Cementless Metaphyseal Sleeves Used for Large Tibial Defects in Revision Total Knee Arthroplasty

Gerald E. Alexander MD, Thomas L. Bernasek MD, Richard L. Crank DO, George J. Haidukewych MD

Abstract

Revision arthroplasty of large tibial defects remains a challenge. Thirty revision knee arthroplasties using a porous titanium tibial sleeve for Anderson Orthopaedic Research Institute (AORI) Type 2B and Type 3 defects with minimum 2 year follow up were retrospectively reviewed. The average Knee Society Score increased from 55 pre-operatively to 92 post-operatively. Six patients had a repeat operation though none were sleeve related. All radiographs at final follow-up showed well fixed components with osseous in-growth. Seven patients had end-of-stem pain, four of which resolved. Our short-term results show that porous titanium sleeves are a promising option when managing large areas of metaphyseal bone loss by filling defects and providing stable construct with biologic fixation.

Keywords: revision total knee arthroplasty, tibial bone loss, porous metaphyseal tibial sleeves.

As the nation-wide trend of increased demand for total knee arthroplasties continues so will the incidence of revision surgery [1]. Reliable and efficient options for tibial component revision decrease as the tibial bone deficiency increases. Small bony defects, such as Anderson Orthopaedic Research Institute (AORI) Type 1, are more frequently managed by bone autograft, structural allograft, cement, or modular augment blocks and wedges [2]. Severe tibial bone loss (AORI type 2B and Type 3) can be challenging and often requires more extensive augmentation and fixation techniques which can be very time consuming. In addition to diaphyseal stem fixation, multiple techniques have been described to reconstruct these large defects including allograft reconstruction, mesh augmentation, tantalum cone placement with cementation, custom made implants and tumor megaprostheses [3–15,21].

Press-fit metaphyseal sleeves are a relatively new strategy to combat tibial structural defects. Taking advantage of biological fixation of osseous integration, these components avoid potential complications of cemented block and wedge augments and the potential disease transmission of allografts, while providing a stable scaffold for joint reconstruction [16–18]. The purpose of this study is to report on the use of a titanium metaphyseal sleeve that is fixed to the tibial component by a Morse taper and does not require cement fixation to the tibia for stability in cases of severe tibial bone loss. We hypothesize that cementless metaphyseal sleeves used for large tibial defects in revision knee arthroplasty will have good clinical results, demonstrate osseous in-growth, and have minimal complications. The primary outcome in this study includes functional results, with a focus on radiographic evaluation of the sleeve, as well as an unexpected finding of end-of-stem pain.

Materials and Methods

After formal institutional review board approval, our patient database was retrospectively reviewed. Our inclusion criteria were patients who were classified as either AORI Type 2B or 3 intra-operatively and had a revision knee arthroplasty using a cementless titanium tibial metaphyseal sleeve implant (Depuy, Warsaw, IN) between January 1, 2005 and December 31, 2008. Exclusion criteria were any patients who had cementing of tibial components, incomplete pre and post-operative Knee Society Scores (KSS), unknown implant sizes, and incomplete, missing, or inadequate pre and post-operative radiographs. Over that time span, 41 patients were identified. There were 10 patients lost to follow-up, and three patients who had incomplete KSS documentation, leaving 38 revision arthroplasty components in 28 patients available for review which consisted of 14 males and 14 females with a mean age of 71 (range, 48–83). The mean follow-up of the patients was 33 months (range, 24–52 months). Reasons for revision included grossly loose components (15 patients), second-stage re-implantation for infection (8 patients), severe osteolysis (5 patients), and knee instability (2 patients). All operations were performed or directly supervised by one of the two senior authors.

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The patients’ charts were retrospectively reviewed for component sizes, type of fixation, and complications. In addition, pre- and post-operative KSS and functional knee scores were obtained and compared. Similarly, AP, lateral and sunrise view radiographs were taken on all patients both pre and post-operatively and at two-year follow-up on all 28 patients. Radiographs were fluoroscopically-guided in 25 of the 28 patients. Films were assessed for component position, osseous in-growth, signs of loosening defined as implant migration or a 2 mm or greater radiolucency along the entirety of the component, fracture, or any other subtle complication. All radiographs were evaluated by two independent orthopedic surgeons.

Percent contact of host bone with the sleeve was also evaluated with a new grading system. The grading system evaluates the radiographic contact of four cortices with the most proximal edge of the sleeve. Anteroposterior and lateral fluoroscopic views were reviewed and each of four cortices (anterior, posterior, medial and lateral) were awarded a point if contact was achieved as evaluated on imaging. A maximum value is 4 and the minimum value is 0. For values 1 through 3, the deficient cortex is noted in the grading system by defining the anatomic location of the deficiency: A (medial), B (lateral), C (anterior), or D (posterior).

**Surgical Technique**

The surgical approaches used were a standard medial parapatellar arthrotomy, tri-vector, or a gradual quadriceps snip arthrotomy and were based on surgeon preference. Once the components were removed, the metaphyseal deficiency of the tibia was evaluated. The tibial medullary canal was sequentially reamed until endosteal contact was achieved. This defined the stem size for the tibial component. A trial stem was attached for broaching. The proximal tibia was then sequentially broached until the desired metaphyseal sleeve fit at the desired resection level. Firm endosteal fit and rotational stability must be achieved. The broach handle was removed and the final broach used as a proximal tibia cutting guide. The appropriately sized tibial base plate was chosen to ensure proper coverage. The broach was removed and the trial implants inserted. The final implant assembled and the entire construct inserted into the tibia with gentle impaction until the Morse taper is engaged and a stable press-fit obtained into the tibia. Of note, the tibial baseplate does not contact the metaphyseal sleeve and should not bottom out on the host bone in the final assembled construct. The Sigma TC3 Revision Knee Systems (DePuy, Warsaw, IN) were implanted in all patients (Fig. A–D).

![Fig. A](A) Pre-operative AP radiograph showing a Type III AORI tibial defect. (B) Pre-operative Lateral radiograph. (C) Post-operative AP radiograph showing a cementless metaphyseal sleeve. (D) Post-operative lateral radiograph showing a cementless metaphyseal sleeve.
Discussion

Revision knee arthroplasty commonly involves management of significant bony defects that complicate the procedure and may compromise long-term results. To address these defects and achieve a stable construct, techniques such as impaction grafting, bulk allograft, modular tumor or custom components, tantalum metaphyseal cones, allograft prosthesis composites, or a combination of these may be used [3–15,21]. All of these techniques have proven successful in midterm outcomes, but the risk for disease transmission, graft resorption, and fracture is a concern. In addition, the cost of devices such as custom prostheses and tumor implants may limit their availability and use.

Recently, tantalum metaphyseal sleeves have been introduced to address these situations and have shown a promising early outcome [16–18]. To obtain fixation of the implant to the tantalum metaphyseal sleeve, the implant must be cemented to the sleeve. This could potentially serve as a site for failure due to debonding of the cement-implant interface, and adds operative time to the case. This construct using the metaphyseal sleeve relies on a Morse taper design, which allows for total cementless fixation of components.

Overall, our patients had excellent results with median post-operative KSS improving to 92 from 55.5 pre-operatively (P = .001). Functional knee scores were unchanged, but this is not necessarily a reflection of the knee revision surgery and may be due to the degenerative hip or chronic back complaints typically seen in our patients.

Out of 30 revision knee arthroplasties, 7 (23.3%) complained of end-of-stem pain. All 7 patients were treated conservatively with anti-inflammatories, and infection was ruled out with blood work (complete blood count, erythrocyte sedimentation rate, C-reactive protein) and aspiration. Two patients had resolution of symptoms within the first 6 months and two more patients had resolution of symptoms with the first two years, leaving three patients (10%) still with chronic end-of-stem pain. The pain was mild to moderate and did not interfere with activities of daily living in six of the seven patients. One patient continued to have severe pain which markedly impacted his daily activity, and was revised to a cemented stem. The natural course and resolution with time and conservative treatment in our group mirrors reports elsewhere in the literature [19,20]. One patient did try a bone-stimulator which provided no relief. All three patients who continue to have pain had the longest diaphyseal stems (up to 150 mm), and small diameter stems (10–16 mm). Stem length was not statistically significant (P = .139), whereas stem diameter was (P = .05). Small stem diameter, though statistically significant, we feel is misleading as to the true cause. Diaphyseal stems are non-slotted at diameters of 10 to 14 mm, and sizes greater than 14 mm diameter are slotted. Though slotted versus non-slotted stems did not prove to be significant (P = .075), we feel the solid non-slotted design is the true cause of pain. Unfortunately, our sample size is under-powered to detect significance in regards to slotted stems. Statistical analysis shows we would need at least twenty patients to reach the minimum population size to detect such difference if it does indeed exist. Our current data suggests that there is a modulus mismatch at the stem tip related to non-slotted, small diameter diaphyseal stems, but further evaluation with a larger sample size is required.

A limitation to this study is the 10 patients who were lost to follow-up. Despite the loss to follow-up, 30 arthroplasty procedures is a comparable sample size in similar studies that have been recently published [21–23]. Additionally, our sample size was too small to statistically determine the likely cause of end-of-stem pain. Though small diameter is significant, it is likely the combined effect of the solid, longest stems. Finally, this is a retrospective series without a control or comparative study arm.

In conclusion, the short-term results of a cementless titanium metaphyseal sleeve appear promising with significant increases in

### Table

<table>
<thead>
<tr>
<th>Potential Variables Causing End of Stem Pain.</th>
<th>Pain</th>
<th>No Pain</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Host bone contact (median, range)</td>
<td>4 (3–4)</td>
<td>4 (1–4)</td>
<td>.811</td>
</tr>
<tr>
<td>Stem diameter (mm)</td>
<td>11 (10–16)</td>
<td>15 (12–20)</td>
<td>.050</td>
</tr>
<tr>
<td>Stem length (mm)</td>
<td>150 (75–150)</td>
<td>75 (75–150)</td>
<td>.139</td>
</tr>
<tr>
<td>Titanium stem</td>
<td>5/7 (71.4%)</td>
<td>8/24 (33.3%)</td>
<td>.099</td>
</tr>
<tr>
<td>Slotted stem</td>
<td>0/5 (0%)</td>
<td>5/8 (62.5%)</td>
<td>.075</td>
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The design of the implant both fills the bony defect and provides a stable scaffold through biologic fixation to build the final component construct. The incidence of end-of-stem tibia pain may be related to longer diaphyseal stems in this design. However, long-term follow-up will further show the benefits of biologic fixation of metaphyseal sleeves in revision total knee arthroplasty.

References