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Original Research Article

FUNCTIONAL OUTCOME OF TOTAL KNEE REPLACEMENT IN PATIENTS WITH TIBIAL AND FEMORAL DEFECTS MANAGED WITH METALLIC AUGMENT VERSUS AUTOLOGOUS BONE GRAFTING

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ABSTRACT

Background: Advanced knee osteoarthritis may be associated with tibial and femoral bone defects that complicate total knee replacement by compromising implant support, alignment, joint line restoration and early stability. Metallic augments provide immediate mechanical support, whereas autologous bone grafting offers biological reconstruction and preservation of bone stock. The objective is to evaluate and compare the functional outcomes of total knee replacement in patients with tibial and femoral bone defects managed using metallic augments versus autologous bone grafts.

Materials and Methods: This prospective and retrospective comparative study was conducted in the Department of Orthopaedics, Subharti Medical College, Meerut. A total of 33 patients with tibial and/or femoral bone defects >5 mm and <25 mm undergoing primary total knee arthroplasty were included. Fifteen patients were managed with metallic augmentation and 18 patients with autologous bone grafting. Patients were assessed using Visual Analog Scale (VAS), Knee Society Score (KSS), Oxford Knee Score (OKS), range of motion (ROM), gait recovery, weight bearing, radiological alignment, loosening, graft incorporation and complications. Data were analysed using Microsoft Excel 2019 and SPSS version 21.0, with $p < 0.05$ considered statistically significant.

Results: The study included 33 patients, with 15 in the Metallic Augment group and 18 in the Autologous Bone Graft group. AORI Type 2 defects were the most common, occurring in 24 patients. Mean defect size was 13.47 ± 5.99 mm in the Metallic Augment group and 16.11 ± 4.96 mm in the Autologous Bone Graft group. Metallic augmentation allowed earlier weight bearing (1.67 ± 0.49 weeks vs 5.06 ± 0.94 weeks) and independent gait (3.53 ± 0.99 weeks vs 6.78 ± 1.06 weeks). At final assessment, KSS was 89.93 versus 88.89, OKS was 44.00 versus 44.94, and ROM was 113.33° versus 108.11° in the Metallic Augment and Autologous Bone Graft groups, respectively. Within-group functional improvement was significant ($p < 0.001$), while between-group differences were not significant.

Conclusion: Both metallic augmentation and autologous bone grafting were effective for managing tibial and femoral bone defects during primary total knee replacement. Metallic augmentation provided earlier weight bearing and gait recovery, while autologous bone grafting enabled biological reconstruction and bone stock preservation. Final functional and radiological outcomes were comparable between groups.

Keywords: Total knee replacement, Total knee arthroplasty, tibial defect, femoral defect, metallic augment, autologous bone graft, AORI classification, Knee Society Score, Oxford Knee Score.

INTRODUCTION

Knee osteoarthritis is one of the most common disabling musculoskeletal disorders and remains a major indication for total knee arthroplasty. Progressive degenerative joint disease produces cartilage degeneration, subchondral bone changes, osteophyte formation, synovial inflammation and mechanical failure of the joint. In advanced disease, structural deformity may be associated with defects of the tibial plateau and, less commonly, the femoral condyles. These osseous deficiencies are particularly important during total knee replacement because they directly influence implant stability, joint line restoration and postoperative alignment.[1,2]

In varus knees, chronic medial compartment overload can produce asymmetrical wear and erosion of the medial tibial plateau. Defects may be contained, with preservation of the cortical rim, or uncontained, with peripheral deficiency. Femoral condylar defects can also occur in severe deformity and may affect flexion gap balance and rotational alignment. Inadequate management of such defects can lead to malalignment, instability, implant loosening and early failure of the prosthesis.

Several reconstructive strategies are available for bone defects encountered during total knee replacement. These include bone cement with or without screws, modular metallic augments, autologous bone grafts, allografts, metaphyseal sleeves and porous metal cones. The choice depends on defect size, containment, bone quality, ligament stability, AORI type and the need for immediate mechanical support.[3-5]

Metallic augments provide predictable mechanical support, restore the deficient bony surface and allow early weight bearing. However, they do not restore bone stock and may create concerns during future revision surgery. Autologous bone grafting uses the patient's own resected bone and offers osteogenic, osteoinductive and osteoconductive potential, with the advantage of biological incorporation and preservation of bone stock. Its limitations include technical demand, graft resorption, delayed union and delayed rehabilitation in selected cases.[6-8]

The present study was conducted to evaluate and compare functional, radiological and early postoperative outcomes of total knee replacement in patients with tibial and femoral defects managed using metallic augments versus autologous bone grafting.

MATERIALS AND METHODS

Study Design: Prospective and retrospective comparative study.

Study Area: Department of Orthopaedics, Subharti Medical College, Meerut.

Study population: IPD patients with tibial and/or femoral bone defects undergoing primary total knee replacement.

Sample size: 33 patients.

Study duration: 2 years.

Study groups: Group 1 included 15 patients managed with metallic augmentation. Group 2 included 18 patients managed with autologous bone grafting.

Inclusion Criteria

Patients with bone defect >5 mm and <25 mm in tibia or femur or both were included. The outcomes assessed included restoration of longitudinal, rotational and angular stability, restoration of the joint line, restoration of soft tissue stability and reconstitution of bone.

Exclusion Criteria

Patients not willing or medically unfit for surgery, patients undergoing knee replacement with history of trauma, patients without bone defect and patients undergoing revision arthroplasty were excluded.

Follow-up protocol: Patients were followed after surgery using standardized clinical, functional and radiological parameters at 3 months and 6 months. Pain, gait, radiological findings and functional ability in activities of daily living were assessed.

Outcome assessment: Pain was assessed using VAS. Functional outcome was assessed using KSS and OKS. ROM, time to weight bearing, time to independent gait, time to union in the autologous graft group, postoperative mechanical axis, radiological loosening, infection, DVT and delayed union were recorded.

Statistical Analysis: Data were entered in Microsoft Excel 2019 and analysed using SPSS version 21.0 (IBM Corp., Armonk, NY). Categorical variables were expressed as frequencies and percentages, whereas continuous variables were expressed as mean ± standard deviation. Student's t-test, Mann-Whitney U test, Chi-square test and Pearson or Spearman correlation were used as appropriate. A p-value of <0.05 was considered statistically significant.

RESULTS

Baseline Demographic Characteristics

The study included 33 patients, with 15 patients in the Metallic Augment group and 18 patients in the Autologous Bone Graft group. Age distribution included 8 patients aged <60 years, 19 patients aged 60-69 years and 6 patients aged ≥70 years. There were 15 males and 18 females. Diabetes mellitus was present in 10 patients, hypertension in 6 patients, combined hypertension with diabetes mellitus in 7 patients and no major comorbidity in 10 patients.

Table 1: Defect characteristics between study groups

Variable	Category / Parameter	Metallic Augment (n=15)	Autologous Bone Graft (n=18)	Total / Result
AORI classification	Type 1	6	3	9
AORI classification	Type 2	9	15	24
Defect size	Mean ± SD	13.47 ± 5.99 mm	16.11 ± 4.96 mm	-
Defect containment	Contained	7	10	17
Defect containment	Uncontained	8	8	16

AORI Type 2 defects were more frequent than Type 1 defects. Mean defect size was higher in the Autologous Bone Graft group, while contained and uncontained defects were nearly equally distributed overall.

Table 2: Intraoperative and early postoperative parameters

Parameter	Metallic Augment (n=15)	Autologous Bone Graft (n=18)
Bone Reconstitution	15 No	18 Yes
Time to Union (weeks)	-	4.17 ± 0.71 (3-5)
Weight Bearing (weeks)	1.67 ± 0.49 (1-2)	5.06 ± 0.94 (4-6)
Independent Gait (weeks)	3.53 ± 0.99 (2-5)	6.78 ± 1.06 (5-8)

Metallic augmentation provided immediate structural stability, allowing earlier weight bearing and independent gait. Autologous bone grafting required time for biological incorporation, although radiological union occurred within 3-5 weeks in all cases.

Pain reduction was clinically evident in both groups, and within-group reduction in VAS was statistically significant in both groups ($p < 0.001$).

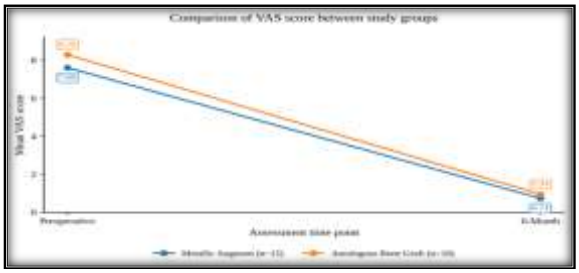

Figure 1: Comparison of VAS score between study groups

Table 3: Functional outcome comparison at final assessment

Functional parameter	Metallic Augment	Autologous Bone Graft	Within-group improvement	Between-group difference
6-Month KSS	89.93	88.89	p <0.001 in both groups	Not Significant
6-Month OKS	44.00	44.94	p <0.001 in both groups	Not Significant
6-Month ROM	113.33°	108.11°	p <0.001 in both groups	Not Significant

Both groups demonstrated significant postoperative functional improvement. Final KSS, OKS and ROM were comparable between groups without statistically significant intergroup difference.

Table 4: Radiological outcome comparison

Radiological parameter	Metallic Augment (n=15)	Autologous Bone Graft (n=18)
Post-op Mechanical Axis (mean ± SD)	5.0 ± 0.0°	5.0 ± 0.0°
Radiological Loosening	0	0

Postoperative radiographs demonstrated restoration of mechanical alignment in both groups, with no radiological loosening in either group.

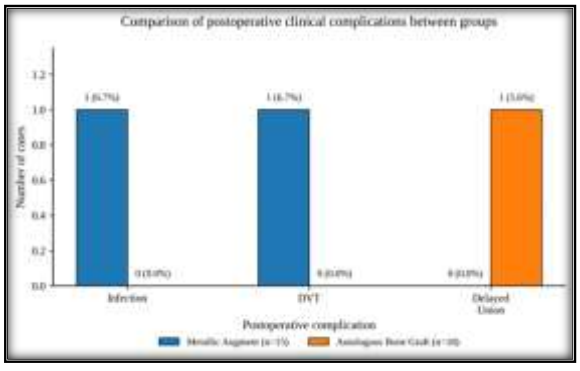

Figure 2: Comparison of postoperative clinical complications between groups

Clinical complication rates were low in both groups. Infection and DVT occurred in the Metallic Augment group, while delayed union occurred in the Autologous Bone Graft group. These differences were not statistically significant.

DISCUSSION

The current research was carried out in the Department of Orthopaedics, Subharti Medical College, Meerut over a two-year period. A total of 33 patients with tibial and/or femoral bone defects ranging from >5 mm to <25 mm undergoing primary total knee arthroplasty were included. Fifteen patients were managed with metallic augmentation and 18 patients were managed with autologous bone grafting. The study compared restoration of alignment, joint line integrity, mechanical stability and functional recovery using clinical and radiological parameters at follow-up.

The demographic profile showed that the 60-69-year age group was the most common, comprising 19 out

of 33 patients. Eight patients were aged <60 years and 6 patients were ≥70 years. The study population included 18 females and 15 males, showing a slight female preponderance. Comorbidity analysis showed diabetes mellitus in 10 patients, hypertension in 6 patients, combined hypertension and diabetes in 7 patients, and no major comorbidity in 10 patients. This baseline distribution was reasonably balanced between the two study groups.

Defect analysis showed that AORI Type 2 defects were more common than Type 1 defects. Type 2 defects were present in 24 patients, while Type 1 defects were seen in 9 patients. The mean defect size was 13.47 ± 5.99 mm in the Metallic Augment group and 16.11 ± 4.96 mm in the Autologous Bone Graft group. Contained defects were observed in 17 patients and uncontained defects in 16 patients. These findings indicate that both groups included clinically relevant metaphyseal defects requiring structural or biological reconstruction.

Metallic augmentation provided immediate structural support and allowed earlier rehabilitation. Mean time to weight bearing was 1.67 ± 0.49 weeks in the Metallic Augment group compared with 5.06 ± 0.94 weeks in the Autologous Bone Graft group. Similarly, independent gait was achieved earlier in the Metallic Augment group at 3.53 ± 0.99 weeks compared with 6.78 ± 1.06 weeks in the Autologous Bone Graft group. This supports the mechanical advantage of metallic augmentation in providing early construct stability.

Autologous bone grafting provided biological reconstruction and preservation of bone stock. In the Autologous Bone Graft group, all 18 patients underwent bone reconstitution and radiological union occurred at a mean of 4.17 ± 0.71 weeks, with a range of 3-5 weeks. This finding supports the utility of autologous grafting in selected patients, particularly where biological restoration and preservation of future revision options are important.

Both groups demonstrated significant improvement in pain and functional outcome. VAS improved significantly in both groups, with within-group significance of $p < 0.001$. KSS at final assessment was 89.93 in the Metallic Augment group and 88.89 in the Autologous Bone Graft group. OKS was 44.00 and 44.94, respectively. ROM was 113.33° in the Metallic Augment group and 108.11° in the Autologous Bone Graft group. Although the Metallic Augment group showed slightly higher ROM, the intergroup difference was not statistically significant. Radiological outcomes were satisfactory in both groups. The postoperative mechanical axis was 5.0 ± 0.0° in both groups. No patient developed radiological loosening. In the autologous graft group, graft incorporation was observed without collapse or component subsidence. These findings were comparable with Sugita et al. and Hosaka et al., who reported stable graft union and maintained alignment after autologous bone grafting in primary total knee arthroplasty.[6,7]

The present findings are also consistent with Sohn et al., who reported that autologous impaction grafting did not compromise long-term survivorship or functional outcome.[8] The mechanical advantage of metallic augmentation is supported by biomechanical work by LaMonica et al., who showed that augment thickness, polyethylene thickness and stem length influence tibial baseplate load transfer in revision total knee arthroplasty.[9]

Literature on severe bone defects also supports the role of porous metallic metaphyseal fixation in selected cases. Spinello et al., Eder Halbedl et al., Zampieri et al. and other authors have reported satisfactory outcomes with tantalum cones and metaphyseal fixation in complex revision settings.[10-12] However, the present cohort consisted of moderate defects, mainly AORI Type I and Type II patterns, where both metallic augmentation and autologous bone grafting produced comparable results.

The overall complication rate was low. Infection was recorded in 1 patient in the Metallic Augment group and none in the Autologous Bone Graft group. DVT occurred in 1 patient in the Metallic Augment group and none in the Autologous Bone Graft group. Delayed union occurred in 1 patient in the Autologous Bone Graft group and none in the Metallic Augment group. No statistically significant difference was observed between groups for these complications.

The limitations of this study include the small sample size of 33 patients, single-centre design and relatively short follow-up. Long-term follow-up is required to evaluate late graft resorption, stress shielding, aseptic loosening, implant survivorship and revision-related outcomes. Further studies with larger cohorts and advanced imaging-based defect assessment may help refine patient-specific reconstructive algorithms.

CONCLUSION

The present study demonstrated that both metallic augmentation and autologous bone grafting are effective reconstructive options for managing moderate tibial and femoral bone defects during primary total knee replacement. Both techniques achieved acceptable mechanical alignment, implant stability, pain relief and functional improvement. Metallic augmentation provided earlier weight bearing and earlier independent gait because of immediate structural stability. Autologous bone grafting provided biological reconstruction, graft incorporation and preservation of bone stock. No statistically significant difference was found between the groups in final functional outcome, radiological stability or early complication rate. The choice of reconstruction should therefore be individualized according to defect size, containment, AORI classification, patient age, bone quality and intraoperative stability.

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