (15 years or more)^(1,2,6). Total arthroplasty with mobile platforms like LCS has shown comparable results in long-term follow-up⁽⁹⁾.

In addition to the general complications inherent to arthroplastic procedures, the use of mobile tibial polyethylene bearings has some specific complications.

There may be a greater likelihood of developing posterolateral instability due to the greater anteroposterior translation of the mobile polyethylene than that observed in fixed platforms. There can also be impingement of the anterior compartment of the knee, especially if the patellar adipose panniculus is not properly dried.

The most common complication is the rotational dislocation of the polyethylene (spin-out), which can be partial or total (Figures 4, 5, 6, 7, and 8). This is a complication related to technical error, in other words, the surgeon.



Figure 3 – Metal tibial tray with preservation of the posterior cruciate ligament for the use of mobile polyethylene meniscus. Observe the tracks on the metal tray for the polyethylene menisci.



Figure 4 – Surgical detail showing beginning of the rotational dislocation (spin-out) phenomenon of the mobile tibial polyethylene.



Figure 5 – Sequence of rotational dislocation of the mobile tibial polyethylene. Note its transverse position in relation to the metallic components.



Figure 6 – Complete rotational dislocation. Detail with the knee in extension. Note the complete inversion of the tibial polyethylene.

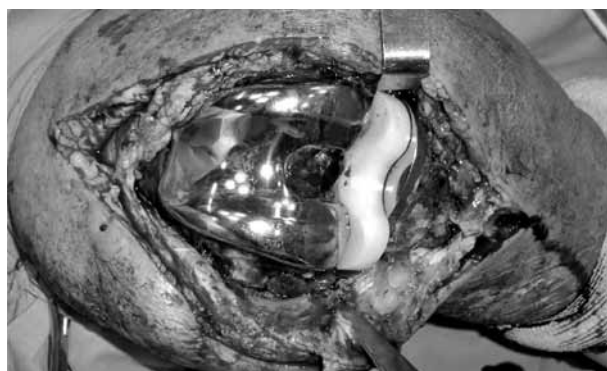


Figure 7 – Complete rotational dislocation. Detail with the knee in flexion. Note the rotational discrepancy between the metal tibial tray and the polyethylene.

In order to prevent the occurrence of rotational dislocation, some designs incorporate metal pins to the tibial tray, one anterior and one posterior. However, this can lead to a decrease in the degree of rotation of the polyethylene and to the possibility of increased friction and wear.

CONCLUSION

The use of mobile tibial platforms has great appeal from a biomechanical point of view, especially in rela-



Figure 8 – Radiological appearance of complete rotational dislocation (spin-out) of the tibial polyethylene in the profile view. Note the complete inversion of the polyethylene, especially in the outline on the right. Surgical image inserted for comparison.

tion to the lesser wear of the polyethylene, and also for allowing for rotational self-adjustment between the tibial polyethylene and the tibial tray. However, we can not overlook the possibility of rotational dislocation of the polyethylene, which can lead to the need for revision.

The basic surgical principles of total knee arthroplasty, especially those related to the symmetry of the flexion and extension spaces and proper ligament balancing, must be respected. Otherwise, regardless of the type of prosthesis or polyethylene used, we will certainly compromise the results of surgery.

A very important factor in our environment is the high cost of prostheses with fixed platforms, apart from the difficulty of accessing the system, which ends up making its wider use not viable.

We hope that, in the near future, these obstacles are overcome so that we can also rely on this surgical alternative for the treatment of the degenerative knee joint diseases.

REFERENCES

- Horowitz SM. Particulate debris and osteolysis. In: Lotke PA, Garino JP, editors. Revision total knee arthroplasty. Philadelphia: Lippincott-Raven Publishers; 1999.p.31-41.
- Callahan JJ, Insall JN, Greenwald AS, Douglas DA, Komistek RD, Murray DW, et al. Mobile bearing knee replacement: concepts and results. J Bone Joint Surg Am. 2000;82(7):1020-41.
- Wasielowski RC, Parks N, Williams I, Surprenant H, Collier J, Engh G. Tibial insert undersurface as a contributing source of polyethylene wear debris. Clin Orthop Relat Res. 1997;(345):53-9.
- Otto JK, Callaghan JJ, Brown TD. Mobility and contact mechanics of a rotating platform total knee replacement. Clin Orthop Relat Res. 2001;(92):24-37.
- Dennis DA, Komistek RD, Mahfouz MR, Outten JT, Sharma A. Mobile-bearing total knee arthroplasty. Do the polyethylene bearings rotate? Clin Orthop Relat Res. 2005;(440):88-95.
- Scott RD. Mobile versus fixed bearings in total knee arthroplasty. In: Total knee arthroplasty. Philadelphia: Saunders, 2006;16-9.
- Most E, Li G, Schule S, Sultan P, Park SE, Zayontz S, Rubash HE. The kinematics of fixed- and mobile-bearing total knee arthroplasty. Clin Orthop Relat Res. 2003;(416):197-207.
- Huang CH, Ma HM, Liao JJ, Ho FY, Cheng CK. Late dislocation of rotating platform in New Jersey Low Contact Stress knee prosthesis. Clin Orthop Relat Res. 2002;(405):189-94.
- Buechel FF Sr, Buechel FF Jr, Pappas MJ, D'Alessio J. Twenty-year evaluation of meniscal bearing and rotating platform knee replacements. Clin Orthop Relat Res.2001;(388):41-50.
- Dennis DA, Komistek RD, Mahfouz MR. In vivo fluoroscopic analysis of fixed-bearing total knee replacements. Clin Orthop Relat Res. 2003;(410):114-30.
- Banks S, Bellemans J, Nozaki H, Whiteside LA, Harman M, Hodge, WA. Knee motions during maximum flexion in fixed and mobile-bearing arthroplasties. Clin Orthop Relat Res. 2003;(410):131-8.
- Chiu KY, Ng TP, Tang WM, Lam P. Bilateral total knee arthroplasty: one mobile-bearing and one fixed-bearing. J Orthop Surg. 2001;9(1):45-50.
- Kim JS. Comparison of fixed-bearing and mobile-bearing total knee arthroplasties. Clin Orthop Relat Res. 2001;(392):101-15.