Use of modular metal block augments and medullary stem augments in primary total knee arthroplasty: 2-year follow-up

Khaled Mohamed Diab

Department of Orthopaedic Surgery, Faculty of Medicine, Zagazig University, Zagazig, Egypt

Correspondence to Khaled Mohamed Diab, MD, PhD, Department of Orthopaedic Surgery, Faculty of Medicine, Zagazig University, Zagazig, Egypt
E-mail: khaleddiab@hotmail.com

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Background
The success of total knee arthroplasty depends on obtaining and restoring mechanical alignment, maintaining the joint line, balancing ligaments and soft tissue, restoring the function of quadriceps, achieving a stable implant, and reconstructing substantial amounts of bone lost using metal wedges or by stem augmentation. The benefits of modular augments lie in the simplicity of rectifying the bone defect without the additional risks associated with bone grafts. The aim of this study was to present the results obtained from the use of augments in a group of patients with primary osteoarthritis, who had a significant degree of varus deformity, and to show its applicability.

Patients and methods
Twenty-five patients (average age 69 years) who had a varus alignment of the knee of more than 20° were included in this study. The mean follow-up period was 24 months. All procedures were performed using a standard technique, and a P.F.C. Sigma Knee Replacement was implanted in all cases. Rehabilitation and mobilization began on the first postoperative day assisted by a physical therapist with full weight bearing. Outcomes were evaluated using the American Knee Society Score.

Results
The mean improvement in the postoperative arc of flexion was 33°. The average Knee Society knee score was 44 points preoperatively and 82 points at the final follow-up. One patient developed peroneal nerve palsy; this patient recovered after 2 months.

Conclusion
The study concludes that the use of modular metal block augmentation devices for peripheral tibial defects could serve as a simple, rapid, and dependable technique that yields predictable results, and the inclusion of a medullary modular stem in the implant component confers greater stability for the prosthesis. There are no standards for the augmentation in primary total knee arthroplasty, and each case should be dealt with according to the degree of deformity and bony defect intraoperatively.

Keywords:
knee arthroplasty, knee prosthesis, osteoarthritis, results

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Introduction

Steady developments in the field of arthroplasty research in recent decades have led to total knee replacement becoming one of the most successful orthopedic operations. Long-term follow-up studies indicate a survival rate of at least 90% within 15 years [1,2]. Primary total knee arthroplasty (TKA) using modern implants results in more than 95% good to excellent results [3].

The numbers and indications of primary knee replacements are expanding, and the procedure is now being offered to younger and more active patients than in the past [4]. The success of TKA depends on restoration of mechanical alignment, maintenance of the joint line, balance of ligaments and soft tissue, restoration of the function of quadriceps, achievement of a stable implant, and reconstruction of substantial amounts of bone lost using metal wedges or by stem augmentation.

To achieve good long-term biological stabilization, initial secure mechanical stability is vital. A lack of initial stability can lead to resorption of bone at the implant–tissue interface and can consequently result in loosening and failure of the prosthesis [5].

Bone loss around the knee in the setting of TKA remains a difficult and challenging problem for orthopedic surgeons. Uncontained peripheral bone defect in the posteromedial tibial plateau is not an infrequent problem even in primary TKA, especially in large angular deformities [6].

There have been improvements in the design of prostheses in recent years, the most important of which are the introduction of metal wedge augmentation and modular fluted stems with a variable offset, which improve the alignment and allow press-fit fixation [7–9].

The benefits of modular augments lie in the simplicity of replacing the bone defect without the additional risks associated with bone grafts. In most situations involving proximal tibial reconstruction, a stemmed implant is commonly used. Modular metallic augments are being increasingly used when proximal tibial bone stock is deficient. Intramedullary stems used in conjunction with tibial metaphyseal metallic augments reduce the mechanical burden in the surrounding bone by reducing bone stresses and micromotion between the implant and the adjacent bone [10].

Cameron and Jung [11] showed that the additional use of a tibial stem on its own markedly reduced the micromovements of a cementless tibial implant, especially as it affects mediolateral movement.

The use of modular tibial metal augmentations should be considered as an effective solution to severe proximal tibial bony deficiencies. The wedge allows a proper tibial cut to be made, and it helps in restoring the normal joint line. It allows fast recovery of the patient with immediate weight bearing [12].

The aim of this study was to present the applicability and the results of the use of augments in a group of patients with primary osteoarthritis who have a severe degree of varus deformity.

Patients and methods

Between January 2006 and December 2009, a period of 4 years, 25 patients with a varus alignment of the knee of more than 20° were included in this study. All patients presented at and were operated on at King Faisal Specialist Hospital and Research Center, Jeddah, Saudi Arabia.

Patients were followed up for a minimum of 2 years. The mean follow-up period was 30 months (range 24–48 months). There were 15 men and 10 women (60 and 40%, respectively). The average age at the time of operation was 69 years (range 59–77 years).

Anteroposterior radiographs with the patient in the standing position and lateral radiographs were obtained preoperatively and postoperatively and were assessed for alignment of the limb, position of the components, and presence and location of radiolucent lines at the bone–cement interface.

All procedures were performed using a standard technique. The anteromedial parapatellar approach was used in all patients. The most difficult part of soft tissue release was in the lateral aspect. Great care was taken to release the soft tissue gradually and in a titrated manner. The lateral retractor was looked up and attention to avoid affection for the lateral peroneal nerve. Flexion and extension gaps were created to obtain adequate balance; moreover, intraoperative laxity was judged manually.

P.F.C. Sigma Knee Replacement (DePuy Orthopaedics Inc., Orthopaedic Drive Warsaw, Indiana, USA) was used in all patients. Modular augmentation blocks were used to restore the correct position of the joint line, balance flexion, and extension gaps and improve the rotation of the femoral component.

Preoperative estimation of the expected medial upper tibial defect was carried out for all patients on the basis of anteroposterior and lateral radiographs. This provides an idea on whether the block will be a wedge or a step, and depending on that, its degree or height. During the operation, all types and sizes of wedges and stem augments were available. The real defect was measured intraoperatively using a Vernier caliper and a fully assembled trial of metal blocks with a tibial tray was

Table 1 Details of different augments, stems, and blocks used

Stem augments	Number of cases	Modular metal blocks	Number of cases
Length (115 mm)		Step wedge	
10 mm	2	10 mm	4
12 mm	6	15 mm	13
14 mm	4		
Length (150 mm)		Hemi wedge	
12 mm	5	20°	8
14 mm	8		
Total number of cases	25	Total number of cases	25

Table 2 American Knee Society Score [13]

	Point
Pain	
None	50
Mild or occasional	45
Stairs only	40
Walking and stairs	30
Moderate	
Occasional	20
Continual	10
Sever	0
Range of motion	
5° = 1 point	25
Stability	
Anteroposterior	
< 5 mm	10
5–10 mm	5
10 mm	0
Mediolateral	
< 5°	15
6–9°	10
10–14°	5
> 15°	0
Subtotal	[–]
Deductions points (minus)	
Flexion contracture	
5–10°	2
10–15°	5
16–20°	10
> 20°	15
Extension lag	
< 10°	5
10–20°	10
> 20°	15
Alignment	
5–10°	0
0–4°	3 points each degree
11–15°	3 points each degree
Other	20
Total deductions	[–]
Total knee score	[–]

Figure 1

(a–d) Preoperative and (e–h) postoperative anteroposterior standing view and lateral view radiographs of a 59-year-old female patient. Varus of 25° was observed in the right knee preoperatively, which showed balanced alignment postoperatively on using a medial tibial metal block and a tibial stem. The left knee shows less varus and was operated upon with no augmentations.

attempted; thereafter, stability was evaluated by maintaining stable extension and flexion gaps, as well as femoral–tibial alignment using external alignment roads.

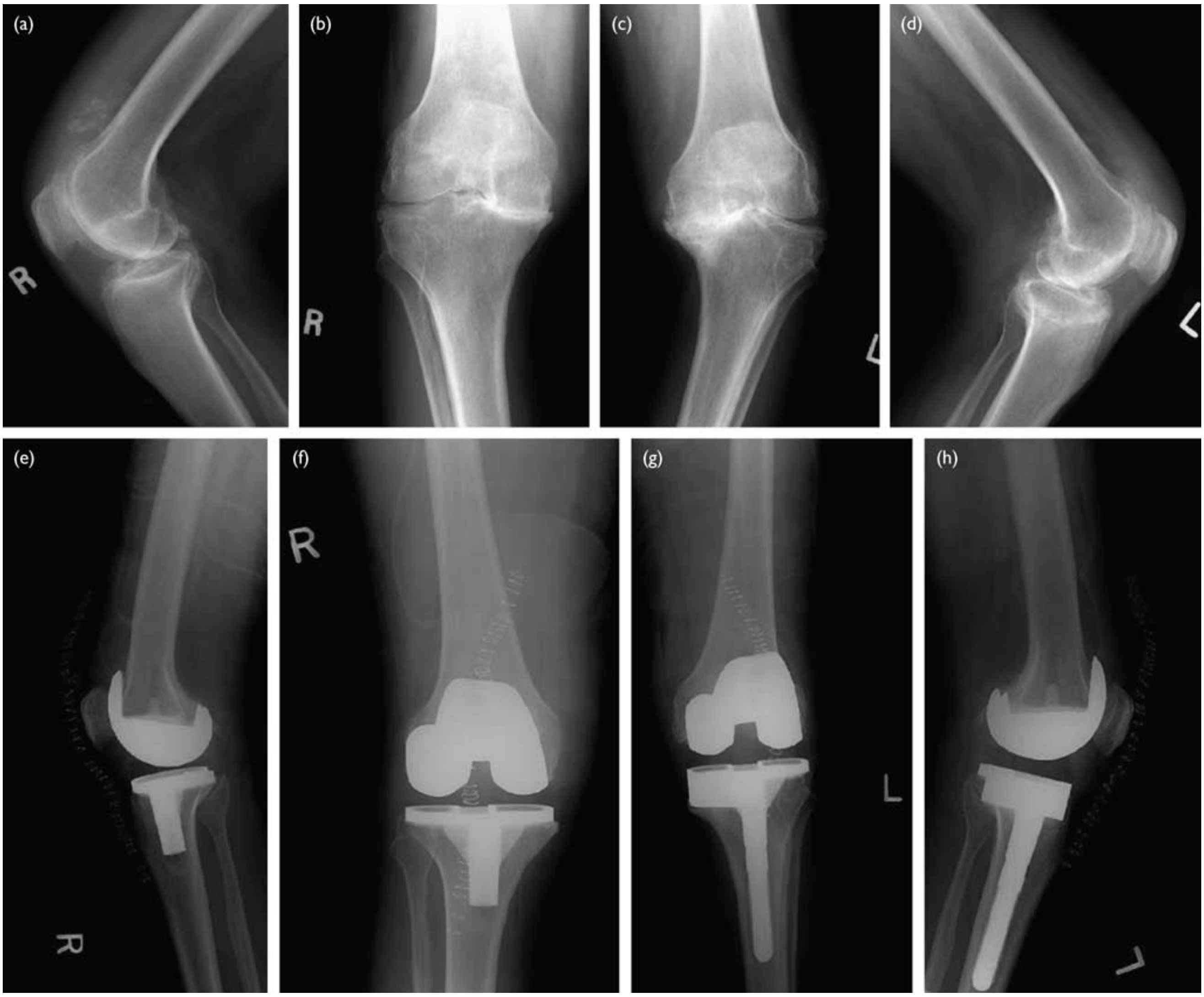
Modular metal blocks have three shapes: step wedge, hemiwedge, and full wedge. The step wedge block is available in three heights: 5, 10, and 15 mm. The hemiwedge block is available in two angles: 10 and 20°, and the full wedge block is available in two angles: 10 and 15°. The tibial medullary stem augments are of three lengths: 75, 115, and 150 mm, and the diameter is from 10 to 24 mm with a 2 mm increment.

The tibial medullary stem augment was used to improve the stability of the tibial component. Reaming was started with a small-diameter reamer and the medullary canal was sequentially reamed until a firm endosteal engagement was established, so that the stem is seated as press-fit and noncemented, whereas the implants were cemented at the metaphyseal interfaces. It was essential that the intramedullary stem be inserted centrally into the medullary canal. If there was a discrepancy between central medullary rod position and an optimally positioned joint surface, the difference was made up with augmentation wedges. In some cases, the tibial or the femoral surface had to be recut to conform to the wedges.

The different sizes and types of modular augments used, either as metal blocks or as medullar stems, are shown in (Table 1).

Intravenous cefazolin as an antibiotic (2 g administered one and a half hours before inflation of the tourniquet, followed by 1 g every8 h for 3 days) and subcutaneous enoxaparin as an antithrombotic (40 mg on the night before surgery and 40 mg daily continued through the seventh postoperative day) were used for prophylaxis in all patients, followed by administration of oral antithrombotic medication for three more weeks, in combination with compression stockings.

Figure 2



(a–d) Preoperative and (e–h) postoperative anteroposterior standing view and lateral view radiographs of a 72-year-old male patient. Varus of 20° was observed in the left knee preoperatively, which showed balanced alignment postoperatively on using a medial tibial metal block and tibial stem. The right knee shows less varus and was operated upon with no augmentations.

Postoperative management and care was similar for all patients. A splint was applied with the knee in 15° of flexion and was worn for the first 24 h after the operation. Rehabilitation started with continuous passive knee movement initiated at 60° and continued in an increasing manner gradually. All patients began walking with crutches or a walker and started active and passive range-of-motion exercises on the first day after the operation. The patients used crutches or a walker, with full weight bearing, for 6 weeks and then used a cane for 6 weeks under the supervision of a physical therapist.

All patients in this study remained in the hospital and received rehabilitation until safe, double-crutch mobilization was possible; they could ascend several stairs; and they could flex the knee to 90° or more.

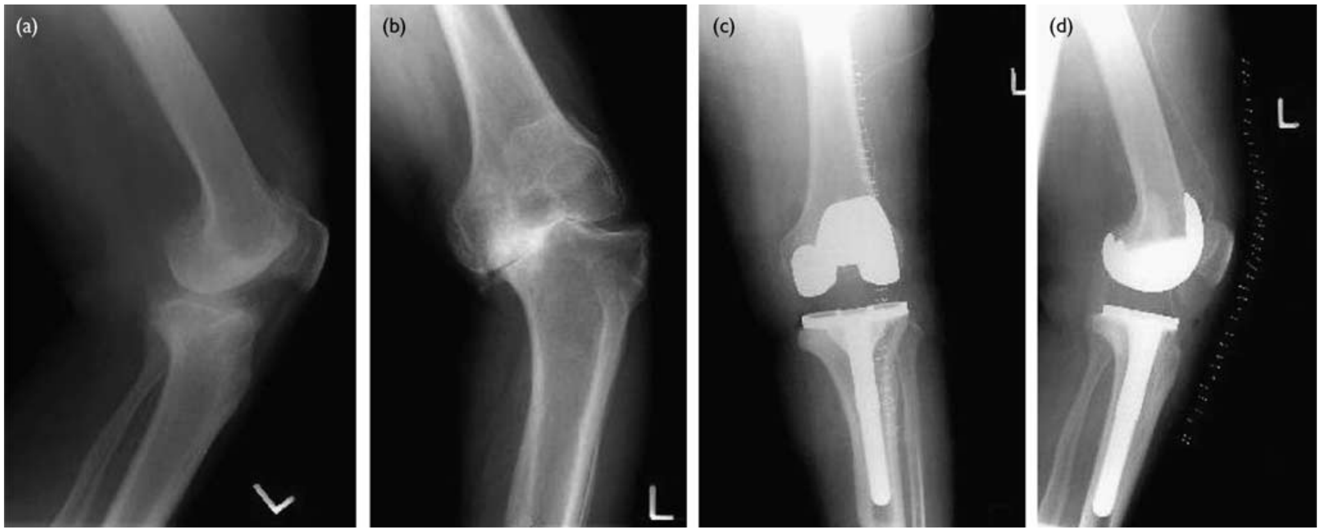
Clinical and radiographic evaluations were carried out postoperatively and at the latest follow-up. The position of the components was assessed and also evaluated for signs of loosening and or bone loss.

Outcomes were evaluated using the American Knee Society Score (0–100 points) [13]. The score was computed before surgery and at the latest follow-up and compared. Preoperative and postoperative range of motion was recorded.

The American Knee Society has proposed this rating system (the American Knee Society Score) to be simple but more exact and objective (Table 2).

This system is subdivided into a knee score that rates only the knee joint and a functional score that rates the patient's ability to walk and climb stairs. There are three main parameters: pain, stability, and range of motion. A total of 100 points will be assigned to a well-aligned knee with no pain, 125' of motion, and negligible

Figure 3



(a–b) Preoperative and (c-d) postoperative anteroposterior standing view and lateral view radiographs of a 65-year-old male patient. Varus of 32° was noted in the left knee preoperatively, which showed balanced alignment postoperatively on using a tibial stem.

anteroposterior and mediolateral instability. A total of 50 points is assigned to pain, 25 for stability, and 25 for range of motion [13].

Results

The mean follow-up period was 30 months (range 24–48 months). This study presents the results of a prospective clinical follow-up of 25 patients operated upon for TKA using P.F.C. Sigma Knee Replacement (DePuy Orthopaedics Inc.) with augmentation using metal blocks or wedges and stems.

The mean preoperative arc of motion was 66 ± 18° (range 50–100°). The mean improvement in the postoperative arc of flexion was 33 ± 17°. The average length of physiotherapy before resuming near-normal activities was 28 days (range 22–50 days).

The mean hospital stay was 8 days (range 7–15 days), and patients were discharged when could walk safely with the aid of double-crutch mobilization, could ascend several stairs, and flex the knee to 90° or more.

Before surgery, the average American Knee Society Score was 44 points (range 36–72). The average American Knee Society Score for all the knees at the final follow-up was 82 points (range 57–94). Improvement was significant.

Radiologically, there were no signs of loosening zones at the latest follow-up for all patients.

Medical complications were not recorded for any of the patients included in this study. One patient developed peroneal nerve palsy and was managed by removal of all constrictive dressings and repositioning of the knee to 20–30° of flexion. A plantigrade ankle foot orthosis was applied and stretching was started to prevent equinus contracture. After 2 months, EMG and nerve conduction studies showed recovery, and patients done well afterward.

Figures 1–5 show examples for the preoperative, postoperative, and follow-up radiological studies on TKA using different augmentation techniques for osteoarthritis of the knee joint.

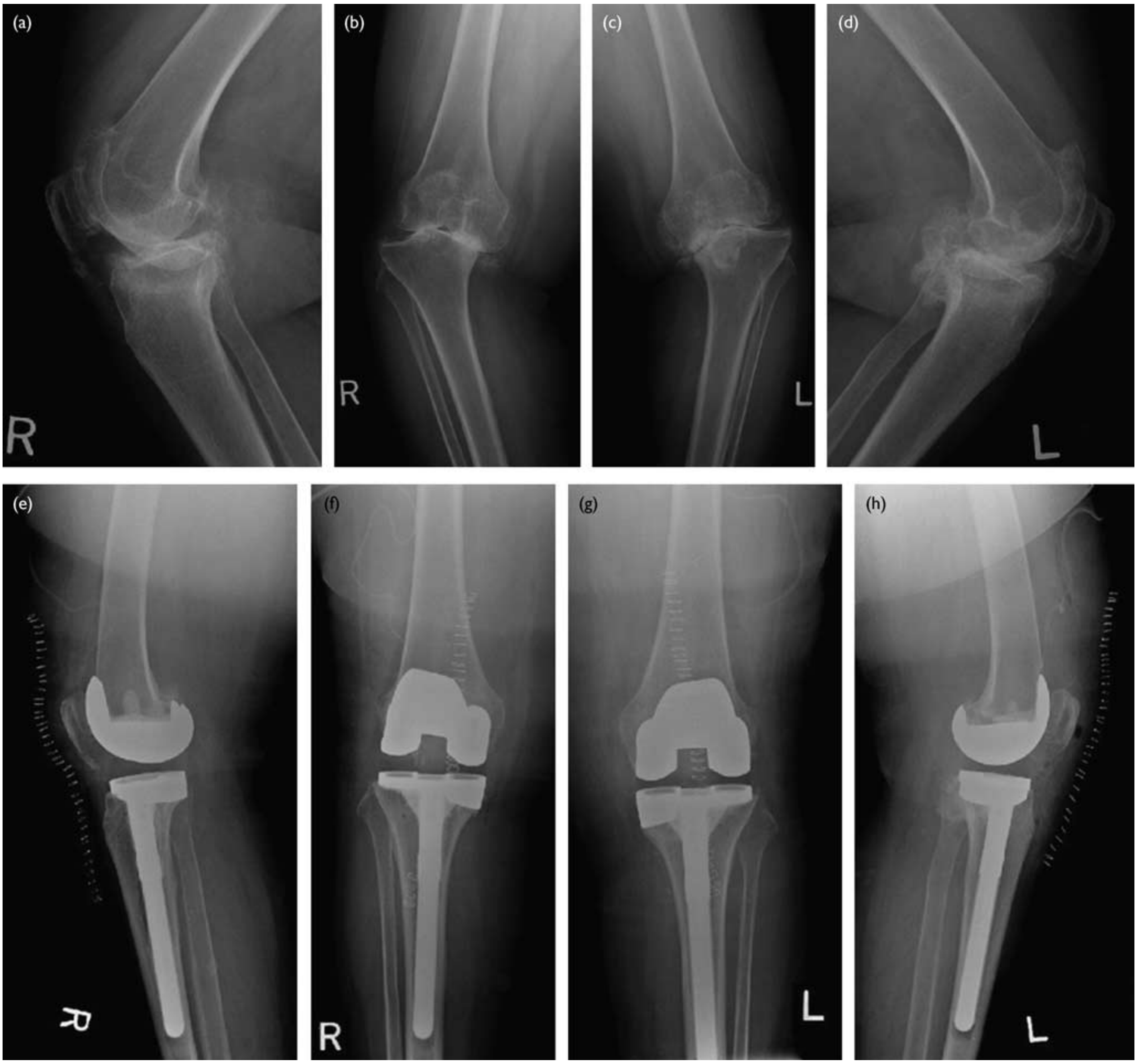
Discussion

To provide stable implant fixation and to reestablish the correct joint line in the case of bony defects, they can be treated with cement, modular augments, custom-made implants, and bone grafts [9,14,15]. The selection of the augmentation technique should be made on the basis of the defect size, patient age and life expectancy, and whether the prosthetic augments can be used in the vast majority of defects [16]. In this study, different modular augments were used to correct bony defects.

In the recent study by Kim *et al.* [6], the results in 94% of patients at a mean follow-up of 32 months were evaluated as good or excellent after using metal block, and there were no radiolucent lines beneath the bone–cement interface or the tibial tray. The same conclusion was drawn in this study with the same mean follow-up period.

Knees managed with intramedullary stem augmentation were found to have radio-opaque lines adjacent to the stem on follow-up radiographs. The sclerotic halo around the tip of the stem could be interpreted as evidence for the stem's function in load sharing and might reflect secure fixation of the tibial tray in the bony interface; this

Figure 4



(a–d) Preoperative and (e–h) postoperative anteroposterior standing view and lateral view radiographs of a 77-year-old female patient. Varus of 22° in the right knee and 20° in the left knee was observed preoperatively, which showed balanced alignment postoperatively on using a medial tibial metal wedge and a tibial stem in both knees.

might induce pain, which is called 'end of stem pain' [6]. This kind of pain was not encountered in this study, which may be because of the relatively short follow-up period.

Hernandez-Vaquero *et al.* [17], in their study, support the argument that the use of a cemented stem reduces proximal stresses but may result in proximal bone resorption. Although the use of a stem provides excellent resistance to lift-off and shear, proximal resorption may contribute toward tibial component loosening, which is a primary threat to survival and is a complication factor for revision surgery. All patients in this study underwent tibial stem augmentation and were noncemented with a cemented tibial tray.

Jazrawi and Bai [18] reported that press-fit stems provide stability equivalent to that provided by shorter cemented stems and do not increase proximal stress shielding. Cementless stems cause less stress shielding compared with cemented stems [19]. The use of short cemented stems is associated with less consistent results [20]. The current trend is to cement the condylar surface and use the stem in the cementless press-fit manner; this technique was used in all patients of this series.

Studies have been carried out to evaluate cemented and noncemented stems. Murray *et al.* [21] reviewed 40 revision TKAs with cemented stems at an average follow-up of 58 months and observed no reoperations for mechanical loosening. Whaley *et al.* [22] reviewed 38

Figure 5

(a–d) Preoperative and (e–h) postoperative anteroposterior standing view and lateral view radiographs of a 68-year-old male patient. Varus of 23° was observed in the right knee preoperatively, which showed balanced alignment postoperatively on using a medial tibial metal block and a tibial stem. The left knee showed less varus and was operated upon with no augmentations. (i–k) Four-year follow-up radiographs.

revision TKAs and found the 11-year component survivorship free of revision for aseptic loosening to be 95.7%. Haas *et al.* [19] studied 74 revision TKAs using cementless stems with an average follow-up of 3.5 years and observed 84% good or excellent results with an 83% survival at 8 years. Another study by Gofton *et al.* [23] reviewed 91 revision TKAs with 93.5% survival at 8.6 years. All tibial stems used in this series were non-cemented press-fit stems.

Varus deformities are usually located at the periphery in the posteromedial aspect of the tibia, and valgus deformities very often lead to contained posterolateral tibial defects in conjunction with a lateral femoral condylar deficiency. All patients had severe varus deformities of more than 20°. The reconstruction of bone loss is primarily based on intraoperative assessment [24]. For this purpose, all possible augments such as blocks or stems were available preoperatively in order to achieve a stable implant.

Mechanical loosening of the tibial component is a frequent cause of failure of TKA, and it is related to malalignment and unbalanced ligaments, with an unstable fixation or decreased bone quality near the prosthesis [25]. In this series, this fact was taken into consideration to achieve good alignment and balance during surgery.

There is no consensus on the length of the central stem to achieve the best load transfer and fixation, although the use of long stems on the tibial component is advocated; the role of tibial stem length in load transfer and fixation is still under debate [5]. In this study, stem length was varied and tailored as per requirement in each case to achieve mechanical stability.

Whittaker *et al.* [26] reported that when selecting the method of reconstruction and the materials for surgery, the potential for future further revision must be considered together with the life expectancy, functional demand, and comorbidities of the patient. Restoration of bone stock is preferable, particularly if a future further revision is considered likely. This was taken into consideration when choosing a suitable block of augment to save the bone as much as possible during surgery in this series of patients.

Despite the high mean age of the patients (up to 77 years), medical complications were not common.

This study has some limitations. These limitations are the relatively short duration of follow-up and the relatively small patient population sample. However, it included only one group of patients with primary TKA with the use of augments for primary osteoarthritis.

Conclusion

The use of modular metal block augmentation devices for peripheral tibial defects could be a simple, rapid, and dependable technique that yields predictable results. The inclusion of a medullary modular stem in the implant component confers more stability to the prosthesis and hence results in more longevity.

There are no standards for augmentation in primary TKA and each case should be dealt with according to the degree of deformity and bony defect intraoperatively after achieving stability and balance of the prosthesis and knee.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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