Knee replacement survival rates with all-polyethylene or metal-backed tibial components – what do the Registries say?

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Abstract

Background: With increasing numbers of primary total knee arthroplasty and ongoing economic pressure the use of all-polyethylene tibial components maybe an alternative option to achieve cost savings without an adverse impact on outcomes

Methods: A search of all publically available joint replacement registry data investigated the performance of all-polyethylene tibial components compared to metal backed modular tibial components.

Results: All-polyethylene tibial components were used in 0.47% of Australian and 1.2% of England and Wales national register reported knees. 2.6% of Norwegian fixed platform knees were all-polyethylene. Large institutional registers from the United States of America reported usage rates of 4%, 8.3% and 8.9%. Revision rates for all-polyethylene implants were comparable or better than modular components in all registries. Only one registry had sufficient data on patients aged less than 65 years who report a hazard ratio of 0.26.

Conclusion: In patients 65 years and older all polyethylene tibial components have similar rates of revision compared to metal backed. There is insufficient data in younger patients.

Introduction

Early total knee arthroplasty systems almost exclusively utilized all-polyethylene tibial components. When the tibial component was identified as a substantial source of implant failure [1-3], significant attention was directed towards improving these early systems. In-vitro biomechanical analyses that followed [4-6], demonstrated metal-backed components to have reduced stresses on the underlying cancellous bone and better distribution of symmetric loading forces when compared to the all-polyethylene designs. This lead to metal-backed tibial components to be more widely used, despite some metal-backed variants yielding highly unfavorable results [7]. Subsequently, further developments of metal-backed designs incorporated modularity, which al-

lowed for intra-operative flexibility as well as the ability to apply a porous coating, and contributed further to the decline in the all-polyethylene tibial component use [7-9].

Concerns about implant deformity and subsidence raised by the biomechanical models, have not been echoed by long-term follow-up studies [10-14]. Failure rates of all-polyethylene tibial components are reported at rates of less than 10%, with even lower failure rates for patients aged 70 or older. A recent prospective study of 443 total knee arthroplasties reported survivorship of all-polyethylene tibial components of 99.4% at 14.3 years follow-up [15].

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Economic pressures have stimulated a revisit of all-polyethylene designs. With increasing volumes of total knee arthroplasties [7,16-19], cost savings can be substantial. Some studies report considerable cost reduction of 24-48% when all-polyethylene instead of metal-backed tibial implants are used [7,8,15,17].

We examined currently available registry data in joint replacement registries from Australia, New Zealand, The United Kingdom, Norway, Sweden, and regional registries from the United States of America. We revisited the original design premise that metal-backed tibial components were superior to all polyethylene tibial components and performed a review of the current literature.

Registry Data

Currently, only two national joint registries specifically report on all-polyethylene tibial prostheses: the National Joint Registry (NJR) for England and Wales and the Australian Orthopaedic Association National

Joint Replacement Registry (AOANJRR). Most other registries do not provide publically available data on all-polyethylene tibial components or their survival [20-22]. The Register of Orthopaedic Prosthetic Implants [23] only reports on all-polyethylene implants in unicompartamental knees. The Swedish Knee Arthroplasty Register [24] remarks that all-polyethylene tibial components had been used, but fails to elaborate on their prevalence or outcomes. Minimal data is available from the Norwegian Arthroplasty Register [25]. The registry recorded an all-polyethylene tibial component in 65 out of 2494 (2.6%) fixed platform knees in 2009. All-polyethylene prostheses use in the previous years has been almost non-existent, with merely eleven all-polyethylene implants recorded since 1994. No outcome measures are provided.

The AOANJRR began data collection on September 1st in 1999 and data collection was implemented in a staged fashion, capturing all joint replacements on a national level in 2002. All Australian hospitals undertaking joint replacement surgery contribute data to the registry. As of December 2012, the registry recorded 342457 primary total knee replacements. 240983 were modular fixed bearing and in 1225 knees an all-polyethylene component was used, representing an overall uptake of merely 0.47%. Cumulative percent revision rates were similar for the

first two years between metal backed and all-polyethylene components (HR 0.90; $p=0.654$) but after this time, all-polyethylene components had a higher rate of revision (HR 1.75; $p<0.001$). Rates of revision vary, depending on which implants had been used. The Stryker Scorpio Series 7000 and the Optitack-PS performed worse than all other prostheses in this group and, when excluded, there was no observable difference (all-polyethylene excluding Optitack and Scorpio 3.1 [1.7, 5.6] compared to modular 5.2 [5.1, 5.4]). Furthermore, due to the low number of all-polyethylene tibial prostheses used, direct and meaningful comparison with modular fixed bearing knees becomes difficult.

The National Joint Registry of England and Wales was established in 2003 and data is contributed by NHS and privately funded operations. As of March 2013, 490939 cemented primary total knees were recorded [26]. All-polyethylene tibial implants were used in 6124 knees (1.2%). Uptake of all-polyethylene components has steadily increased from 0.3% in 2003 to 2.1% of yearly procedures. Kaplan Meier estimates of failure rates at 9 years are promising (2.64%; 1.96-3.55, 95% CI) and are, in fact, lower than those of unconstrained, fixed cemented total knee replacements (2.90%; 2.77-3.04, 95% CI).

Data from community registries is available via prospective studies. Rand and colleagues [27] examined 11606 primary joint replacements registered at the Mayo clinic between January 1978 and December 2000. All-polyethylene designs had been used in 464 knees (4%) with 97% (94-99, 95% CI) projected survivorship at 10 years; comparing favorably to metal-backed implants (90%; 89-91, 95% CI).

Another community registry showed similar results. Gioe and colleagues [15] examined 5420 primary total knee replacements. 443 knees (8.9%) received an all-polyethylene tibial implant. The authors reported a Kaplan-Meier survival at 14.3 years of 99.4% for revisions for any reason and of 99.7% for revisions where aseptic loosening or wear was used as the end-point.

In a recent prospective analysis [28] of the Kaiser Permanente Total Joint Replacement Registry 27657 primary total knee replacements were examined. All-polyethylene tibial component uptake was 8.3% (2306). The authors found lower revision rates for the all-polyethylene components (0.30 vs. 0.65 for modular implants per 100 observed year). They also demonstrated that, in age adjusted models, patients younger than 65 years had a decreased risk of

revision for any cause if all-polyethylene rather than modular components had been implanted (HR 0.26; 95% CI 0.35-0.99; $p=0.045$).

Discussion

Currently available registry data appears to be consistent with previously published data for elderly patients [12-15,29]. Pagnano and colleagues [12] followed 81 knees in 59 patients 75 years or older for 8.1 years. Only one patient required revision surgery for medial instability. Extrapolated survivorship at 14 years was 98% for any cause and 100% for symptomatic aseptic loosening. Similarly, an earlier study of 98 primary total knee replacements with an average patient age of 82 years [29] demonstrated that 97% of all-polyethylene tibial components did not require revision surgery at 12 years.

Two recent systematic reviews [30,31] showed similar results. All-polyethylene tibial components were shown to perform on par to their metal backed counterparts. In fact, Voigt and colleagues [31] demonstrated that this was independent of implant manufacturer and that the all-polyethylene tibial implants had a smaller probability of failing due to instability than the metal backed designs.

Data for younger patient cohorts has been limited. One small study examined all-polyethylene tibial components in 38 patients who were younger than 60 years of age [32,33]. After a mean follow-up of 12.4 years (range 12-18), the authors reported a survivorship of 95.5% as well as excellent performance in activities of daily living.

The study from Moham and colleagues [28] shows promising results for younger patients. However, a high prevalence of metal-backed implants and an overall poor uptake of the all-polyethylene alternatives render the survival data of tibial designs in this younger age group inconclusive. This appears to be reflected in the cumulative percent revision rates of the AONJRR. More than half of the all-polyethylene tibial implants in the AOANJRR were Stryker Scorpio Series 7000 or Optitrack-PS. These implants performed slightly worse than the other implant types and its predominance in the relatively small number of revisions skews the overall outcomes. It would be interesting to see if exclusion of these two implants from the AOANJRR data as well as a separate analysis for younger patients would yield different results.

Previously, several authors have ascribed the good outcomes of all-polyethylene designs to the inherent-

ly low activity levels in older patients [12,29]. However, the advantages that all-polyethylene implants offer, namely avoidance of mechanical interlocking and backside wear issues as well as higher resistance to wear due to thicker polyethylene, do not support that argument. Whether our results are due to different loading stresses on the tibial component in more active patients or are related to inherent differences in these two patient cohorts and their environmental exposures is unclear. Discrepancies in expectations of implant performance and surgical outcome might also result in a higher rate of revisions related to pain between these two age groups.

When revising a total knee arthroplasty for wear, the advantages of an isolated bearing exchange is appealing. The potential advantage of benign revision options with implant retention and polyethylene liner exchange has not performed as expected; there is a high rate of failure with isolated polyethylene exchange which has been attributed to deterioration of the polyethylene locking mechanism [34,35]. Modular metal-backed tibial implants may have a different mode of failure compared to non-modular implants. Backside wear is a unique consequence of tibial modularity [36] and may present with silent osteolysis that can be associated with dramatic bone

Figure 1. Modular metal-backed knee arthroplasty associated with asymptotic osteolysis at seven years. The knee was revised with implant exchange and extensive bone defect grafting.

deficiency (Figure 1). Further, the addition of metal-backed implants obscures imaging leading to poor detection and definition of osteolytic defects compared to a non-metal implant [37]. Conversely, revision for wear of an all-polyethylene implant is usually a simple procedure as the polyethylene implant is readily removed with a power saw without additional bone loss and the original cement mantle can occasionally be preserved (Figure 2).

Figure 2. Non-modular all-polyethylene knee arthroplasty in a 24 year old male with post traumatic arthritis. Revised for symptomatic wear-related instability and effusion at 30 years with a primary implant.

Radiostereophotogrammetric analysis (RSA) has been shown to be highly sensitive in predicting mechanical failure of the tibial component based on progressive implant migration at one to two years after operation [8,38,39]. Randomized RSA studies have not demonstrated metal-backed tibial components to be superior to their all-polyethylene counterparts [8,40-44]. In a randomized trial, Hyldahl and colleagues [42] prospectively examined 40 cemented low-conforming total knee arthroplasties (AGC, Biomet) using RSA. The authors found no difference

in migration between twenty all-polyethylene tibial components and twenty identical, but metal-backed components at two years after surgery. The same authors [43] also examined 40 patients where tibial components (AGC, Biomet) were horizontally cemented, leaving the stem uncemented. Their results at two years follow-up showed that the metal backed components had sustained significantly more longitudinal rotation and had significantly higher maximal total point motions than the all-polyethylene implants.

There is a significant price differential between all-polyethylene and metal-backed tibial components. This is often justified by more intra- and post-operative advantages of the metal-backed designs: possibility for cementless fixation, polyethylene liner selection after tray insertion, liner exchange without removing the tibial component and excellent clinical outcomes [7,45-47]. Nevertheless, previous research has failed to show any significant superiority of the metal-backed systems [48-51]. For example, Bettinson and colleagues examined 293 patients in their prospective randomised controlled trial and concluded that, at ten years, there was no significant difference in survivorship between the all-polyethylene and metal-backed designs. With increasing volumes of total knee arthroplasties and a changing health-care environment, justification of an increased expense of metal-backed tibial components, in particular for an elderly patient cohort, becomes increasingly difficult.

In areas where all-polyethylene tibial components are actively promoted [15,28], their use is relatively high. Data from the UK and Norway shows increasing all-polyethylene prostheses uptake [25,26] and this could be related to increased awareness or costing pressures. In contrast, all-polyethylene tibial implant use in other regions is either stagnant [16,52] or so low that registries do not report on it. It is uncertain why this is the case.

Despite registry data being in line with previous research, fundamental limitations exist and these predominately reflect the nature of data collection. As the registry focuses on surgical outcomes of primary knee replacements, clinical and radiological outcomes are not recorded. Similarly, registry data can be adjusted for patient demographics, but not for the indication for implant selection by the operating surgeon for either the primary or subsequent revision, possibly resulting in a degree of selection bias between the two implant types.

Conclusion

Current registry data, together with previously published research, suggests that in patients 65 years and older all polyethylene tibial components have similar rates of revision as metal backed designs. This highlights the necessity to rethink indications for all-polyethylene tibial components in this patient cohort. Recent data for younger patients is promising, however, due to the high prevalence of metal backed options and an overall poor uptake of all-polyethylene implants, data for the use of all-polyethylene components in this cohort is inadequate.

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