Outcomes of a Newer-Generation Cementless Total Knee Arthroplasty Design

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Abstract: Newer-generation cementless total knee arthroplasties (TKAs) aim to improve durability, function, and longevity. In a large series of cementless TKAs at a mean 4-year follow-up, the authors evaluated (1) survivorship, (2) range of motion, (3) patient-reported outcomes, and (4) complications. Mean age was 66 years (range, 34-88 years) and mean body mass index was 32.5 kg/m² (range, 20-54 kg/m²). Aseptic and septic implant survivorships were 96.4% and 99.5%, respectively. Mean extension, flexion, and Knee Society scores improved significantly. There were 3 septic failures. Aseptic failures included 3 aseptic loosenings, 1 polyethylene revision, and 1 revision to a cemented patella. This study showed excellent clinical and patient-reported outcomes of cementless TKA. [Orthopedics. 2015; 38(10):620-624.]

Total knee arthroplasty treatment to relieve pain and function (TKA) is the definitive treatment to relieve pain and improve function in patients who have end-stage degenerative disease processes of the knee. Currently, the mean age of patients undergoing TKA is decreasing, and these younger patients constitute a challenge for orthopedic surgeons because they are likely to have higher activity levels and longer life expectancies, with a need for greater implant longevity.1,2 Therefore, although cemented TKA has shown excellent clinical outcomes and implant survivorship, the long-term durability of cemented fixation has come into question in these high-demand patients.1,2 As a fixation strategy, cement has been shown to have poor resistance to shear and tension forces, which may result in deformation and degradation over time. Consequently, orthopedic surgeons are now looking more often to the use of cementless, press-fit knee arthroplasty designs, which provide a biological fixation to host bone, to increase longevity and reduce the likelihood of future revision surgery.3,4

Cementless fixation has been available for the past 3 decades, but because of less than optimal outcomes with older-generation designs, this method has not gained popularity and wide acceptance.2 Poor implant design leading to aseptic loosening and wear has often been implicated in many of the early failures.4,5 However, recent studies have shown better fixation and longevity of newer cementless designs compared with their cemented counterparts and that, as implant materials have evolved, cementless designs are beginning to gain popularity.1,4,6 offering ease of insertion and decreased operating time. The fixation of cementless designs depends on bone biological fixation onto the surface geometry of the implants, and it is postulated that the fixation interface between bone and metal will form a biologic bond that may provide better long-term results.1,7

However, little published data exist regarding the clinical and radiological outcomes of newer designs of cementless TKAs.8 The purpose of this study was to evaluate...
(1) implant survivorship, (2) range of motion, (3) pain and functional outcomes, and (4) the incidence of postoperative complications in a large series of cementless TKAs at short-term follow-up.

**Materials and Methods**

All patients who had undergone a primary cementless posteriorly stabilized TKA at a single high-volume institution between June 2008 and 2014 were prospectively reviewed. At a mean final follow-up of 4 years (minimum, 1 year), 1025 cementless TKAs in 952 patients were available for study. Twenty-one patients were lost to follow-up, but none had significant symptoms or adverse radiographic changes at their last visit. The patient cohort consisted of 661 women and 291 men who had a mean age of 66 years (range, 34-88 years) and a mean body mass index of 32.5 kg/m\(^2\) (range, 20.54 kg/m\(^2\)). There were 817 patients who had osteoarthritis (86%), 42 patients who had osteonecrosis (4.4%), and 93 patients who had rheumatoid arthritis (9.6%). Institutional review board approval was obtained prior to initiation of this study.

Between June 2008 and June 2013, the prostheses used for 805 TKAs was a cementless beaded, peripatite-coated (PA) femoral component and cobalt-chrome tibial baseplate (Triathlon Total Knee System; Stryker Orthopaedics, Mahwah, New Jersey). This porous-coated implant incorporated multiple layers of cobalt-chromium beads, having a porosity of 35%, a 1.5-mm coating thickness, and a mean pore size of 425 μm. The beads were coated with PA, a highly crystalline solution form of hydroxyapatite. This provides a 3-dimensional coating, rather than an onlay surface. The femoral component incorporates an open posterior-stabilized box with medial and lateral pegs that aid in stability.

In June 2013, a titanium non-PA-coated baseplate (Triathlon Tritanium tibial baseplate; Stryker Orthopaedics) became available and was used exclusively for 220 TKAs. It was designed using a 3-dimensional modeling and analytical technology (SOMA; Stryker Orthopaedics) for more accurate anthropometric sizing, using an extensive computed tomography scan-based database on the tibial baseplate pegs to improve fit and optimal fixation. As a result of identifying the best areas for bone fixation, this system uses a delta keel and 4 pegs instead of screws.\(^9\)

Initially, a beaded, PA-coated patella was used. However, in October 2014, a highly porous metal-backed component with 3 pegs (Triathlon Tritanium Patella; Stryker Orthopaedics) became available and was used from that point on (49 TKAs).

All procedures were performed using a minimally invasive midvastus approach, via a midline skin incision if no other incisions were present. The same surgical technique was used for all implants in this series and has been described previously.\(^9\) Intramedullary guides were used for the femur and extramedullary guides were used for the tibia. The distal femur was cut in 5° of valgus with 3° of flexion, and the proximal tibia was cut at 90° to the longitudinal axis with 3° of flexion in the sagittal plane. Gap-balancing techniques were used to equalize the flexion and extension gaps. All components were implanted without the use of bone slurry; cysts and bone defects, if found, were filled with autologous bone from the bone cuts and sclerotic areas were drilled with a 2-mm drill bit. Following reduction, standard checks of range of motion, stability, and patella tracking were performed. Postoperatively, all patients began an accelerated physical therapy program with full weight-bearing and range-of-motion exercise, and all left the hospital with a flexion of 90° or more.\(^9\)

Radiographically, any evidence of gaps between the implant and the bone, radiolucent lines, reactive changes, component loosening, or subsidence was documented at follow-up visits. Based on the preoperative femorotibial angle on standing anteroposterior radiographs, there were 640 varus knees (mean, 7.5°; range, 5°-30°), 265 valgus knees (mean, 12.5°; range, 5°-30°), and 120 neutral, well-aligned knees (less than 5° of deformity). Although fluoroscopic positioning was not used, all radiographs were performed by 1 of 2 experienced technicians so as to provide relatively uniform results.

Patients were evaluated postoperatively at 6 weeks, at 3 months, and yearly. Outcomes evaluated included Knee Society function and pain scores,\(^10\) range of motion, implant survivorship, and incidence of complications. At this short follow-up, no deaths were recorded, and all patients were doing well at their last postoperative visit (range, 1-7 years).

For continuous variables, descriptive statistics were used to analyze means, SDs, and proportions, and all statistical calculations were conducted with GraphPad Prism version 5.01 software (GraphPad Software Inc, La Jolla, California). Postoperative changes in range of motion and scores were analyzed using a paired Student’s t-test. Kaplan-Meier curves were used in the analysis of survival rates of the prostheses, with revision for any reason as the endpoint. Ninety-five percent confidence intervals were calculated for the survivorships, and a P value less than .05 was considered statistically significant.

**Results**

The overall aseptic and septic implant survivorships were 99.6% (95% confidence interval, 99.2%-99.9%) and 99.5% (95% confidence interval, 98.7%-99.8%), respectively (Figure). There were 8 failures; septic failures included 2 patients who had late deep infections that underwent a 2-staged revision procedure and 1 early infection that underwent irrigation and debridement and polyethylene exchange. At latest follow-up, these patients were function-
tips & techniques

Figure: Aseptic survivorship of the cementless total knee arthroplasty implant.

ing well, with no recurrence of infection.

There were 5 aseptic failures. First, a 70-year-old woman had right tibial baseplate subsidence 6 weeks postoperatively resulting in pain and instability. At reoperation 3 months postoperatively, the baseplate was firmly fixed to bone in the subsided position. The baseplate was revised with a cemented baseplate. The patient was doing well at her last follow-up visit (20 months later). Second, a 64-year-old man presented with persistent pain 6 months postoperatively. He was found to have a thin radiolucent line on the medial and lateral aspects of the baseplate, and underwent reoperation and tibial baseplate exchange 1 year after surgery. Despite the radiolucencies present, the implant was well fixed, requiring significant effort to remove. Spot welding was noted beneath the baseplate. It seemed prudent to replace the baseplate because no other cause of pain was evident. One year postoperatively, the patient was well, having no complaints. Third, a 48-year-old man underwent polyethylene revision for arthrofibrosis. Following debridement and gap balancing, the previously placed 9-mm polyethylene was replaced by an 11-mm implant with excellent stability and range of motion. Fourth, a 48-year-old woman returned for a manipulation under anesthesia 6 weeks postoperatively, and her patella dislodged following manipulation. She was revised to a cemented patella. Lastly, a 64-year-old avid male golfer, who played his first round of golf at 6 weeks postoperatively, presented 1 year after bilateral TKAs. He did well on one side, but had pain and instability on the other. Radiographs revealed subsidence and loosening of the tibial baseplate. Intraoperatively, the baseplate was loose, with a fibrous layer between the bone and the implant. Revision was performed using a cemented tibial baseplate. At 5 months following revision, he was doing well, having full function.

The mean improvement in extension at final follow-up was 5.3° (from 6.5° preoperatively to 1.2° postoperatively; \( P < .0001 \)) and the mean improvement in flexion was 17.5° (from 106.4° preoperatively to 123.9° postoperatively; \( P < .0001 \)).

Knee Society scores improved postoperatively at a mean follow-up of 3 years. The pain Knee Society score improved from 56 points to 93 points \( (P < .0001) \) and the function Knee Society score improved from 56 to 85 points \( (P < .0001) \).

There were a total of 21 complications not classified as implant failures. Surgical complications included 4 patients who required manipulation under anesthesia for postoperative stiffness (0.4%) and 2 superficial wound necroses that required debridement (no components were exchanged) (0.2%). There was 1 peroneal nerve palsy that spontaneously resolved at 6 months. In addition, 2 patients sustained linear fractures at the corners of the femoral box cut. However, these were nondisplaced and the patients’ postoperative rehabilitation was unaffected, with their using crutches or a cane for 6 weeks. Medical complications included 6 deep venous thromboses and 6 pulmonary emboli. Mean length of stay was 3.2 days, and the transfusion rates were 8% and 11% for unilateral and bilateral procedures, respectively.

**DISCUSSION**

Cementless implantation was introduced with the goal of reducing the potential failures associated with cemented interfaces and thus improving the longevity of TKAs, especially in younger, high-demand patients. Although these constructs have been implicated in early failures, newer designs and materials have re-introduced cementless fixation as a viable option for patients undergoing knee arthroplasty. The authors’ results showed that at early follow-up, these implants had excellent aseptic survivorship (99.6%) with improvements in outcome scores and range of motion and an associated low complication rate.

However, this study has limitations. The follow-up was short and thus did not permit evaluation of long-term survivorship and outcomes, which is imperative for the growing population of young patients. However, this study provides promising preliminary results for a cohort of patients who underwent surgery with this cementless TKA system. In addition to the excellent outcomes, no unintended consequences occurred. The authors will continue to follow this patient cohort to determine whether these favorable results become long-term successful outcomes. One could question whether a selection bias exists. However, the authors evaluated all patients who underwent cementless TKA during the aforementioned time period. In all but 3 cases, cementless arthroplasty was planned and performed. In 3 cases (1 case of 45° varus and 2 cases of 40° and 45° valgus), adequate equalization of the flexion and extension gaps could not be achieved and a constrained cemented implant was used.
In addition, data were gathered from only one institution, which may not be representative of the wider population of patients. Future studies should incorporate multicenter evaluations. Despite these limitations, the authors believe this study provides clinically relevant preliminary data on the outcomes of these cementless prostheses.

Cementless arthroplasty designs have been advocated because of better fixation ability and potentially long-term results. Chong et al8 performed a biomechanical study to assess the influence of tibial component fixation techniques on bone resorption following TKA. The authors noted that severe bone resorption occurred more rapidly for the cemented fixation than for the cementless fixation (12 vs 36 months) and concluded that cementless fixation with bony biological fixation was preferred for preserving proximal bone stock and maintaining postoperative fixation stability.

In addition, these newer implants are projected to have a better fit. This newer titanium cementless TKA system is the first implant to be created using 3-dimensional printing, and to use a 3-dimensional computerized technology that provides a database of different bone morphologies from diverse populations. This includes demographic, age, and sex-related variations, as well as variables in shape, size, density, and cortical boundaries, which greatly aids in preoperative planning.11 There are few studies that have evaluated the use of this program in cementless TKAs; however, Eckhoff et al12 compared the symmetry of the left and the right lower extremities in 361 subjects using this technology. The authors noted that there were asymmetries in femoral anteversion, transepicondylar axes, and anatomical axes between the left and the right sides in up to 88% of the population. Therefore, the use of these databases may aid in patient-specific prosthesis design and preoperative planning to ensure better fit.

Several studies have shown good clinical outcomes following the use of cementless TKA components, with survivals ranging between 96% and 98% at 14- to 20-year follow-up.13-15 Cossetto and Gouda16 evaluated the outcomes of a similar cementless TKA design at a mean 5-year follow-up in 205 consecutive cases. The 5-year survivorship was 98.9%, with 1 revision due to aseptic loosening and 1 due to instability. The mean postoperative Knee Society score was 92, compared with 57 preoperatively. The mean range of motion at final follow-up was 117°. Harwin et al17 assessed the outcomes of the same cementless TKA design in 110 patients at a mean follow-up of 36 months. The mean function Knee Society score improved by 31 points postoperatively (from 53 to 84 points), and the mean range of motion improved to 127° of flexion from 101° postoperatively. At latest follow-up, there was no evidence of component loosening in the patients. Complications included 1 deep infection and 1 superficial wound necrosis that were successfully treated, and 1 hematoma that was surgically evacuated.

Conversely, some studies have shown less than satisfactory results following cementless TKA. However, some argue that these may be attributed to correctable design flaws. Moran et al18 evaluated outcomes in 108 cementless TKAs and observed a 19% failure rate at 5 years. Park and Kim19 evaluated the outcomes of simultaneous cemented and cementless knee arthroplasties in the same patients (100 knees). At a mean 14-year follow-up, the authors noted no significant differences in Knee Society scores or range of motion between the implants (P>.05), with a survival rate of 100% in both groups (95% confidence interval, 0.93-1.0). Meneghini and de Beaubien19 evaluated 106 consecutive cementless TKAs and observed 9 failures at a mean follow-up of 18 months. The authors identified that mean height was greater in the failure group compared with the well-functioning group (72.5 vs 65.8 inches; P=.001) and concluded that high early failures predominantly occurred in tall, heavy men and may be related to overloading of the medial tibia. Therefore, when considering cementless fixation, appropriate patient selection may be necessary to ensure good postoperative outcomes.

In addition, Fernandez-Fairen et al19 conducted a randomized controlled trial comparing a porous tantalum cementless implant with a cemented conventional component in 145 patients. At 5 years postoperatively, mean Knee Society scores were 90 and 87 points for the uncemented and cemented cohorts, respectively (P=.02). However, there were no differences in the complication frequency (13% vs 17%; P=.4) or aseptic loosening (no radiographically loose components in either cohort) between the uncemented and cemented cohorts. The study was inconclusive as to whether the small differences in functional scores between the groups would outweigh implant cost and performance in the long-term.

CONCLUSION

The current study shows excellent clinical and patient-reported outcomes of cementless TKA. However, the authors are unable to comment on long-term outcomes based on these results alone, and these patients will continue to be monitored to assess for implant function and survivorship. With recent improvements in implant fixation, cementless TKA may be an appropriate option for many patients, particularly those who are younger and likely to require greater implant longevity.

REFERENCES


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