International Journal of Research in Orthopaedics
Juneja J et al. Int J Res Orthop. 2022 Mar;8(2):158-164
http://www.ijoro.org

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20210601

Original Research Article

Our experience of the management of severe bone defects in primary total knee arthroplasty with cement and screws with undersizing of tibia

Johney Juneja[1]*, Rakesh Patil[2], Narendra Vaidya[2], Ramesh Sen[3], Vinay Tantuway[4], A. K. Mehra[1]

[1]Department of Orthopaedics, RNT Hospital, Udaipur, Rajasthan
[2]Department of Joint Replacement, Lokmanya Hospital, Pune, Maharashtra, India
[3]Department of Orthopaedics, Max Hospital, Punjab, India
[4]Department of Orthopaedics, Arthros Clinic, Indore, Madhya Pradesh, India

Received: 10 November 2021
Revised: 06 December 2021
Accepted: 15 December 2021

***Correspondence:**
Dr. Johney Juneja,
E-mail: johney.johney2008@gmail.com

ABSTRACT

Background: There are several options for dealing with tibial bone defects during total knee arthroplasty in severe primary osteoarthritis. The aim of this study was to report the midterm results of TKA with screw and cement augmentation of moderate-sized tibial bone defects.
Methods: Patients with osteoarthritis who had posterior stabilised TKA with screw and cement augmentation of the tibia were reviewed retrospectively. Patients were assessed preoperatively and at follow-up using the International knee society knee score and function score, and radiographic analysis of alignment and signs of loosening.
Results: 60 knee in 60 patients were included in the study. The mean age was 71 years; mean follow-up was 58 months. KS improved from 46 to 76 and FS from 51 to 92. The femorotibial mechanical angle changed from 174 to 178. There were no signs of osteolysis or loosening, and no revisions. Radiolucent lines at the cement bone interface were common but non- progressive.
Conclusions: Midterm clinical and radiographic results of TKA with screw and cement augmentation for moderate tibial defects were satisfactory.

Keywords: Bone defect, Bone cement, Screw, Total knee arthroplasty

INTRODUCTION

Severe deformity in osteoarthritis is often associated with uncontained tibial bone loss. The location of the defect depends on the cause of the disease, but is often posteriormedial, especially in varus osteoarthritis with chronic anterior cruciate deficiency.[1,2] Bone defects may also follow osteonecrosis, trauma or previous osteotomy. Good results after total knee arthroplasty (TKA) depend on many factors, but proper component positioning to restore tibial alignment, joint balancing, and stable and lasting fixation of the tibial prosthesis are particular challenges in these cases. Tibial defects may be addressed in several ways. Grafting, with bone from the femoral cuts, has the advantage of adding bone stock in younger patients, but resorption or failure to incorporate may complicate this technique. Deeper tibial resection will provide a flat surface, but will compromise the mechanical stability due to the smaller size, poorer bone quality and compromised soft tissue envelope attachments. Metal augments have become a popular way of dealing with tibial defects. However, they are expensive, not always available and may require further bone loss due to their off the shelf design, reducing available bone stock if a revision procedure is required in future. This is particularly true when the defect is limited to the posterior part of the plateau, as is often the case.

Although biomechanically inferior to metal augments, the technique of screw and cement augmentation is an attractive option in moderate defects as it is quick, low cost and provides a custom augment without significant further bone or soft tissue compromise.[3] The rationale of the technique is that by using screws into more distal cortex, further direct support is provided to the cement and thence the prosthesis. The indications are moderate peripheral defects of the medial or lateral tibial plateau which do not affect the immediate stability of the prosthesis. This solution has worldwide applicability due to its low-tech nature, but to the authors' knowledge, the results of this technique have only been reported from one institution in the English speaking literature.[4-7]

Aim and objectives

The aim of this study was to report the clinical and radiological results of this technique in moderate defects at midterm follow-up in another cohort and highlight the wide applicability. The study hypothesis was that this technique would allow for restoration of tibial alignment without joint instability, and satisfactory objective and patient reported outcomes with no loosening.

METHODS

Study location and duration

The study was conducted in Orthopaedic department of Lokmanya group of hospital Pune and Max hospital Mohali; Punjab. The study was conducted from 2016 till 2021.

Statistical analysis

Knee Society scores before and after surgery were compared using a paired Student's t-test, $p<0.05$ was considered significant.

Procedure

Data were collected prospectively from all patients with a single timepoint in two cases, and in serial examinations in the remaining, and reviewed retrospectively after follow-up. Clinical data included the preoperative and postoperative knee score (KS) and the functional score (FS) of the knee society scoring system.[8] Laxity was clinically assessed without radiography, by manual varus and valgus stress at 20° and 90°, respectively, and anterior drawer at 90° flexion. Patients were asked to rate their knees on a four-point satisfaction scale: very satisfied, satisfied, dissatisfied and very dissatisfied. Radiographic assessment included standing anteroposterior and long leg alignment views, Rosenberg (preoperatively), lateral views at 30° flexion and Merchant views. The medial femoral mechanical axis (MFA), the medial tibial mechanical axis (MTA) and the femoral tibial mechanical axis (MFTA) were measured on preoperative and postoperative films to determine the coronal correction, and the X-rays were examined for radiolucent lines and osteolysis around the cement, screws and prosthesis according to the 1989 knee society system.[9] Image intensifiers were not used for limb placement, but close attention to radiographic technique was made to optimise visualisation of the interfaces. Digital radiographs were analysed by two surgeons independently and a third if consensus was not achieved.

Inclusion criteria

Inclusion criteria were determined as being aged between 45 to 90 years with BMI >30, having primary TKA, and treatment for tibial bone defects with the BCSA technique during TKA.

Exclusion criteria

Exclusion criteria were as follows: a history of revision knee arthroplasty, valgus malalignment before surgery, primary or revision hip arthroplasty, fractures involving the lower extremity, intraoperative lateral release, amputation of lower extremities at any level, patients with tibial massive cavitary defects, tibial defects secondary to trauma, or pseudoarthrosis of the tibia.

Surgical technique

Procedures were performed through conventional medial (14 varus knees) or lateral (6 valgus knees) parapatellar approaches. Combined intramedullary and extramedullary tibial guidance was used, with a planned perpendicular tibial cut of 9 mm depth referenced from the centre of the lateral tibial plateau in varus knees or 6 mm from the medial plateau in valgus knees, depending on which side was worn. The sagittal alignment of the cut was 0°. Resulting tibial bone defects were then considered for cement and screw augmentation if they were deep enough to accept the head of a 3.5 or 4.5 mm screw and comprised less than 15%-20% of the cut tibial surface (Figure 1). In our experience, this size of defect typically does not compromise the immediate primary stability of the tibial component, but the latter was assessed separately and was a prerequisite for this technique. Surface area was assessed visually in the following way; each hemiplateau was visually bisected to approximate 25% of the total surface area of the tibial plateau. Defects significantly smaller than this area were considered for this technique. Stability was assessed with the trial components in situ, with manually applied varus and valgus stress, any tilting of the tibial component denoting instability. If the stability of the tibial component was felt to be insufficient, a different form of augmentation was considered, such as a metal augment.

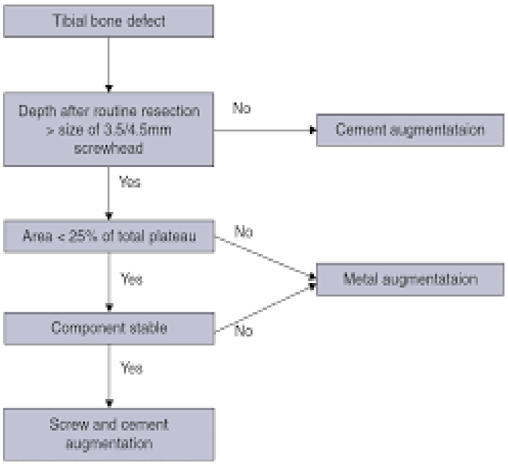

Figure 1: Flow diagram outlining indication for cement, cement and screws and metal augmentation.

Maximum depth of the defect was assessed visually with a ruler after placing a tibial component on the cut surface of the tibia. Depth of bone loss after the initial cut ranged from 4 to 16 mm. The defect was debrided of any soft tissue, but multiple drill holes were not routinely used. Stainless steel screws (3.5 or 4.5 mm) were placed after preparation of the tibial keel to prevent keel/screw impingement, and the screw heads were placed one to two millimetres beneath the tibial prosthesis to prevent direct contact. One screw was used in 16 knees and two screws in 4. The shape and size of the defect dictated the number of screws, and the orientation was such as to engage the tibial cortex. Long stems were used in all cases, providing a minimum keel/stem length of 70 mm to further support the prosthesis.[3] Total stem lengths were 75 mm in 17 knees, 120 mm in 2 and 145 mm in 1. Cemented posterior stabilised prostheses were utilised without increased constraint (4 HLS Noetos and 16 HLS KneeTec, Wright-Tornier, Montbonnot, Saint Martin, France). Cement was applied to the metaphyseal area of the tibial prosthesis/stem construct only. The polyethylene insert used was 9 mm in 18 knees and 11 mm in 2.

RESULTS

Average follow-up was 58 months and the clinical and radiological results are detailed in (Table 2). Preoperative and postoperative radiographs for two patients are shown in (Figure 2-3).

DISCUSSION

Bone loss requiring augmentation in primary TKA was not common in our institution and screw and cement augmentation was used in just over 1% of cases (26 of 2255 knees). This may be due to the early presentation in this developed society. In developing societies, this may not be the case, and as the demand for TKA rises in countries of all developmental stages, methods of controlling cost will become increasingly important.

Table 1: Preoperative characteristics of the study population.

Parameters	Observation
Number of patients	19 (20 knees)
Mean age at TKA, years	71
Female:male	11
Mean body mass index	30
History of surgery	
None	13
Arthroscopy	3
Ligament reconstruction	2
Osteosynthesis	1
Other	1
Reasons for TKA	
Primary osteoarthritis	14
Secondary to meniscal deficiency	2
Secondary to ligamentous deficiency	2
Secondary to fracture	1
Avascular necrosis	1
Preoperative MFTA (°), mean±SD	
Total; N=20	174±13
Varus; N=14	166±5
Valgus; N=6	194±3

Table 2: Preoperative and postoperative radiological parameters and knee score.

	MFTA (°)	MFA (°)	MTA (°)	Fs	Ks
Preop	174±13	91±5	86±7	51±16	45±11
Postop	178±4	90±3	90±1	75±28	90±12

Data presented as mean±SD. FS-function score; KS-knee score of the Knee Society scoring system[8]; MFA-medial mechanical femoral angle; MFTA-femoral tibial mechanical axis; MTA-medial mechanical tibial angle.

Table 3: Rand classification of bone loss (modified from Rand JA, 1991).

Type	% Condylar involvement	Depth (mm)
I (a/b)	Minimal, <50	<5
II (a/b)	>50 to <70	**5-10**
III (a/b)	>70 to <90	>10
IV (a/b)	>90	>10

a) intact peripheral rim, b)deficient peripheral rim

Although various strategies exist to deal with this issue, the ideal intra-operative treatment will not only provide immediate and long-term mechanical stability, good function and ease of revision, but also be low cost. The use of screws and cement remains an uncommon method of dealing with bone loss in primary total knee replacement. In a biomechanical study, Brookes found the stability of the construct appeared lower with this technique compared with the use of hemi wedges, and perhaps this has encouraged the use of metal augmentation.[3]

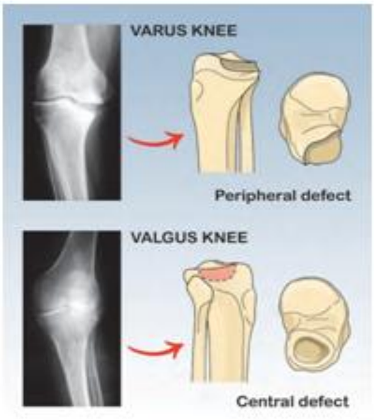

Figure 2: Varus knee appears with bone defect in posteromedial site of tibial plateau. In valgus knee bone defect usually involves the central part of lateral tibial hemiplateau and the external femoral condyle.

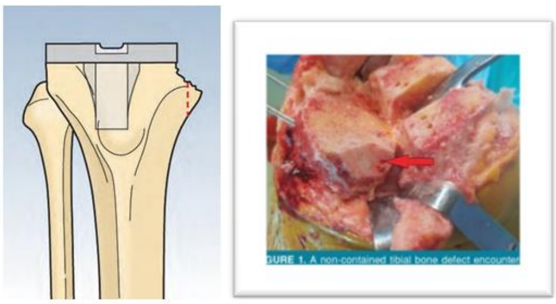

Figure 3: Translating tibial component could be a viable option for very small defect; this technique should not be used in angular deformity due to abnormal concentration of load forces.

In the same study, the stability of screws and cement was higher than cement alone, and the rationale of using screws into the tibial cortex is to provide further direct support for the cement and thence the tibial component. There are several advantages of this technique. It is a quick and low-tech solution and consequently low cost. It can be used with any primary TKA system, without resorting to revision prosthesis, with the associated problems of availability, options of constraint and price. For these reasons, it can be used in most hospital environments worldwide. Because it is essentially a custom augment, the technique preserves the existing bone stock and soft tissue attachments which may be compromised with other techniques, reducing the complexity of both the primary and any subsequent revision procedure. Clinical results of one cohort have been published. Ritter first published reports of the use of cement and screws with favourable midterm to long-term results, and then a larger retrospective study from the database at the same institution followed.[4-7] In the latter study, there was no difference in failure rate in 254 knees with bone defects treated with screws and cement compared with knees without defects and augmentation. The mean follow-up was 83 months and unsurprisingly those patients receiving cement and screws had more severe deformities preoperatively, with bone defects up to 30mm. Radiolucent lines were seen more commonly in those with cement and screws (between 8% and 13%), but were observed to be non-progressive in all patients from both augmented and non-augmented groups. In the current study, the cement and screws technique was used to augment moderate bone defects with an average depth of 6.5mm (maximum of 16 mm) and surface area of around 15%-20% of the cut surface of the tibia. Typically defects of this magnitude will not cause primary instability of the tibial component in our experience, and this has remained a limit of our indication for this technique. Within these parameters, the technique did allow for restoration of tibial alignment without joint instability, and objective and patient-reported outcomes were satisfactory. There was no evidence of loosening at early to mid-term follow-up, although radiolucent lines were seen in six knees. These were non-progressive and ≤2mm in width in common with other reports of TKA with or without augmentation.[4-6,10-14] This was reassuring in this series, but clearly continued surveillance is prudent in these cases. In terms of clinical stability, excessive polyethylene thickness was not required and coronal laxity was satisfactory. Weaknesses of this study are small numbers, five cases lost to follow-up, limited duration of follow-up and the lack of a control group. These limit the conclusions that can be made regarding the relative success of this and other techniques. Longer term outcome study of this cohort will be required to confirm if the clinical and radiological success can be maintained, in particular with regard to the progression of radiolucent lines, and loosening. A further study with a control group of augmentation with cement alone, or metal augments, would contribute further to knowledge in this area. Other methods of dealing with tibial bone loss include deeper resection, bone grafting and the use of metal augments. Increasing the depth of tibial resection will very effectively decrease the area of bone defect, but has several disadvantages. First, it will result in the use of a smaller prosthesis sitting on poorer quality boneand this may affect longevity of the fixation, as well as potential component sizing mismatch.[15,16] Second, the need for a thicker polyethylene insert will increase the torque acting at the tibial component interfaces. Third, future revision procedures will be more complex because of the resulting decreased proximal tibial bone stock. Fourth, the balance of the knee may be affected, as a more distal cut may detach more of the anterolateral capsule and anterolateral ligament from the tibia, as well as posterior–medial capsular tissue. Some of these attachments may remain intact with the routine minimal tibial resection required to perform a TKA due to the area and position of the attachments distal to the joint line (Figure 4).[17-19]

Figure 4: Bilateral varus knee with defect managed with screw and extension rod.

The lateral laxity which may already exist due to the severe varus may be exacerbated, producing a more trapezoidal joint space. Thus, restoration of alignment without instability may become increasingly difficult with deeper tibial resection. Bone grafting has been used in an attempt to improve bone stock and facilitate subsequent revision, and this is especially attractive in the younger patient, although the benefits are as yet undefined.[20] At primary knee arthroplasty, autologous bone is available from the femoral condylar or box cuts.[21,22] The initial cost is low, equating to the use of screws if used, although operating time is increased. Some further bone loss may be necessary when preparing the tibial surface, as sclerotic bone must be removed in its entirety to expose the vascularised cancellous bone necessary for union and incorporation. Depending on the size and stability of the defect and construct, partial weight bearing may be necessary postoperatively.[21] Satisfactory results have been reported, with good incorporation in most, but resorption or collapse of the graft has been a concern.[23-25] Scuderi et al reviewed knees after autologous bone grafting at an average of 27 months and reported no case of non-union, and only one graft collapse without tibial loosening.[21,26] Kawano and Severino similarly reported one graft collapse in 19 bone grafted knees.[23] Laskin reported on 26 patients with deformities over 20° who had autograft augmentation followed for an average of 5 years.[24] Seven patients' grafts subsided or did not incorporate, although none required revision at the time of follow-up. A needle biopsy was performed in nine patients and in five of these the lacunae did not contain osteocytes. Hosaka et al reported good results of bone grafting in 68 knees where there was a high rate of union, but some atrophy of the proximal medial tibia.[26] Use of metal augments has become a standard method of dealing with bone defects of various sizes. Brooks showed good stability with these under medial loading in cadaver specimens, and half tibial augments are commercially available with some primary systems. Results are satisfactory in several studies of primary TKA.[10-12] Lee et al reported no evidence of loosening in 54 patients followed for an average of 79 months.[11] There were non-progressive radiolucencies ≤2mm wide in 11%. Brand et al reviewed 15 primary TKA with defects up to 31 mm augmented with wedges. At 37 months, there was no loosening and non-progressive radiolucent lines in 16%.[10] Tsuka et al followed 33 patients for 48months and found no loosening and radiolucent lines in one-third.[12] One disadvantage of using metal augments is that they are off the shelf designs, and further bone loss is necessary to prepare for them. Due to their symmetrical nature in the anterior-posterior direction, whatever bone loss already existing posteriorly must be matched anteriorly, and vica versa. Thus, in the common posterior-medial defects, the unaffected medial and anterior-medial condylar bone will need to be sacrificed (Figure 5).

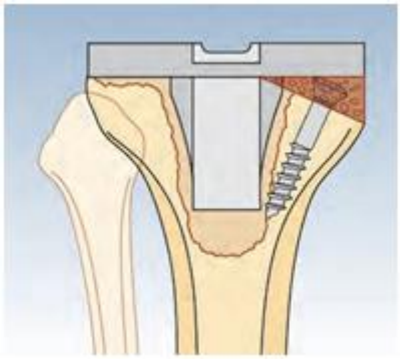

Figure 5: Cement filling could be used with or without screws (modified from Brooks et al).

This is undesirable as this bone is biomechanically favourable and resecting it exposes bone of decreased strength.[15,16] The mechanically superior hemiblocks, which cover around a third of the cut tibial surface, will require an equal depth of bone loss in the more central part of the condyle to produce the desired cut perpendicular to the direction of load transfer. Counter intuitively, use of a wedge, which is optimal for a direct medial defect in that it spares the more central bone, will require even deeper medial bone sacrifice to fill an equivalent-sized posterior defect. Although the effect of this decreased bone stock at future revision has not been defined, it seems illogical to remove further bone to utilise these off the shelf augments when the initial bone loss is only moderate and localised to one part of the plateau. Conversely, when there is a substantial epiphyseal/metaphyseal defect which affects most of the cortical rim of one tibial condyle, less bone needs to be sacrificed to use the hemiblock or wedge, and it will provide the necessary support required in these cases. An additional disadvantage is that some primary systems do not allow for the addition of augments, and revision components are then necessary, possibly with unnecessary increased constraint, depending on what polyethylene inserts are available. The current cost for a half block in our institution is 30000 INR but further cost may result due to the higher price of a revision tibial component. The advantages of the screws and cement technique mean that it has wide applicability. It is quick, low cost, the materials are readily available and it can be used with any TKA system. For these reasons, it can be used in most hospital environments worldwide. Preservation of existing bone stock and soft tissue attachments reduce the complexity of both the primary and any subsequent revision procedure. We continue to use this technique for cases in which there is moderate bone loss without instability of the tibial component and particularly in posterior medial defects. Larger defects which do preclude immediate component stability may benefit from additional support using alternative methods, such as metal augments.

Figure 6: Intraoperative pictures of defect and its management by undersizing tibia, tibial reduction osteotomy, 3.5mm titatnium cortical screw and cement.

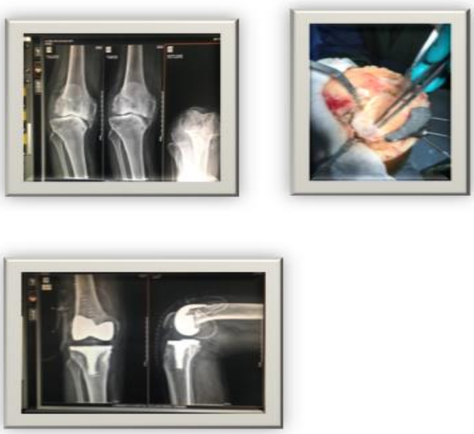

Figure 7: Intraoperative pictures of defect and its management by undersizing tibia, tibial reduction osteotomy, 3.5mm titatnium cortical screw, cement.

CONCLUSION

Technique mentioned in current study is feasable for the treatment of moderate tibial defects encountered during TKA. It is safe, easy to perform, and affordable. In addition, this technique should be considered as a reliable alternative to other cutting edge but expensive options such as tantalum, metal augmentation or structural allografts in cases where surgeons have limited access to these. In this study, screw and cement augmentation of moderate tibial defects in primary TKA did allow for restoration of tibial alignment without joint instability, and satisfactory objective and patient-reported outcomes with no loosening. The technique provides a simple and effective alternative. However, future randomized studies with larger populations and longer follow-up periods should be conducted for further investigation of the clinical success of this technique.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Demey G, Magnussen RA, Lustig S. Total knee arthroplasty for advanced osteoarthritis in the anterior cruciate ligament deficient knee. Int Orthop. 2012;36: 559-64.
2. Dorr LD, Ranawat CS, Sculco TA. Bone graft for tibial defects in total knee arthroplasty. Clin Orthop. 1986;205:153-65.
3. Brooks PJ, Walker PS, Scott RD. Tibial component fixation in deficient tibial bone stock. Clin Orthop Relat Res. 1984;184:302-8.
4. Berend ME, Ritter MA, Keating EM. Use of screws and cement in primary TKA with up to 20 years follow-up. J Arthroplasty. 2014;29:1207-10.
5. Ritter MA. Screw and cement fixation of large defects in total knee arthroplasty. J Arthroplasty. 1986;1:125-9.
6. Harty LD. Medial screws and cement. J Arthroplasty. 2004;19:587-9.
7. Ritter MA, Keating EM, Faris PM. Screw and cement fixation of large defects in total knee arthroplasty. A sequel. J Arthroplasty. 1993;8:63-5.
8. Insall JN, Dorr LD, Scott RD, et al. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res. 1989;248:13-4.
9. Ewald FC. The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. Clin Orthop Relat Res. 1989;248:9-12.
10. Brand MG, Daley RJ, Ewald FC, et al. Tibial tray augmentation with modular metal wedges for tibial bone stock deficiency.1989;248:71-9.
11. Lee JK, Choi CH, Lee JK, Surgeon O, Choi CH. Management of tibial bone defects with metal augmentation in primary total knee replacement: a minimum five-year review. J Bone Joint Surg Br. 2011;93:1493-6.
12. Tsukada S, Wakui M, Matsueda M. Metal block augmentation for bone defects of the medial tibia during primary total knee arthroplasty. J Orthop Surg Res. 2013;8:36.
13. Lotke PA, Wong RY, Ecker ML. The use of

methylmethacrylate in primary total knee replacements with large tibial defects. Clin Orthop Relat Res. 1991;270:288-94.
14. Freeman MA, Bradley GW, Revell PA. Observations upon the interface between bone and polymethyl-methacrylate cement. J Bone Joint Surg Br. 1982;64: 489-93.
15. Hvid I, Hansen SL. Trabecular bone strength patterns at the proximal tibial epiphysis. J Orthop Res. 1985;3: 464-72.
16. Sneppen O, Christensen P, Larsen H. Mechanical testing of trabecular bone in knee replacement. Int Orthop. 1981;5:251-6.
17. Dodds AL, Halewood C, Gupte CM. The anterolateral ligament: Anatomy, length changes and association with the Segond fracture. Bone Joint J. 2014;96-B:325-31.
18. Kosy JD, Mandalia VI, Anaspure R. Characterization of the anatomy of the anterolateral ligament of the knee using magnetic resonance imaging. Skeletal Radiol. 2015;44:1647-53.
19. Vincent JP, Magnussen RA, Gezmez F, et al. The anterolateral ligament of the human knee: an anatomic and histologic study. Knee Surg Sports Traumatol Arthrosc. 2012;20:147-52.
20. Cuckler JM. Bone loss in total knee arthroplasty: graft augment and options. J Arthroplasty. 2004;19:56-8.
21. Scuderi GR, Insall JN, Haas SB. Inlay autogeneic bone grafting of tibial defects in primary total knee arthroplasty. Clin Orthop Relat Res. 1989;248:93-7.
22. Windsor RE, Insall JN, Sculco TP. Bone grafting of tibial defects in primary and revision total knee arthroplasty. Clin Orthop Relat Res. 1986;205:132-7.
23. Kawano CT, Severino NR. Autologous bone graft for tibial defects on knee total arthroplasty. Acta Ortop Bras. 2005;13:120-3.
24. Laskin RS. Total knee arthroplasty in the presence of large bony defects of the tibia and marked knee instability. Clin Orthop Relat Res. 1989;248:66-70.
25. Stockley I, McAuley JP, Gross AE. Allograft reconstruction in total knee arthroplasty. J Bone Joint Surg Br. 1992;74-B:393-7.
26. Hosaka K, Saito S, Oyama T, et al. Union, knee alignment, and clinical outcomes of patients treated with autologous bone grafting for medial tibial defects in primary total knee arthroplasty. Orthopedics. 2017; 40:e604-8.
27. Dixon MC, Parsch D, Brown RR. The correction of severe varus deformity in total knee arthroplasty by tibial component downsizing and resection of uncapped proximal medial bone. J Arthroplasty. 2004;19:19-22.

Cite this article as: Juneja J, Patil R, Vaidya N, Sen R, Tantuway V, Mehra AK. Our experience of the management of severe bone defects in primary total knee arthroplasty with cement and screws with undersizing of tibia. Int J Res Orthop 2022;8:158-64.