



■ KNEE

Management of tibial bone defects with metal augmentation in primary total knee replacement

A MINIMUM FIVE-YEAR REVIEW

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Bone defects are occasionally encountered during primary total knee replacement (TKR) and cause difficulty in establishing a stable well-aligned bone-implant interface. Between March 1999 and November 2005, 59 knees in 43 patients underwent primary TKR with a metal block augmentation for tibial bone deficiency. In all, six patients (eight knees) died less than four years post-operatively, and four patients (five knees) were lost to follow-up leaving 46 knees in 33 patients available for review at a mean of 78.6 months (62 to 129). The clinical results obtained, including range of movement, American Knee Society and Oxford knee scores, and the Western Ontario and McMaster Universities osteoarthritis index, were good to excellent, with no failures. Radiolucent lines at the block-cement-bone interface were noted in five knees (11%) during the first post-operative year, but these did not progress.

Modular rectangular metal augmentation for tibial bone deficiency is a useful option. No deterioration of the block-prosthesis or block-cement-bone interface was seen at minimum of five years follow-up.

When bone defects are encountered at primary total knee replacement (TKR) it can be difficult to introduce stable well-aligned components.^{1,2} The defects generally occur on the tibial side, but can affect the distal femur, and are typically asymmetrical and peripheral, although there may be contained deficiencies owing to cyst formation.^{3,4} Various options are available for managing these defects. We have used rectangular metal augments when managing uncontained peripheral defects of ≥ 4 mm in the proximal tibial plateau. The purpose of this retrospective study was to determine the clinical and radiological results of primary TKR performed using this technique with a minimum follow-up of five years.

Patients and Methods

Between March 1999 and November 2005, 59 primary TKRs requiring a rectangular block augment for the treatment of an uncontained tibial defect were performed in 43 patients by one surgeon (CHC). Of these, six patients (eight knees, 13.5%) died less than four years post-operatively, and four patients (five knees, 8.5%) were lost to follow-up. Accordingly, the remaining 33 patients (46 knees) who were followed clinically and radiologically for a mean of 78.6 months (62 to 129) constitute the study cohort. The study was approved by the institutional review board, and all patients provided informed consent.

There were 31 women and two men with a mean age at operation of 63 years (45 to 75). The original diagnosis was degenerative osteoarthritis (OA) in 26 patients (36 knees), and rheumatoid arthritis (RA) in seven (10 knees). No patient had a history of trauma, fracture or prior surgery involving the affected knee (Table I).

All patients had an uncontained medial peripheral defect on the tibial plateau ≥ 4 mm deep to a maximum depth of 15 mm on the tibial plateau. The depth of the defect was measured after the initial proximal tibial osteotomy had been performed. The implants used included 39 Scorpio prostheses (Stryker, Mahwah, New Jersey), and seven Nexgen LPS prostheses (Zimmer, Warsaw, Indiana). Metal blocks 4 mm or 5 mm thick were used in 21 knees and 8 mm or 10 mm thick blocks in 23 knees. Double-blocks (10 mm + 5 mm) were required in the remaining two knees with defects of 15 mm. A long stem (30 mm to

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Table I. Patient demographics

Demographic characteristic	Number of patients (knees)
Patients	33 (46 knees)
Women	31 (44 knees)
Men	2 (2 knees)
Mean age (range) (yrs)	63 (45 to 75)
Diagnosis	
Osteoarthritis	26 (36 knees)
Rheumatoid arthritis	7 (10 knees)

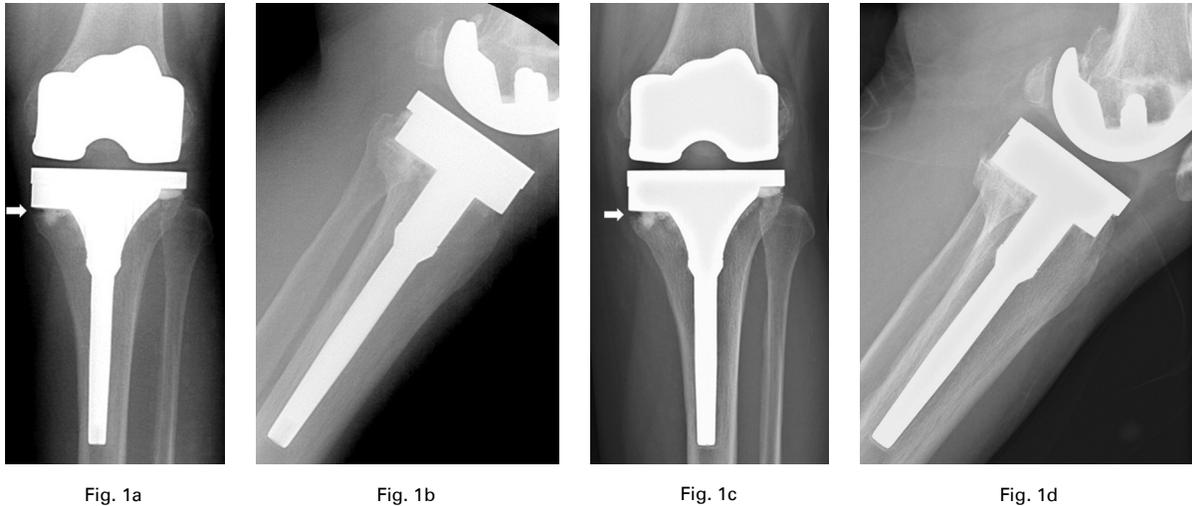


Fig. 1a Fig. 1b Fig. 1c Fig. 1d
 Anteroposterior (a) and lateral (b) radiographs of a patient with a 10 mm medial tibial augment used in conjunction with a long tibial stem at 12 months post-operatively obtained with fluoroscopic positioning to ensure clear views of the interface, showing a radiolucent line (arrow) beneath the block. Anteroposterior (c) and lateral (d) views at seven years post-operatively, showing the non-progressive 1.5 mm radiolucency (arrow) at the cement-bone interface beneath the metal block.

80 mm) was used in 27 knees with augmentations > 5 mm, or when the osseous strength of the defect base was compromised.

Clinical assessment, involving a physical examination and completion of the Knee Society scoring system⁵ for each patient, was undertaken pre-operatively and annually thereafter. The Oxford knee score (OKS)⁶ and the Western Ontario and McMaster Universities (WOMAC) osteoarthritis index⁷ were also recorded at the latest review. Standard anteroposterior (AP), posteroanterior (PA), and long-leg standing radiographs were obtained pre-operatively and at three, six and twelve months post-operatively and annually thereafter. Additionally, supine AP, lateral (focusing on the femoral and tibial components separately) and skyline views were taken under fluoroscopic control to assess the bone-cement interfaces. Radiographs were assessed by an author (JKL) for alignment, component position, the presence of radiolucent lines (RLLs) > 1 mm in width, and osteolysis at the bone-cement interface in accordance with the Knee Society Roentgenographic evaluation system.⁸

Statistical analysis. A paired Student's *t*-test was used to compare the mean values of the Knee Society scores before and after surgery. A *p*-value < 0.05 was regarded as significant.

Results

The mean range of flexion of the 46 knees pre-operatively and at final review was 113° (45° to 135°) and 121° (105° to 140°), respectively. The mean flexion contracture was 9° (0° to 35°) pre-operatively and 3° (0° to 10°) at final review.

The mean pre-operative knee and function scores according to the Knee Society system were 42.0 points

(3 to 75) and 47.6 points (10 to 75), respectively. At the final review the mean knee and function scores had improved to 95 points (80 to 100) and 85.1 points (60 to 100), respectively (*p* < 0.001).

At the final review, all 33 patients had good or excellent scores, according to the OKS and WOMAC scoring systems. The mean OKS was 41.6 points (36 to 46) and the mean WOMAC score was 3 (0 to 6) out of 20 points for pain, 0.8 (0 to 2) out of 8 points for stiffness, and 13.2 (4 to 31) out of 68 points for physical function.

The pre-operative alignments of 45 knees was a mean varus angulation of 9.8° (1.5° to 23.5°), and one knee was in 4.5° of valgus. Post-operatively, all 46 knees were in valgus at a mean of 5° (1.5° to 9.5°).

RLLs were located at the cement-bone interface in five tibial components (11%) at the final review. All appeared during the first post-operative year and had not progressed at the time of the final review (Figs 1 and 2). On the AP view, RLLs were present in Zone 1 (beneath the metal block) in four knees (8.7%) and in Zone 6 (beneath the tip of the stem) in one knee (2.2%). On the lateral view, RLLs were seen in Zone 1 in two knees (4.4%) and in Zone 2 in one knee (2.2%). Of the tibial radiolucencies, four were < 2 mm in width, and one was 2 mm to 3 mm in width. The largest RLL was 2.8 mm wide and was noted in Zone 6 of the tibial component in a knee treated with a 5 mm thick augmentation block. However, this RLL did not progress over four years of follow-up. All RLLs around the tibial components were < 3 mm in width.

For the six patients (eight knees) who died during the course of the study, the mean follow-up was 41 months (36 to 47), at which time all had a good or excellent clinical score, without any tibial RLLs.

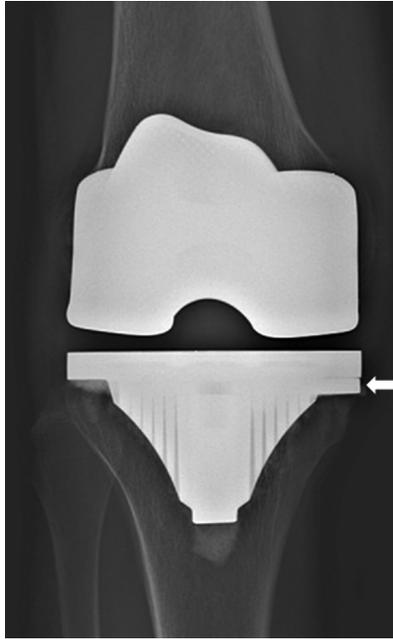


Fig. 2a



Fig. 2b

Anteroposterior (a) and lateral (b) radiographs of a total knee replacement with a 4 mm metal augmentation (arrow) made with fluoroscopic positioning 9.5 years post-operatively. No radiolucencies are seen.

A total of seven patients complained of occasional, mild knee pain. No TKR failed or needed revision.

Discussion

The aetiology of bone defects in primary TKR include erosion secondary to arthritic change, trauma, osteonecrosis, and a previous osteotomy.^{4,9} The defects typically have a condensed sclerotic surface. This contrasts with what is observed at revision surgery, where following removal of a component an osteopenic surface is revealed. Varus deformities are characteristically associated with medial defects, as in our series, whereas central-lateral defects often present with valgus malalignment.^{9,10}

Augmentation is generally required if the tibial component is found to be unstable during trial reduction, and this is likely to happen when > 40% of the bone-implant interface is unsupported by host bone in the presence of a defect greater than 5 mm in depth.^{1,2} Options for treatment include; resection of more tibial bone, filling the defect with cement with or without reinforcing screws, the use of modular augments, bone grafting, or custom-designed components.^{3,4,11-16} Furthermore, the use of a long stem or an offset stem can assist with positioning of the component, supplement fixation, and reduce stress at the bone-implant interface.^{1,17,18}

More tibial resection with a thicker polyethylene insert should be reserved for shallow defects of < 10 mm.^{1,4,9,10,19} It has been shown that a distal tibial resection reduces the strength of osseous support and may result in the use of a

narrower tibial component, further reducing the area of support with increased loading.^{9,17,19} Dorr et al²⁰ recommended that bone resection be limited to 10 mm distal to the lateral subchondral plate or 5 mm distal to the medial subchondral plate.

Defects of < 5 mm can be filled with methylmethacrylate,^{1,4,17,19} and the additional use of a cancellous screw can help to stabilise the component while the cement is polymerising.^{4,21,22} However, several biomechanical studies have questioned the durability of this technique and Insall⁴ advised against it. Limiting the use of cement augmentation to small contained defects has been recommended by several authors.^{1,4,23,24}

Windsor, Insall and Sculco²³ reported using the resected femoral condyle secured with countersunk cancellous screws as an autograft to treat tibial defects in primary TKR. They reported that this enabled restoration of bone stock and more physiological load transfer when union occurs. However, Laskin²⁵ reported a failure rate at five years of 33% after using an autograft in primary TKR. The use of allograft to treat massive defects at TKR has been reported, but these have limited osseous-inductive power compared with autografts and can fail, along with the risk of disease transmission.²¹ Dorr et al²⁰ recommended that graft be used for tibial defects involving > 50% of either medial or lateral plateau, requiring > 5 mm width of cement. Although contained defects are easily filled with bone graft, peripheral defects are more difficult, as the creation of a bleeding bed of host bone may require additional

deeper cuts to remove the sclerotic areas of bone, and filling the host bed with graft may be difficult in cases with severe erosions.^{4,20}

Modular augmentation of the component facilitates the treatment of bony defects. The devices are available in wedge and rectangular shapes, can be attached using cement or screws, allowing up to 20 mm of segmental bone loss to be replaced,²⁶⁻³⁰ and offer immediate support with satisfactory transfer of load.^{26,27,31,32} The short to medium term results of this form of augmentation have been well documented. Brand et al¹² reported a 25% incidence of RLLs at 3.5 years after surgery, but these RLLs were not found to be associated with mechanical failure. Chen and Krackow²⁴ argued that while angular wedges often preserve host bone, rectangular augmentations are more stable biomechanically because they reduce shear loads at the bone-augmentation interface. Augments are suitable for peripheral tibial defects > 5 mm where there is a tendency for the trial to displace at time of reduction.^{1,33}

In the current series, rectangular metal augments were used to treat uncontained defects of > 4 mm. The clinical results obtained, in terms of range of movement, American Knee Society scores, OKS and WOMAC score, were good to excellent, and no failure of the prosthesis was observed. RLLs > 1 mm in width between the block-cement and bone were noted in five knees (11%) during the first post-operative year, after which no further progression occurred.

This study has several limitations. It is based on a retrospective analysis of clinical and radiological data. In addition, two types of prosthesis were used with no uniformity in the type of implant, and ten of the initial series were lost to follow-up, of whom six died less than four years post-operatively. Finally, the pre-operative OKS and WOMAC score were not recorded.

Nevertheless, this study provides encouraging results regarding the stability of the rectangular block-cement-bone interface at a mean follow-up of more than six years. Modular metal augmentation with a rectangular block remains our preferred technique for the treatment of peripheral tibial plateau deficiency when a defect of ≥ 4 mm remains after initial tibial resection.

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