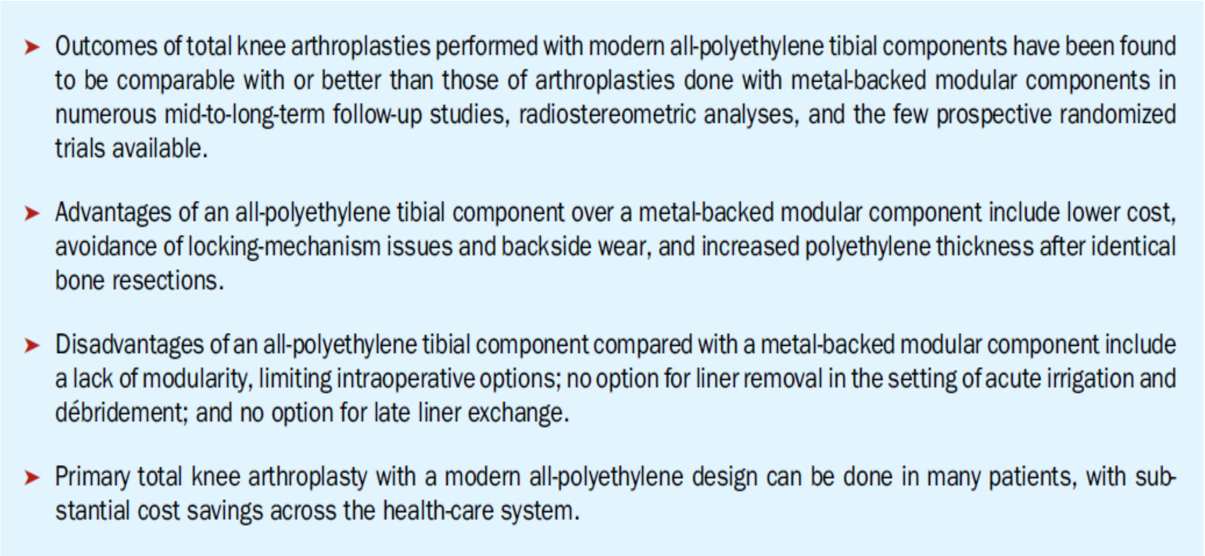
Current Concepts Review

The All-Polyethylene Tibial Component in Primary Total Knee Arthroplasty

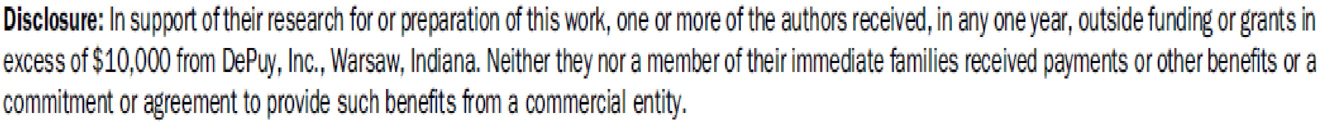


- Outcomes of total knee arthroplasties performed with modern all-polyethylene tibial components have been found to be comparable with or better than those of arthroplasties done with metal-backed modular components in numerous mid-to-long-term follow-up studies, radiostereometric analyses, and the few prospective randomized trials available.
- Advantages of an all-polyethylene tibial component over a metal-backed modular component include lower cost, avoidance of locking-mechanism issues and backside wear, and increased polyethylene thickness after identical bone resections.
- Disadvantages of an all-polyethylene tibial component compared with a metal-backed modular component include a lack of modularity, limiting intraoperative options; no option for liner removal in the setting of acute irrigation and débridement; and no option for late liner exchange.
- Primary total knee arthroplasty with a modern all-polyethylene design can be done in many patients, with substantial cost savings across the health-care system.

Early tibial designs in total knee arthroplasty systems were almost uniformly all-polyethylene, and total condylar arthroplasties (both cruciate-retaining and cruciate-sacrificing or substituting) with use of these tibial components showed survival rates of >90% at the time of long-term follow-up1-7. Failure of these early all-polyethylene tibial components was frequently due to aseptic loosening, which was generally attributed to poor surgical technique or flaws in some of the all-polyethylene tibial designs8-15. Use of metal-backed tibial components with the total condylar design likewise yielded excellent results4,6,16-18, and with time surgeons perceived advantages with the newly modular components, which provided increased intraoperative flexibility and the ability to apply a porous coating. However, some design modifications with modular metal backing did not fare so well. Less congruent designs that promoted so-called rollback coupled with a heat-pressed, thin polyethylene insert were associated with poor results19-21. There were other issues with modular metal backing, including micromotion secondary to suboptimal locking mechanisms, socalled backside wear, osteolysis, and rising manufacturing costs19,22-29. Thus, potential advantages combined with lower cost prompted renewed interest in modern all-polyethylene tibial designs. Pressure regarding implant cost in a rapidly changing health-care environment may more directly impact surgeons in the future. The purpose of this review is to outline the clinical rationale behind the use of all-polyethylene tibial designs, the design criteria necessary for success, and the implications of more widespread use of the all-polyethylene tibial design.

Historical Background

Designs favoring articular congruency have generally been the deciding factor in the success or failure of all-polyethylene tibial components. In particular, suboptimal results with the University of California, Irvine (UCI) all-polyethylene tibial design may have been important in the development of metal-backed tibial components. These relatively thin, flat, u-shaped allpolyethylene tibial components failed at rates of 7% to 17.4% in clinical series with two to eight years of follow-up9,10,15. The frequent finding of polyethylene deformation (cold flow) of tibial components retrieved at revision, the fact that only 5.0 and 7.5-mm thicknesses were available, the relative lack of articular congruency, and the limited tibial surface coverage were major concerns raised in these studies. Improper technique, including poor component alignment, poor component fixation, and soft-tissue imbalance, were also identified as causes of early failure15 (Fig. 1).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In the time frame in which these design and technique failures occurred, biomechanical and finite-element-analysis studies suggested a role for metal backing of the tibial component. Proposed advantages of a metal-backed tibial component included decreased bending strains in the stem, reduced compressive stresses in the cement and cancellous bone beneath the baseplate (especially during asymmetric loading), and effective distribution of eccentric load onto a large area of the proximal part of the tibia30-37. Metal backing was also thought to act in a heat-sink capacity, lowering the overall temperature during curing at the bone-cement interface38. Although initially metalbacked monoblock designs were predominant, as metalbacked tibial designs incorporated modularity, surgeons saw advantages to the increased intraoperative flexibility, the ability to use longer stems and modular augments, and the ability to apply porous coating if desired. Gradually, all-polyethylene tibial components were largely abandoned in favor of metalbacked tibial components, which have become predominant in total knee arthroplasty28,29,39-41. According to the Hospital Purchasing Database41, which contains data from 100 to 200 large U.S. hospitals, usage of all-polyethylene tibial components ranged from 0.8% to 1.5% of all total knee arthroplasties annually between 2003 and 2008. Similarly, an all-polyethylene tibial component was used in only 0.6% (248) of the 42,791 cases recorded in the National Joint Registry39 from England and Wales in 2004. In the HealthEast Joint Registry, which contains data from institutions with surgeon advocates of allpolyethylene tibial components28,40, usage is recorded as ranging between 3.9% and 12.9% annually and was 10.7% in 2008.

Reconsideration of the All-Polyethylene Tibial Component

Like the all-polyethylene tibial component, metal-backed tibial components have been associated with excellent results when used with the total condylar design4,6,16-18. Thus, the question arises: What has led to the recent reconsideration of the allpolyethylene tibial design? Distinct from monoblock metal backing, other design modifications that incorporated the concept of a metal-backed tibial component occasionally proved problematic with longer follow-up. As Engh et al.19

Fig. 1
A standing anteroposterior radiograph of two different all-polyethylene tibial designs used in the past shows failure related to tibial subsidence, improper soft-tissue balance, or some combination of these mechanisms.

commented: ‘‘The potentially negative aspects of these design changes (a less congruous interface, metal-backing, screw holes in the baseplate, and modular inserts) were not at first fully appreciated.’’ The assumption of improved survivorship and clinical performance with metal-backed tibial components (as compared with all-polyethylene tibial components), as predicted by some of the biomechanical analyses30-38, has been difficult to demonstrate in clinical practice.Moreover, even the perceived advantage of modularity has been questioned in more recent studies22-25. These concepts (modularity and biomechanical features) as well as issues surrounding cementless fixation and implant cost deserve greater scrutiny.

Modularity of Components

The advantages and disadvantages of modularity with a metalbacked tibial component seemclear to most surgeons (Table I).

The potential for exchange of the polyethylene insert is a presumed advantage, especially in younger patients, who might require revision in the future. However, at least three separate studies have identified the relatively limited role of isolated polyethylene exchange for addressing wear42-44. In a multicenter study, Bert et al.45 reviewed sixty-two revision total knee arthroplasties performed secondary to failure of the modular tibial insert. In fifty-five cases (89%), there was obvious scoring or other damage to the femoral and/or tibial components, necessitating revision of one or both components. A simple liner exchange seems appealing but implies that the mode of wear failure has not involved axial malalignment necessitating complete revision and has been detected before osteolysis or severe wear has compromised the metal backing. Two recent studies with short to midterm follow-up do support the practice of isolated liner exchange, with or without bonegrafting, in selected cases with well-fixed and aligned femoral and tibial components46,47. Full revision of well-fixed total knee components can lead to substantial bone loss, and modular polyethylene exchange may therefore be a reasonable option in certain cases.

The metal-backed tibial component also allows a final stability trial after the components have been cemented in place. In the senior author’s experience (T.J.G.) in a teaching institution, the lack of this option has not been a limiting feature of the all-polyethylene tibial component, as revisions due to instability were rare with both designs in randomized trials28,48,49. The metal-backed tibial design offers different stem and augment options that cannot be added to the allpolyethylene tibial component, but these options are seldom needed in a primary total knee arthroplasty and their necessity is routinely determined with preoperative templating. Moreover, nothing in the current all-polyethylene tibial designs precludes the surgeon from switching to a metal-backed tibial component intraoperatively if conditions dictate. In addition, when a patient requires removal of the tibial component alone, an all-polyethylene tibial component can be removed more easily, and with less chance of damaging a retained femoral component, by simply cutting the polyethylene stem.

Micromotion at the liner-tray interface of modular components is known to liberate polyethylene debris, despite the apparent security of the liner-capture mechanism25,50-53. The size of the liberated debris is within the biologically active range with respect to macrophage stimulation54, which might account for the increased synovitis and osteolysis seen after the introduction of modularity26 (Figs. 2-A, 2-B, and 2-C). In a study of modular tibial baseplates, Parks et al.25 found that even at the lowest loading level of 100 Nall inserts moved an average of at least 100 mm relative to the baseplate and at 400 N all inserts moved an average of at least 500 mm in at least one direction. In a separate retrieval study of 124 polyethylene

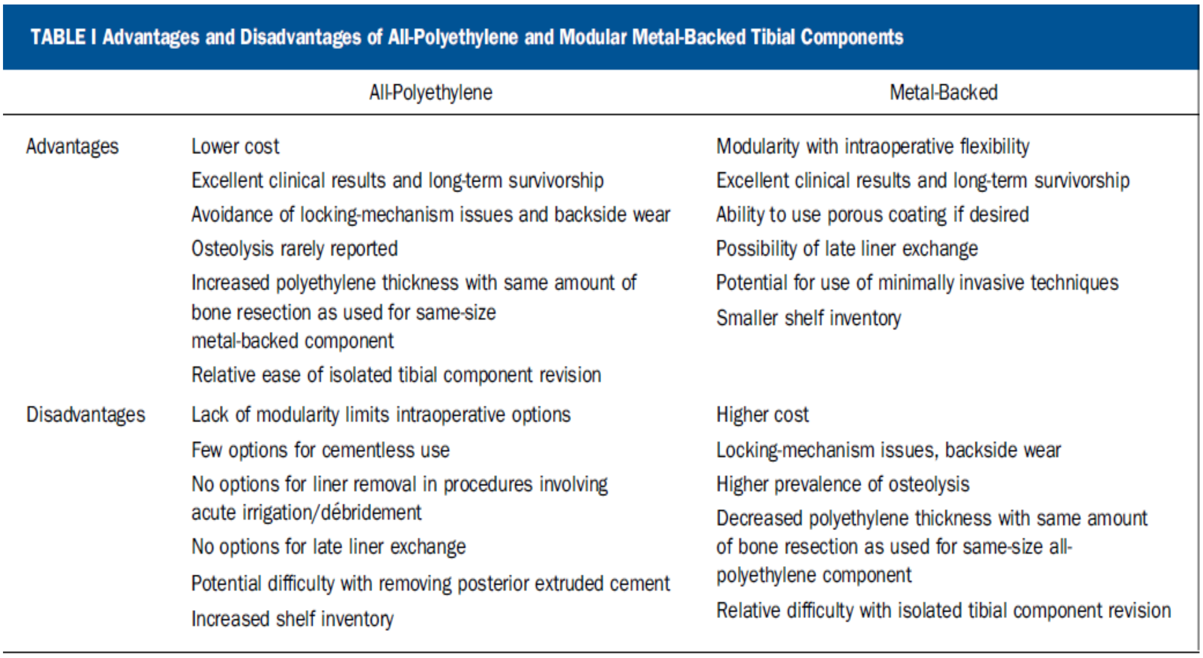

TABLE I Advantages and Disadvantages of All-Polyethylene and Modular Metal-Backed Tibial Components

	All-Polyethylene	Metal-Backed
Advantages	Lower cost	Modularity with intraoperative flexibility
	Excellent clinical results and long-term survivorship	Excellent clinical results and long-term survivorship
	Avoidance of locking-mechanism issues and backside wear	Ability to use porous coating if desired
	Osteolysis rarely reported	Possibility of late liner exchange
	Increased polyethylene thickness with same amount of bone resection as used for same-size metal-backed component	Potential for use of minimally invasive techniques
	Relative ease of isolated tibial component revision	Smaller shelf inventory
Disadvantages	Lack of modularity limits intraoperative options	Higher cost
	Few options for cementless use	Locking-mechanism issues, backside wear
	No options for liner removal in procedures involving acute irrigation/débridement	Higher prevalence of osteolysis
	No options for late liner exchange	Decreased polyethylene thickness with same amount of bone resection as used for same-size all-polyethylene component
	Potential difficulty with removing posterior extruded cement	Relative difficulty with isolated tibial component revision
	Increased shelf inventory	

Fig. 2-C

Cystic lesions representing osteolysis are seen surrounding the tibial component (Fig. 2-A) and femoral component (Fig. 2-B) of a modular total knee replacement in conjunction with articular surface wear of the polyethylene insert (Fig. 2-C).

tibial inserts, moderate-to-severe backside wear was frequently observed in all of the twelve different designs studied, independent of the capture mechanism23. The average volumetric wear rate was 138 ± 95 mm3/yr22. Similarly, in a report on four different tibial baseplate locking mechanisms, Li et al.53 found clear backside wear in twenty-four (44%) of fifty-five inserts, and the manufacturer’s stamped markings had been removed completely from eight of the twenty-four (Fig. 3). How mobile-bearing designs and improvement in fixed-bearing locking mechanisms, sterilization methods, and the polyethylene itself might affect this area of active research remains to be demonstrated.

The results of studies of monoblock metal-backed tibial components might reasonably be expected to elucidate the issue of modularity in total knee arthroplasty. Although there is a lack of Level-I and Level-II studies comparing metal-backed monoblock and modular designs, numerous retrospective cohort studies55-58 have shown monoblock metal-backed tibial designs to have either better or equal survivorship, and be associated with less osteolysis, than modular metal-backed tibial designs. However, the cost differential between monoblock metal-backed and all-polyethylene tibial components still favors the all-polyethylene design, and monoblock metalbacked tibial components are not featured in most manufacturers’ product lines.

Modularity does have benefits in some revisions performed to address instability, in which an insert with additional constraint may be employed59-61. It may also have a role in revisions due to early acute hematogenous infection62, as some surgeons suggest that liner exchange allows more complete synovectomy and access to the implant interface—an interface that does not exist with monoblock all-polyethylene tibial components. However, recent research has demonstrated a limited role for open d´ebridement and polyethylene exchange in the setting of presumed acute infection, in which multiple other variables contribute to success or failure63-65. In a meta-analysis by Silva et al.65, d´ebridement and insert exchange successfully controlled the infection in less than onethird (173; 32.6%) of 530 cases.

Fig. 3

A retrieved modular insert shows burnishing associated with backside wear and a broken peripheral capture mechanism. The arrows denote where the polyethylene of the capture mechanism has separated from the insert.

Biomechanics of Metal Backing

The longevity of the polyethylene articulating with the femoral component has been shown to be affected by numerous factors, including the duration of implantation and the thickness, conformity, and specific formulation of the polyethylene used66,67. Metal backing reduces the thickness of the polyethylene insert that is used compared with an identically sized allpolyethylene tibial component, forcing the surgeon to choose between additional bone resection and decreased polyethylene thickness when selecting the metal-backed tibial component.

As long as the actual insert thickness is at least 8 mm, metal backing should have little influence on surface wear66,68. Theoretically, an all-polyethylene tibial component of 8 to 10 mm in thickness would be more durable than a metal-backed tibial component of identical thickness, accounting for the thickness of the baseplate. In their ten-year follow-up study of a widely used metal-backed total knee arthroplasty design, Schai et al.69 noted that the 8-mm insert that was commonly used had an actual polyethylene thickness of 5.5 mm and that no liner of >10 mm in thickness was revised for wear.

Although, on the basis of the aforementioned biomechanical studies[31,66,70], metal-backed tibial components are perceived to have the advantage of improved load distribution to the proximal part of the tibia, the interface between the tibial component and the osseous tibia may be adversely affected by the metal backing. The increased stiffness of the metal baseplate increases the tensile forces on the plateau opposite the side subjected to compressive loading (the so-called teetertotter or see-saw effect)[31]. Therefore, as long as a central stem is used, an all-polyethylene tibial component may be less prone to this effect than a similarly designed metal-backed tibial component, or at least this may be the case for components of up to 13 mm in thickness. Thicker all-polyethylene tibial components can be as stiff as similarly sized metal-backed tibial components[8].

One method for evaluating the findings of various in vitro biomechanical or finite-element-analysis studies over relatively brief time frames in vivo is radiostereometric analysis[71,72]. Radiostereometric analysis has extremely high resolution and has been shown to predict the risk of future aseptic loosening on the basis of initial implant migration. Randomized clinical studies employing radiostereometric analysis have not shown metal-backed tibial components to have improved fixation or decreased subsidence compared with all-polyethylene tibial components, irrespective of bone quality[12,29,73-78]. In a prospective randomized trial involving radiostereometric analysis of the coronally flat Freeman-Samuelson total knee arthroplasty design (Sulzer Orthopaedics, Zug, Switzerland), Adalberth et al.[74] found no difference ($p > 0.05$) in migration between twenty all-polyethylene tibial components and eighteen metal-backed tibial counterparts. The all-polyethylene tibial implants showed no migration between one and two years after the operation, a finding known to be of positive prognostic importance with regard to predicting future aseptic loosening[72]. In a similar study of the AGC (anatomic graduated component) total knee arthroplasty design (Biomet, Warsaw, Indiana), the same group of authors[75] reported the migration of all-polyethylene tibial components to be on a par with, or sometimes less than, that of metalbacked tibial components ($n = 17$). Rotational motions of the all-polyethylene tibial components were as low as, and maximum lift-off was significantly lower than ($p = 0.017$), those of the metal-backed tibial components.

Cementless Fixation

Cementless total knee arthroplasty technology was an outgrowth of the emerging use of cementless fixation in total hip arthroplasty and the ability to apply porous substrates to newly modular metal-backed designs. Metal-backed modular tibial components allow cementless fixation with a porous coating whereas all-polyethylene tibial designs typically do not. Advocates of cementless fixation of total knee arthroplasty components would therefore have little interest in allpolyethylene tibial designs. However, most studies directly comparing cemented and cementless designs have generally favored the former since cemented implants had equal survivorship and cost less79-81. Similarly, the results of studies based on the Swedish Knee Arthroplasty Register, the Mayo Clinic registry, and the HealthEast Joint Registry have also favored cemented over cementless fixation in total knee arthroplasty82-85. Unless a surgeon is committed to a cementless total knee arthroplasty design for reasons other than survival of the implant (e.g., avoidance of the use of cement in minimally invasive approaches), a cemented all-polyethylene tibial component can be used in an uncomplicated primary total knee arthroplasty with favorable long-term survival.

Implant Cost

Surgeons are increasingly called on to help manage the rising costs of health care86,87, and the American Academy of Orthopaedic Surgeons has issued a position statement that endorses that role88,89. The cost saving that could be realized with the use of an all-polyethylene tibial component in selected patients is substantial (20% to 50% compared with the cost of its metalbacked tibial counterpart)28,29,40,48,49,90-92. In a randomized study by one of us (T.J.G.) and colleagues48,49, the all-polyethylene tibial component cost, on the average, US$675 less than a metal-backed tibial component of the same design. In a community registry study28, one of us (T.J.G.) and colleagues reported an average negotiated cost of $3035 for metal-backed tibial implants and $2078 for all-polyethylene tibial implants. Savings of approximately $95,000 for every 100 patients receiving an all-polyethylene tibial component were realized. If all patients seventy-five years of age or older had received an all-polyethylene tibial component, the inflation-adjusted savings on implant costs alone would have been $1.17 million over fourteen years. If all patients older than seventy years of age

(43% of the patients treated with a total knee arthroplasty in this registry database in 2005) had received an all-polyethylene tibial component, the savings would have been $2.15 million. Pomeroy et al.92 showed a 20% to 30% (more than $75,000) decrease in implant costs when all-polyethylene tibial components rather than metal-backed tibial components of the same design were selectively used for patients over seventy years of age. Healy et al.90 noted that, with the implementation of a clinical pathway and knee-implant standardization program, the use of all-polyethylene tibial implants increased from 0% in 1992 to 14% in 1995, which was one of the factors that reduced the average implant cost by 24.7% in 1995. Similarly, Muller et al.29 estimated that, of 42,791 primary total knee arthroplasty procedures recorded in the Annual National Joint Registry Report39 in England and Wales in 2004 (60% of the total performed in that year), only 248 were done with an all-polyethylene tibial component. If 50% of the approximately 70,000 primary total knee arthroplasties undertaken each year had been done with an all-polyethylene tibial implant, a net savings of £21 million (approximately 39 million in 2004 U.S. dollars) per annum would have resulted. (The cost was £1139 for the metal-backed tibial component and £541 for the all-polyethylene tibial component.)

Although some have noted that stocking both allpolyethylene and metal-backed tibial components increases inventory costs93, this cost appears to be minor in comparison with the potential savings. The results of cost-effectiveness analysis would of course depend on the relative rates of revision of modern metal-backed tibial and all-polyethylene tibial designs as noted in direct comparative studies. Since such studies are infrequent and extant studies have generally shown the survival of all-polyethylene tibial components to be equal or superior to that of metal-backed tibial components, and the cost to be less, further analysis may not be warranted.

Between 2000 and 2004, of the top ten surgical procedures in the United States, total knee arthroplasty had the most rapid increase in inpatient hospital cost for all payers94. With the volume of total knee arthroplasty increasing and healthcare reform a looming issue in the United States, there have been numerous proposals for bundling the episode of care of total knee surgery94,95 that may make the all-polyethylene tibial component an even more cost-effective option.

Clinical Studies Comparing All-Polyethylene and Metal-Backed Tibial Designs

There is a paucity of evidence-based research directly comparing the clinical performances of all-polyethylene and metal-backed tibial components. In a prospective, randomized, controlled trial consisting of 316 total knee arthroplasties in 290 patients, one of us (T.J.G.) and Bowman[48] found no difference in clinical or radiographic outcomes between the two groups at a mean of forty-nine months postoperatively. At eight to twelve years (mean, 115 months) postoperatively, with one patient lost to follow-up, 167 total knee replacements (ninety-seven with an all-polyethylene tibial component and seventy with a metal-backed tibial component) remained[49]. There were no differences in knee function[96], range of motion, stability, or radiographic parameters between the groups. The ten-year rates of survival of the all-polyethylene tibial components were 91.6% with revision for any reason as the end point and 100% with aseptic loosening as the end point. The rates of survival of the metal-backed tibial components were 88.9% and 94.3%, respectively ($p = 0.04$). Similarly, in a randomized trial of forty-one patients, Muller et al.[29] found no difference in the findings on radiostereometric analysis, Oxford knee scores[97], Short Form-12 scores[98], alignment, or range of motion at twenty-four months postoperatively, although the study was underpowered to identify a difference in these parameters.

In a prospective, randomized, controlled study of 312 total knee arthroplasties in 273 patients, 136 fixed-bearing allpolyethylene tibial components were compared with 176 mobilebearing rotating-platform metal-backed tibial components of the same design[99]. After a minimum of two years (mean, fortytwo months) of follow-up, no significant difference (p ‡ 0.05) was noted between the groups with regard to the Knee Society pain or clinical scores[96], WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) scores[100], selected Short Form-36 scores[101], range of motion, or revision rates.

In a prospective study of data on 443 total knee arthroplasties in 378 patients recorded in a community-based registry, one of us (T.J.G.) and colleagues[28] found the rate of survival of all-polyethylene tibial components at 14.3 years to be 99.4% with revision for any reason as the end point and 99.7% with revision due to aseptic loosening or wear as the end point. The cumulative revision rate of 1% for the allpolyethylene tibial components was better (p = 0.02) than the 4.9% rate in a comparative cohort of 4977 metal-backed tibial components in 4109 patients during the same time frame. However, once the hazard ratio was adjusted for the variables that met the confounder criteria (age and cruciate-retaining versus cruciate-substituting design), there was no difference in the risk of revision between the all-polyethylene and metalbacked tibial implants.

In a retrospective review of eighty-one all-polyethylene tibial components (total condylar or cruciate condylar design) in fifty-nine patients (mean age, seventy-nine years) followed for a mean of 8.1 years, Pagnano et al.93 noted the survival rate at fourteen years to be 100% with symptomatic loosening as the end point and 98% with a revision for any reason as the end point. A number of corroborative studies have been published in recent years. Most have been retrospective and chronologically biased toward the metal-backed tibial components, which typically were implanted later in the surgeon’s experience with the same total knee arthroplasty, or the authors used either matched-pair analysis or nonrandomized cohorts in their comparison of various all-polyethylene and metal-backed tibial designs. None of these studies showed superiority of the metal-backed tibial design, and the authors have universally encouraged greater use of all-polyethylene tibial components (see Appendix)8,14,26,91,92,102-105.

Most of the above studies comprise relatively elderly populations (sixty years of age or older), and all-polyethylene tibial components have not been evaluated extensively in younger patients. However, in a review of the results of fiftyfour total knee arthroplasties performed in thirty-eight patients who were less than sixty years of age, Ranawat et al.106 reported excellent clinical performance and survivorship at a mean of five years postoperatively. There was no radiographic evidence of component loosening, progressive radiolucent lines, or osteolysis.

Role of All-Polyethylene Tibial Design and Surgical Technique

It would appear that the ideal design for all-polyethylene tibial components would have round-on-round conforming or moderately conforming articulation surfaces. In a finiteelement-analysis study, Bartel et al.31 found that compressive stresses on the cancellous bone were increased substantially when the load was applied to a single plateau; however, when loading was distributed more equally on both plateaus, the stresses in the cancellous bone under the all-polyethylene tibial component was nearly equal to those in the cancellous bone under the metal-backed tibial component. The stresses were greatest when there was extreme edge-loading, which was typically seen when there was varus-valgus tilt of implants with a flat-on-flat geometry in the coronal plane. In a study of 536 flat-on-flat nonconforming coronal design all-polyethylene tibial components in 405 patients, Faris et al.11 reported a failure rate of 68% at ten years. Fifty-eight (73%) of seventynine failures occurred in association with loosening or collapse of the bone beneath the medial tibial plateau. Ritter13 had earlier reported a one-year revision rate of 3% and a 15% rate of radiographic evidence of collapse of the medial tibial plateau in the same study population. In addition to the flat coronal geometry, the I-beam stem and undersurface of this particular design do not offer the same mechanical means of fixing the device in the cement as do the undercuts in other designs. This design flaw has been acknowledged11,13, and all-polyethylene tibial designs that provide better coronal conformity28,48,49 theoretically should not have the same failure mode. In contrast, metal-backed components of the same design have had excellent long-term survival, consistent with the findings of finite element analysis55. A recent in vitro wear-simulator study107 also suggested that the newer gamma-irradiated-ina-vacuum, moderately cross-linked polyethylene inserts combined with a smooth cobalt-chromium baseplate may show low wear rates even with a low-conformity, flat design. However, the authors of the study did not test an all-polyethylene tibial design, and moderate congruity still appears prudent in all-polyethylene tibial designs.

Although round-on-round designs help to minimize liftoff and edge-loading, the surgical technique is primarily responsible for reduction of lift-off since this can occur with any design and is a function of overall limb alignment108,109. The surgical instrumentation system that the surgeon favors for implantation of a metal-backed tibial design is typically employed to implant an all-polyethylene tibial design from the same manufacturer. Tibial drills or punches may vary slightly between the designs. The trials of the components are identical, but since the all-polyethylene tibial component is nonmodular the surgeon must be satisfied with the findings of the intraoperative examination of stability prior to cementation. We recommend that surgeons using a posterior-stabilized all-polyethylene tibial system cement the femoral component initially during the one-stage cementing process, since the post of an all-polyethylene tibial component of a posteriorstabilized design may interfere with easy seating of the femoral component. In our experience, exposure has not been a problem despite skin incisions averaging £12 cm and use of a variety of so-called less invasive approaches to the extensor mechanism. Any posterior cement is cleared prior to reduction of the femur on the all-polyethylene tibial implant. We have limited experience with cruciate-retaining all-polyethylene tibial designs but in those settings the tibial component should be cemented first during the one-stage cementing process. Computer navigation techniques may ultimately prove to be of assistance in eliminating failures of all-polyethylene tibial components secondary to poor alignment or instability related to surgical technique.

Overview

In conclusion, all-polyethylene and metal-backed tibial components have both advantages and disadvantages. The advantages of the metal-backed tibial component proposed on the basis of in vitro biomechanical studies have not necessarily translated into improved results in either early radiostereometric analyses or long-term clinical studies. Numerous studies support the concept that a stemmed cemented all- polyethylene tibial design with a minimal thickness of 8 mm favoring articular congruency and available in multiple sizes remains practical for primary knee arthroplasty in the majority of patients. The metal-backed tibial component offers greater intraoperative flexibility in that a final trial may be performed after the components are cemented in place. The metalbacked tibial component also offers options of stems and augments, which cannot be added to the all-polyethylene tibial component, but these options are not used for the majority of total knee arthroplasties and the need for them is typically identified during preoperative planning. Nothing in the most current total knee arthroplasty designs precludes the surgeon from changing the intraoperative plan and using a metal-backed tibial component if conditions dictate. The appeal of liner exchange in certain situations is obvious; however, if the entire tibial component must be removed, an all-polyethylene implant can be removed more easily and with less chance of damaging a retained femoral component. The contribution of backside wear to overall volumetric wear and subsequent osteolysis is essentially nonexistent with use of all-polyethylene tibial designs. Finally, the issue of cost clearly favors the all-polyethylene tibial component, and evolving health-care reform models may increasingly force the surgeon to participate in the cost debate. In light of the current basic-science, clinical, and economic evidence, equal consideration should be given to the use of all-polyethylene and metalbacked tibial implants in primary total knee arthroplasty.

Appendix

A table presenting clinical studies comparing allpolyethylene and metal-backed tibial total knee arthroplasty components is available with the electronic version of this article on our web site at jbjs.org (go to the article citation and click on ‘‘Supporting Data’’).

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