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ORIGINAL ARTICLE

An Early Experience with a Novel Technique of Total Knee Arthroplasty for Osteoarthritic Knee with Coexistent Traumatic Tibia Diaphysis Fracture

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Abstract

Background Treatment of tibia (upper third and diaphysis) fracture together with severe osteoarthritis (OA) poses challenge to an orthopedic surgeon. Traditionally, it is treated through three-stage surgeries, first fracture fixation followed by implant removal and finally surgery of total knee arthroplasty (TKA). Herein, we describe a novel TKA procedure using long-stemmed tibia component. This one-step technique not only addresses arthritis of the knee joint but also helps in assisting fixation of the fracture.

Materials and Methods We reported outcomes of three female non-diabetic patients with OA who developed tibia shaft fracture following trauma. Range of motion and quadriceps strengthening exercise were initiated immediately after the procedure. X-rays anteroposterior and lateral views of the operated limbs were obtained at post-operative week-6 and week-12. We allowed the patients' toe touch weight-bearing immediately after the surgery. The patients were progressed to full weight-bearing after confirming radiological union on the X-rays.

Results At follow-up, all treated patients were able to mobilize with good range of motion of the operated knee and with union of the fracture. The American Knee society scores and WOMAC pain and stiffness scores improved significantly.

Conclusion This novel technique offers one-stage solution to the complex situation of osteoarthritis of the knee with associated tibia shaft fracture, thereby reducing future hospital admissions/surgeries and associated costs and complications. Further, it allows faster rehabilitation.

Keywords Osteoarthritis · Tibia shaft fracture · Long-stemmed tibia · One-staged total knee arthroplasty · Novel technique

Abbreviations

OA	Osteoarthritis
TKA	Total knee arthroploasty
IM	Intramedullary
AP	Antero-posterior

Introduction

The most common long bone injuries include fractures of the tibia shaft or tibia diaphysis which usually occur as a result of accident, falls, direct trauma and/or combined bending and torsion forces [1–3]. Among several factors identified, smoking habit, lack of physical activity, menopause, family history and osteoporosis have been reported frequently [4]. Clement et al. [5] in a study of 233 tibial diaphyseal fractures in the elderly (> 65 years of age) reported a greater rate of non-union i.e. 10%. These elderly patients often present challenge to the surgeon as malalignment secondary to osteoarthritis predisposes to delayed union or non-union due to increased stress at the fracture site. Furthermore, factors associated with osteoarthritis including osteopenia, corticosteroid use and abnormalities of calcium metabolism affect the strength of the bone and thereby make them liable to

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non-union [6]. Being a load sharing implant, intramedullary (IM) nailing causes less stress shielding and facilitates early loading and weight-bearing which make it more beneficial over cast immobilisation and plating [7–9]. The procedure of IM nailing not only preserves hematoma and cambium layer of periosteal required for bone healing but also reduces the rate of infection [9]. These together attribute to higher union rate and reduced risk of implant failure. Furthermore, the operative and healing time can be reduced to a great extent which ultimately enables mobilisation of the patients in a short span of time. However, literature describing surgical methodology for the treatment of tibial shaft fracture or diaphysis fracture of tibia co-existing with OA is limited. We developed a novel technique to manage traumatic closed tibia shaft fracture with co-existent severe OA of knee joint. In our technique, we attempted to manage both the problems using one-stage total knee arthroplasty together with a long-stemmed tibia component having a good diaphysis fit.

Materials and Methods

We share our experience of treating patients ($n=3$) with one-stage total knee arthroplasty (TKA) with a long-stemmed tibia component for closed traumatic tibia shaft fracture and concomitant severe osteoarthritis of the knee joint. All the patients had low energy type of trauma. We conducted this retrospective review of the three operated cases with local ethics committee approval. Informed consent was also received from all the included patients. A single team of experienced orthopedic surgeons performed all three surgeries. All the patients had a clinical follow-up at day 2, week 6, week 12, week 24, 1 year and 2 year post procedures and a radiological follow-up at 6 weeks and 12 weeks post surgery. American Knee Society Score (AKSS) for clinical and functional outcomes and WOMAC score for pain and stiffness assessments were performed at post-procedural day-2, week-6, week-12, week-24, 1-year and 2-year follow-up by an independent observer.

Procedure

The surgery was performed under combined spinal and epidural anesthesia. TKA was performed through medial para patellar approach. Tourniquet was used in all the cases. In all three patients maxx freedom knee system posterior-stabilized implant (maxx orthopedics Inc., Pensylvania, USA) was used. This particular implant is selected because it offers more variables of the available tibia stems, both for the diameter and length in Indian patient morphology than any other implant system. (The stem provides a choice of 24 straight stem extensions ranging from 7.5 to 16.5 mm and lengths of 40–150 mm) (Fig. 1). Upper tibia preparation was done using intramedullary

Fig. 1 Implant used

rod alignment technique. The position of the IM rod across the tibia fracture was confirmed through anteroposterior (AP) and lateral projections on the image intensifier. IM reamers of increasing diameters were used to ream the tibia until a good diaphysis fit was achieved. Long-stemmed tibia trial component was introduced. The position of the tibia tray and stem was determined through AP and lateral views. Distal femur was prepared in a routine fashion and a trial reduction was carried out. Intraoperatively anteroposterior stability and mediolateral stability of the trial implants were checked by the operating surgeon. Prior to cementing the implant, pulse lavage wash was given. However, tibia stem was not cemented. The bone graft obtained from the distal femoral condyle cut, notch/chamfer cut was utilized for grafting the fractured tibia site, (through a small separate incision or the primary TKA incision). The operative wound was closed in layers over a negative suction drain. All the three patients in this case series had associated fibula fracture. Hence, resection of the fibula was not required to be done to allow good collapse at the fracture site. None of the patient preoperatively was diagnosed to have osteoporosis nor was any one of them on long term bisphosphonate therapy. They had their DEXA scan post-operatively which showed osteoporosis and hence were treated with calcium and vitamin D supplementation and 12 months of injectable terriparetide treatment.

Post-operative Rehabilitation

Routine knee range of motion and quadriceps muscle strengthening exercises were commenced immediately after the surgery. We allowed the patients' toe touch weight-bearing immediately after the surgery protected with a short knee brace for the tibia acting as a Sarmiento type of corset. The patients were progressed to full weight-bearing after confirming radiological union on the X-rays. The reason for cautious approach for weight-bearing is the extended tibial stem has no locking

Fig. 2 Pre-operative and post-operative x-rays of patient A

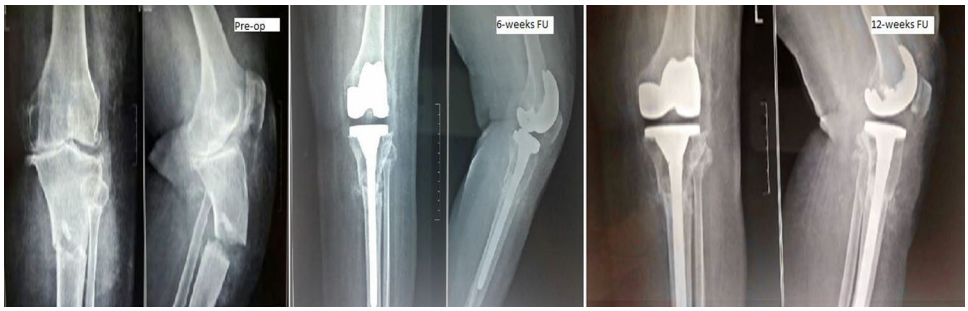

Fig. 3 Pre-operative and post-operative x-rays of patient B

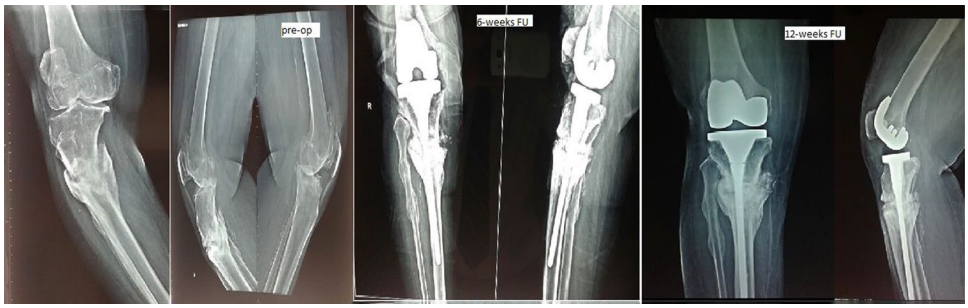

Fig. 4 Pre-operative and post-operative x-rays of patient C

Table 1 Implant sizing for the patients

Patient	Age	Limb operated	Femoral component	Tibia base plate	Tibia liner	Stem extension
A	72 years	Right	Size C	Size 2	C1-2 11 mm	13.5 mm × 150 mm
B	84 years	Left	Size C	Size 1	C1-2 14 mm	12 mm × 150 mm
C	73 years	Right	Size B	Size 2	B1-2 11 mm	9 mm × 150 mm

option distally (As is available in certain revision hip systems). Follow-up was continued till 2 years of the surgery. Pre-operative and post-operative radiographs are shown in Figs. 2, 3, 4.

Results

The present case series includes three female patients diagnosed with tibia shaft fracture following trauma with co-existent severe knee OA. All the patients were non-smoker, non-diabetic and at post-menopausal age. Long-stemmed tibia component was utilized during one-stage total knee arthroplasty. Posterior stabilized fixed-bearing (PS/FB) knee implants were implanted in all three cases with valgus alignment of 4–5°. The details of component sizing are depicted in Table 1.

Pre-procedural clinical characteristics like range of motion, American Knee Society Score (AKSS) for clinical and functional outcomes, and WOMAC score for pain and stiffness could not be obtained due to advanced age of the

patients, the intensity of pain due to fracture and unwillingness of the patients to go for physical examination. Hence, all the aforementioned assessments were performed at post-procedural day-2, week-6, week-12, week-24, 1-year and 2-year follow-up. Range of motion improved consistently throughout 2-year follow-up. Clinical AKSS score improved after the surgery suggesting reduced intensity and frequency of the pain with appropriate varus-valgus alignment. Likewise, improvement in functional AKSS scores was also noted at follow-up. The WOMAC pain and stiffness score at follow-up were suggestive of improvement in the pain and stiffness (Tables 2, 3, 4).

Discussion

The fractures of tibia shaft or tibia diaphysis need to be treated on an urgent basis. The available treatment modalities include cast immobilisation, IM nails and plates. Open reduction and internal fixation with the plate is one of the treatment options for these fractures. However, the prolonged healing period and restriction for weight-bearing make the patients immobilize for at least 3 months after the procedure [10]. Infection at operative site and skin necrosis are other discouraging factors that limit its acceptance as a preferred treatment approach [10]. Owing to the prolonged healing time, plating delays subsequent TKA, it is noteworthy that treatment of tibia shaft fracture further requires removal of hardware at the time of TKA which impart high treatment cost to the patient. Similarly, the presence of IM nails hinders the placement of tibia component of TKA. Hence, an IM nail also needs to be removed surgically before TKA. One-stage TKA with the long-stemmed tibia component can address this unmet clinical need as it eliminates need for multiple surgeries required for the management of tibial shaft fracture and at the same time allow TKA for co-existing knee osteoarthritis. Long-stem extension of the tibial component implantation during the same TKA surgery would bypass the fracture site and simultaneously stabilize and repair the fracture. Requirement of anesthesia only during one surgery reduced surgical/anesthetic risk as well as lowers the hospital expenditure and risk of infection.

Several studies have evaluated one-stage TKA surgery with implantation of long-stem tibia component for stress fractures of the tibia in patients with severe OA [6, 11–15]. To the best of our knowledge, there are no reported studies of the use of single-stage TKA with long-stem tibia component for traumatic fracture of the diaphysis of the tibia with co-existent OA of the knee. In our study, all the three patients had a fracture of the tibia following a fall (trauma/injury).

Mittal et al. [6] reported the outcomes of 11 men and 18 women who were treated with fixed-bearing posterior-stabilized TKA for OA or rheumatoid arthritis. The patients had associated tibial ($n=31$) and femoral ($n=3$) stress fractures. Clinical outcomes at an average follow-up of 51 months were encouraging with significant improvement of Knee Society clinical and functional score together with united fractures. Moskal et al. [13] reported a unique technique for managing three patients who had non-union of a proximal tibial stress fracture adjacent to an arthritic knee joint. The patients were treated with concomitant TKA involving angular correction at the stress fracture non-union site, bone grafting, and stabilization of the non-union site with a long-stemmed tibial component and a unicortical plate. In two instances, fibular osteotomy was needed to achieve the preferred angular correction. Another case series reported

Table 2 Assessment of patient A

Patient A	ROM	Clinical AKSS	Functional AKSS	WOMAC pain score	WOMAC stiffness score
Day 2	98°	47	0	3	4
Week 6	110°	62	30	2	2
Week 12	122°	90	75	1	1
Week 24	122°	90	75	1	1
One year	122°	90	75	1	1
Two year	122°	90	75	1	1

Table 3 Assessment of patient B

Patient B	ROM	Clinical AKSS	Functional AKSS	WOMAC pain score	WOMAC stiffness score
Day 2	98°	45	0	3	3
Week 6	106°	61	35	2	1
Week 12	122°	90	90	0	0
Week 24	122°	90	90	0	0
One year	122°	90	90	0	0
Two year	122°	90	90	0	0

Table 4 Assessment of patient C

Patient C	ROM	Clinical AKSS	Functional AKSS	WOMAC pain score	WOMAC stiffness score
Day 2	92°	39	0	4	4
Week 6	96°	63	15	3	2
Week 12	118°	77	70	1	1
Week 24	118°	77	70	1	1
One year	118°	77	70	1	1
Two year	118°	77	70	1	1

satisfactory early functional outcomes of the 34 patients treated with TKA. Stress fracture of tibia and associated arthritis was addressed through single surgical procedure using long-stem tibial component, metal augments, corrective osteotomy [14]. Similarly, radiological and functional outcome of one-stage TKA with long stem for 20 patients with varied degrees of knee arthritis and proximal tibia stress fractures confirmed restoration of limb alignment and fracture healing at mean follow-up of 28 months [15].

This is one of its kind studies that describe 2-year functional outcomes of one-stage TKA that used long-stemmed tibial component with good diaphysis fit for simultaneous treatment of severe OA and traumatic tibial fractures. Earlier reported studies [6, 11–15] are all for the simultaneous management of severe OA and associated stress fracture of the tibia and not for the fracture of the tibia following trauma/injury. It showed improved functional and clinical knee scores at 2-year follow-up. Apart from cost-effectiveness, less frequent hospital admissions/surgeries, early rehabilitation and ambulation, reduced fracture healing time, low infection rate or wound complications make this technique as an attractive treatment approach. Our study has certain limitations. The interpretation of the results needs careful consideration of small sample size and lack of metabolic workup of the patients. Notably, all the fractures treated in this study were extra-articular fractures. Other limitation of our study is we did not have radiographs of the knee prior to the patient sustaining trauma. Presence of pre-trauma radiographs would have made sure that these were not stress fractures of tibia (which happens in severe varus OA knee) which became displaced fracture due to trivial trauma.

Conclusion

One-stage TKA with the use of long-stemmed tibial component can be considered as a combined treatment approach for traumatic tibial fracture with co-existent knee OA. Single surgical procedure reduces hospital admissions, multiple surgeries and thereby associated costs and complications. Faster rehabilitation is an added advantage of this novel procedure. However, larger randomized study is required to reciprocate similar findings.

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Availability of Data and Materials Not applicable.

Declarations

Conflict of Interest There are no competing interests.

Ethical Approval Institutional review board approval was obtained before the study. Also all patients were consented.

Ethical Standard Statement This article does not contain any studies with human or animal subjects performed by the any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Consent for Publication We hereby give our consent for publication.

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