



Management of the bone loss by metaphyseal sleeves in primary and revision knee arthroplasty: clinical experience and outcome after forty three cases

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Abstract

Aim of the study Management of metaphyseal bone loss in complex primary and revision TKA is a challenge for surgeons. Out of various types of bony defects, large metaphyseal bone loss (AORI types IIB and III) requires special augments in the form of cones or sleeves. The aim of this study is to assess the reliability of metaphyseal sleeves, in dealing with massive bone defects to provide stability for immediate weight bearing and also to check short to mid-term survivorship of metaphyseal sleeves in Asian population by assessing various parameters and complications.

Methods This is a retrospective study that includes 36 patients (43 knees), operated from 2011 to 2019. Patients with AORI type IIB (large metaphyseal bone defect) and AORI type III (metaphyseal defect with compromised collateral ligaments) were included. We included both the primary and revision knee arthroplasties in our study. Our interest in this study was to look for incidence of intra-operative iatrogenic fracture on the one hand, and post-operative complications in the form of peri-prosthetic joint infection and aseptic loosening on the other hand. Knee Society Score (KSS) was used to assess improvement in patient's clinical outcome. SPSS version 23 was used to process data.

Results The average age of patients in our study was 59.4 (SD 9.78) years. Male to female ratio was 21:15. The average follow-up was 5.42 (SD 2.24) years with the longest follow up of nine years. Metaphyseal sleeves were used in 12 primary TKA and 31 revision TKA. During surgery, iatrogenic fracture of tibial condyle was encountered in three patients (6.9%), all were managed without any intervention and union was achieved in all cases. There was not a single case with aseptic loosening as per radiological criteria in our study. Peri-prosthetic joint infection (PJI) was encountered in a single case (2.3%). Pre-op Knee Society Score (KSS) was 36.21 (SD 7.43) where as it improved to 92.00 (SD 5.66), six months after surgery. Also the range of flexion was increased from 76.83° (SD 14.07°) to 122.91° (SD 4.84°).

Conclusion In our study, metaphyseal sleeves showed excellent short to mid-term survivorship in AORI types IIB and III bone loss in Asian population. These results are comparable to various studies conducted on North American and European population. Metaphyseal sleeve is a reliable tool in the armamentarium of the arthroplasty surgeon. It is user friendly implant and provides immediate stability to allow full weight-bearing mobilization.

Keywords Total knee arthroplasty · Metaphyseal sleeves · AORI classification · Revision TKA

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Introduction

According to National joint registries worldwide, knee arthroplasties are being performed more frequently in North America, Europe as well as in Asian countries with every passing year [1, 2]. It is because of continuous research, upgradation, and introduction of new designs that the performances as well as durability of implants have improved a lot and as a result, patients are more satisfied after arthroplasties [3]. Due to excellent outcome of knee arthroplasty more and more young patients are offered this surgery. There is corresponding increase in rate of revision knee arthroplasty according to National Joint Registries. The Asian population present very late for knee arthroplasty with complex deformity and significant bone loss. Whether complex primary or revision arthroplasty; managing bone defects is one of the common problems encountered by surgeons [4]. Arthroplasty surgeons are looking for a reliable implant to deal with massive bone loss, which would provide immediate stability as well as improve long-term survival.

Various classifications are being floated from time to time for such bone defects. Classifications are mostly based on the severity of boneloss, site, and extent of bone damage. The most commonly used classification nowadays is Anderson Orthopaedic Research Institute (AORI) classification [5]. It divides boneloss in three types. In type I, there is a minor contained bone defect near joint line not affecting metaphysis. In type II, there is a bony defect in metaphyseal area of bone, and it is further divided in two sub types A or B depending on the involvement of one or both condyles, respectively. But in type III, apart from extensive bone loss, collateral ligaments are also compromised.

Management of type I defects is very straightforward. Small bone defects can be managed by morcellized or structural autografts or by using bone cements [6, 7]. It is type II defects that are more complex and require more gadgets. In case of type IIA, defect is usually large and in addition to this if cortical rim is deficient too, then metal augments are used in the form of wedges [8]. Unlike cement which takes the shape of defect, extra bone needs to be cut to accommodate such wedges. Good to excellent results are shown in literature regarding long-term survivorship of these wedges. In AORI type IIB where defect is even bigger a different type of modular implants are required. In past, structural allografts were used to make-up the gaps but results were not that promising. Lack of availability, increase risk of infection, fracture, non-union and implant loosening [9] were the issues that resulted in decline in the use of structural allografts in type IIB bone loss. Therefore, in last two decades highly porous tantalum cones [10] and metaphyseal sleeves [11] are in practice to address bone loss. In AORI type III defects, hinged implants are required in addition to metaphyseal sleeves to overcome varus/valgus stress as collaterals are not intact. The aim of

these cones or sleeves is to not only fill the defect but to provide a stable base for the implant. Moreover being porous coated, they initiate bone ingrowth resulting in more biological fixation. Metaphyseal sleeves are stepped in shape and are made of titanium covered with beads resulting in bone ingrowth and more stable fixation [12]. Many studies have shown excellent short to mid-term results of sleeves. According to the study of Martin-Hernandez et al. [13], aseptic loosening was not encountered in a single patient after a mean follow up of six years (1.0–8.9 years) in 150 patients, after using metaphyseal sleeves. Similar results were depicted in a study by Agarwal et al. [14]. In his study on 104 cases, loosening was found in only two cases.

Material and methods

In this retrospective study, 36 patients (43 knees) were included. The duration of this study was from 2011 to 2019. This study was conducted in Liaquat National Hospital, Karachi, which is a tertiary referral center with more than 400 primary and 60 revision knee arthroplasties. We included cases with AORI types IIB and III in our study. Patients with any medical condition that affects the results like osteoporotic bone (T score < -2.5 as per bone density test), and extra-articular bone deformity (requiring osteotomies or stemless tibial or femoral components) were excluded from our study. We included both the primary and revision arthroplasties in our study. All the surgery was performed by a single surgeon with more than three decades of experience. We used DePuy Synthes® Metaphyseal sleeves in combination with press fit stemmed PFC® SIGMA® PS, PFC® SIGMA® TC3 (AORI type IIB) or S-ROM® Noiles™ Rotating Knee Hinge System (AORI type III). There were ten knees with AORI type III bone defects, all were managed by S-ROM® Noiles™ Rotating Knee Hinge System in addition to metaphyseal sleeves. Extended Tibial Tuberosity Osteotomy (ETTO) was done in four surgeries to remove tibial components and cement. Better exposure of knee was also achieved by ETTO. After placement of component, Ethibond was used to fix tibial tuberosity (Fig. 1) and union was achieved in all cases without any complication.

Tibial metaphyseal sleeves are oblong in shape whereas femoral metaphyseal sleeves are trapezoidal in shape. Bone cement was applied manually over the intact femoral condyle and similarly on the tibial condyle to provide immediate stability to the prosthesis. Iatrogenic fracture during surgery was also noted. All patients were regularly followed up. All patients were allowed to bear full weight with walker and knee immobilizer on the very next day after surgery. Even patients with ETTO followed the same protocol. Continuous passive motion (CPM) was used from first till fourth post-operative day. It was used on an average of two hours per day. Post-operative periprosthetic infection was diagnosed clinically and by laboratory

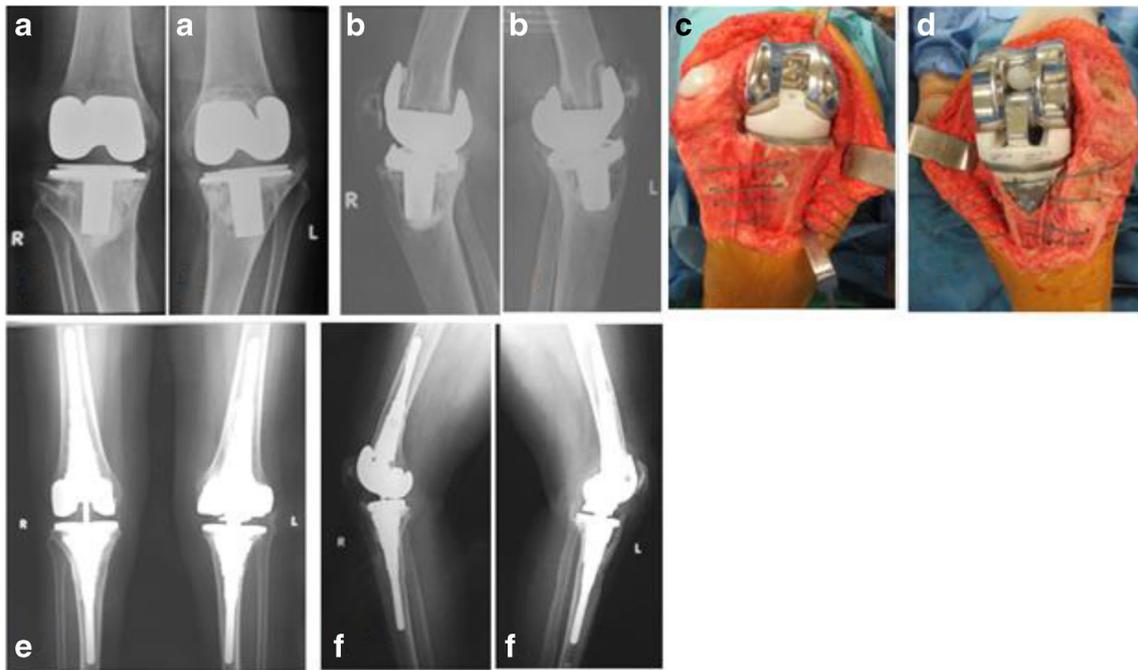


Fig. 1 A&B) Aseptic loosening, C) Right knee: PFC® SIGMA® TC3 and reduction of Tibial tuberosity after ETTO with Ethibond, D) Left knee: S-ROM® Noiles™ and reduction of Tibial tuberosity after ETTO with Ethibond, E&F) AP radiographs after 4 months

investigations. Aseptic loosening was diagnosed on the basis of clinical history and plain radiographs. Knee society score was used to assess functional outcome before and after surgery. SPSS version 23 was used to process data.

Results

The mean age of patients in our study was 59.4 (SD 9.78) years (range 49 years to 70 years). There were 21 male patients and 15 female patients in our study. The average follow-

up was 5.42 (SD 2.24) years with the longest follow up of nine years. Metaphyseal sleeves were used in 12 primary and 31 revision TKA (Table 1) (Fig. 2).

The most frequent size of tibial Metaphyseal sleeves used was 37 mm (minimum and maximum sizes used were 29 mm and 53 mm, respectively). Similarly the most frequent size of Femoral Metaphyseal sleeves used was of 40 mm (Table 2).

During surgery, iatrogenic fracture of tibial condyle was encountered in three patients (6.9%) during removal of previous implant, all were managed without any instrumentation and union was achieved in all cases (Fig. 3).

Table 1 Detail of all TKA with Metaphyseal sleeves

Primary or revision	No. of patients	Unilateral or bilateral	No. of surgeries	Tibial or femoral metaphyseal sleeves	No. of sleeves	PFC®SIGMA® PS, PFC®SIGMA® TC3 or S-ROM®NOILES	No. of implants
PrimaryTKA	11	Unilateral TKA	10	Tibia	9	PFC®SIGMA® PS	9
			1	Femur	1	PFC®SIGMA® TC3	1
		Bilateral TKA	1	Tibia	2	S-ROM®NOILES	2
Revision TKA	25	Unilateral TKA	19	Tibia	20	PFC®SIGMA® PS	5
			1	Femur	14	PFC®SIGMA® TC3	18
		Bilateral TKA	6	Tibia	9	S-ROM®NOILES	8
				Femur	7		
Total	36	Unilateral TKA	29	Tibial Metaphyseal Sleeve	40	PFC®SIGMA® PS	14
		Bilateral TKA	7	Femoral Metaphyseal Sleeve	23	PFC®SIGMA® TC3	19
						S-ROM®NOILES	10

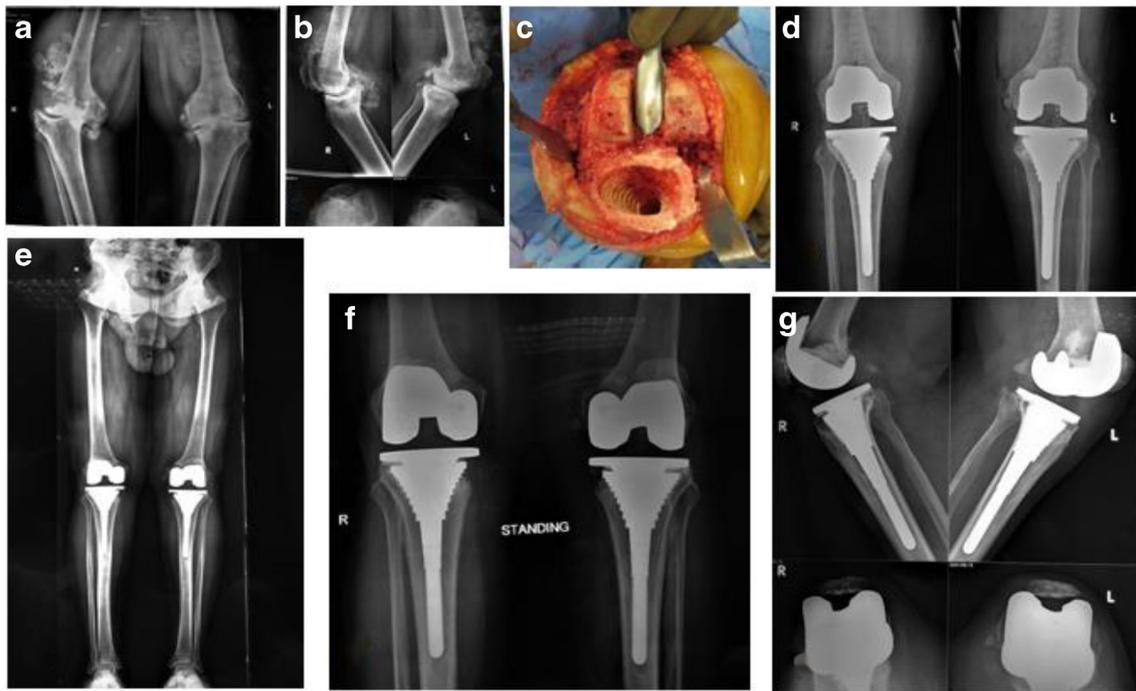


Fig. 2 A & B) Anteroposterior & Lateral Radiographs with skyline view: Advance OA involving both knees with varus deformity, C) Intra-operative reaming of Tibia with medial loss of cortex, D) Post-op AP radiographs, E) Scanogram, D) AP, Lateral & Skyline radiographs after 1 year

Radiolucent lines were seen in two cases (4.6%). One was complex primary and the second one was revision TKA. These radiolucent lines were at bone-cement interface, on the medial tibial condyle, in both cases. But after subsequent follow-ups, these lines were found to be non-progressive and patients were symptomless. There was not a single case with aseptic loosening in our study (Table 3).

Peri-prosthetic joint infection was encountered in a single case (2.3%) that was superficial and was managed

successfully by antibiotics. Pre-op Knee Society Score KSS was 36.21 (SD 7.43) which improved to 92.00 (SD 5.66), six months after surgery. The range of flexion was increased from 76.83° (SD 14.07°) to 122.91° (SD 4.84°) (Table 4).

Discussion

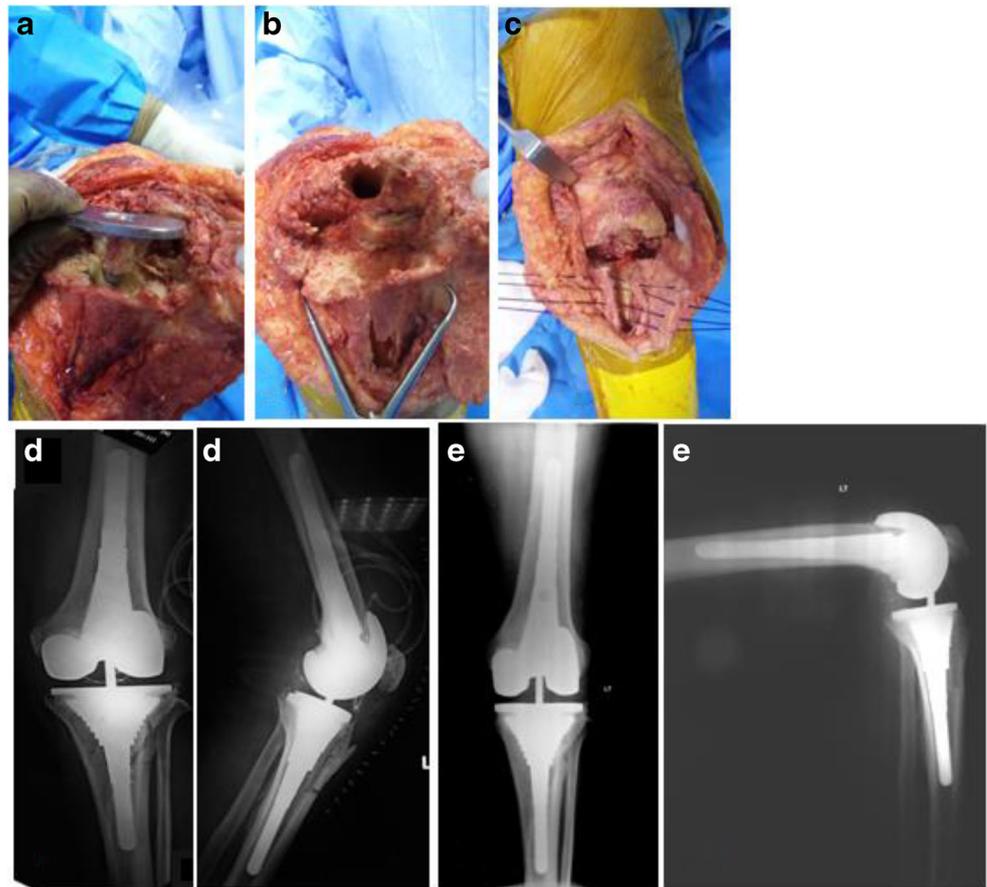
The number of TKA is increasing by every passing year. Because of excellent long-term survivorship, TKA is nowadays recommended procedure even in relatively younger age group [15]. As a result; surgeons are encountering more and more complex primary and revision knees. Modern-day TKA prosthesis are designed keeping in view the concept of zonal fixation. In simple primary knee, there is little or no bone loss near the joint line so after routine cuts; ample bone stock is available for a solid bone-implant fixation. Hence, it is the zone 1 (epiphysis) of tibia or femur, where the fixation of component takes place in simple primary TKA.

But this is not the case in AORI type II or III. There is an extensive bone loss in zone 1. Therefore, achieving good fixation in zone-1 is not possible. In such cases, metaphyseal sleeves are one of few options. The goal in such cases is to achieve fixation in metaphysis and diaphysis of bone (zone II and III, respectively). Metaphyseal sleeves are porous coated that initiates bone ingrowth in metaphyseal part of bone [16]. Moreover, these sleeves fill the bone loss (AORI types II and III). Metaphyseal sleeve also avoids stress shielding; hence, it

Table 2 Sizes of DePuy Synthes® metaphyseal sleeves available and used

Size (mediolateral dimension)	No. of cases	Percentage
Tibial metaphyseal sleeve		
29 mm	05	12.5%
37 mm	23	57.5%
45 mm	10	25.0%
53 mm	02	5.0%
Total	40	100%
Femoral metaphyseal sleeve		
31 mm	0	0%
34 mm	05	21.7%
40 mm	14	60.8%
46 mm	04	17.3%
Total	23	100%

Fig. 3 A) Removal of Tibial component, B) Perforation of anterior Tibial cortex, C) Use of Ethibond to reduce Tibial tuberosity osteotomy with closure of defect, D) Post-op AP & Lateral Radiographs, E) AP & Lateral Radiographs after 6 months



improves bone quality. There are several studies that demonstrated good bony ingrowth in the metaphyseal region because of porous coated sleeves. According to Fedorka CJ et al. [17], out of 74 cases, bone ingrowth was confirmed radiologically in 69 cases. In our study, no aseptic loosening was seen radiologically, around metaphyseal sleeve. Radiolucent lines were seen in two cases but both of them were non progressive and were present at cement-bone interface over medial tibial condyle.

For achieving fixation in zone III, cemented or uncemented stems are used. The disadvantages of cemented stem include; difficulty in removal of cement in case of revision, it promotes stress shielding, stem does not fill medullary cavity fully so

there is a chance of mal positioning of implant [18]. We used cementless stems in our study. There were three intra-operative iatrogenic fractures in our study, while removing the previously implanted tibial component. All the three fractures were managed without any instrumentation and union was achieved later on. According to Bugler K E et al. [19], there was one intraoperative iatrogenic fracture out of 35 operations. Other studies have shown even better results when it comes to iatrogenic intra-operative fractures [16, 20].

Studies worldwide have shown excellent survivorship of metaphyseal sleeves ranging from 98% to 100%. In the study by Alexander et al. [14], Agarwal et al. [6], not a single

Table 3 Intra and Post-op complications

S. no.	Complications:	Yes (%)	No (%)	Total
1.	Iatrogenic fracture	3 (6.9%)	40 (93.1%)	43 (100%)
2.	Aseptic loosening	0 (0%)	43 (100%)	43 (100%)
3.	Radiolucent lines	2 (4.6%)	41 (95.4%)	43 (100%)
4.	Peri-prosthetic joint infection	1 (2.3%)	42 (97.7%)	43 (100%)

Table 4 Knee Society Score and range of flexion statistics

	N	Pre-Op		Post-Op		p value
		Mean	Std. deviation	Mean	Std. deviation	
Knee Society Score	43	36.21	7.43	92.00	5.66	< 0.005
Range of flexion (degrees)	43	78.83°	14.7	122.91°	4.84°	< 0.005

revision surgery was done because of aseptic loosening. This is the case with our study as well. Not a single revision is done in our study because of aseptic loosening, or any other associated conditions, showing excellent short to mid-term survivorship of 100%.

Conclusion

Metaphyseal sleeves are excellent and feasible option for the management of bone metaphyseal defects in complex primary or revision TKA (AORI type IIB and III). There are chances of intra-operative complications like iatrogenic fracture which if addressed properly, has no negative effect on outcome.

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Compliance with ethical standards

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

Ethics approval This retrospective study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of Liaquat National Hospital approved this study.

Consent to participate Both verbal and written consent were obtained from all the patients included in this study.

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