

## A 30-mm Cemented Stem Extension Provides Adequate Fixation of the Tibial Component in Revision Knee Arthroplasty

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### Abstract

**Background** The optimal stem length and method of fixation for the tibial component in revision knee arthroplasty remains controversial. The use of a cemented 30-mm stem extension provides certain advantages compared with other methods of fixation, but there are few published results.

**Questions/purposes** We therefore asked (1) what is the survivorship (with respect to loosening and repeat revision) of tibial component revisions when a 30-mm stem extension is used; and (2) what factors are associated with the appearance tibial radiolucent lines?

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**Methods** We retrospectively reviewed 54 patients (58 knees) with fixation of the revision tibial component with a 30-mm cemented stem extension; another seven patients died and 11 patients had these components but were lost to followup. These implants represented 74% of our tibial revisions during the period in question (76 of 103); general indications for using them were need for a varus-valgus constrained liner or proximal bone loss requiring a metaphyseal cone or metal augment with an intact diaphysis. The Anderson Orthopaedic Research Institute tibial defect was Grade 1 in 37, 2A in 10, 2B in four, and Grade 3 in seven knees; constrained liners were used in 34% (20 of 58 knees). Patients were evaluated and followed for a mean of 5 years (range, 2–12 years).

**Results** There were no revisions for tibial component loosening. One patient had débridement and liner exchange for late infection. Radiolucent lines were seen in 25 tibial components but only eight knees had radiolucencies in four or more zones. There were significantly fewer radiolucencies in revisions that used metaphyseal cones (20 in eight knees with cones compared with 53 in 17 without,  $p = 0.013$ ).

**Conclusions** The cemented 30-mm tibial stem extension provided excellent fixation in knee revision arthroplasty, even with metaphyseal defects and constrained polyethylene liners, although this series included relatively few patients with severe tibial defects. Longer followup is required for patients with radiolucent lines to confirm that the fixation will remain durable.

**Level of Evidence** Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

### Introduction

Revision of the tibial component of TKA may be required for component loosening, instability, polyethylene wear,

osteolysis, malposition, or infection as part of a one- or two-stage reimplantation. Revision may include the use of porous metaphyseal cones or sleeves for bone loss and may require the use of a nonlinked varus-valgus constrained polyethylene liner [10, 14]. Fixation of the revision modular tibial component can be performed with cement, with cementless porous-coated components, or a hybrid technique with cement fixation of the proximal tibial tray but a press-fit of the distal stem. A recent systematic review of the literature evaluated the results of these three methods of fixation and stated that no final recommendation could be made regarding the optimal fixation technique in revision TKA [3]. However, patients who have revision with “long” press-fit cementless stems seem to have more tibial stem-tip pain and lower knee scores [1, 2]. In addition, the senior author (PFL) has seen patients with breakage of these stems [10].

In the review of several studies of cemented tibial components, a wide variety of stem lengths was reported, ranging from 30 mm to 100 mm, with some only described as “long” [6, 9, 13, 15, 16]. Because the potential complications of revision TKA include infection and loosening, a cemented stem of varying lengths may pose an extreme challenge for later removal. In the modular TKA system used by the senior author since 1998, there are several choices of stem extension: 30 mm, 100 mm, 155 mm, and 200 mm. The two longest stem extensions are available as straight or offset stems and generally are recommended only for cementless use. This prosthetic system also requires some type of stem extension for long screw fixation of a varus-valgus constrained polyethylene liner [11]. A “short” 30-mm cemented stem extension may provide the best choice with secure fixation even with metaphyseal bone loss and the use of a varus-valgus constrained polyethylene liner, yet permit easier removal than longer cemented stems. In addition, a short, cemented stem extension should theoretically avoid the end of long, uncemented tibial stem-tip pain. However, there are no studies to our knowledge that specifically evaluated the radiographic results, loosening and radiolucent lines, in tibial component revisions using only 30-mm stem extensions.

We therefore asked two questions: (1) what is the survivorship (with respect to loosening and repeat revision) of tibial component revisions when a 30-mm stem extension is used; and (2) what factors are associated with the appearance of tibial radiolucent lines?

## Patients and Methods

This is a retrospective review of prospectively collected data. Between 1998 and 2011, one surgeon (PFL)

performed 103 revision TKAs in which the index tibial component was revised. In 10 knees, a primary tibial component without any stem extension was used, and in 17 knees, with a bulk allograft or an unusual tibial anatomy, a long uncemented stem was used. This study involved the remaining 76 knees (72 patients) in which the modular tibial component with 30-mm stem extension was completely cemented. We specifically recalled those patients who had not been seen in the previous year. Seven patients (seven knees) had died, one of a myocardial infarction on the second postoperative day and six before the minimum 2-year followup. Eleven patients (11 knees) had followup from 9 to 18 months, had not had a reoperation, but refused to return for further examination. This left 54 patients (75% of the original group) with 58 knee revisions with a cemented 30-mm tibial stem extension for inclusion in the study (Fig. 1). General indications for use of this approach during the period in question were the need for a varus-valgus constrained liner or proximal tibial deficiency that could be reconstructed with a metal wedge or cone and without a defect of the proximal tibial diaphysis. The patients were followed for a mean of 5 years (range, 2–12 years).

Nine patients (nine knees) were included in a previous study [10]. The data were collected in an institutional review board-approved practice study incorporating clinical and radiographic data collection.

There were 27 knees in 26 male patients and 31 knees in 28 female patients with a mean age of 66.8 years (range, 47–85 years). The mean patient weight was 96 kg (range, 54–154 kg) and the mean body mass index was 33 kg/cm<sup>2</sup> (range, 21.6–49.6 kg/cm<sup>2</sup>). The preoperative diagnosis was aseptic loosening in 20 knees, reimplantation for infection in 10 knees, instability in 23 knees, component malposition



**Fig. 1** This photograph shows the 30-mm modular tibial stem and the two tibial trays with which it was used. The tibial tray on the left was used when a tantalum cone or metal augment was needed, whereas the tibial tray on the right was routinely used for all other revisions.

in two knees, and a stiff, painful knee in three knees. For 47 patients, this was the first revision, for 10 patients, this was the second revision, and for one patient, this was the third revision. Patients undergoing reimplantation for infection were treated with two-stage revisions with a static, high-dose antibiotic cement spacer, and the duration between stages was no less than 5 weeks [8].

The techniques used for the prosthesis implantation and the tantalum cone have been previously described [10, 14]. Using the knee arthroplasty bone loss classification system of the Anderson Orthopaedic Research Institute (AORI) [4], the preoperative tibial defect was 1 in 37 knees, 2A in 10 knees, 2B in four knees, and 3 in seven knees. Intraoperatively, 16 knees had a defect that required some type of augmentation. Ten knees had a tantalum cone, five knees had a metal wedge, and one knee had a tantalum block (all Zimmer, Warsaw, IN, USA). In one knee, a 4.5-mm titanium screw and cement was used for the defect. We generally added a cementless metaphyseal cone to the tray above the cemented 30-mm stem extension when there was AORI 2B or 3 metaphyseal deficiency; 12 of the original 76 knees (16%) and 10 of the 58 knees with adequate followup (17%) had metaphyseal cones as part of the reconstruction. Twenty-seven of the original 76 knees and 20 of the 58 knees with adequate followup received a varus-valgus constrained polyethylene component as part of the reconstruction. In all knees, a 25-mm polyethylene cement restrictor was placed to occlude the tibial medullary canal below the 30-mm stem extension, and two packs of Simplex-P tobramycin cement (Howmedica Stryker Osteonics, Mahwah, NJ, USA), delivered by a large-bore syringe, were used for fixation of the tibial component. The polyethylene liner was posterior-stabilized in 38 knees and varus-valgus constrained in 20 knees (all Zimmer) with the decision based intraoperatively on stability of trial components [11, 12].

The patients started ambulation, weightbearing as tolerated, with a walker on the first postoperative day. All patients received supervised physical therapy twice daily and used a continuous passive motion machine while in the hospital. Supervised physical therapy was continued after discharge at home or at a skilled nursing or rehabilitation facility for 4 to 6 weeks.

The primary study endpoint was radiographic loosening or reoperation for any reason. Failure was defined as reoperation for tibial loosening, rerevision, or radiographic loosening. The secondary study endpoint was the presence and number of zones with radiolucent lines and the factors associated with the presence of radiolucent lines. The patients were evaluated clinically by an experienced clinical research nurse (ESS) using the classic pain and functional score systems of the Knee Society [7]. Radiographic evaluation was performed, by both authors

together, using the system of the Knee Society [5] using standing AP, lateral, and sunrise radiographs for radiolucent lines and axial alignment (with “neutral” defined as between 3° and 9° of valgus). Fluoroscopic positioning of the knees was not performed. For the purpose of analyzing factors related to the presence of radiolucent lines, we grouped the knees into those with and without radiolucent lines and also those with radiolucent lines in less than four zones (50) and those knees with radiolucent lines in four zones or more (eight). Statistical analysis of factors related to the presence of tibial radiolucent lines was performed using Fisher’s exact test with a *p* value < 0.05 considered statistically significant.

## Results

There was no loosening of any tibial component and no re-revision was performed. One patient, with rheumatoid arthritis, developed a late hematogenous infection at 4.5 years after surgery and had a débridement and liner exchange by another surgeon and remains on an oral antibiotic.

There were no tibial radiolucent lines in 33 knees (57%). Seventy-three tibial radiolucent lines were seen in 25 knees (43%). These were seen on either the 6-week or 6-month postoperative radiograph and were not progressive. The tibial radiolucent line was 1 mm in thickness in one zone in five knees, in two zones in six knees, and in three zones in six knees. There were five knees with a 1-mm thick tibial radiolucent line in four zones and three knees that had radiolucent lines in more than four zones (one with five zones, one with six zones, and one with seven zones). The only factor we analyzed that was associated with the development of radiolucent lines was the use of a porous tantalum cone. Reconstructions that used a tantalum tibial cone were less likely to develop radiolucent lines, 20 radiolucencies in eight knees with cones and 53 radiolucencies in 17 knees without a cone (*p* = 0.013). There was no correlation among type of polyethylene (posterior-stabilized versus varus-valgus constrained; *p* = 0.43), thickness of the polyethylene liner (*p* = 0.28), patient age (*p* = 0.46), patient weight (*p* = 0.055), AORI defect grade (*p* = 0.13), or the presence of tibial radiolucent lines. The mean postoperative femorotibial knee alignment was 6° valgus (range, 4°–8° valgus).

## Discussion

The best method of fixation of the tibial component and the best length of tibial stem in revision TKA are unclear. There have been studies advocating fully cemented tibial components with stems of variable length, uncemented long

**Table 1.** Studies of cemented tibial components in revision TKA

Study	Stem length (mm)	Number of knee revisions	Tibial loosening (%)	Survival	Mean followup (months)
Kim and Kim [9]	100	29 of 114	4	96%, 10 years	86
Mabry et al. [13]	30	45	6	89%, 10 years	122
	60	25			
Fehring et al. [6]	variable	107	7	93%, 6 years	53
Whaley et al. [16]	Long	22	0	94%, 10 years	120
	short	16			
Murray et al. [15]	long	25	0	97.5%, 5 years	58
Present study	30	58	0	100%, 5 years	60

stem components, and hybrid fixation with a cemented tibial tray and uncemented long stem [3]. There are specific advantages and possible disadvantages with all three techniques; thus, a consensus has not been reached. The introduction of tantalum tibial metaphyseal cones has provided an alternative to bulk allografts and megaprotheses for deficient metaphyseal bone but require cementing of the revision component into the cone [10, 14]. However, there is no agreement on the best stem length for these revisions or for cemented tibial components in general. Reviewing a single-surgeon series of 58 knee revisions, we sought to evaluate the following questions: (1) what is the survivorship (with respect to loosening and repeat revision) of tibial component revisions when a 30-mm stem extension is used; and (2) what factors are associated with the appearance of tibial radiolucent lines?

This study has several limitations. First, the patient cohort was relatively small but similar in size to other studies of cemented revision tibial components [6, 9, 13, 15, 16]. However, it was adequate in size to identify at least one predictor variable, the use of metaphyseal cones, which were associated with a lower likelihood of the development of radiolucent lines. Second, this was not a randomized study comparing this 30-mm cemented stem extension with other methods of fixation. This means that selection bias could have influenced the results, and generally selection bias makes results appear better than they might appear in a better-controlled study; however, we used this reconstructive approach in most of our reconstructions, even in patients with large tibial defects, and so we do not perceive this bias to be severe. Third, this study involved one experienced revision knee surgeon using one prosthesis system, and the results may not be applicable to other surgeons and implant systems. Fourth, there were seven patients who died before the minimum 2-year followup and 11 patients refused to return for complete evaluation. However, these knees were functioning well at the time of last followup. Fifth, fluoroscopic positioning of the knees was not possible in the office setting and the number of radiolucent lines may be underestimated. However, most of the radiolucent lines recorded were present in the metaphyseal

zones adjacent to the tibial tray, so we do not believe that the presence of radiolucent lines was underestimated. Sixth, there were a variety of tibial defects and two types of polyethylene liner used. However, this represents a typical spectrum of tibial revisions that will be encountered by surgeons. Relatively few tibial defects (seven of 54) were Grade 3, and so this needs to be considered when interpreting and generalizing our results. Finally, the mean followup time of 5 years may not be long enough to detect loosening with the 30-mm cemented tibial stem extension. However, the radiolucent lines did not appear to be progressive.

The success of fixation and absence of loosening of these revisions performed with a cemented 30-mm tibial stem extension is difficult to compare with other series of cemented tibial components because of the variety of stem lengths used, severity of tibial metaphyseal deficiency, defect reconstruction, and length of followup (Table 1). Mabry et al. [13] reported 89% survival at 10 years in a series of 70 knee revisions with modular cemented stems. Four knees had both femoral and tibial components rerevised for loosening. A 30-mm stem was used in 45 knees, but a 60-mm stem was used in 25 knees. No rationale was given for the use of the longer stem, and a variety of bone grafts and augments was used for metaphyseal defects. In the series of 107 cemented stems, with a mean followup of 53 months, reported by Fehring et al. [6], there were seven that had “possible loosening.” However, the stem lengths varied and were not specifically reported. In a series of 114 knees reported by Kim and Kim [9], using the same modular stem implant system in the present study, there were only five knees that required rerevision at a mean followup of 7.2 years. However, a 100-mm stem extension was routinely used, and it was fully cemented in only 29 knees. The other two studies of cemented tibial components describe the stem length as either “standard” or “long” and thus are difficult to compare with our study [15, 16].

The 30-mm cemented stem extension tibial component performed well despite the presence of metaphyseal tibial defects in 16 knees and the use of the constrained condylar polyethylene in 20 knees. This suggests that if the revision knee is properly aligned, fixation with the 30-mm cemented

stem is adequate, even when additional constraint is used. It has been reported that the tantalum metaphyseal cone has a high rate of early osseointegration and metaphyseal fixation [10, 14]. Thus, long stem fixation is probably not necessary when the revision includes this implant. Long stem uncemented tibial stems have been associated with the end of stem pain and lower knee scores [1, 2]. We analyzed factors that could contribute to the occurrence of these radiolucent lines. The use of a tantalum metaphyseal cone was the only variable found to be predictive; patient age or weight, polyethylene type or thickness, and severity of bone deficiency were not correlated with tibial radiolucent lines. This is likely because the cone is press-fit into the deficient bone and the cement is placed directly into the porous metal surface rather than the damaged proximal tibia.

In conclusion, we found the 30-mm cemented stem extension provides adequate fixation for the tibial component in revision TKA, even in knees with metaphyseal defects reconstructed with tantalum cones and in knees with varus-valgus constrained polyethylene liners required for stability, although this series included relatively few patients with severe tibial defects. However, the length of followup is still relatively short compared with those studies with long stem cemented or uncemented components. Longer followup is required for those patients with tibial radiolucent lines and to determine if the fixation with a 30-mm cemented stem extension will be durable.

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