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Arthroplasty Tips and Tricks: Diaphyseal Impaction Grafting and Metaphyseal Cone for Severe Tibial Bone Loss in Revision Knee

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Introduction

With the prevalence of revision knee arthroplasty continuing to rise, it is important to have several techniques available to address bone loss in the revision setting.^{1,2} Multiple treatment algorithms have been proposed to help surgeons manage bone loss in the revision knee setting to restore the patient's limb alignment, joint line, soft tissue balance, patellar tracking, and range of motion.^{3,4}

One particularly challenging instance is the patient with a previously violated diaphysis, resulting in a sclerotic diaphysis combined with metaphyseal bone loss. The sclerotic diaphysis impairs cemented stem fixation, and that lack of initial stability impairs bone ingrowth onto a metaphyseal cone and subsequent long term fixation.

One solution that has been proposed for this challenging problem is diaphyseal impaction grafting in combination with metaphyseal cone for patients with severely compromised bone. This has been described with promising initial results. The purpose of this paper is to describe a case report utilizing the technique of diaphyseal impaction grafting with a metaphyseal cone for a patient with severe tibial bone loss in a revision knee and review literature regarding this technique.⁵

Case Report

This is a 76 year old female who presented to clinic with several years of worsening right knee pain. She has a history of a right total knee arthroplasty (TKA) in 2000 and subsequent revision TKA in 2005. On physical exam, notable findings are that her BMI is 43, range of motion is 0-95 degrees, and she has an intact extensor mechanism. She also had gross varus and valgus instability throughout range of motion. Her x-rays demonstrate evidence of loosening of her tibial component, marked bone loss, marked shortening of the leg and lowering of the joint line. Preoperatively, an infectious workup was obtained including bloodwork and synovial aspirate to rule out periprosthetic infection and was negative.

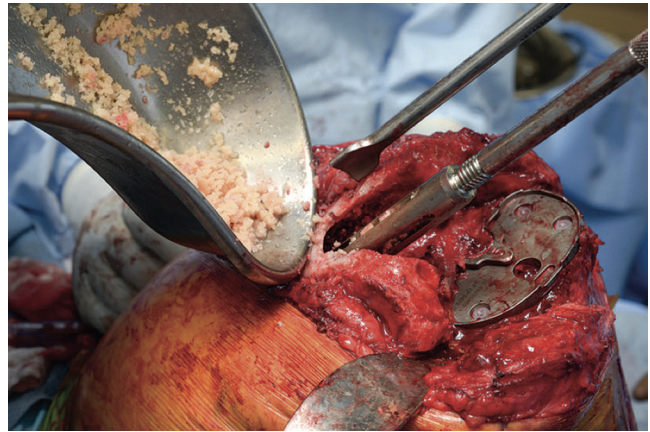
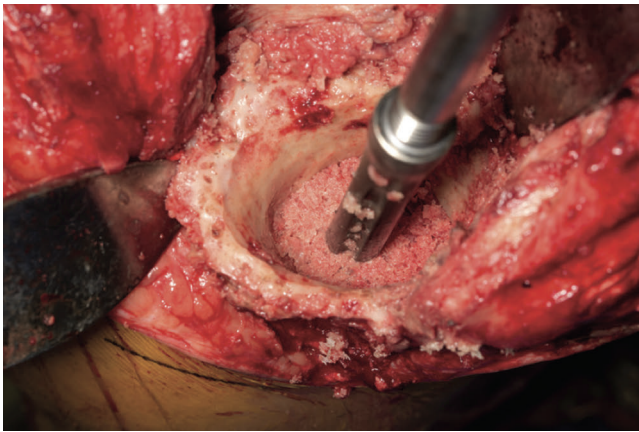
She was indicated for a revision TKA. Plan A was to revise the tibia only with impaction bone grafting and a metaphyseal cone. Plan B was to revise both components with tibial impaction bone grafting and a metaphyseal cone. Intraoperatively, she was found to have an Anderson Orthopedic Research Institute Type IIB AORI IIB bone loss involving both tibial plateaus, which was consistent with preoperative planning. The femoral component was not loose. Therefore, we proceeded with the initial plan of revising the tibial component only, with diaphyseal impaction grafting using a metaphyseal cone, and cementing stem.

We used the original technique for impaction grafting originally described by Hovelius and modified by Bedard et. al. with the use of cones. Sclerotic canals are irrigated and debrided. Then, the diaphysis is touch reamed and either a bone plug or cement restrictor is placed 2 cm distal to where the tip of the implant will end. A reamer or trial stem is placed centrally in the position of the final implant and to guide the placement of cancellous autograft surrounding the trial stem. Small pieces (no larger than 5mm) are introduced around the stem in batches and densely impacted to fill approximately 1-2 cm at a time. This is repeated until the graft is impacted to the level of the metaphyseal cone. The bone graft should be packed densely enough that after removing the trial stem, no bone graft should fall into the reconstituted diaphyseal canal.

Then, a metaphyseal cone is implanted in standard fashion. Any gaps between the implant and the host bone are supplanted with autograft. Then, the diaphysis is carefully prepared and a cement gun is used to fill the canal and cone in a retrograde fashion. Finally, the implants are implanted.

Discussion

The goals of a revision TKA, like that of a primary TKA, are to restore limb alignment, joint line, soft tissue balance, patellar tracking, and range of motion. This goal can be



complicated by bone loss in the revision setting, making it a challenging endeavor. Patients can have bone loss due to several etiologies including infection, osteolysis, loosening and mechanical bone loss, stress shielding, and iatrogenic loss during revision surgeries. It is important to determine the cause of bone loss as part of the preoperative workup.

Bieganowski et al give several tips in approaching the revision TKA. The authors state: “rTKA can be broken down into three steps, generalized as follows: (1) reestablish the tibial platform, (2) restore the flexion gap, and (3) reconstitute the extension gap.”³ They also advise regarding the use of intraoperative anatomic landmarks to evaluate for bone loss and estimate the location of the joint line: “One may theoretically estimate femoral bone loss by assuming that the normal distance from the lateral and medial epicondyles to the joint line is 25 mm and 30 mm, respectively. The adductor tubercle is usually 40–45 mm proximal to the joint line. Furthermore, a rough calculation of the depth of tibial bone loss begins with the presumption that the fibular head is 15 mm distal to the joint line.”³

Bone loss requires a systematic approach and multiple techniques based on differing severity and location. It is important to have a preoperative plan based on imaging, but know that final classification of bony defects cannot be done until after implant removal. The most commonly used classification in the revision knee is the Anderson Orthopaedic Research Institute (AORI) classification. Several proposed treatment algorithms propose treatments based on the amount of bone loss and therefore the AORI type. As described above in the case report, this patient was classified as an AORI IIB, in that they had bone loss of both tibial plateaus.

AORI Classification.⁷

Type	Description
I	Minor and contained cancellous bony defects that do not affect implant stability
II	Moderate to severe cancellous and/or cortical bone defects IIA: one tibial plateau or femoral condyle IIB: both tibial plateaus or femoral condyles
III	Massive cavitary and segmental bone loss of both tibial plateaus and/or femoral condyles with/without ligament or tendon involvement

Treatment algorithms have been proposed to suggest management of bony defects. An article by Sheth et. al provides a systematic approach to bone loss in rTKA and a framework for the treatment and implant selection based on available reconstruction options.⁴ Bieganowski et al reviews each surgical technique and the AORI type for which it is indicated for. They also review the pros and cons of each technique. This article indicates both impaction bone grafting and metaphyseal cones are indicated for AORI II/III defects. This article does not review the use of impaction bone grafting in combination with metaphyseal cones.³

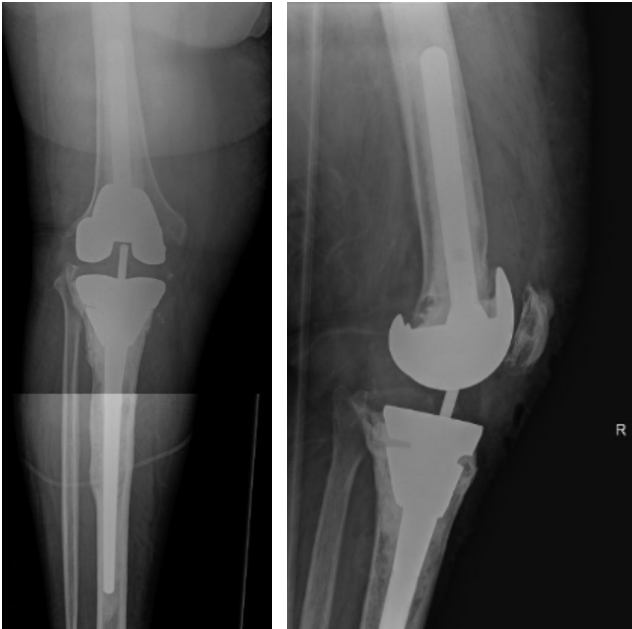
Finally, this article by Bedard et. al. describes outcomes in the use of metaphyseal cone and diaphyseal impaction grafting in the same technique as described above. 33 revision TKAs underwent this technique and had 100% survival at 5 years from aseptic loosening. 6 knees (17%) required further revision; 4 for infection and two for periprosthetic fracture. 1 unrevised patient had asymptomatic loosening. All unrevised TKAs were incorporated radiologically. This study suggests promising clinical outcomes in patients undergoing this technique.⁵



Conclusion

Bone loss in the revision TKA is a challenging issue, but a sclerotic diaphysis in combination with substantial metaphyseal bone loss is a particularly challenging issue.

Diaphyseal impaction grafting with a metaphyseal cone is a promising solution for this issue. Surgeons must have a systematic approach and several techniques ready to address bone loss in the revision knee.



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