Highly Cross-linked Polyethylene in Posterior Stabilized Total Knee Arthroplasty: Early Results

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KEYWORDS

• Posterior stabilized total knee arthroplasty • Highly cross-linked polyethylene • Tibial post

KEY POINTS

- Highly cross-linked polyethylene with altered mechanics has recently been introduced to total knee arthroplasty.
- Concern exists regarding the altered properties, in particular with respect to the tibial post in a posterior stabilized design.
- No new complications in short-term outcomes were noted with this novel material.

INTRODUCTION: NATURE OF THE PROBLEM

Total knee arthroplasty (TKA) is an effective, reliable, and durable treatment of end-stage symptomatic arthritis of the knee.[1] However, with conventional polyethylene, mechanical failure consisting of wear, osteolysis, and loosening are the primary source for failure in active patients[2] and at long-term follow-up following some modular TKA systems.[3] Other designs have not shown the same rate of loosening, although osteolysis remains a concern.[4,5] Newer designs with conventional polyethylene have not yet shown significant wear and osteolysis at early follow-up, but long-term studies do not exist.[6]

The successful introduction of a highly cross-linked polyethylene into total joint arthroplasty began in the hip as a response to excessive wear and osteolysis noted with conventional polyethylene stored in air.[7] Short-term clinical studies by Hodrick and colleagues[8] and Minoda and colleagues[9] recently showed successful outcomes with highly cross-linked polyethylene in a posterior cruciate–retaining TKA design.

This is the first clinical study to examine outcomes with highly cross-linked polyethylene applied to a posterior stabilized design. The polyethylene post provides a further area for concern with the altered mechanical properties of highly cross-linked polyethylene. We sought to determine whether this new substance affects the short-term outcomes of posterior stabilized TKA, and specifically to address the concerns of tibial post failure.

THERAPEUTIC OPTION

Institution Review Board approval was obtained for this study. A retrospective review was performed of prospectively collected data in our institutional joint database. One-hundred and twenty

Investigations performed at the Insall Scott Kelly Institute, New York, New York.
Disclosures: William J. Long has consulted for Biomet Inc and Zimmer Inc. He is an editor for Elsevier. Gabriel Levy has no disclosures. Giles R. Scuderi is a consultant for Zimmer Inc. He is an editor for Elsevier.
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Orthop Clin N Am 43 (2012) e35–e38
http://dx.doi.org/10.1016/j.ocl.2012.07.005
0030-5898/12/$ – see front matter

TKAs were performed on 98 patients from January 2005 to September 2006. There was no selection bias because this was a consecutive series, and, in all TKAs performed during this period by the senior author with posterior stabilized polyethylene, a highly cross-linked liner was used.

There were 76 unilateral procedures and 22 bilateral procedures. In all cases, a modular cemented, high-flexion, posterior stabilized TKA system was used (Zimmer Inc, Warsaw IN). The average age at surgery was 62.8 years (range 29–84 years). There were 34 men and 64 women. Indications for surgery included 107 cases of degenerative joint disease (DJD), 3 cases of avascular necrosis, 1 case of gout and 1 of posttraumatic DJD; 5 cases of aseptic loosening; 2 cases of failed unicompartmental knee arthroplasty, and 1 case of TKA stiffness.

All patients were managed with our standard postoperative TKA protocol, which consisted of a physical therapy program with an in-hospital continuous passive motion device and rapid rehabilitation weight bearing as tolerated. A multimodal pain management plan was introduced at the time of surgery.

Radiographic review was performed at standard intervals, including a postoperative anteroposterior (AP) and lateral radiograph in the recovery room. Clinical and 3-view radiographic follow-up was obtained at 6 weeks, 3 months, 1 year, 2 years, and 5 years after surgery. KSS were calculated before surgery and as part of our routine follow-up.

CLINICAL OUTCOMES

A total of 120 TKAs were performed on 98 patients. There were 5 deaths (7 knees), and 2 revisions in this patient cohort. Follow-up was obtained in 108 of the remaining 111 knees (97%). Ninety-seven patients had a full clinical and radiographic evaluation at an average 52 months (range 24–68). Fourteen patients were contacted by phone at a mean 72 months after TKA, filled out a questionnaire, but declined to return to the office. Three patients were lost to follow-up before obtaining a 2-year follow-up.

The average preoperative Knee Society Scores (KSS) were 49.7 clinical and 51.5 for function, with a mean range of motion (ROM) of 3° to 116°. The average postoperative KSS was 87.7 clinical and 89.7 for function, with a mean ROM of 0° to 123°. There were no known cases of polyethylene or post failure.

Complications requiring return to the operating room occurred in 3 patients, including 1 case with arthrofibrosis requiring 2 manipulations. The patient is currently doing well with an ROM of 5° to 120°. A second case revised for progressive multidirectional instability at 45 months in a patient with Crohn disease. In a third case, in which a posterior stabilized insert was used at the time of revision for aseptic loosening, there was progressive instability and this was revised to a constrained liner at 2 years. There was no visible sign of polyethylene wear at the time of either revision.

Radiographic review was obtained in 97 knees at an average 48 months (range 24–68 months). Mean individual component positions were femoral valgus angle of 5.9° and flexion of 2.5°, tibial varus angle of 2.1°, and posterior slope of 3.8°, which created an average postoperative tibiofemoral alignment of 3.8° of valgus. There were 4 cases of tibial lucencies less than 1 mm and 1 case of 1-mm lucency under the anterior femoral phalange. None of these were progressive. There were no cases of radiographic loosening or progressive radiolucent lines.

COMPLICATIONS AND CONCERNS

Reduction in wear, osteolysis, and loosening are the goals associated with the introduction of highly cross-linked polyethylene. In improving the material properties, compromises cannot be made that diminish the mechanical properties of the polyethylene.

The cross-linked polyethylene used in this study (Prolong, Zimmer Inc) is made from GUR 1050 molded sheet bar stock treated with approximately 6.5 Mrad of E-beam irradiation, melt annealed, gas plasma sterilized, and packaged in air. It has been compared with its predecessor; the LPS flex design, in several in vitro studies. Improved wear characteristics have been shown in standard knee simulators and when bone cement was added to reproduce third body wear.[10] Higher wear and fatigue strength were also noted compared with conventional polyethylene in simulators reproducing activities of daily living and stress loading following artificial aging of these materials.[11] Improved tibial post durability and decreased wear was shown in simulator post stressing compared with conventional polyethylene.[12]

There have been multiple case reports in the literature documenting post failures with conventional polyethylene.[13] To our knowledge, there has only been 1 case reported with a highly cross-linked polyethylene post.[14] Several surgical and design characteristics affect the amount of anterior tibial post impingement in cadaveric[15] and fluoroscopic clinical[16] studies. In an in vitro study of tibial post resistance to fatigue failure, a comparison between aged conventional polyethylene to 7.5 Mrad and 10 Mrad highly cross-linked designs was