# Surgical management of combined osteoarthritis knee and proximal tibial stress fracture via long tibial stem total knee arthroplasty: assessment of medium-term results

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**Background**
The combined osteoarthritis knee and proximal tibial stress fracture is an uncommon condition that increases the complexity of the management for both. No common consensus among surgeons regarding management guidelines. We assessed the medium-term results (minimum 5 years) of using long tibial stem total knee arthroplasty (TKA) to restore limb alignment, achieve fracture union, and resurface the arthritic joint in a single procedure.
**Methods**
Total of 23 patients with combined osteoarthritis knee and proximal tibial stress fracture were enrolled in this study. Of those 23 patients, 18 were females and five were males. All patients were managed surgically by TKA (PCL sacrificing) with a long tibial stem (straight or with offset). Assessments of union and tibiofemoral alignment were carried out using radiographs. Clinically, patients were evaluated by assessment of knee range of motion, knee society score (KSS), and knee injury and OA outcome score.
**Results**
The average follow-up period was 6.5±2.3 years (range from 5 to 9 years) all fractures united in 3–8 months (average 3.2 months), and mean range of motion improved from 89°±8° to 119°±6°, mean knee society score improved from 32±8 to 87±5, mean knee injury osteoarthritis outcome score improved from 27±6 preoperatively to 79±5 after a minimum of 5 years follow-up. no complications (instability, infection, or patella mal-tracking) were reported, although 1 case had a femoral intraoperative condyle fracture which was fixed by screws with no effect on the outcome.
**Conclusion**
The use of a long tibial stem TKA is an effective and reproducible single surgical procedure in the management of combined osteoarthritis knee and proximal tibial stress fracture. Satisfactory clinical scores and radiological outcomes were achieved and proper limb alignment was restored obviating the need for further fixation or grafting.

**Keywords:**
knee arthritis, long stem, stress tibia fractures, total knee arthroplasty

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## Introduction

A stress fracture is defined as a partial or complete fracture caused by cyclic, sub-threshold loading on bone without violent trauma [1,2].

Microfracture occurs with accelerated remodeling without enough time to heal completely, just to receive another stress load that prevents such healing, eventually leading to stress fracture [3,4]. Stress fractures occur due to a disparity between the mechanical load versus the strength of the bone to which the load is applied. Two forms are included, fatigue stress fractures; created by abnormal loads to normal bones (march fracture), and Insufficiency stress fractures; created by normal loads on abnormal (unhealthy i.e. arthritis or hyperparathyroidism) bones [5,6].

Tibial stress fractures associated with degenerative arthritis knee are rare representing 0.04% of the total knee arthroplasty (TKA) cases conducted in the same period In Zagazig University hospitals. Cyclic loads concentrated on the proximal tibia metaphysis are caused by deformities in the coronal plane with an arthritic knee causing stress fracture. The already present osteopenia increases the damage. Secondary malalignment caused by arthritis magnifies the fracture site stress, eventually leading to non-union [7]. The combined osteoarthritis knee and proximal tibial stress fracture is first described by Wheeldon 1961 [8] in rheumatoid patients then following studies described the condition in osteoarthritic patients [9–11].

In the literature, few number case series with relatively short follow-up, and different patterns of the fracture (intra and extra-articular) could not provide surgeons with recommended solutions with enough evidence-based results. Management includes activity modification with orthosis [12], long tibial stem TKA alone [13,14], or with add-on osteosyntheses with bone grafts [15]. It is the only study in our center Zagazig University.

To our knowledge, this study provides the results of a relatively larger number of patients with a longer follow-up period (minimum 5 years) with the target of improving treatment guidelines, describing the surgical procedure, and analysis of medium-term results.

## Patients and methods

After the Institutional Review Board (IRB) approved the conduction of the study, twenty-three patients (18 females and five males) who had combined osteoarthritis knee and proximal tibial stress fracture were enrolled in this study. The mean age was 63 ± 4.6 (54–71) years. The associated fibular stress fracture was present in 15 patients. Preoperative deformities consist of varus deformity in 20 and valgus in 3 cases. The mean time from fracture diagnosis to surgery was 15 ± 3 months. Thirteen patients had one or more preoperative comorbidities (diabetes, hypertension, Dyslipidemia, or ischemic heart disease).

All cases were operated between March 2013 and September 2016. Preoperative data collection included a goniometer assessment of knee range of motion (ROM), knee society score as surgeon-based functional evaluation (KSS) [16], and knee injury and osteoarthritis outcome score (KOOS) as patient-based functional evaluation [17]. Radiographic evaluation included standing full-length lateral and anteroposterior views of the knee and tibia. All cases were grade 4 of OA according to Kellgren and Lawrence's classification. Stress fractures appeared radiographically as grey cortex signs, clear fracture lines, the reaction of the periosteum, and callus formed by the endosteum or sclerosis [18]. ESR and CRP were routinely investigated in all cases to exclude any septic focus. Preoperative data were summarized in Table 1.

Our workup also included Osteoporosis assessment with bone densitometry (DEXA), serum calcium, phosphorus, and alkaline phosphatase, and metabolic bone diseases evaluation to exclude Paget disease cases or bone tumors e.g. multiple myeloma. Also, intraarticular stress fractures and acute cases were excluded.

**Table 1 Preoperative demographics and criteria**

| | | |
|---|---|---|
| Age | 63 ± 4.6 (54–71) years | |
| Sex | 18 Females (78.2%) | 5 Males (21.7%) |
| Preoperative KSS (mean±SD) | 32 ± 8 | |
| Preoperative KOOS (mean±SD) | 27 ± 6 | |
| Preoperative ROM (mean±SD) | 89°±8° | |
| Fibular stress fracture | 15 present (65.2%) | 8 absent (34.7%) |
| Preoperative deformity | 20 varus (86.9%) | 3 valgus (13.1%) |
| Time-lapse from fracture to surgery | 15 ± 3 months | |
| Comorbidities (n of patients) | 13 with (56.5%) | 10 without (43.4%) |

KOOS, knee injury and osteoarthritis outcome score; **KSS**, Knee society score; ROM, range of movement.

Only extraarticular chronic stress fracture cases with nonunion were included in this work, and no MRI was needed. All cases received long tibial stem TKA, operated by the same surgical team.

### Surgical technique

Long-stemmed posterior cruciate sacrificed TKR was used, (Nexgen Zimmer, Warsaw, IN, USA). Spinal anesthesia was applied for 14 patients, epidural anesthesia in six, and general anesthesia was used in three. Pneumatic Tourniquet was used in all surgeries, minimizing blood loss intraoperatively, facilitating field visualization, and enhancing cement-bone interface. The mean tourniquet time was 70 ± 13 min, tourniquet placement was high on the affected thigh, inflation to 450 mmHg was done after exsanguinating the limb, and deflation was done after component placement and cement hardening. A standard midline skin incision with medial parapatellar arthrotomy was adopted. The measured Resection technique was used in combination with the gap balancing technique (hybrid technique). The femoral cuts were performed first in a standard manner (distal cut then remaining cuts using 4 in 1 jig leaving the notch or the box cut to be the last after tibial preparation to avoid weakening the condyles). The reference in femoral cuts was the trans epicondylar axis, the posterior condylar axis, and the whiteside's line to adjust the femoral external rotation of 3° and the valgus position of 5° in males and 7° in females of the femoral component.

No highly constrained insert was used due to the absence of collateral ligament insufficiency. In this study, we didn't resurface the patella performing just denervation.

The intra-articular deformity is corrected with proper soft tissue releases by performing standard cuts using bone graft for contained defects or wedges in uncontained defects when needed. Reduction was maintained by the assistant in the same way that reduction is held in intramedullary nailing of the tibia followed by proper reaming under fluoroscopic image avoiding cortex penetration.

Tibial preparation started with establishing the proper entry point then with the usage of the narrowest reamer to breach the medullary canal correcting the extra-articular deformity that resulted from the stress fracture. In all patients; the fracture was non-united and the deformity was mobile and correctable so the tibia was aligned followed by proper reaming under fluoroscopic image avoiding cortex penetration, we also used long stems with offset and adjustable tray when needed allowing both proper tibial component placement without displacement and simultaneously fix the fracture and transforming stress tensile deforming forces into compressive forces.

The trial stem attached to the trial base plate was hammered into the medulla and components were checked clinically and fluoroscopically. Figure 1.

In the current study, the stem lengths varied from 10 to 20 cm to guarantee that at least approximately two cortical bone diameter lengths were used to bypass the fracture site, and after proper alignment, the final component was assembled. Standard cementing of the femoral component was done, only the tibial tray and the proximal part of the stem engaging the metaphysis cemented avoiding cement extrusion into the fracture site.

The trial reduction was done followed by a final tibial insert. The fibular osteotomy was not needed in any case whether the fibula was stress fractured or not. No other methods of fixation or bone grafting were needed for the stress fracture as reaming facilitated healing along with deformity correction without exposing the fracture site.

*Postoperative care and follow-up*

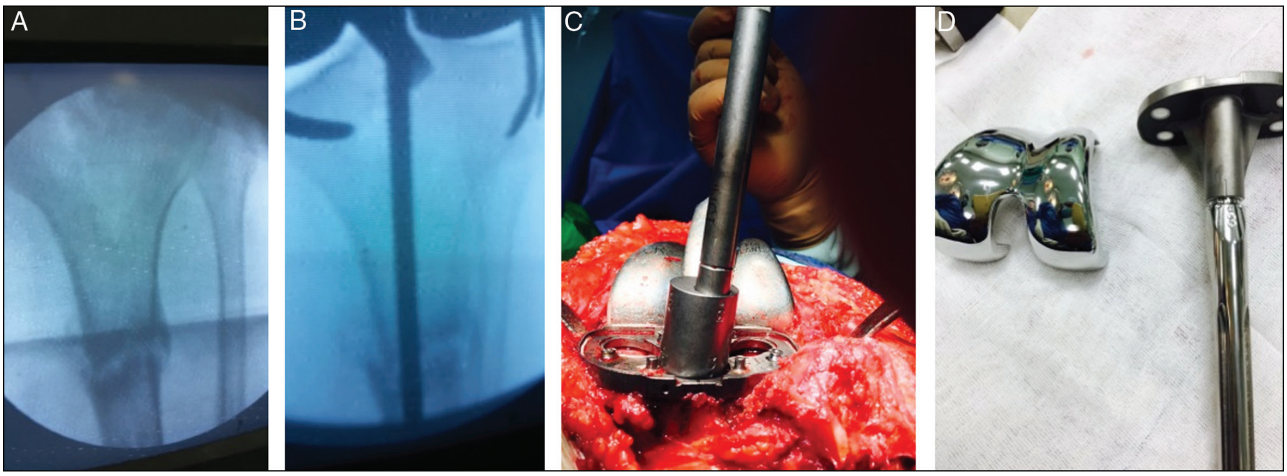
Knee movement in bed started after vacuum suction removal within 24–36 h. Partial weight-bearing and walking frame wearing long knee brace used for 6–8 weeks followed by full weight-bearing after fracture union aided with a stick and hinged knee brace until fracture consolidated. Osteopenia, osteoporosis, and underlying bone-weakening morbidities were addressed and treated while performing rehabilitation.

Pre and Postoperative follow-up was done clinically by the KSS, (KOOS) and radiologically by using standard radiographs at 6 weeks, 3 months, 6 months, and 1 year, and yearly thereafter. Union was determined as the absence of pain at the fracture site and the presence of three bridging cortices in two orthogonal imaging planes.

**Statistical analysis**

Analysis of data was performed by using SPSS (Statistical Program of Social Sciences, Version 19 (Chicago, Illinois). Analysis of quantitative parameters was performed in the form of average, standard deviation, and range. Paired $t$-test and $\chi^2$ test were used for the comparison of quantitative parameters

**Figure 1**




(a) intraoperative fluoroscopic view aligning the deformity, (b) reaming under fluoroscopic observation, (c) determining the proper offset, (d) the final components.

**Table 2 Detailed table of age, gender, fibular stress fracture association, pre and more than 5 years postoperative knee society score, mean knee injury and osteoarthritis outcome score, and range of motion**

| Patient No | Age (years) | Sex | Fibula stress fracture | Preop KSS | Preop Mean KOOS | Postop KSS | Postop Mean KOOS | Preop ROM | Postop ROM |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 63 | F | Y | 25 | 23 | 88 | 80 | 90 | 130 |
| 2 | 69 | F | Y | 32 | 25 | 93 | 76 | 105 | 115 |
| 3 | 70 | F | Y | 37 | 32 | 91 | 82 | 85 | 120 |
| 4 | 61 | F | N | 28 | 23 | 87 | 78 | 80 | 115 |
| 5 | 64 | F | N | 42 | 34 | 91 | 81 | 75 | 120 |
| 6 | 70 | M | Y | 26 | 22 | 84 | 74 | 90 | 125 |
| 7 | 63 | F | Y | 24 | 22 | 86 | 77 | 100 | 130 |
| 8 | 60 | F | Y | 28 | 23 | 93 | 88 | 85 | 130 |
| 9 | 62 | F | Y | 50 | 44 | 93 | 91 | 85 | 130 |
| 10 | 55 | F | Y | 22 | 21 | 72 | 70 | 105 | 115 |
| 11 | 64 | F | Y | 36 | 32 | 92 | 84 | 80 | 120 |
| 12 | 71 | M | N | 33 | 27 | 88 | 80 | 75 | 115 |
| 13 | 62 | M | Y | 32 | 26 | 87 | 79 | 80 | 115 |
| 14 | 68 | F | Y | 35 | 31 | 91 | 83 | 95 | 105 |
| 15 | 69 | F | Y | 21 | 20 | 71 | 69 | 75 | 120 |
| 16 | 60 | M | N | 49 | 43 | 92 | 90 | 95 | 115 |
| 17 | 63 | F | N | 27 | 22 | 92 | 87 | 90 | 120 |
| 18 | 69 | F | N | 23 | 21 | 85 | 76 | 95 | 115 |
| 19 | 62 | M | Y | 25 | 21 | 83 | 73 | 80 | 120 |
| 20 | 59 | F | Y | 41 | 33 | 90 | 80 | 95 | 115 |
| 21 | 61 | F | N | 27 | 22 | 86 | 77 | 85 | 120 |
| 22 | 54 | F | N | 36 | 31 | 90 | 80 | 95 | 110 |
| 23 | 63 | F | Y | 31 | 24 | 92 | 77 | 105 | 120 |
| Mean | **63±4.6** | | | **32±8** | **27±6** | **87±5** | **79±5** | **89±8** | **119±6** |

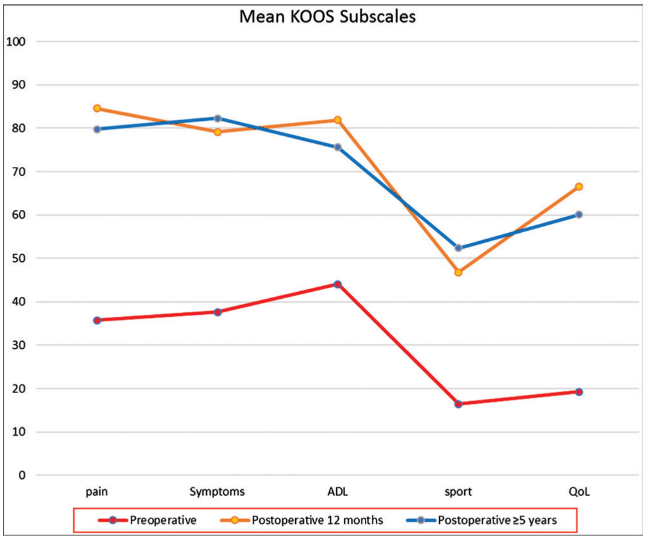
KOOS, knee injury and osteoarthritis outcome score; **KSS**, knee society score; ROM, range of movement.

in the same group before and after the procedure. Pearson correlation test was used regarding different ages, sex, time-lapses, comorbidities, and preoperative deformity. *P* value less than 0.05 was considered to be significant.

## Results

A total of 28 patients matched the study inclusion criteria but five were lost in the follow-up so the study was conducted on 23 patients. The average follow-up period was 6.5±2.3 years (range from 5 to 9 years) all fractures united in 3–8 months (average 3.2 months). After a minimum of 5 years of follow-up, mean ROM improved from 89°±8° (range 75°–105°) to 119° ±6° (range 110°–130°) which was found to be significant, the *P* value was 0.04 (<0.05), mean KSS improved from 32±8 (range 21–50) to 87±5 (range 71–93), The value of Paired *T*-test showed *t* as 52.854 (*P* <0.001) which is significant, Mean KOOS improved from 27±6 (range 20–44) preoperatively to 79±5 (range 70–91), Paired *T*-test was statistically significant (*t* was 31.0112, *P* <0.001). Table 2, Fig. 2.

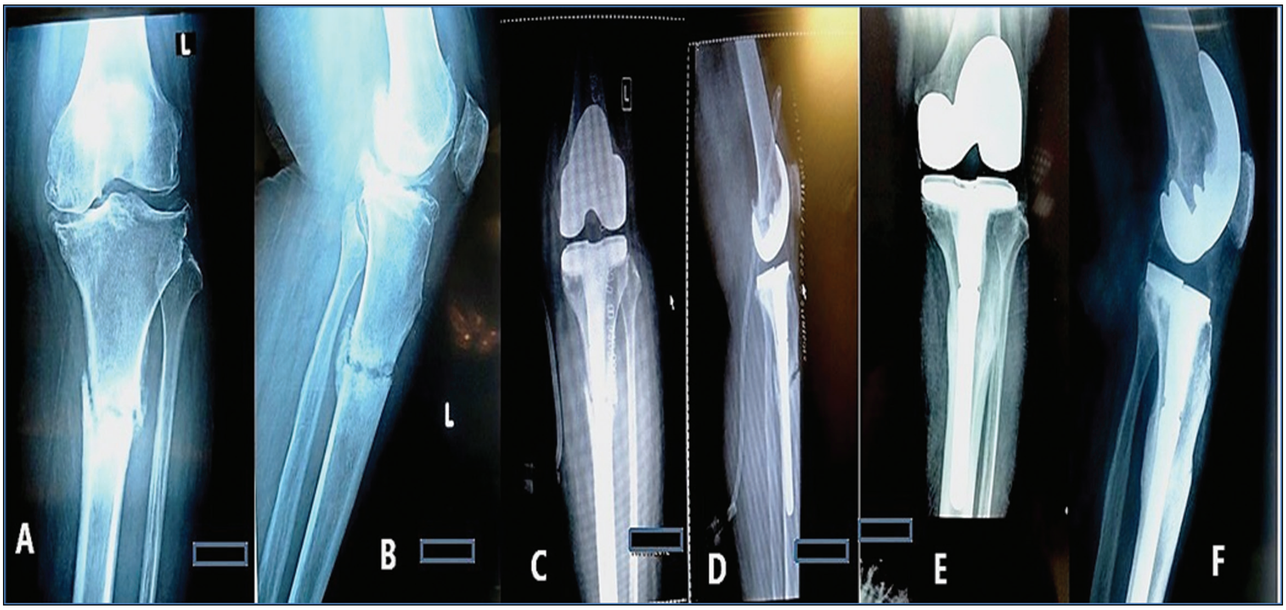
**Figure 2**




Mean KOOS subscales. ADL adult daily living, Qol quality of life.

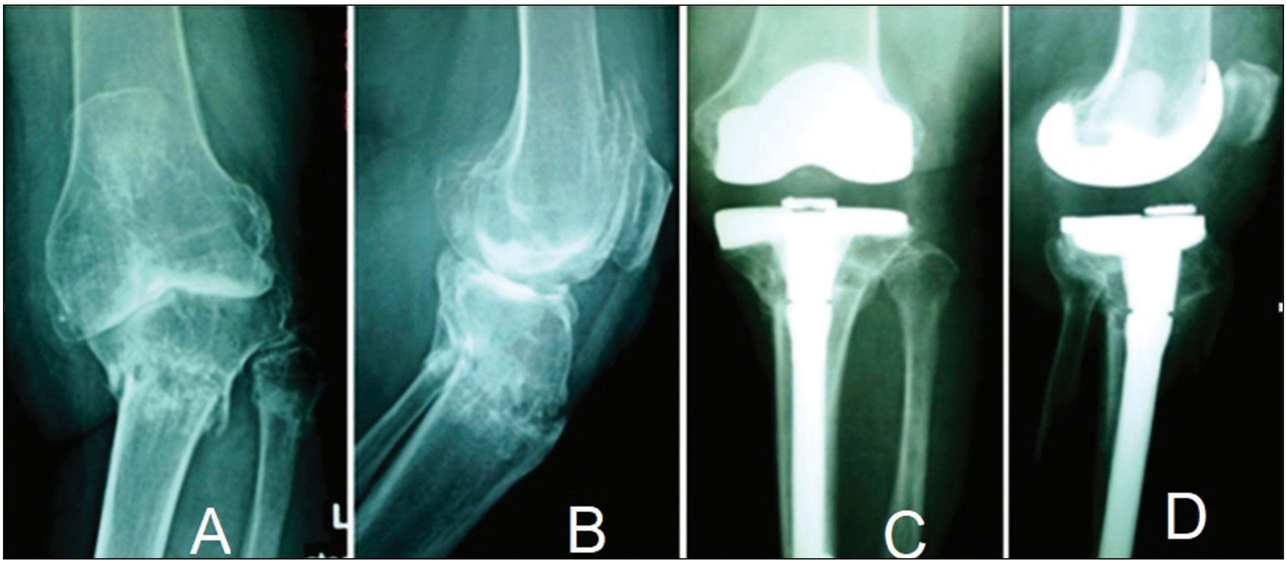
The Average tibiofemoral angle improved from 26.6° varus preoperative deformity to 6.9° valgus postoperatively (range from 4° to 7°), and a *P* value of 0.03 (<0.05) showed significant improvement in limb alignment. Regarding Component alignment, the mean femoral angle (α angle) was 97.2° (ranges between 94° and 98°), the mean tibial (β) angle was 89.2°(ranges between 86° and 90.5°) and the posterior tibial slope angle (σ angle) was 4.9°(ranges between 0° and 8°). Figures 3, 4.

**Figure 3**




Case N 12 A-B preoperative AP and lateral radiographs, C-D immediate postoperative radiographs, E-F radiographs after 5 years follow-up.

**Figure 4**




Case N 19 A-B preoperative AP and lateral radiographs fracture is shown by discontinuity of 4 cortices in ap and lateral view and pseudo arthrosis is evident cortices, C-D radiographs after 5 years follow-up.

Pearson correlation test did not show a correlation between KSS or KOOS on one hand regarding age, gender, time-lapse, or preoperative deformity on the other hand. Regarding the complications, one case had a femoral intraoperative lateral femoral condyle fracture which was fixed by screws requiring delayed weight-bearing and prolonged healing time of the stress fracture which healed within 8 months.

No other intraoperative or postoperative complications such as wound infection, skin necrosis, joint or implant instability, or patellar mal tracking. There was no loosening detected in the last follow-up in any case.

## Discussion

The combination of a metaphyseal stress fracture of the proximal tibia and knee arthritis is not common and both pathologies positively affect each other, the association between limb malalignment and osteopenia adds more difficulties, and this puts the bone in a mechanical disadvantageous situation.

Unequal loads with continuous weight-bearing cause osteoarthritis to progress while healing will not, which in turn exacerbates the deformity and eventually the osteoarthritis and the nonunion. Reviewing the literature showed that stress fracture proximal tibia in arthritic knees is a problem that occurs mainly in developing countries due to educational, cultural, and economic issues [19,20].

Clinically, In knee arthritic patients, the development of ambulation inability and increased pain raise suspicion of fracture occurrence and warrant radiological confirmation by plain radiography, while magnetic resonance images can provide early diagnosis [21]. Conservative treatment of tibial stress fractures associated with knee arthritis was tried by some authors [10,12]. Casts and braces were used with prolonged immobilization inducing knee stiffness which included failure to correct malalignment and induced further arthritis and pain. Prolonged healing periods were noticed with a high incidence of nonunion and refracture.

The surgical management should aim to correct malalignment, provide fixation of the fracture, and replace arthritic surfaces of the knee joint. [14,15]. Wolff *et al.* in 1991 [22] and Tey *et al.* [23] adopted two stages of surgical management, fixing the fracture first either by plates or nails with bone graft followed by knee replacement after the fracture is healed. This two-stage intervention comprises two operative procedures for the already compromised patients, increasing morbidities such as infection, and the interval between the two stages complicates the rehabilitation program as it is hard to implement or bear weight in the painful arthritic knee. Fixation of the fracture first is not technically demanding, yet it does not guarantee union and requires skin and soft tissue stripping in plate fixation or demands extraction during 2nd stage in nail fixation which compromises the fracture and can cause malalignment again threatening the knee replacement prosthesis.

One stage procedure is another option that lowers the morbidities and includes two varieties, one is a simultaneous fixation by plate (uni cortical plate) or intramedullary nail and TKA without stem according to Dhillon *et al.* 2011 [24] and Erdogan *et al.* [25], those procedures were found to be lengthy and extensive requiring separate incisions and lack the stable intramedullary unified support of the stem in TKA.

The second variety which is adopted by many authors [9,14,15,19] as well as the present study is the primary total knee prosthesis with a long stem with or without offset. Tibial stemmed TKA, decreases micromotion, presents shear resistance, and prevents the tibial lift thus improving the overall stability and lowering the possibility of the implant aseptic loosening [26] The stem acts as an intramedullary device for the stress fracture, thereby providing early postoperative weight bearing. Reaming of the medullary canal obviates the need to open the fracture site as the reaming grafts the fracture site from within. The use of tibial stemmed TKA obviates the soft tissue compromise by not adding more incisions, thereby decreasing operative time compared with TKA with separate addon prosthesis. The above-mentioned advantages motivated several surgeons toward this trend. Soundarrajan *et al.* in [27] achieved fracture healing in all cases in the mean of 4 months. Mullaji *et al.* 2010 [18] improved the mean KSS from 36.7 to 90.3.

Mullaji *et al.* 2010 [18] reported stem perforation to the tibial cortex due to the use of a straight stem with incomplete correction of alignment that was asymptomatic to the patient after healing of the fracture. We did not have a such problem due to the availability of offset stems, we closely followed the progress of reamers under C-arm fluoroscopy to avoid iatrogenic tibial perforation, also we have found that the exposure of the fracture, fibular osteotomy, or bone graft were unnecessary.

The limitations of this study included the number of cases which is not yet large enough to establish consensus and also some cases had only 5 years of follow-up so longer follow-up is required in future studies, However, according to Pan *et al.* [28] and Jabalameli *et al.* [29]; the available publications are limited number case series with short follow-up. In the current study, we achieved satisfactory stability and alignment with fixed-bearing posterior-stabilized tibial stemmed TKA, matching the results of the literature that adopted the same technique with relatively more patient numbers and longer follow-ups. Our results supported the previous reports and confirmed our hypothesis that a one-stage procedure with a long tibial stem bypassing the fracture site addresses arthritis, the malalignment, and acts as an internal splint for the fracture.

## Conclusion

The use of a long tibial stem TKA is an effective and reproducible single surgical procedure in the management of combined osteoarthritis knee and proximal tibial stress fracture. Satisfactory clinical scores and radiological outcomes were achieved and proper limb alignment was restored obviating the need for further fixation or grafting.

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### Ethical standards

All human studies have been approved by the appropriate ethics committee and have therefore been performed following the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

### Ethical approval

All the procedures performed in studies involving human participants were by the ethical standards of the institutional and national research committee and with the 1975 Helsinki Declaration as revised in 2000.

### Informed consent

Informed consent was obtained from all the patient participants included in the present study.

### Data availability statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

### Institutional Review Board Statement

The Institutional Review Board have reviewed this research and allowed the experimental protocol.

### Author Contributions

Conceptualization, investigation, methodology, formal analysis, software writing-original draft, SE-A, AMAE-W, and YS; investigation, methodology, formal analysis, validation, resources, SE-A, AMAE-W; resources, data curation, validation, writing-review and editing, visualization, YS; funding acquisition, YS. All authors have read and agreed to the published version of the manuscript.

### Conflicts of interest

There are no conflicts of interest.

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