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Can Technological Advances, and Better Perioperative Care, Shift Total Knee Arthroplasty to a Younger Age Range?

By

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Symptomatic knee osteoarthritis has been diagnosed in over 11.5% people in the US over the age of fifty. This accounts for over 4 million patients. Of those patients diagnosed with symptomatic knee OA, 31.6% of males and 31.3% of females, have an intact primary total knee replacement. According to Winters AR et al, from 1999-2009, the number of primary knee replacements performed annually in the US doubled, with >97% of these performed for the diagnosis of knee OA.¹

Total Knee Arthroplasty (TKA) is considered the end-stage treatment for symptomatic knee OA, with symptom improvement exceeding 85%, with a less than 1% failure rate. With the high success rate and relatively low risk of failure, more patients are opting for TKA at younger ages. Historically, patients would have to wait until they were at least 60 years of age before this was a viable option. Due to the younger age at the time of the procedure, there is speculation that more of these patients will require revision surgery later in life.¹

The first TKA was performed in Germany in 1860 and was made of ivory. The first hinged prosthesis was used in 1951 and was made of acrylic. Since that time, prosthesis implants have been made out of many different metal alloys and use a metal-on-polyethylene articular surface. Cobalt-chromium alloys are the most frequently used alloys today and are a hard, tough, corrosion resistant, and biocompatible metal. Although these alloys have a low percentage of patient allergies, they can release small metal ions into the body and can cause allergic reactions similar to a nickel allergy.¹

Most TKA prostheses today are made of a type of titanium alloy with an additional surfacing alloy that allows for bone in-growth. Titanium alloy allows a small amount of flexibility to decrease the incidence of bone resorption and atrophy. This, combined with other metal alloys such as tantalum, provide a reliable prosthesis that is flexible, corrosion resistant, and biologically compatible. The Polyethylene used in most implants is made of an Ultra High Molecular Weight Polyethylene. This allows
for even more reduction in wear, enabling the knee implant to last much longer than normal polyethylene plastics.\textsuperscript{1}

Some of the advances could increase the life span of knee prosthetic implants to 20-25 years. Typical life span for most knee replacements is speculated to be around 15-20 years. This raises the question, that with the increase in technology, why is total knee arthroplasty not able to be performed in a younger population, 40-55 years of age, on a regular basis? It is frequently assumed that performing a TKA is not medically responsible in a patient younger than 55-60 years old, because of the possibility that they could need a costly revision in the future. Most of the studies, that are represented in this review of the literature, do not include ages of the patients in their studies. The use of severity, compartments involved, and quality of life measurements are what most studies base their findings on. With increase in prosthetic implant age at the time of possible failure, those qualifiers should be included in the synthesis of the studies, but also exclude the need for older ages as a qualifier to perform a TKA.\textsuperscript{2}

\textbf{Literature Review}

The studies reviewed were screened for inclusion and exclusion criteria. The criteria most important to this review were the age of the patients at primary knee replacement, the type of prosthesis used, how long that prosthesis has lasted with little to no complication rates, and how perioperative care could increase the survivability of the TKA prosthesis. The limited amount of large studies produced in this review is part of the limitations that will be addressed.

The studies that were chosen were reviewed using certain criteria: year of study (less than 10 years old), patient selection criteria, size of analysis group, analysis method, alternative treatment options, treatment options compared, relevance to the topic to be discussed, and length of study. Most of the studies included did not mention the age groups of the participants. This was a limitation to this
review and will be addressed in the conclusion. The studies included had a good quality of evidence but were limited in size and scope. They either had few patients or were limited to one Orthopedic practice/group.

Discussion

Long-term outcomes are now achieved in the majority of patients undergoing knee replacements. This can be attributed to the advances in arthroplasty devices and improvements in technical surgical skills and expertise, or better knowledge, of periprocedural complications. There are also several new periprocedural predictors that are used to determine if a patient will be a successful candidate for elective TKA, also improving long-term outcomes.³

Studies estimate there are as many as 4.8% of females and 3.4% of males in the US, who are more than 50 years old, that are currently living with a total knee replacement. This number equates to approximately 4 million adults.¹ This accounts for approximately one-third of the US population with a diagnosis of symptomatic knee osteoarthritis. With the large frequency of total knee replacements in the US, there is a chance for a sizeable increase in the incidence of total knee revision. Also, likely, with the number as high as 15% of TKA having worsening or persistent pain three to four years postoperatively, the healthcare cost associated with TKA could rise as well. These patients require higher levels of healthcare utilization and may have reduced levels of physical activity and be at heightened risk of death due to other comorbid conditions as compared to the general population.

The prevalence of TKA in the US should raise the question of osteoarthritis prevention, such as better control of obesity and limiting the incidence of knee injury.⁴ Reducing the nationwide prevalence of obesity could avert approximately 100,000 total knee replacements over the remaining life span for adults in the US who are fifty to eighty-four years old.¹

BMI effects on Total Knee Arthroplasty
One of the most common diagnoses leading to total knee replacement is symptomatic knee osteoarthritis. One of the most common causes of knee OA in younger populations is obesity. The increasing prevalence of obesity could lead to an increase in symptomatic knee OA, which could then lead to an increase in the need for total knee replacements in the younger patient population. This could pose several issues for Orthopedic surgeons to evaluate before performing knee replacements on younger and obese patients. The incidence of patients with both a history of TKA and obesity was 31% in 1990 and increased to 52% by 2005.

One study compared the use of minimally invasive TKA (MIS-TKA) to 3 groups of obese patients to determine the effect of obesity on the survival of total knee replacement at 3 months, 1 year, and 5 years postoperatively. The groups used for this study were separated into groups using BMI. They classified 371 knees into 3 groups: group A (BMI < 25.0 kg/m²), group B (25.0 kg/m² < BMI < 29.9 kg/m²), and group C (BMI > 30.0 kg/m²). The mean age was 69.0 years old and follow up period mean was 361 weeks.

In this study, they determined that the use of an MIS-TKA procedure did not lead to poor clinical outcomes in obese patients as compared to nonobese patients in the same study. They determined there was no clinical significance between groups at the 3-month, 1 year, and 5 years follow-ups in terms of clinical outcomes and radiological outcomes. They determined that MIS-TKA can be a reliable and safe option in obese patients regardless of the level of BMI. The limitations of this study is that all of the MIS-TKA performed were by one experienced surgeon.

Yet another study determined that it was not necessarily the increased BMI that led to TKA failure, but that it could be the size of the prosthesis used as well as body mass. Their study consisted of 6548 patients, and 6 different surgeons, from 1983-2004. Additionally, they also created a second cohort of 81 TKA patients where they implanted radiostereometric beads to identify slight shifts in the
tibial component of the total knee replacement. They determined that when a smaller tibial component was used, combined with the increased force of patient mass, it was likely to fail sooner. Although they determined that increased body mass and small component size could lead to early prosthetic failure, the overall failure rate was 0.8% at 3.1 years post-TKA.\(^6\)

**Younger population Total Knee Arthroplasty**

The application of total knee replacements to younger populations has historically been discouraged out of concern for needed revisions due to aseptic loosening and prosthetic wear. Arthritic disease in the younger, more active patient, is common and expected to increase. There are surgical options for these patients that are short of a total knee replacement. Interventions can include arthroscopy, osteotomy, and arthrodesis, besides all of the other more conservative treatment options to prolong the disease treatment before more definitive care is required. Arthritic disease, coupled with the increase in obesity at a younger age, can present orthopedics with the difficult decision of ultimately performing definitive care on younger patients.

The accelerated failure rates, and the difficulty of performing subsequent revisions, is the primary concern of knee replacement surgeries performed in patients younger than 55 with knee pain.\(^4\) After prospectively following knee arthroplasty results in patients 55 years and younger in their community joint registry, they hypothesized cemented total knee arthroplasty would demonstrate superior survival over other designs. They also considered whether preoperative diagnosis, age grouping, gender, cruciate ligament status, or index surgery year influenced survival of the knee arthroplasty in this group.\(^4\)

From 1991 to 2005, this study followed 1047 patients age 55 years and younger who underwent a TKA during this period. Out of the 1047 patients, 73 patients had revisions performed. Their definition of revision included removal, exchange, or addition of any prosthetic component. Over the time of the
study, the total yearly percentage of patients younger than 55 that were entered into the registry increased from 4.6% in 1991 to 17.1% in 2005, with 5% being younger than 40 years old. Osteoarthritis was the primary underlying diagnosis in 93.3% of the patients. The registry included 48 surgeons.

The 14-year cumulative survival rate for all knee arthroplasty procedures was 74.5%, with only 73 patients needing revision. It was determined that cemented prosthesis survival rate at 14 years was acceptable in patients 40-55 years old. There was no use of other variables, such as obesity and other comorbidities, in their review of the literature and only used the registry results in their own data pool. They determined that the most common cause for revision in this population was from aseptic loosening (31.5%) followed by wear/osteolysis (19.2%). This study also compared their results to other registries and concluded that, along with the percentage of revisions staying the same, that other studies determined that cementless and uni-compartmental replacements were at a higher risk of failure over the same period of time.

**How to determine if the procedure will succeed**

It has, however, also become evident that prosthesis survival may not be an accurate or true measure of success when patient satisfaction is taken into account and, by this criterion, a small but important group of patients do not improve or even get worse. Following this understanding, the focus has moved away from just implant survival to patient-reported outcomes that concentrate on the patient’s experience and level of satisfaction with the operation. The difficulty lies with identifying the determinants of outcome, as well as using the most appropriate and accurate method for collecting and interpreting the patient-reported outcomes. A successful joint replacement should result in pain relief, function improvement and patient satisfaction.

One study used the Physiological and Operation Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) to predict the risks of complications and mortality 30 days after surgery. The
purpose of this study was to evaluate the POSSUM scoring systems in patients who underwent surgery for a total hip or knee replacement.\textsuperscript{7}

They used a total of 227 patients who either underwent a total hip or total knee replacement. They used the predictive score from the POSSUM assessment before and 30 days postoperative. The patient population had a mean age of $66.4 \pm 12.5$ years, with 57\% females. In this particular study, they had postoperative complications in 49 patients, and the POSSUM predicted 49 cases.\textsuperscript{7} This represented a clinically significant result; however, the size of the study limits its usefulness.

Their conclusion was that the POSSUM accurately predicted morbidities in patients undergoing primary total hip or knee replacement. They believe that a computer-based form of the POSSUM could serve as a useful tool for surgical audits and large-scale benchmarking. They were not able to elicit any compounding factors as related to age. They do outline some limitations in study size and lack of statistical analysis in assessing the mortality of patients. With more patients, and inclusion of emergency and traumatic cases, they might have had more variability in their study.

**Perioperative Care Improvements**

In many cases, the use of Enhanced Recovery Pathways (ERPs) may also improve patient outcomes after a TKA. The Agency for Healthcare Research and Quality, along with the American College of Surgeons and Johns Hopkins Medicine Armstrong Institute, have developed a Safety Program for Improving Surgical Care and Recovery. These ERPs can improve patient recovery, but have not been implemented very well nationally.\textsuperscript{8}

Christopher Childers et al. conducted a review of elective TKA and Total Hip Arthroplasty and how the use of ERPs may have improved patient outcomes. They reviewed 16 components of the perioperative patient care and how they relate to long term recovery and prosthesis survival. Preoperative care concentrated on ten components that were concerned with patient comorbidities and
controlling them, intraoperative components concentrated on wound drains only, and postoperative components included early mobilization, continuous passive motion, extended duration of VTE prophylaxis, early feeding schedule, and effective discharge planning and education.\textsuperscript{8}

The conclusion of this study found that identifying and addressing these 16 components will not only enhance patient recovery outcomes but could also lead to longer lasting prostheses. They offered that many of the interventions outlined in this review should become a part of the patient's comprehensive evaluation prior to surgery. The goal of these interventions is to reduce adverse events and enhance recovery, but also to set appropriate expectations for the patient and family. With better control of the ten components offered in this review, it is likely the patient will heal better and understand the limitations of the new prosthesis, which then could lead to longer prosthesis survival.\textsuperscript{8}

**Conclusion**

After review of the literature available, the answer to the question of why TKA is not performed in younger patients with symptomatic knee osteoarthritis remains wholly unanswered. The studies that are available are merely comparing the data of failure vs success in those that have had knee replacement surgery before the age of 55. They contrast the different technologies and procedures used and relate it to activity level. Most of these studies are based on information that is 20 years old, and several technological advancements have happened since that research was conducted. The finding from these studies indicates that the future of knee replacements is in the advancements of 3D technology and the limited, short term, studies in this area are promising. This advancement in technology, coupled with greater emphasis on BMI reduction and knowledge of perioperative practices, could lead to longer, more reliable prosthesis survivability.


