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ORIGINAL PAPER

Preliminary results of managing large medial tibial defects in primary total knee arthroplasty: autogenous morcellised bone graft

Takehiko Sugita [1] · Toshimi Aizawa [2] · Naohisa Miyatake [1] · Akira Sasaki [1] · Masayuki Kamimura [2] · Atsushi Takahashi [2]

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Abstract

Purpose This study reports a case series of 44 primary total knee arthroplasties (TKAs) using autogenous morcellised bone grafting for large (≥10-mm-deep) medial tibial defects, which are generally repaired using metal augmentation. The bone-grafting technique is described in detail and the radiological outcomes are presented.

Methods A total of 44 TKAs were followed up for a mean period of 58 months (range 24–139 months). Multiple drill holes were made in the sclerotic floor of the defect, followed by the impaction of morcellised cancellous bone grafts to fill the defects. Tibial components were fixed using the cemented or noncemented technique and no internal fixation devices were used. Stem extension of the tibial component was only used in one TKA.

Results Radiograms revealed that the grafted bone was completely incorporated into the host bone within one year post-operatively. No grafted bone absorption or collapse was detected. A clear zone between the tibial component and grafted bone was observed in six knees, but it did not become enlarged thereafter.

Conclusions The presented technique provided favourable radiological outcomes and had several advantages: (1) it enables preservation of as much bone as possible for future revision surgery; (2) it is cost effective and simple because metal augments, internal fixation devices and stem extension are not needed; (3) it can be used in the same manner any defect to a depth ≥3 mm. Thus, this is an acceptable and reproducible alternative technique.

Keywords Total knee arthroplasty · Bone graft · Tibial defect · Autogenous bone · Morcellised bone

Introduction

Total knee arthroplasty (TKA) provides favourable long-term outcomes [1–4]; however, managing bone defects in primary TKA is still challenging. Various methods have been reported for managing medial tibial defects in primary or revision TKA, such as filling with bone cement [5, 6], autogenous [7–11] or allogenous [12, 13] block bone grafting and metal augmentation [14–18]. Generally, a defect depth of <5 mm should be filled with bone cement, that of 5–10 mm with bone grafts and that of >10 mm with metal augmentation, as Vail et al. [19] indicated in their textbook. In this study, we report a case series of 44 TKAs in which we used autogenous morcellised bone grafting for large (≥10-mm-deep) medial tibial defects. This study aimed to describe this bone-grafting technique in detail and to analyse its radiological outcomes retrospectively.

Materials and methods

The study protocol was approved by the Institutional Review Board of our clinic. Written informed consent was obtained from all patients. During June 2003 to April 2014, 47 TKAs in 45 patients were performed using the following presented bone-grafting technique. One patient (one TKA) died,

✉ Takehiko Sugita
t-sugita@tohokuseikei.com

1 Department of Orthopaedic Surgery, Tohoku Orthopaedic Clinic, 4-9-22 Kamiyagari, Izumi-ku, Sendai-city 981-3121, Japan

2 Department of Orthopaedic Surgery, Tohoku University Graduate School of Medicine, 1-1 Seiryo-machi, Aoba-ku, Sendai-city 980-8574, Japan

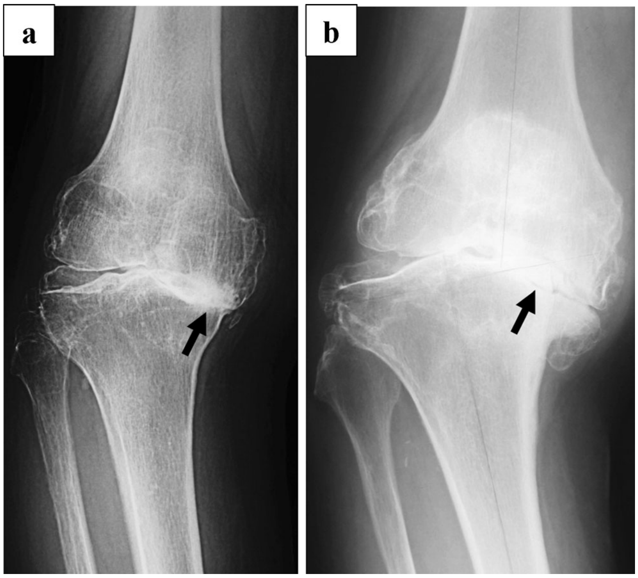

Fig. 1 Defect classification according to Watanabe [20] (*black arrows*): **a** flat peripheral and **b** slant peripheral types

and two patients (two TKAs) were lost before the two year follow-up evaluation. Thus, a total of 44 TKAs (42 patients) were followed up for a mean period of 59 months (range 24–139 months). Eight patients were men (nine TKAs), and 34 were women (35 TKAs); mean age at surgery was 73.9 years (range 56–85 years). Pre-operative diagnoses were osteoarthritis ($n = 33$), rheumatoid arthritis ($n = 3$), osteonecrosis of the medial tibial condyle (7) and Charcot's joint ($n = 1$). Implants were from LCS (Depuy, Warsaw, IN, USA), Profix (Smith & Nephew, Memphis, TN, USA), Magna-ROM 21 (Centerpulse, Austin, TX, USA), Genesis II (Smith & Nephew) and NexGen (Zimmer) in 1, 2, 5, 10 and 26 TKAs, respectively. All TKAs were performed by a single surgeon (TS). Defect type according to Dorr's classification [10] was central in one knee and peripheral in 43 and according to Watanabe's classification [20] flat peripheral in 12 and slant peripheral in 31 (Fig. 1). Mean depth ($n = 44$), mediolateral width ($n = 40$) and anteroposterior width ($n = 40$) of the medial tibial defect measured after the horizontal osteotomy of the tibial articular surface were 12.3 mm (range 10–23 mm), 17.5 mm (range 10–26 mm) and 36.9 mm (range 30–45 mm), respectively.

Figure 2 shows the the grafting technique used in this study. Multiple drill holes were made in the sclerotic floor of the defect to promote vascularity beneath the floor (Fig. 2a). Morcellised cancellous bone was obtained from the resected femoral and tibial subchondral bones. To prevent bone cement from entering the space between the graft and tibial host bed, grafts were firmly impacted using a metal bar and manual pressure. An assistant's index finger was used as a bank during impaction to prevent the grafted bone from crumbling (Fig. 2b and c). Tibial components were fixed similarly (Fig. 2d). No internal fixation devices were used, and extension of the tibial stem was used in only one knee (with Charcot's joint).

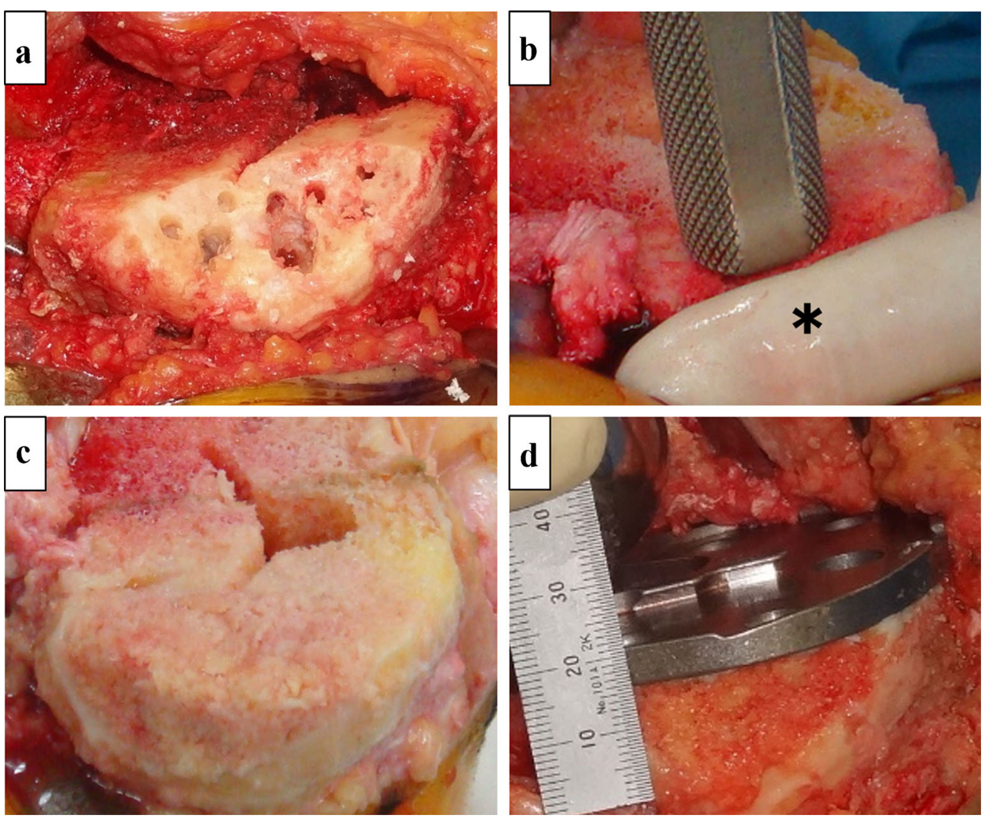

Fig. 2 Bone-grafting technique: **a** Multiple drill holes on the sclerotic floor of the defect. **b**, **c** Morcellised cancellous bone grafts firmly impacted using a metal bar and manual pressure. During impaction, an assistant's index finger (*asterisk*) was used as a bank to prevent grafted bone from crumbling. **d** Tibial component fixed using bone cement

Table 1 Patient demographic data and radiological outcomes

Case no.	Age at surgery (years)	Sex	Preoperative diagnosis	TKA system	Defect measurements (mm)			Type of defect	Follow-up (months)	Clear zone	Marginal sclerotic line
					Depth	Mediolateral width	Anteroposterior width				
1	82	F	OA	LCS	10	15	35	Flat peripheral	48	−	−
2	77	M	RA	Magna-ROM 21	15			Slant peripheral	36	−	−
3	78	M	RA	Magna-ROM 21	12			Central	31	−	−
4	75	F	OA	Magna-ROM 21	11			Flat peripheral	124	−	+
5	56	F	OA	Magna-ROM 21	10			Slant peripheral	139	−	−
6	65	F	OA	Magna-ROM 21	10	19	39	Flat peripheral	114	−	−
7	71	F	Ne	Profix	11	16	31	Slant peripheral	67	+	+
8	72	F	OA	Profix	11	15	36	Flat peripheral	120	+	+
9	72	F	Ne	Genesis II	11	10	35	Flat peripheral	102	−	−
10	71	F	OA	NexGen	10	14	39	Slant peripheral	98	−	+
11	68	F	OA	NexGen	18	20	45	Flat peripheral	92	−	−
12	81	F	RA	Genesis II	15	17	41	Slant peripheral	96	−	+
13	81	F	OA	Genesis II	12	24	34	Flat peripheral	40	+	+
14	74	F	Ne	NexGen	14	19	30	Flat peripheral	54	−	+
15	81	F	OA	NexGen	11	15	31	Slant peripheral	88	−	+
16	85	F	OA	NexGen	10	21	39	Flat peripheral	78	−	+
17	72	M	OA	NexGen	10	23	40	Slant peripheral	86	−	+
18	58	F	Cha	NexGen	23	20	40	Slant peripheral	78	−	−
19	74	M	Ne	Genesis II	14	15	38	Flat peripheral	82	+	+
20	82	F	OA	Genesis II	12	15	37	Slant peripheral	72	−	+
21	69	F	OA	NexGen	12	16	38	Slant peripheral	64	−	+
22	79	F	OA	NexGen	11	22	37	Slant peripheral	66	−	+
23	63	M	Ne	Genesis II	10	17	30	Slant peripheral	41	−	−
24	85	F	OA	NexGen	10	15	38	Slant peripheral	55	−	+
25	76	F	OA	Genesis II	12	22	38	Slant peripheral	60	−	+
26	77	M	Ne	NexGen	12	16	31	Flat peripheral	65	−	−
27	78	F	OA	Genesis II	11	19	35	Slant peripheral	54	+	+
28	64	F	OA	NexGen	10	16	35	Slant peripheral	27	−	+
29	74	F	Ne	Genesis II	15	18	37	Slant peripheral	42	−	+
30	76	F	OA	NexGen	11	15	38	Slant peripheral	48	−	+
31	59	F	OA	NexGen	10	16	37	Slant peripheral	42	−	+
32	63	M	OA	NexGen	11	26	39	Slant peripheral	42	−	+
33	80	F	OA	NexGen	17	20	45	Slant peripheral	30	−	+
34	75	F	OA	Genesis II	15	22	38	Slant peripheral	37	−	−

Table 1 (continued)

Case no.	Age at surgery (years)	Sex	Preoperative diagnosis	TKA system	Defect measurements (mm)			Type of defect	Follow-up (months)	Clear zone	Marginal sclerotic line
					Depth	Mediolateral width	Anteroposterior width				
35	78	F	OA	NexGen	10	22	40	Slant peripheral	28	–	+
36	78	F	OA	NexGen	16	15	34	Slant peripheral	37	–	+
37	72	M	OA	NexGen	11	23	42	Slant peripheral	36	–	+
38	67	F	OA	NexGen	10	10	30	Slant peripheral	30	–	–
39	73	M	OA	NexGen	17	23	38	Slant peripheral	30	+	+
40	83	F	OA	NexGen	14	12	38	Slant peripheral	24	–	+
41	82	F	OA	NexGen	10	16	38	Slant peripheral	25	–	+
42	74	F	OA	NexGen	13	18	37	Slant peripheral	24	–	+
43	84	F	OA	NexGen	12	11	39	Flat peripheral	24	–	+
44	66	F	OA	NexGen	10	13	32	Slant peripheral	25	–	+

TKA total knee arthroplasty, *M* male, *F* female, *OA* osteoarthritis, *RA* rheumatoid arthritis, *Ne* osteonecrosis of the medial tibial condyle, *Cha* Charcot's joint

Partial weight-bearing was allowed four to five days after surgery. Full weight bearing was allowed after one to two weeks in most patients.

Results

Patient demographic data and radiological outcomes are summarised in Table 1. Post-operative radiological changes in the grafted bone are shown in Fig. 3. In general, the grafted bone exhibited osteosclerotic changes two to three months post-operatively (Fig. 3a). Subsequently, the grafted bone became less dense, and bony trabeculae were detected (Fig. 3b). Finally, the grafted bone was completely incorporated into the host bone, with bony trabeculae crossing the interface within one year post-operatively (Fig. 3c). No absorption or collapse of the grafted bone was detected; trabeculae were observed in all knees. A clear zone between the tibial component and grafted bone was observed in six knees, but it did not enlarge thereafter. The margin of the grafted area represented a sclerotic line similar to a bony cortex in 32 TKAs (72.7%) (Fig. 4).

Discussion

The most important finding of this study is that radiological outcomes after autogenous morcellised bone graft for large medial tibial defects in primary TKA were favourable. Grafted bone was completely incorporated into host bone without absorption or collapse within one year post-operatively. Various methods to manage medial tibial defects in primary or revision TKA [5–18] have been reported. Vail et al. [19] recommended method selection based on defect depths. Panegrossi et al. [21] stated that the choice between different surgical options depended on defect dimension, bone quality and patient's quality of life. Lotke et al. [5] and Ritter et al. [6] reported favourable results using methylmethacrylate for large tibial defects in primary TKA. Favourable clinical and/or radiological results using metal augmentation have also been reported by several authors [14–18]. However, using both bone cement and metal augmentation is more disadvantageous than autogenous or allogenous bone graft for preserving bone stock. The bone–implant interface in knees with metal augmentation forms a complex shape, which creates continuing concern regarding implant loosening. Rawlinson et al. [22] used cadaver knees to biomechanically confirm that the use of a tibial stem reduced bone stress and limited micromotion between the metal wedge and surrounding bone; they recommended using a tibial stem. When a tibial stem is used, additional concern regarding any further loss in bone stock will occur during revision surgery.

For preserving bone stock, an autogenous or allogenous bone graft has been well established as being superior to bone

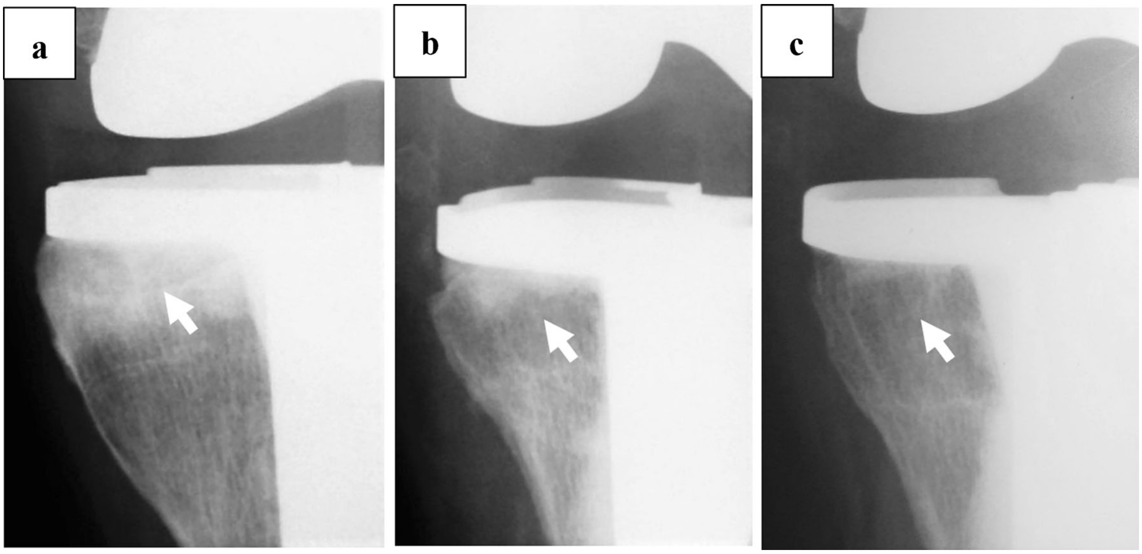

Fig. 3 Post-operative radiological changes in grafted bone (*white arrows*): **a** Osteosclerotic changes two to three months following surgery. **b** Less dense and bony trabeculae were detected. **c** Completely incorporated into host bone, with bony trabeculae crossing the interface

cement and metal augmentation. Many authors reported favourable results following an autogenous block bone graft in primary TKA [7–11]. However, it is difficult to obtain a bone block ≥10-mm thick from a resected femoral or tibial bone. Internal fixation devices were used for these block bone grafts. Moreover, Mullaji et al. [11] used a tibial stem extender when bone grafting was performed for defects ≥10 mm. An allogenous block bone graft was used primarily for revision TKA [12, 13]. For both autogenous and allogenous block bone grafting, additional bone cuts in the defect and a block bone to adjust for shape are required. However, some authors used autogenous morcellised bone [20, 23, 24]. Watanabe et al. [20] reported five TKAs with slant peripheral defects using two bones resected from the femoral condyle. They were driven like pegs into two gutters created on the floor of the tibial defect, with bone chips impacted around the pegs. Kharbanda et al. [23] reported six TKAs with larger bone defects (>25-mm deep) using morcellised impaction autograft supported by wire mesh fixed with screws, as well as tibial stem extenders.

Fig. 4 Margin of grafted area showed a sclerotic line similar to a bony cortex (*white arrow*)

We previously reported our experience using two bone-grafting techniques: (1) Two resected subchondral bone plates from the lateral tibial plateau were driven into two gutters made on the floor of the medial tibial defects to create bony support posts, and morcellised cancellous bone was impacted around the posts (in 19 TKAs); (2) Morcellised cancellous bone was impacted to fill the defect (in 26 TKAs) [24]. Internal fixation devices, metal mesh support and stem extender were not used in our procedures. We further reported that remodeling of grafted bone was faster in the latter 26 TKAs than in the former 19 procedures. Accordingly, 44 TKAs using only morcellised cancellous bone impaction were assessed in the study we report here.

This study revealed that our technique has several advantages over others: Firstly, as much bone as possible can be preserved for future revision surgery. Moreover, the bone–implant interface in knees with metal augmentation forms a complex shape, causing continuing concern regarding implant loosening. Thus, this technique can be considered for patients undergoing standard TKA without bone graft, as trabeculae were clearly depicted on radiograms after a maximum of one year. In addition, this technique provides a “biologic reconstruction” and “physiologic load transfer,” as described by Hanna et al. [25]. Secondly, this technique is cost effective and simple to perform, because metal augments, internal fixation devices, mesh supports and stem extenders are not required. Toms et al. [26] experimentally revealed that if support of rim of defects was sufficient or if a long stem was used, an impacted morcellised bone graft achieved adequate initial stability. However, we discovered that a morcellised bone graft for a slant peripheral defect without a wire mesh supporter and a stem extender demonstrated favourable radiological outcomes. We believe the medial soft tissue wall plays a role in preventing the grafted bone from crumbling after surgery. Thirdly, autogenous morcellised bone grafts can be used for any defect ≥3-mm depth in the same manner without any special preparation. In contrast, additional bone cuts are required in order to adjust defect shape to the metal augmentations or block bone.

A relatively short follow-up period and a small number of patients represent limitations. Because knees undergoing TKA with a bone graft could be considered similar to standard TKA without a bone graft, and because trabeculae were clearly depicted on radiograms after a maximum of one year, a minimum of a two year follow-up period following a morcellised cancellous bone graft, as in this study, could be sufficient. Because only 47 (4.9%) of 967 TKAs during June 2003–April 2014 had a medial tibial defect of ≥10-mm depth, such defects can be considered rare. The number of patients reported by Ahmed at al. for an autogenous block bone graft in primary TKA [8] and by Lee et al. for a metal augmentation in primary TKA [16] was 18 and 46, respectively. Another limitation is that no clinical data were reported. Although a single surgeon (TS) performed all TKAs, some were performed at different hospitals as invited surgeries. Because the clinical evaluation scales differed among hospitals, the same clinical scoring data could not be collected. Accordingly, only radiological outcomes were focused on in this study.

Conclusion

Because this bone-grafting technique provided favourable radiological outcomes and had some advantages compared with metal augmentation, block bone grafting or filling with bone cement, it can be considered an acceptable and reproducible alternative to those procedures.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Funding There is no funding source.

Ethical approval Not required.

Informed consent Informed consent was obtained from all participants.

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