Structural autogenic grafts to manage medial tibial bone defects during primary total knee arthroplasty

Mostafa A. El-Khalik, Moheib Ahmed, Mahmoud A. El-Ghafar

Department of Orthopedic Surgery, Mansoura University, Mansoura, Egypt

Correspondence to Moheib Ahmed, MD, Department of Orthopedic Surgery, Mansoura University, Mansoura, 35516, Egypt.
Tel: +20 100 349 8196; fax: 05022267016;
e-mail: moheibahmed@yahoo.com

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Aim of study
The aim of the study is to compare the results of primary total knee arthroplasty with large bone defects treated with autologous bone grafts from resected bone cuts with a group of patients in whom knee arthroplasty was made without the need for bone grafting.
Patients and methods
In all, 256 knees of patients suffering from painful osteoarthritis and who were admitted to Mansoura University Hospital over a period between 2003 and 2007 were studied. Bone stock defects were treated in 79 knees by structural solid bone from resected bone cuts and were fixed by screws. The control group consists of 167 knees treated in the same period without the need for bone grafting and prostheses were implanted directly on the resected surfaces. All patients were assessed according to Knee Society Score (KSS) parameters. The radiographs were analyzed with special regard for: correctness of implant placement, presence of radiolucent zones both around implants and grafts, and bone grafts healing.
Results
Bone grafts were incorporated in 79 knees within an average of 5.6 months. There was no graft collapse or stress fractures, loosening, or nonunion. The minimum follow-up period was 10 years. The postoperative KSS of both groups (total knee replacement (TKR) with no grafting and TKR with grafting) improved markedly ($P<0.0001$) from the preoperative values, while the postoperative KSS did not differ significantly ($P=0.51$ and 0.66) between the two groups
Conclusion
The use of autologous bone grafting for bone stock reconstruction in primary TKA are comparable with the results of TKR without the need for bone grafting. Autogenic bone grafting for defects in TKR is justified as it is biological, naturally harvested, and is cost effective besides preserving bone stock for future revisions.

Keywords:
autogenous graft, total knee replacement, tibial defect

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Introduction

Lately presented osteoarthritic knees with severe varus deformity are frequently associated with uncontained proximal tibial bone defect. Restoring tibial bone defect is important to provide stable placement of the tibial component, proper alignment of the implant, and over all limbs. This in addition to soft tissue balance achieves best option for successful TKA outcome.

Many surgical techniques have been described to manage tibial defect encountered with primary TKA including cement filling with or without supporting screws, thicker tibial cut, tibial component lateralization, autogenic bone graft, metal augment, custom implant, and structural bone allograft [1–14].

The use of bone–cement and metallic wedge may not be appropriate to manage large bone defects, especially in young, active patients, and use of thicker cut or putting tibial tray more laterally have many biomechanical drawbacks. There are many drawbacks that may be associated with the use of allograft or metal augments [14–17].

The use of bone grafts from already available resected bone cuts provide many benefits, allowing thinner cuts to preserve strong proximal tibial bone for optimal thickness of cement and implant fixation, bone graft added to bone stock for future revision especially with young adults. The use of grafts from resected cuts are cost effective, naturally available, and are technically easy [5–8].

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Reports on the outcome of autogenic grafting for tibial bone defect is still controversial. The study by Watanabe *et al.* [5] documented that 3% of bone grafts for tibial bone defect failed at 6.8 years after TKA and Laskin [18] reported 33% failure rate at 5 years after TKA for large tibial defects while Ahmed *et al.* [6] reported there was no case of failure during 10 years of the follow-up period.

The current study is a long-term prospective study designed to evaluate the clinical and radiological outcomes of primary TKA in marked deformity with medial tibial bone defects. This defect is managed by autogenic bone graft and the outcomes are compared with those of standard TKA without significant bone defects.

Patients and methods

The present study included 256 cases suffering from painful osteoarthritis presented to Mansoura University Hospital over the period between 2003 and 2007. They were scheduled for primary TKA, for participation in a prospective study. Four patients died during the period of study due to causes unrelated to the surgical intervention and six patients were lost to follow-up and were excluded from the study. The patients were divided into two groups, control group of 167 knees without tibial grafting and the grafted group consisted of 79 knees had tibial bone defects managed by structural grafting.

All patients provided informed consent and the study protocol has ethics committee approval.

The mean age of the patients at the time of the index surgery was 56.7±6.8 years (range, 46–70 years) and the mean BMI was 34.2±4.58 kg/m^2 (range, 26–50 kg/m^2). The preoperative diagnosis was osteoarthritis in all cases. Preoperatively, there was no significant difference between the two groups regarding age, BMI, sex, side, pain, range of motion, radiographic alignment, and clinical or function Knee Society Score (KSS) (Table 1).

During the study period, we used cemented, stabilized TKA (Zimmer NexGen LPS, Zimmer Biomet, Warsaw, IN, USA). In expected cases with extensive tibial bone defects or severe lateral ligament laxity, we prepared for primary TKA and a backup for the revision system was always available. The decision to select the revision system was confirmed by intraoperative findings only, while the patients with major angular deformity that clearly required an osteotomy or use of a more constrained design were early excluded. Structured bone graft from the distal femoral cut or the lateral tibial condyle cut was applied when the bone defect after bone cutting comprised an area of more than 50% of a single condyle to a depth of more than 5 mm and not more than 25 mm. Meanwhile, when the defect was smaller than 5 mm in depth, cement filling, and/or increased tibial bone resection were performed. When the defect was more than 25 mm in depth, modular prosthesis with metal wedges or block was used.

Table 1 Patient's characteristics and preoperative knee scoring

	TKA, no grafting (*N*=167 cases)	TKA, grafting (*N*=79 cases)	*P* value
Age (years)	56.8±7.1	56.2±6.1	*0.66*
Sex (male/female %)	14/86	23/77	0.22
Side (right /left %)	51/49	39/61	0.30
BMI (kg/m^2)	33.9±4.6	34.6±4.2	0.35
Preoperative pain	17.7±5.64	12.5±4.0	0.07
Postoperative pain	46.4±5.7	45.1±2.5	0.51
P value	0.00	0.00	
Preoperative range of motion	18.7±4.4	18.1±2.1	0.55
Postoperative range of motion	21.1±2.0	20.1±1.1	0.07
P value	0.00	0.00	
Preoperative knee scoring	27.2±15.4	16.8±8.0	0.06
Postoperative knee scoring	89.9±11.2	88.9±4.9	0.66
P value	0.00	0.00	
Preoperative walking	17.2±9.2	11.7±6.9	0.67
Postoperative walking	40.7±6.9	39.1±4.7	0.11
P value	0.00	0.00	
Preoperative stair clamping	19.4±14.2	14.6±7.2	0.84
Postoperative clamping	36.3±7.4	34.2±5.0	0.15
P value	0.00	0.00	
Preoperative function score	32.6±22.3	25.1±13.2	0.38
Postoperative function	74.7±13.2	73.1±6.6	0.49
P value score	0.00	0.00	

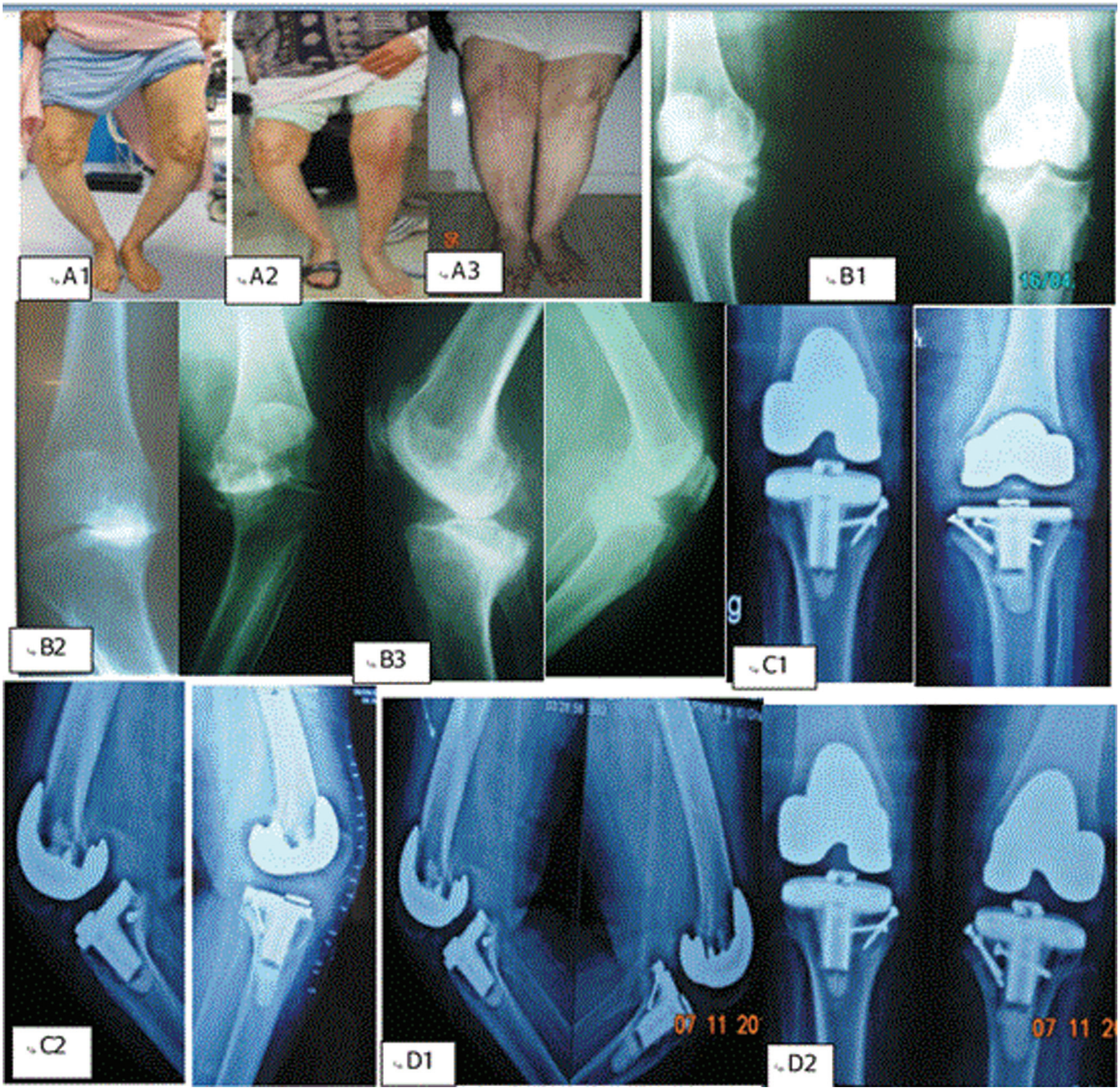
The comparisons were made with use of the independent samples *t* test or χ^2 test as appropriate. The values are given as the mean ±SD.

Surgical technique

Surgeries were done under spinal or general anesthesia using a pneumatic tourniquet and through the paramedical standard approach. The most common defect of a varus knee is presented in the posteromedial region of the tibia and is defined by the presence of a stony subchondral sclerosis. Thin tibial cut (6–8 mm from the lateral plateau) was resected and then the defect on the proximal tibia was measured as regards width and depth, using a millimeter scale. The proximal tibial cut width was also measured and the ratio of the defect to proximal tibial cut surface was calculated. Defects that involved between 25 and 50% of the tibial cut surface and measuring more than 5 mm in depth (range, 5–25 mm) were bone grafted using structural grafts. When the depth of the tibial defect is more than 25 mm, there was a poor quality of bone of proximal tibia or the patient was morbidly obese, tibial stem extension was used. The sclerosed edge of the tibial defect was managed by an oblique cut to freshen the edges for graft incorporation by using a saw and multiple drilling. The aim of surface preparation was to reach the cancellous, porous trabecular bone. Bone grafts originating from the proximal tibial cut or distal femur cut were fashioned to fit into the defect and then fixed with screws by using a technique described by Sculco [14].

Postoperative care was identical for patients who underwent TKA without the bone graft. Weight bearing and walking exercises were initiated at the

Figure 1



A1: preoperative photo, A2: postoperative photo after Unilateral TKR, A3: postoperative photo after Bilateral TKR; B1: preoperative anteropostrior radiography nonwieght bearing, B2: preoperative anteropostrior radiography, weight bearing, B3: preoperative lateral radiography; C1: postoperative radiography anteropostrior, C2: postoperative radiography lateral; D1:final follow-up radiography anteropostrior, D2: final follow-up radiography lateral.

first postoperative day; nevertheless, the range of motion exercises were performed without restriction. The patients were evaluated clinically and radiographically according to the Knee Society Clinical and Radiological Rating System [19,20] KSS system was assigned preoperatively at 6 weeks, 3 months, 6 months, and 1 year; and annually thereafter. The radiographs were analyzed with special regard for: implants alignment, any radiolucency around implants or grafts, and bone grafts healing. Graft incorporation on the radiograph was evaluated by two criteria: (a) presence of continuity of trabecular lines between the graft and the host bone and (b) inability to determine the boundary between the graft and the host bone.

Statistical analysis

Data were analyzed using the statistical package for the social sciences, version 16. Qualitative data were presented as number and percent. Statistical evaluation was performed using the independent sample *t* test or χ^2 test as appropriate. The values are given as the mean and SD. Statistical significance was considered for *P* values less than 0.05 (Fig. 1).

Results

Results for each parameter of the KSS system for both groups were obtained from clinical evaluation at 10 years follow-up as shown in Table 1.

The postoperative KSS of both groups (total knee replacement (TKR) with no grafting and TKR with grafting) improved markedly ($P<0.0001$) from the preoperative values, while the postoperative KSS pain and clinical scores did not differ significantly (P=0.51 and 0.66) between the groups. Although, both the KSS functional score did not differ significantly (P=0.49) between the groups, it improved significantly compared with the preoperative value ($P<0.001$). Both groups demonstrated a superior postoperative range of motion as measured with a goniometer with no significant difference between them. The preoperative flexion contracture improved significantly in both groups. There was no significant additional cost for TKR with the grafting group relative to other groups (Fig. 2).

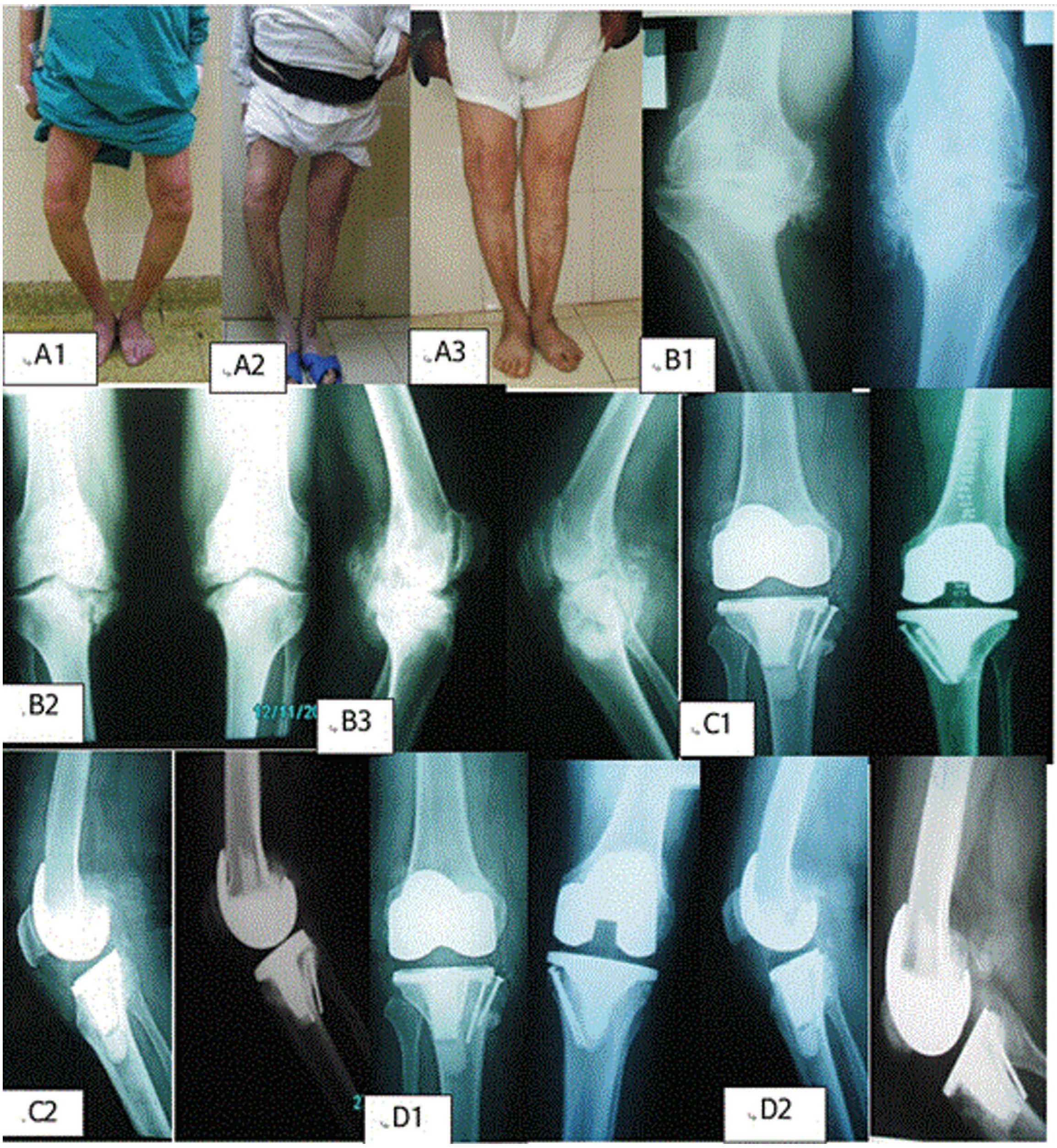
TKA with the grafting group had 97.4% success rate with 94.8% excellent and good results. Poor result was 2.6%. One case was candidates for revision due to deep infection that required a two-stage exchange arthroplasty. All the patients had complete incorporation of the grafts on average 5.6 months (range, 4.5–8 months) based on the criteria mentioned above. The incorporation of smaller grafts (<25–50% of tibial surfaces with a depth of <5 mm) was faster than larger grafts that need more time for creeping substitution. There were no late (>6 months) failures due to graft absorption. Nonunion of the graft, collapse, stress fractures, or loosening was not seen in any of the cases. Aseptic implant loosening was not seen. Tibial stem extension was used in 23 cases from the 79 cases of the grafted group. Stem extension uses were indicated in cases that have large defects (>50% of the total tibial surface), smaller defects in morbidly obese patients, and lastly in cases with medial –tibial defect and lateral tibial osteoporosis.

Radiographic parameters that were measured did not vary significantly between the two groups of the study (Table 2). Preoperative anatomic alignment of TKA with the bone graft group ranged from 40° to 15° anatomical varus (mean, 22.3° of varus), which improved postoperatively to an average of 5.27° of anatomical valgus, alignment of the femoral component in the coronal and sagittal plane, alignment of the tibial component in the sagittal and coronal planes, and patellar tracking were similar between the two groups.

Discussion

In Egypt, the incidence of presence of obesity and clinically presented knee osteoarthritis especially in women over 50 years is high [21,22]. But in this developing country and due to of financial causes, people presented for knee replacement very late with severe deformity and bone loss. Large peripheral bone defects of proximal tibia of the osteoarthritic knee usually present a challenge during performing a primary TKR with severe varus deformity. As a rule, if the bone deficiency is more than 25% of the remaining supporting cancellous bone of tibial cut, reinforcement of the bone defect is indicated. The asymmetrical bone defect can be managed using bone–cement, cement with screws, increased tibial resection, bone grafting, custom implants, or metal wedges [5–15]. Bone–cement with or without screws are optimal for small defects of less than 5 mm or 10 mm after the tibial cuts, respectively [23]. Resection of more than 9 mm from the intact surface of the tibia is not recommended as it compromises correct wising and fixation of the tibial tray [24]. The use of structural allografts has many drawbacks such as donor availability, risk of infection,

Figure 2



A1: preoperative photo, A2: postoperative photo after Unilateral TKR, A3: postoperative photo after Bilateral TKR; B1: preoperative anteropostrior radiography nonwieght bearing, B2: preoperative anteropostrior radiography, weight bearing, B3: preoperative lateral radiography; C1: postoperative radiography anteropostrior, C2: postoperative radiography lateral; D1:final follow-up radiography anteropostrior, D2: final follow-up radiography lateral.

graft absorption, bad incorporation, and refractures. While the use of metallic augments allows selective managing of severe bone loss in the tibia (>25% of the tibial cut surface) allows immediate weight bearing and durable stability. But augments are expensive and it does not restore bone stock needed for further revision in young patients [25].

All the above-mentioned limitations and drawbacks can be solved if we use autografts from resected bone cuts that provide many benefits, allowing thinner bone cuts that preserve strong supporting cancellous bone of the proximal tibia, leading to optimal cement mantle and durable implant fixation. Advantages of bone graft includes adding bone stock for future revision especially with young adults, naturally available, grafts from resected cuts reduced the cost, technically easy, and reduces the need for custom implants and prevents implant failure by successful reconstruction of large osseous defects with no risk of nonunion, infection, or disease transmission [5–8] (Fig. 3).

In this prospective study, our aim was to report the outcomes of primary TKR with the use bone grafts from resected cuts that accurately fitted and fixed by screws to well-prepared recipient defects of the medial tibial condyle. We used at least two screws for initial stability of the graft and for compressing the graft to the prepared surfaces. The 10-year results of TKRs with grafts were compared with the control group of normal TKRs and show no differences. The postoperative KSSs improved significantly and there were no graft failures or aseptic loosening in the period of study.

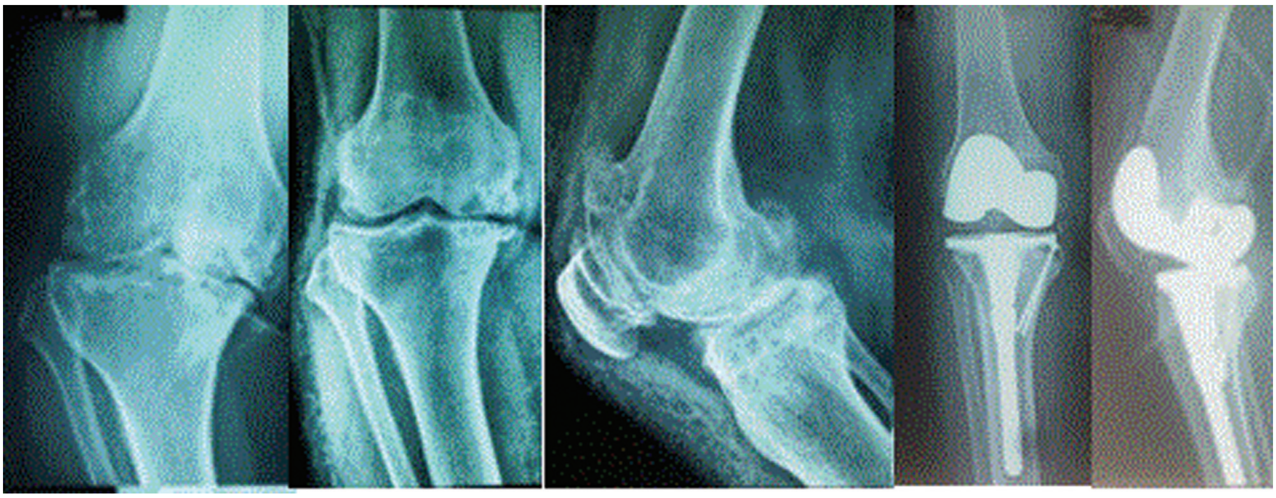
Table 2 Preoperative and postoperative radiological evaluation

Radiographic parameters	TKA, no grafting (*N*=167 cases) (deg.)	TKA, grafting (*N*=79 cases) (deg.)	*P* value
Axial			
Preoperative	10.6 ±14.6 of varus	22.3±9.3 of varus	0.00
Postoperative (angle omega)	6 ±1.5 of valgus	5.27±2.85 of valgus	0.84
Femoral component			
Coronal (alpha angle)	96.6±0.76	95.8±1.05	0.49
Sagittal (angle gamma)	0.18±0.62	0.43±1.36	0.19
Tibial component			
Coronal (angle beta)	89.37±1.57	88.58±2.81	0.06
Sagittal (angle sigma)	84.8±0.75	84.92±0.93	0.32
Patellar tracking			
Normal	160 cases	79 cases	0.76
Tilt	7 cases		
Radiolucent line nonprogressive (%)			
Tibial components	15.3	2.5	0.43
Femoral components	17	2.5	

For excellent graft incorporation Dorr [26] enumerates the following steps: (a) making host bony bed viable with bleeding surfaces, (b) ideal fitness of the graft to the defect with proper fixation, (c) full coverage of the graft by the tibial component and avoid unloading of the graft to prevent resorption and collapse of the graft, (d) avoid overloading of the graft by correct alignment of the components and limb with limiting weight bearing until union, (e) stem extension uses are indicated in cases that have large defects (>50% of total tibial surface), smaller defects in morbidly obese patients, and lastly in cases with medial tibial defect and lateral tibial osteoporosis.

Many reports encourage the use of autogenous grafts for labial defect. Ahmed *et al.* [6] reported absence of graft failure after a period of follow-up of 10 years. Watanabe *et al.* [5] performed autologous bone grafting in 30 TKRs with no screws and all cases showed successful healing. Parks and Engh [27] showed excellent clinical results of TKR with bone graft after evaluating the histopathology of nine bone grafts (autografts and allografts). All cases showed no change in the bone–cement interface, no graft collapse. The authors recommend the use of autografts in primary TKR. Kharbanda and Sharma [3] used autogenic bone grafts in 54 knees at 7.8 years of average follow-up. The graft incorporation occurred within 6 months without collapse, loosening, or nonunion. Liu *et al.* [10] operated 50 knees with medial tibial bone grafts using screws for fixation and found no differences on the outcome with the control group of TKA with no significant defects. They reported 6% of failure rate of the graft. Gaweda *et al.* [28] compared the results of TKR with bone grafting

Figure 3



A case of sever posteromedial defect that was managed by autogenous graft that fixed by screws and protected by stem.

(both solid and morselized) in 37 knees with 37 normal TKRs without the use of bone grafts and found no difference in the long-term outcome of two groups. Bone grafts healed in 21 knees.

On the other hand, Laskin reported a high failure rate (33% after a 5-year follow-up) after treatment of large tibial bone defects during primary TKA in patients with severe mediolateral instability using autogenic bone graft and proper soft tissue balance. The authors recommend the use of prosthetic blocks or wedges in large tibial defects but to continue to use bone grafting for smaller, circumscribed defects. So, the use of autogenous grafts on large tibial defects of more than or equal to 40% of cut surfaces with a depth of more than 2 cm has some limitations. During the preparation of the host bed of defect, the sclerotic bone should be completely removed to expose viable cancellous bone, this making the defect larger. Here autogenous bone grafts obtained from resected cuts may not be sufficient for grafting; therefore, the use of metal augment in these cases may be more reasonable.

Stem uses in TKA is to provide more support for implant fixation, to distribute shear stress, and to reduce stress on the graft–host interface and proximal tibia [29,30]. In 21 cases of the grafted group of this study, we used stems to protect the graft from collapse in large defects (≥40%) to distribute stress in the proximal tibia in cases with poor bone quality.

Conclusion

The use of autologous bone grafting for bone stock reconstruction in primary TKA is comparable with the results of TKR without the need for bone grafting. The value of this method increased because autologous grafting is a simple technique, accessible, inexpensive, and effective with good midterm results. Structural autogenic grafts should be used in defects more than 5 mm deep and involving 25–50% of the cut proximal tibial condyle surface during primary TKA. The use of a stem to protect tibial tray fixation is indicated for large defects (≥40%).

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Nil.

Conflicts of interest

There are no conflicts of interest.

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