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Are Cementless Stems More Durable Than Cemented Stems in Two-stage Revisions of Infected Total Knee Arthroplasties?

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Abstract

Background The routine use of stems in revision TKA improves survival rates by enhancing the stability of the prosthesis. The ideal method of stem fixation (cemented or uncemented) in two-stage reimplantation remains controversial.

Questions/purposes The purpose of this study was to answer the following questions: (1) Are rerevision rates for aseptic loosening comparable between cemented stems and uncemented stems in two-stage reimplantation? (2) Is the reinfection rate comparable between antibiotic-impregnated cemented stems and uncemented stems for two-stage reimplantation? (3) Are there any differences in Knee Society radiographic scores between stem techniques?

Methods A retrospective analysis was performed in all patients who underwent two-stage reimplantation between 1990 and 2010 at Anderson Orthopaedic Research Institute (AORI) and OrthoCarolina (OC). One hundred fourteen patients with 228 stems met the inclusion criteria. Of these 228 stems, 102 stems were cemented and 126 stems were uncemented. The indication for stem fixation was largely institution specific; AORI used cementless stems 92% (118) of the time, whereas OC used a cemented stem 92% (92) of the time. A 2-year minimum radiographic and clinical followup was required for inclusion into the study. Radiographic evaluations were performed using a modification of the Knee Society radiographic score.

Results Rerevision rates for aseptic loosening were comparable with three cemented and three cementless stem constructs. The reinfection rate was also comparable between cemented and cementless stems ($p = 0.86$). Using post hoc analysis, 32% of cemented stems were radiographically classified as loose or closely observe (33 of 102) compared with 17% of the cementless stem group (21 of 126; $p = 0.006$). Patients with good bone quality had a

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
Data collection was conducted at OrthoCarolina Hip and Knee Center, Charlotte, NC, USA, Anderson Orthopaedic Clinic, Alexandria, VA, USA, and OrthoCarolina Research Institute, Charlotte, NC, USA. Data were analyzed at OrthoCarolina Research Institute.

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significantly lower rate of radiographic loosening compared with patients with poor bone quality (p = 0.01). There was no significant correlation with radiographic loosening and level of constraint (p = 0.90) or use of articulating versus static antibiotic spacer (p = 0.06).
Conclusions In this retrospective study, cementless diaphyseal-engaging stems had a lower rate of radiographic failure than did cemented stems in two-stage reimplantation. Reinfection rates remain similar despite the absence of antibiotic cement in the cementless constructs. At this time we believe the use of hybrid, cementless diaphyseal-engaging stems should be considered as a possible option at the time of reimplantation.
Level of Evidence Level III, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Two-stage reimplantation TKA for infection is a challenging procedure for numerous reasons including significant bone loss, poor host bone quality, ligamentous instability, poor skin envelope, and extensor mechanism issues [2, 23]. The success of two-stage reimplantation for infection has ranged from 80% to 100% [5, 19, 30, 37, 39, 40]. The routine use of stems in revision TKA improves survival rates by enhancing the stability of the prosthesis [7, 8, 20, 29]. Stemmed implants improve rotational stability, allow bypass of structural defects, and reduce stresses at the bone-implant surface [1, 35]. The ideal method of stem fixation however remains a controversial issue.

Excellent survivorship of fully cemented stems for revision TKA has been reported [21, 38]. Additionally, cementless, diaphyseal-engaging stems with cement along the undersurface of the femoral/tibial components, along the metaphyseal portion (stem/coupler interface) of the implant, and the metaphysis, in a so-called “hybrid” technique, are a fixation alternative that have also shown excellent 5- and 10-year survivorship in aseptic revision TKA [14, 17, 26, 27, 31, 41]. Both cemented and hybrid cementless stem fixation techniques are currently being used during reimplantation for periprosthetic knee sepsis.

The purpose of this study was to answer the following research questions: (1) Are rerevision rates for aseptic loosening comparable between cemented stems and hybrid cementless stems in two-stage reimplantation for infection? (2) Is the reinfection rate comparable between antibiotic-impregnated cemented stems and hybrid cementless stem fixation for two-stage reconstruction in infection? (3) Are there any differences in modified Knee Society radiographic scores between the two stem techniques?

Patients and Methods

A retrospective analysis of data collected prospectively from two centers (OrthoCarolina Charlotte, NC, USA [OC], and Anderson Orthopaedic Research Institute, Alexandria, VA, USA [AORI]) was performed in all patients who underwent two-stage reimplantation for septic TKA between 1990 and 2010. We queried our database over that 20-year period for patients who underwent a two-stage revision for infection; this resulted in 174 patients with adequate followup, defined as 2-year minimum AP/lateral radiographs and clinical followup. Of the 174 patients for inclusion, 60 patients (34%) were excluded for having a cemented and uncemented stem, positive intraoperative reimplantation cultures, or a previous antibiotic spacer placed at a referring institution. This left a total of 114 patients with 228 stems for analysis. Of these, 102 stems (45%) were cemented and 126 stems (55%) were uncemented. Loss to followup was 25% among the cemented stems and 18% for the cementless stems (p = 0.19). Infection was confirmed in all patients by positive intraoperative cultures obtained at the time of extensive débridement, explant, and antibiotic spacer placement. All patients underwent a two-stage procedure with placement of a static (42 patients [37%]) or articulating (72 patients [63%]) antibiotic spacer and a minimum of 6 weeks of intravenous antibiotic according to microbial sensitivities. Infectious disease consultants followed all patients for the complete course of antibiotics. The decision on timing to perform reimplantation was determined after serial serum C-reactive protein and erythrocyte sedimentation rate laboratory studies trended toward normal, culture-negative knee aspirations after a complete antibiotic course, and intraoperative frozen section had no evidence of acute inflammation Culture-negative knee aspirations were only obtained once the patients had completed a full 6-week intravenous antibiotic course and only after a 14-day drug holiday. We did not collect detailed information regarding the specific microorganism treated.

Patients in both the cemented and uncemented groups averaged 65 years of age and the stem groups were similar with respect to sex. Of the 51 patients with a cemented stem, there were 26 males (51%) and 25 females (49%). Of the 63 patients with uncemented stems, there were 32 males (51%) and 31 females (49%). Choice of stem fixation technique was largely institution-specific. AORI performed 10 cemented (9.8%) and 118 uncemented (93.7%) stems, whereas OC performed 92 cemented (90.2%) and eight uncemented (6.3%) stems. Reviewing the cortical thickness and remaining amount of cortical bone stock on both the AP and lateral plain radiographs allowed us to subjectively assess bone quality. Bone quality was then recorded as follows for both the femur and tibia: good cortex on AP and lateral radiographs, good cortex on AP or lateral radiographs, or poor cortex on both AP and lateral radiographs. We did not record the femoral or tibial bone loss associated with reconstruction.

At the time of the explant, in an effort to eradicate infection, both the tibial and femoral canals were aggressively hand-reamed until cortical contact was achieved. For all cemented stem reconstructions, intramedullary canal cement restrictors were placed in the femur and tibia. A cement gun was used to retrograde fill and pressurize the canal before insertion of the stemmed implant. Cement was also finger-packed along the dried, bony cut surfaces as well as being placed on the undersurface and metaphyseal portion (stem/coupler interface) of the implant. Antibiotic-impregnated cement was used for both cemented and cementless reconstructions. Cement type and cement antibiotic selection/dosing were based on surgeon preference and not recorded in our study.

The hybrid cementless technique consists of aggressive intramedullary line-to-line hand reaming of the femur and tibia until good cortical contact is achieved. This technique consists of finger-pressurization of doughy cement on the clean, dried, cut bony surface and along the undersurface and metaphyseal portion (stem/coupler interface) of the tibial and femoral implant. Cement was not placed into the diaphysis. The appropriate stem length was chosen by the level of cortical engagement; the stem implant chosen required at least a 4-cm diaphyseal press-fit. Over the 20-year collection period, a variety of implants was used for reconstruction and the decision on implant type was surgeon-dependent. We did not record implant manufacturer data, stem length, stem diameter, use of stem offset, or use of implant augments.

Radiographic evaluations were performed by two independent surgeons (WBB, WGH). Modification of the Knee Society scores for radiographic analyses was performed for all 114 patients (228 stems) according to the system described by Fehring et al. [11]. According to this system, femoral and tibial components were defined as stable, closely observe, or loose by the number and width of radiolucencies present [11]. First, the width of radiolucent lines for each zone in millimeters surrounding the femoral and tibial component in the AP and lateral plane is recorded. Then, the total width for each zone is added and a numeric score is generated for each component. Femoral components with radiolucencies ≤ 8 = stable, 9 to 19 = closely observe, and ≥ 20 = loose. Tibial components with radiolucencies ≤ 9 = stable, 10 to 22 = closely observe, and ≥ 23 = loose.

Standard descriptive analysis included mean, variance, and proportions. A bivariate analysis was conducted using a chi square test to determine the association among stem type, rerevision rates, and failure modes. A Student's t-test was used to determine differences in age, followup, and time to revision with respect to stem type.

Results

Rerevision rates for aseptic loosening were comparable between cemented and cementless stem constructs. At a mean followup of 45 months (range, < 1–109 months), there were three aseptic loosening failures (3%) in the cemented stem group. At a mean followup of 52 months (range, < 1–192 months), there were three aseptic loosening failures (2%) in the cementless stem group.

The reinfection rate was comparable between cemented and cementless stem constructs ($p = 0.86$). Rerevision for recurrent sepsis occurred in 10 (20%) of the 51 patients in the cemented stem group, whereas 15 (24%) of 63 uncemented stems were rerevised for sepsis.

There was a higher radiographic failure rate in the cemented stem group compared with the cementless stem group. Using post hoc analysis, combining the categories closely observe and loose showed 17% (21 of 126) of uncemented stems and 32% (33 of 102) of cemented stems were classified as loose or closely observe ($p = 0.006$). Five (4.9%) cemented stems and two (1.6%) uncemented stems appeared radiographically loose ($p = 0.02$). Twenty-eight (27%) cemented stems and 19 (15%) uncemented stems were defined as closely observe ($p = 0.02$). As a result of the small cell frequencies of less than five in 33% of the cells, caution in interpreting this p value of 0.02 is advised. Thirty-six (32%) of the 114 tibial stems were classified as loose or closely observe compared with 18 (16%) of the femoral stems ($p = 0.005$). Twenty-eight (23%) of the 120 constrained stems and 26 (24%) of the 108 unconstrained stems were radiographically classified as loose or closely observe ($p = 0.90$). Of the 128 stems implanted in good bone cortex, 21 stems (16%) were classified as loose or closely observe, whereas 33 (33%) of the 100 stems reconstructed in poor-quality bone were classified as loose or closely observed ($p = 0.01$). There was no significant difference in radiographic loosening between static and articulating antibiotic spacers ($p = 0.06$). No tibial or femoral stem fractures occurred during insertion of the hybrid cementless stem reconstructions.

Discussion

Periprosthetic knee infection is a devastating complication for patient and surgeon alike. Two-stage reimplantation is the gold standard for effective treatment at this time.

Eliminating periprosthetic infection is dependent on defining the offending organism, the condition of the soft tissue envelope, the ability to perform a thorough débridement, and obtaining stable fixation during the second stage of the procedure [9, 33, 34]. Intramedullary stem use enhances fixation in revision TKA; because of this, most revision knee systems offer cemented and cementless stem extensions to enhance stability of the revision construct. The results of stem fixation in aseptic revision TKA have been clarified recently in the literature. Cemented metaphyseal engaging stems are superior to metaphyseal-engaging cementless stems [11]. However, good results can be obtained with cementless fixation provided the diaphysis is engaged [26]. At this time there is no consensus on whether cemented or cementless stems are superior in the setting of two-stage revision for the infected TKA. We found no difference in revision rates for aseptic loosening or recurrent infections between these two fixation approaches, but our radiographic failure rates with cemented stems were very concerning.

We recognize this study has a number of limitations. First, the potential for selection bias is high; the surgeon may have decided to proceed with a cemented stem reconstruction in those patients with very large canals, poor bone quality, and/or significant bone loss. However, in our study, stem reconstruction type was largely driven by institutional preference rather than bone loss and/or bone quality.

Second, our conclusions showing higher radiographic failure rates when combining closely observe and loose cemented stems should be made with caution because these observations were identified in our post hoc analysis. Also, we are unable to formulate any conclusions regarding the influence of stem type/design, stem length, stem diameter, stem augments, or offset couplers may have on stem durability. It is also possible that a surgeon's decision-making and/or technique has evolved over the length of the 20-year study. This evolution may have an influence on the survivorship of the implant reconstruction.

Another limitation in our study is that we did not characterize the specific microorganism or the cement/antibiotic formula used for each of the antibiotic spacers. Specific virulent microorganisms (eg, methicillin-resistant *Staphylococcus aureus*) may have contributed to a higher failure rate compared with those stems infected with a microorganism less virulent. Another weakness in our study is that we did not analyze cemented and cementless stem failure rates independently according to femoral and tibial implants. Although we observed a higher radiographic failure rate for the tibial stems, it is unknown whether the radiographically failed stems were cemented or uncemented. Despite these weaknesses, we believe this article presents meaningful data to consider when choosing between cemented and uncemented stem fixation for second-stage TKA.

To answer our first question, we found a similar aseptic failure rate for cemented (3%) and uncemented (2%) stems. Our aseptic rerevision rate is similar to several studies reporting 2% to 16% aseptic failure rates after cemented or cementless stem revision TKA for any diagnosis [6, 14, 17, 31, 32, 38, 41]. One study reported no component revisions for aseptic loosening in 40 monoblock, fully cemented long-stemmed revisions at an average followup of 58.2 months [25]. Thirty-eight posterior-stabilized, fully cemented stems performed in revision TKAs have 95.7% component survival free of revision for aseptic loosening at 11 years [38]. One institution reported on 73 revision TKAs for aseptic loosening using a posterior-stabilized implant of one design with modular, fully cemented femoral and tibial stems; their 5- and 10-year implant survivorship free of revision for aseptic failure were 98% and 92%, respectively [21].

Cementless stems perform well in aseptic revision TKA. Eighty-nine TKAs that underwent revision with hybrid, cementless stem implants demonstrated 5% aseptic loosening rate at a mean of 5.9 years [14]. Another study reported only two (6%) of 33 hybrid uncemented revision knees required rerevision for aseptic loosening at 3-year followup [6]. In contrast, one study of 63 aseptic revision TKAs showed a 16% aseptic mechanical failure rate at 5.75 years [32]. More recently, several studies have better defined the surgical technique for hybrid uncemented stem reconstruction and are reporting excellent midterm survivorship rates. One hundred thirty-five revision TKAs, at a minimum 2-year followup, reported only two revisions for aseptic loosening [41]. Kaplan-Meier survivorship analysis demonstrated a probability of survival free of revision for aseptic loosening of 98% at 12 years. Another recent study evaluating 88 revision total knee reconstructions with hybrid cementless stems reported Kaplan-Meier survivorship free of aseptic loosening was 100% at 5 years and 90% at 10 years [31]. Retrospective analysis of survivorship rate of revision TKA using hybrid stem fixation in 119 patients showed 0% aseptic loosening at 62 months followup [16].

To answer our second question, we found no significant difference in our reinfection rates between the cemented and uncemented stems. Type 2 error is possible as a result of our fixed sample size by number of patients available in the study. The lower septic rate observed in the fully cemented stems may be secondary to the use of antibiotic cement in the intramedullary canals. However, several studies report similar reinfection rates after two-stage revision TKA for both fully cemented stems 8% to 24% and hybrid uncemented stems 6% to 17% [15, 16, 18, 24, 26, 31, 41]. To the best of our knowledge, this study represents the only comparative study of cemented and cementless stem reconstruction for replantation in septic TKA.

To answer our third question, our study showed an increase in radiographic lucencies in the cemented stems that is concerning for their long-term survival. Previous studies have shown 32% to 61% of fully cemented stems and 10% to 74% of hybrid cementless stems have adjacent radiolucencies [4, 7, 13, 14, 17, 26, 32]. Although the majority of these studies used the Knee Society radiographic scoring system to evaluate radiolucencies, they categorized radiolucencies based on progression. In our study we used the Knee Society radiographic scoring system to define the stems as stable, closely observe, or loose based on the number and width of radiolucencies. Comparison between studies is difficult because of the difference in stem radiolucency categorization. In one recent study of 100 TKAs revised with hybrid cementless stems, radiolucent lines were observed in 15% of tibias, 1% of femurs, and 3% of both, whereas 2% were radiographically defined as loose [41]. Of the stems radiographically defined as loose, rerevision was recommended. Stem length, stem diameter, or tibial augment use did not correlate with incidence of radiolucency [41]. In another study of hybrid cementless stems, 17 (19%) tibial and two (2%) femoral components revealed radiolucencies [31]. Two of these components were defined as radiographically loose and subsequently rerevised. It is unknown what clinical significance radiolucencies may have on long-term survival rates. We do not know whether stems defined as closely observe are more likely to progress to loose but this is concerning for both stem types classified in this way.

We also sought to determine if there was any correlation between radiographic findings and level of tibial polyethylene constraint. Unlike other studies reporting higher aseptic failure rates with constrained tibial liners, we observed similar radiographic failure rates between unconstrained and constrained tibial liners in both cemented and uncemented stems [14, 36]. We have previously reported no correlation in reinfection rates, bone loss, Knee Society pain scores, or final post reconstructive range motion with type (static or articulating) of antibiotic cement spacers [10, 12]. Our current study also demonstrates no correlation in stem radiolucencies with type of antibiotic cement spacer.

Regardless of stem reconstruction type, the tibial stems in our study had a significantly higher radiographic failure rate than femoral stems. Several studies report 2% to 26% prevalence of radiolucent lines along cemented and uncemented tibial stems; radiolucencies were more common along the tibial rather than femoral implants [4, 14, 17, 28, 31, 32]. At least one other study has also shown a higher radiographic failure rate in tibial stems as compared with femoral stems [32].

Because microorganisms have been cultured in 40% of the intramedullary canals of periprosthetic total knee infections, many surgeons aggressively ream the tibial and femoral canals and place antibiotic-impregnated dowels in the canals to help eradicate infection [22]. We believe this débridement technique removes the majority of cancellous bone, creating a densely sclerotic tube that may compromise cement fixation. Superior cemented stem fixation relies on adequate cement interdigitation with the corticocancellous bone during the second stage. Although cemented stem fixation has historically worked very well in aseptic revisions, we are concerned that the resultant sclerotic, cortical tube found after aggressive reaming during the first stage may have led to the radiographic findings observed in our study.

In conclusion, our study showed hybrid, cementless diaphyseal-engaging stems have equivalent rerevision rates and better radiographic findings than cemented stems in two-stage reimplantation for infection. Reinfection rates remain similar despite the absence of antibiotic cement around the cementless stems. At this time, we believe the use of hybrid cementless stems should be considered at the time of reimplantation. Future studies should focus on clarifying the outcomes based on femoral/tibial stem implant design, surgeon techniques, and stem reconstruction based on bone quality/loss. Investigations to further elucidate functional and pain-related results are also warranted. It is unknown if accepting the occasional issues of insertional fracture and end of stem pain observed with the hybrid cementless technique is worth the improved radiographic findings [3].

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