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Original Article

Total knee arthroplasty with long tibial stem for tibial stress fractures with knee osteoarthritis: Two birds with one stone

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ABSTRACT

Purpose: The treatment and outcome of tibial stress fractures concomitant with knee osteoarthritis (OA) are complicated. The aim of this study was to evaluate the functional and radiological outcome of total knee arthroplasty with long tibial stem as a treatment for patients having knee OA and tibial stress fracture.

Methods: Patients who were diagnosed to have proximal tibia stress fracture along with knee OA at our institution between June 2013 and November 2018 were included in our study. All patients underwent total knee arthroplasty with long tibial stem. Preoperative and postoperative functional assessments were done according to range of movement of the knee joint, knee society score and knee injury and OA outcome score. Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency and proportion for categorical variables.

Results: Twelve patients were included in the study. All patients were found to have stress fractures in the proximal half of tibia and extra-arthrosis. Four patients had non-union/delayed union, and 8 patients had acute fractures. The average preoperative range of movement was 88.1°, which improved to 116.3° at 3 months following surgery. It was found that the fracture has healed in all cases. Mean knee society score improved from 32.9 preoperatively to 89.3 at 1 year follow-up. Knee injury and OA outcome score improved from a mean score of 28.3 preoperatively to 81.1 at 1 year follow-up.

Conclusion: Stress fractures can occur in the proximal tibia in patients with knee OA. Total knee arthroplasty with tibial stem provides a suitable solution for both conditions. Additional plating or bone graft is unlikely to be required.

Introduction

Stress fractures are caused by a mismatch between the strength of the individual's bone and the mechanical load placed on the bone. This mismatch maybe due to abnormal stress on normal bones termed as fatigue fractures, or due to normal stress on abnormal bones termed as dysfunctional fractures.[1] Tibia is one of the most common sites of such fractures.[2]

Tibial stress fractures seldom occur in patients with degenerative knee osteoarthritis (OA). When tibial stress fractures occur with knee OA, the treatment and outcome of both are complicated.[3] Tibial stress fractures can be managed conservatively with a cast, which, however, requires prolonged immobilisation and often heals with a varus malalignment. Surgical management traditionally includes open reduction and internal fixation with plating or intramedullary nailing.[1] However, neither of these methods has been applied to manage knee OA. Total knee arthroplasty (TKA) with tibial stem has recently been proposed as a treatment option for such cases, which provides a composite solution for both conditions. We studied 12 patients having knee OA and tibial stress fracture, who underwent total knee replacement with long tibial stem.

Methods

Institutional ethics committee approval was obtained for this study. Patients with proximal tibia stress fracture along with knee OA at our institution between June 2013 and November 2018 were included in our study. Preoperative assessment included range of movement (ROM) of the knee joint using a goniometer, functional assessment of knee society score (KSS),[4] and knee injury and OA

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outcome score (KOOS).[5] Radiological assessment included anteroposterior and lateral radiographs of knee joint, and full length anteroposterior and lateral radiographs of tibia. Changes of OA were graded using Kellgren and Lawrence system. The diagnosis of stress fractures was based on radiographs. Features suggestive of stress fracture on radiograph include the "grey cortex sign", visible fracture line, periosteal reaction, endosteal callus formation and linear sclerosis.[6] Patients having acute stress fracture or non-union of stress fractures were both included in the study. MRI was done, if further imaging was deemed necessary.

All patients underwent TKA with long tibial stem. The surgery was performed by the same surgeon. Midline incision was made, and then medial parapatellar approach was used to expose the joint. Bone cuts were made and soft tissue balancing was done. Tibia stress fracture was reduced under fluoroscopic guidance. After placing the trial tibial tray, entry point for the tibia stem was determined. Serial reaming was done with hand reamer. The length of the stem required was determined under fluoroscopic guidance using a radio-opaque ruler, so that the stem would bypass the fracture site comfortably. The determined tibial stem was attached to the tibial base plate, and then inserted. Only the tibial base plate was cemented (Fig. 1). Cruciate retaining systems and deep dish polyethylene inserts were used. Knee bending and partial weight bearing walking were initiated on the first day postoperatively. Full weight bearing walking was initiated 6 weeks after surgery, once radiological evidence of callus formation was noted at the fracture site. Patients were followed up at regular intervals at 2 weeks, 6 weeks, 3 months, 6 months, 1 year and 3 years. Any patient lost of follow-up in the first 3 months postoperatively were excluded from the study. Fracture healing and signs of implant loosening were analyzed by radiographs. Postoperative functional assessment included enquiry of pain at fracture site/knee joint, measurement of ROM at the knee joint, KSS and KOOS.

Results

Twelve patients (8 female and 4 male) were included in the study. Mean age of the patients was 67.3 years (range 62–74 years). Of them, 7 cases (58.3%) involved the right side, and 5 cases (41.7%) involved the left side. The mean body mass index of patients was 23.14 kg/m^2. All patients were found to have stress fractures at the meta-diaphyseal junction of the tibia, approximately in the region of junction between proximal and middle third of the tibia (Fig. 2). All cases were related to unilateral and extra-articular fractures with varus angulation. Four patients had non-union/delayed union of tibia stress fracture (Fig. 3), and 8 had acute fractures. Nine patients (75.0%) had Kellgren Lawrence grade IV OA, while 3 (25.0%) had Kellgren Lawrence grade III OA. Of them, 5 patients (41.6%) had a stress fracture of fibula additionally (Table 1).

The long stem used in TKA was Depuy Sigma Fluted rod (Warsaw, USA) 10 mm × 150 mm in 5 cases, and Smith and Nephew Genesis II Long stem 10 mm × 150 mm (Memphis, USA) in 7 cases. The average preoperative ROM improved from 88.1° to 116.3° at 3 months after surgery. The fractures in all cases were healed (bony union of at least 3 cortices). The mean union time of the fractures was 9.4 weeks.

The mean KSS improved from 32.9 (range 23–51) preoperatively to 89.3 (range 73–94) at 1 year follow-up. The average functional KSS improved from 23.75 (range 10–40) to 77.5 (range 60–90). KOOS increased from a mean of 28.3 (range 22–45) preoperatively to 81.1 (range 71–92) at 1 year follow-up (Table 2). Only 1 patient complained of pain in the operated region that would significantly affect her routine activities. Mean duration of follow-up was 38 months (range 14–64 months). No patients required further procedures in the operated knee till last follow-up.

Discussion

Stress fractures, especially insufficiency fractures, are the result of abnormal bones under normal or traumatic loads. They may occur spontaneously or following minor trauma. It is more common in weight bearing bones of the lower limb compared with the upper limb. Tibia is commonly involved, with majority of them occurring in the proximal half of tibia,[7] which can be treated conservatively with immobilisation and avoidance of weight bearing. However a significant risk of non-union often requires surgical fixation with an intramedullary rod or a plate.[8] Uncommonly, they occur in a patient with pre-existing knee OA.[9] The possible link between stress fracture and knee OA may be presence of osteoporosis due to advanced age or mechanical forces due to deformities caused by knee OA.[10] However, to conclusively determine the basis of this association, further studies and biomechanical analysis are required. We found that the mean age of our patients was 67 years, with 83% of them having osteoporosis and 75% having significant varus deformity of the knee joint. It is known that stress fractures that occur in such patients treated with conservative measures can cause non-union.[11] There were 4 such patients in our study who developed non-union after conservative management of the stress fracture.

The treatment options are varied. Knee OA and stress fractures can be addressed individually depending on the severity of each.

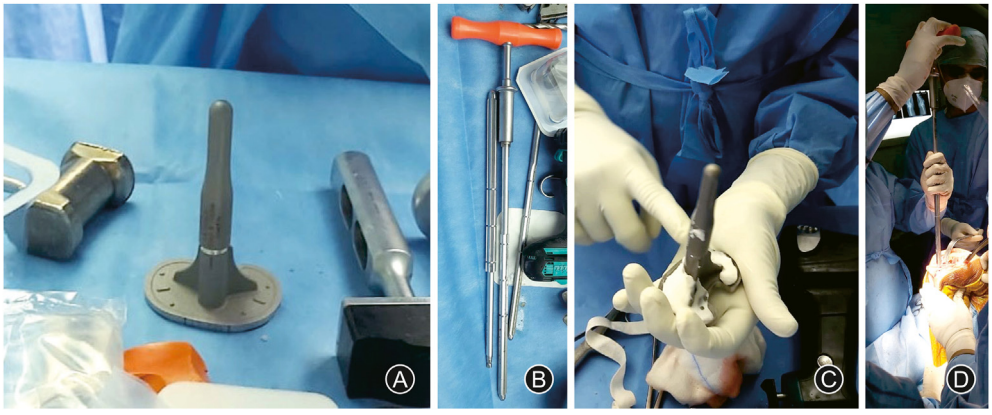

Fig. 1. Intraoperative instrumentation and technique. (A) Tibia stem extension attached to tibial tray; (B) Hand reamers used for serial reaming; (C) Tibial baseplate cementation before being inserted; and (D) Hand reaming of tibial intramedullary canal prior to placement of stem.

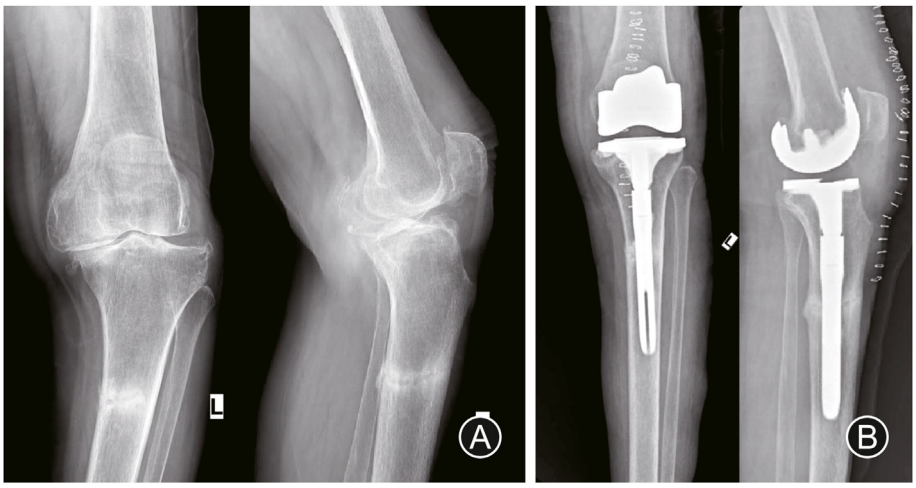

Fig. 2. Illustrative case of a 67-year-old female with OA and fresh proximal tibia stress fracture. (A) Anteroposterior and lateral radiographs of left knee of a 67-year-old female patient, showing decreased medial joint space, osteophytes and genu varum deformity. Tibial stress fracture is noted in the posterolateral aspect of tibia at the level of junction of metaphysis and diaphysis. (B) Post total knee arthroplasty radiograph showing tibial stem of size 12 mm × 150 mm crossing the tibial stress fracture site.

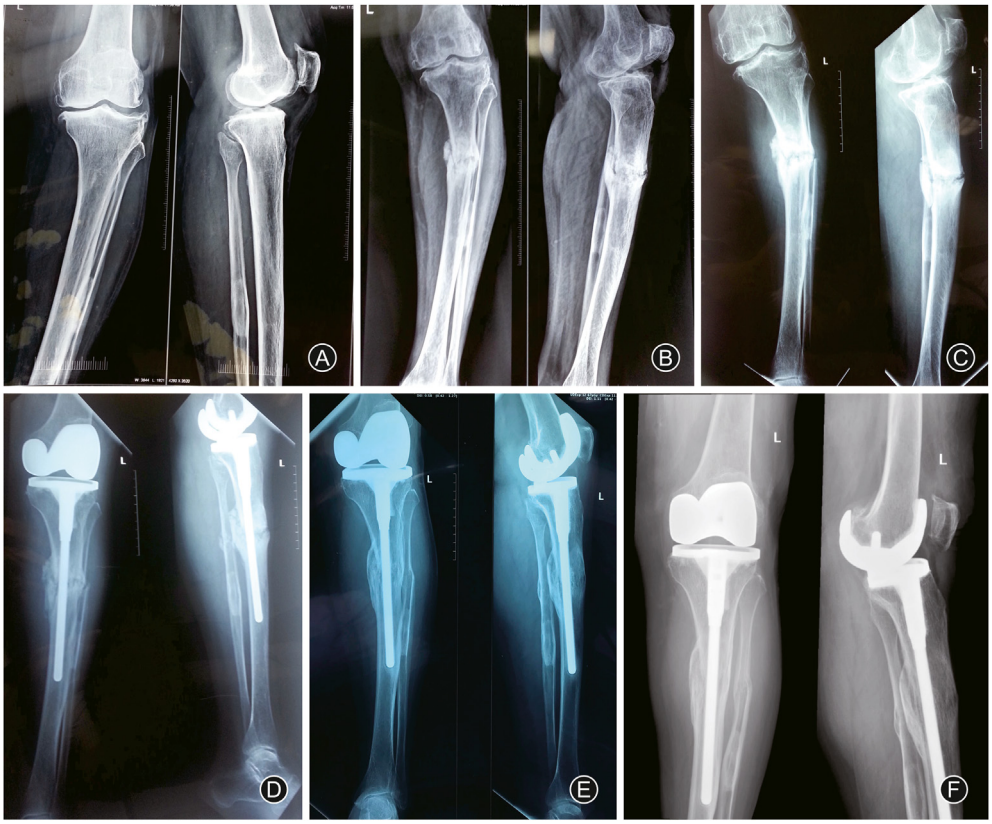

Fig. 3. Illustrative case of 64-year-old female having OA and non-union of proximal tibia stress fracture. (A) Anteroposterior and lateral radiographs of left knee and leg of a 64-year-old female patient, with left knee OA, which was being managed conservatively with analgesics. (B) Radiographs show stress fracture in proximal tibia. (C) After 6 months of conservative management of stress fracture, radiographs show fracture line still visible, and fracture of fibula at the same level. (D) Radiographs after she underwent total knee arthroplasty with tibial stem of size 10 mm × 150 mm. (E) Radiographs show complete union of all 4 cortices of tibia 3 months after surgery. Fibula fracture also appears united. (F) Radiographs show no signs of loosening of implants and no fractures 5 years after surgery.

Conservative management can be attempted for both, but it does not completely relieve pain and require non-weight bearing before the fracture is healed. Hence, surgical management is the first choice, when the 2 conditions occur simultaneously. The 2 conditions can be addressed separately by surgery. Tibia stress fracture can be addressed with the intramedullary nailing of tibia, or plating. Total knee replacement can be done simultaneously. TKA using a long stem addresses both the conditions with a single procedure. Tibial stem extensions have been used in TKA, usually for revision of TKA, as it increases the stability by decreasing micro motion, provides shear resistance and reduces tibial lift-off. They also reduce the chance of aseptic loosening of the implant.[12]

Table 1
Patient characteristics, grade of OA and stress fracture characteristics.

Patient No.	Age (years)	Sex	Side	Osteoarthritis Kellgren Lawrence grade	Fibula stress fracture	Acute fracture/delayed union
1	65	F	Left	Grade IV	Absent	Acute
2	68	F	Right	Grade IV	Present	Acute
3	71	M	Right	Grade IV	Absent	Delayed union
4	62	F	Right	Grade III	Absent	Acute
5	67	F	Left	Grade IV	Absent	Acute
6	74	F	Right	Grade IV	Present	Delayed union
7	68	M	Right	Grade III	Absent	Acute
8	66	F	Left	Grade IV	Present	Acute
9	69	F	Right	Grade IV	Absent	Acute
10	63	M	Right	Grade III	Absent	Delayed union
11	64	F	Left	Grade IV	Present	Delayed union
12	70	M	Left	Grade IV	Present	Acute

OA: osteoarthritis.
Note: All fracture type was meta-diaphyseal junction.

Table 2
Pre-operative functional assessment, tibial stem implant used, and postoperative follow up functional assessment.

Patient No.	Preoperative KSS	Preoperative KOOS	Preoperative ROM	Tibial stem used	ROM at 3 months postoperative	KSS at 1 year postoperative	KOOS at 1 year postoperative
1	34	28	80	Smith and Nephew Genesis II Long stem 10 mm × 150 mm	110	89	81
2	37	33	90	Smith and Nephew Genesis II Long stem 10 mm × 150 mm	115	93	85
3	23	22	60	Smith and Nephew Genesis II Long stem 10 mm × 150 mm	110	73	71
4	51	45	110	Smith and Nephew Genesis II Long stem 10 mm × 150 mm	130	94	92
5	29	24	90	Smith and Nephew Genesis II Long stem 10 mm × 150 mm	125	94	89
6	25	23	70	Smith and Nephew Genesis II Long stem 10 mm × 150 mm	120	87	78
7	27	23	75	Smith and Nephew Genesis II Long stem 10 mm × 150 mm	110	85	75
8	43	35	95	Depuy Sigma Fluted rod 10 mm × 150 mm	120	93	82
9	29	24	80	Depuy Sigma Fluted rod 10 mm × 150 mm	110	88	79
10	38	33	105	Depuy Sigma Fluted rod 10 mm × 150 mm	120	92	83
11	33	26	90	Depuy Sigma Fluted rod 10 mm × 150 mm	120	94	77
12	26	24	70	Depuy Sigma Fluted rod 10 mm × 150 mm	105	89	81

KSS: knee society score; KOOS: knee injury and osteoarthritis outcome score; ROM: range of movement.

However, the drawbacks of using tibial stems include stress shielding, an increased risk of peri-prosthetic fracture and end-of-stem pain.[13] The use of long stems in TKA provides a solution for knee OA and tibial stress fracture in a single procedure. The tibial stem serves as an intramedullary fixation device for stress fracture, thereby allowing early mobilisation post-operatively. The additional advantages include the avoidance of any additional scars and the preservation of soft tissue coverage. And it saves the operative time compared to TKA with additional plate of the fracture.

These benefits have prompted several orthopaedic surgeons to explore this option recently.[14–16] Soundarrajan et al.[14] found that all tibial stress fractures healed by 4 months following TKA with tibial stem. Mullaji et al.[16] found that the mean KSS increased from 36.7 to 90.3 preoperatively. However, most of the published literature are case series with limited case number and short follow-up durations.[17–19] It is advisable for the tibial stem used to belong to the same manufacturer as that of the tibial base plate, to avoid miss-match between components.[20] Some studies have explored the use of long tibial stems being supplemented by plate fixation of the fracture.[21,22] Stress fractures of the proximal tibia can occur in patients with knee OA, in which the treatment and functional outcome will be complicated. TKA with tibial stem provides a suitable solution for such conditions. We have found that it can produce excellent functional outcome, and all fractures have healed. Additional plating or bone grafting is unlikely to be required.

Funding

Nil.

Ethical statement

Informed consent was obtained from all the patients for this study.

Declaration of competing interest

The authors declare no conflict of interest.

Author contributions

SNP was the principal investigator, was responsible for obtaining of medical records, patient data and digital radiographs. MMK was the chief operating surgeon and obtained consent from the patients for the study. PKV, RR and PK were responsible for data

curation and analysis of data. SNP and PKV drafted the initial manuscript. MMK, RR and PK reviewed and modified the manuscript. All authors reviewed and accepted the final manuscript.

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