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The Survival of Total Knee Arthroplasty: Current Data from Registries on Tribology

Review Article

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Abstract *Background:* Polyethylene (PE) wear is a major contributor to implant loosening following total knee arthroplasty (TKA), and advanced bearings in TKA are being investigated with hopes of reducing or eliminate wear-related loosening. Currently, information on knee tribology is available from national joint registries and may be the best tools to evaluate the efficacy and safety of design innovations in joint arthroplasty. *Questions/Purposes:* We performed a review of national joint registries trying to answer the following questions: "Which is the main factor directly related to revisions rate in TKA?" and "Are there new bearing options better than conventional ones?" *Methods:* A review was performed of all published annual reports of National Joint Registers, as well as of the literature. The search was carried out using and comparing the National Joint Registers. *Results:* Current data from registries for total knee arthroplasty indicates that age is the major factor affecting the outcome of primary total knee replacement. The 10-year cumulative revision rate for non-cross-linked PE was 5.8% and for XLPE it was 3.5%. The effect of cross-linked polyethylene was more evident in the younger patients. The survival of the oxidized zirconium (OxZr) femoral component appears better when compared to a similar age group of patients with conventional group of prostheses. Our review suggests that the revision rates are half for the OxZr components compared to conventional CoCr femoral components. *Conclusions:* Age is the most relevant single factor related to revision rate. Cross-linked PE has a statistical lower revision rate at 10 years compared to conventional PE and, in the OxZr group, the revision rate is 2 times lower than Co-Cr in the same group of age.

Keywords polyethylene · oxinium™ · total knee arthroplasty

Introduction

Polyethylene (PE) wear and osteolysis still remain a great concern with the use of total knee arthroplasty (TKA). The prevalence and severity of which are related to multiple factors including patient age and activity level, surgical factors and implant factors like geometry, level of constraint, and bearing options.

With respect to bearing options, fewer are available for TKA compared to the hip including conventional and cross-linked polyethylene (XLPE) for the tibial component and cobalt–chrome (Co–Cr) and oxidized zirconium for femoral component. Both XLPE and oxidized zirconium have only been introduced recently, and it is still a matter of debate whether in the long term they reduce wear [7, 8].

Perhaps the best current sources of scientific data for the study of knee tribology are national joint registries. Registries typically report the outcome of joint arthroplasty from a large population of patients in a given country or region. Revision rate is usually well-documented as well-defined and objective parameter.

We therefore performed a systematic review of national joint registry trying to answer the following questions: "Which

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is the main factor directly related to revisions rate in TKA?" and "Are there new bearing options better than conventional ones?"

Methods

A systematic review was performed of all published annual reports of national joint registers, as well as of the literature. The search was carried out using the summary webpage listing of the EFORT portal, Google, and the links sections of the websites of the National Joint Registers [1, 13, 17, 22, 23]. Register data for analysis were obtained from annual reports or, if available, from journal publications. We compared only the highest value registry reports, type A.1.1.1.1. according to Labek et al. [10].

The following national arthroplasty registries contained relevant information on knee tribology: The Australian Orthopaedic Association Joint Replacement Register (AOANJRR) [1], the New Zealand Joint Register [23], the Swedish Knee Arthroplasty Register [22], and the National Joint Registry for England, Wales, and Northern Ireland [13].

The main outcome measure was considered revision rate per 100 observed component years which was introduced in orthopedics by the Australian Joint Replacement Registry [1] and has had widespread acceptance.

Results

Analyzing all the factors related to revision rate, patient age is the major factor affecting the outcome of primary total knee replacement. The rate of revision increases with decreasing age, and this difference increases with time. According to the AOANJRR [1] after 4 years, those aged less than 55 years have over 4.5 times the rate of revision compared to those aged 75 years or older. At 13 years, cumulative percent revision of primary total knee replacement is 14.9 (95%, CI 13.7, 16.3) in the group under 55 and 3.1 (95%, CI 2.9, 3.4) in patients over 75. This data are similar in all registries studied [13, 22, 23], with the chance of knee joint revision after primary surgery being far higher in patients belonging to the under 55 of age group.

Focusing the search on tribology, we have consistent data comparing conventional PE vs XPLE in the AOANJRR [1]. The 10-year cumulative revision rate for non-cross-linked polyethylene was 5.8% (95%, CI 5.7–6.0) and for cross-linked polyethylene it was 3.5% (95%, CI 3.2–3.8) (>6.5-year HR = 2.2 (1.5–3.1); $p < 0.001$). The main reason for the difference in revision rate was a reduction in the rate of revision for the wear-related problems of loosening and osteolysis. At 10 years, there is a difference in the cumulative incidence for loosening; 0.8% for cross-linked polyethylene compared to 1.7% for non cross-linked polyethylene. The effect of cross-linked polyethylene was more evident in the younger patients. For patients less than 65 years of age, the 10-year cumulative revision rate for non-cross-linked polyethylene was 8.8% (CI 8.5–9.1), and it was 4.9% (CI 4.3–5.5) for cross-linked polyethylene ($p < 0.001$).

There is limited data regarding femoral components composed of oxidized zirconium (OxZr), available as Oxinium™ (Smith & Nephew, Memphis, TN, USA). In the National Joint Registry for England, Wales, and Northern Ireland, the cumulative percentage probability of a first revision with Genesis II™ (Smith & Nephew, Memphis, TN, USA) TKA is a little higher in the Oxinium™ group compared to Co-Cr, with the cumulative percentage probability of first revision (95% CI) of Genesis II™ Oxinium™ being 5.8% (95%, CI 4.4–7.6) [13]. However, the median age of the Oxinium™ knee patients is 58 (54–63) which is 11–13 years younger than all the other groups of patients. If we consider the NJR [13] data on revision, matching for age, we have to notice that the cumulative percent revision of primary total knee replacement in patients with similar median age is about 10%. Suggesting that Oxinium™ may substantially reduce wear and component loosening.

Discussion

Registries have been developed with great success in Scandinavia [22] for more than 30 years, and impressive proof has been established of their usefulness for outcome measurement. Furthermore, during the past 10 years, many other similar registries [1, 13, 23] have been set up in many other countries so that an increasing number of datasets have become available. Arthroplasty registries play a critical role in improving the outcome of joint replacement surgery. They provide unique community-based comparative data that enables individual surgeons to identify best practice that is relevant to their own approach to arthroplasty surgery. Nowadays, in many of them, long-term outcomes and survivorship after total knee arthroplasty are available, and all the main factors related to revision rate have been analyzed [14, 15].

Since new bearing options have only been recently introduced for TKA, they still require long-term validation and surveillance. Currently, data from registries are the best tools for this purpose.

One limitation of registries exclusively is the focus only on revision rate not considering patient satisfaction or findings radiological imaging. Additionally, there are other potential flaws in the registry data such as missing entries, data quality, and data analysis. However, revision rate is a recognized, well-defined, and objective parameter after arthroplasty, and this indicator is well-suited for comparative analyses [18–20].

The first and most significant data we collected from registries is that, while TKA has a low rate of revision, there is incredible variation with age and in all the registries age is the most relevant single factor related to failure. That is not completely surprising, but the numbers are very impressive with the group of patients below the age of 60 years having 4 times the rate of revision at 10 years compared to the patients over 75 years. It is therefore important to examine those design innovations which may reduce this higher rate of revision in younger people.

We well know that extensive research on bearing surfaces is being conducted to seek ideal bearing surfaces for TKA. Despite many attempted alternatives in geometry, materials, and surface modification of the metal, only two main innovations have been adopted including introduction

of highly cross-linked PE tibial components and OxZr as an alternative bearing for femoral component.

Cross-linked polyethylene was developed to reduce bearing surface wear and thus help improve durability. Although several in vitro studies have indicated XLPE has excellent wear resistance, significantly greater than that of conventional PE, there is a paucity of clinical reports at medium or long-term follow-up [5–11].

The 2014 AOANJRR annual report [1] indicates, for the first time since its introduction in TKA that, at 10 years of follow-up, there is significantly higher rates of revision in non-cross-linked polyethylene compared to cross-linked polyethylene for all patients who underwent TKA for osteoarthritis [21].

This study has demonstrated that while there is an overall reduction in the rate of revision for all ages when XLPE is used, this is more evident in the younger age group (<65). The difference in the younger age population may become even significant with longer follow-up.

On the counter surface that articulates with PE, oxidized zirconium has been developed for the femoral component. Preliminary studies in vitro have indicated an excellent wear reduction for this material. OxZr femoral components reduce in vitro PE wear from 55 to 42% when compared to cobalt–chromium femoral components. There are medium- to long-term reports for Oxinium™ [2–4, 6–9, 12, 16], but further studies with longer follow-up are required to confirm this trend and demonstrate the advantages of this materials for TKA.

However, registry data on for OxZr requires a more accurate interpretation. Since the introduction of Oxinium™, it has not been used in all patients. Its use if favored for younger patients, with high activity levels, and older patients were usually considered only if they were sensitive to nickel. This selection bias makes the median age of the Oxinium™ patients significantly lower the median age of all the other knees in the registries and makes comparison between results often very inappropriate, since it has been demonstrated that age is the single most important factor related to revision rate. When the variable of age is controlled for in the analysis, OxZr has potentially half the revision rate of conventional cobalt–chrome femoral components. The combination of XLPE with Oxinium™ has not yet been reported sufficiently [1], limiting our ability to make recommendations regarding this couple.

In conclusion, current data from registries for total knee arthroplasty indicates that age is the most relevant single factor related to revision rate, cross-linked PE has a statistical lower revision rate at 10 years compared to conventional PE and in the Oxinium™ group the revision rate is 2 times lower than Co–Cr in the same group of age.

Compliance with Ethical Standards

Conflict of Interest: Fabrizio Matassi, MD, Christian Carulli, MD, Luigi Sirleo, MD, and Andrea Cozzi Lepri, MD, have declared that they have no conflict of interest. Roberto Civinini, MD, reports personal fees from Smith & Nephew, outside the work. Innocenti, MD, reports personal fees from Smith & Nephew, outside the work.

Human/Animal Rights: This article does not contain any studies with human or animal subjects performed by the any of the authors.

Informed Consent: N/A

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