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An alternative treatment for osteoporotic Su Type III periprosthetic supracondylar femur fractures: Double locking plate fixation

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ABSTRACT

Introduction: Patients with Su Type III fractures based on total knee arthroplasty (TKA) constitute a patient group with problematic treatment and management. Although it has difficulties, open reduction and internal fixation is one of the treatment options.
Method: A retrospective evaluation was made of 22 patients surgically treated in our clinic with double locking, low contact titanium plate and screw for a Su Type III periprosthetic fracture based on TKA. The patients were evaluated with bone mineral densitometry, postoperative Knee Society Score (KSS), WOMAC and radiological evaluations.
Results: The mean follow-up period of the patients was 68.6 ± 15.5 months, with pain-free weight-bearing determined at 4.9 ± 1.1 months and mean radiological union at 18.5 ± 4.3 weeks. Revision was required because of non-union in 2 (9.09%) cases. The postoperative KSS value was 81.8 ± 7.8, the WOMAC value was 78.1 ± 5.3 and the T-score was −3.3 ± 0.3. At the final follow-up examination, a correction loss (4.9° ± 1.5°) was determined in the mean knee valgus angle according to the mechanical axis, which was statistically significant but remained within the physiological limits ($p = 0.21$).
Conclusion: In addition to providing the advantages of rigid fixation together with early and effective rehabilitation, satisfactory clinical and radiological results were obtained with the application of double locking plate and screw in the treatment of periprosthetic femoral fractures based on TKA, with osteoporosis.
Level of evidence: Level IV, Therapeutic study.

Introduction

In parallel with the increasing number of arthroplasty applications today, the prevalence of periprosthetic supracondylar femur fractures (PSFFs) following total knee arthroplasty (TKA) is also increasing.[1,2] The majority of patients are in the geriatric age group, and their fractures are generally the result of a minor trauma.[3] This patient group is usually exposed to an accompanying clinical table of problems, which constitute a risk of fracture, with osteoporosis being the most common one.[4,5]

The treatment is technically difficult and the complication rates are relatively high. Fixation failure in 4%, nonunion in 9%, revision surgery in 13% and infection in 3% of the cases have been reported.[6] In the application of locking plate with the potential adverse effects of underlying factors, high rates of reduction loss, nonunion and failure have been reported.[6–8] Therefore, the need for a stronger and long-lasting technique for these patients who are at particular risk of treatment failure is obvious.

In this study, we aimed to present the clinical and radiological results of the cases treated with double locking plates and screws for Su Type 3 PSFFs following TKA.

Patients and methods

All cases treated for distal femur periprosthetic fractures following TKA in our clinic between the year 2007 and 2012 were retrospectively examined. Patient data were retrieved from the

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hospital records. A total of 22 patients (4 males, 18 females; mean age: 72.7 ± 4.5 years, range: 68–82 years) were included in our study. Patients were monitored for duration of the track and they were able to participate in the final evaluation. The inclusion criteria were defined as having a Su Type 3 periprosthetic fracture following primary TKA, stable femoral and tibial components, a t-score of <−3.0 in one of the localizations of the femoral neck, L4 or L5, and osteosynthesis applied with the double locking plate and screw technique. Thirteen patients (59.1%) had a history of osteoporosis (eight patients had been treated with alendronate and five with etidronate), seven patients (31.8%) had a history of ipsilateral hip arthroplasty and six patients (27.3%) had a history of smoking. Basic demographic data of the patients and additional pathologies are presented in Table 1.

The Su classification was used in the evaluation of the periprosthetic fracture (Table 2). We preferred Su classification over Rorabeck classification, since in the first classification, the bone stock of the distal fragment is more indicative in the evaluation of the fracture line location and course, while in the latter, the fracture line displacement and the stability of the prosthesis are taken into consideration. Su Type 3 periprosthetic supracondylar fractures are fractures where the distal fragment is within the fracture line and the implant looks stable on anteroposterior (AP) and lateral knee radiographs.[9,10]

The fracture line and localization were evaluated in all patients on AP and lateral radiographs, and with tomography where necessary (Fig. 1). Following antibiotic prophylaxis with first-generation cephalosporin (cefazolin 1 g IV), spinal anesthesia was performed. Using a sterile tourniquet, an arthrotomy was made using the old TKA midline incision and a medial parapatellar approach (Fig. 2). Following reduction, iliac spongious autograft was used in 13 cases (59.1%) to fill the metaphyseal defects. In five cases (22.7%) within this group, additional cortical-spongious autograft was taken from the iliac wing and was applied as bridging graft across the fracture line (Fig. 3).

Then double locking plates were placed medially and laterally and stabilization was provided using locking cortical and spongious screws in the distal femur. For each plate, a maximum of three divergent screws were placed in the distal fragment. Following bleeding control, a negative pressure air drain was placed and the incision was closed. A plaster cast was applied with the knee in 30° of flexion (Fig. 4). The cast was removed three weeks later and range of motion (ROM) exercises were begun. Upon observation of radiological findings of union (cortical continuity in at least three of four cortices), active weight-bearing was permitted.

The patients were followed up and evaluated radiologically at two-week intervals for the first two months, then at four-week intervals until the sixth month and later every six months until the final follow-up. Pain-free weight-bearing, time to radiological union, presence of ipsilateral hip prosthesis, varus, valgus and recurvation angulation, limb length discrepancy, Knee Society Score (KSS), WOMAC score and ROM were evaluated in the follow-up period and at the final evaluation. Correlations between clinical results were assessed.

Table 1
Basal demographic data.

Variable	n (%) mean ± SD
Gender (M/F)	4/18 (18.2/81.8)
Age (years)	72.7 ± 4.5
Diabetes	6 (27.3)
Hypertension	9 (40.9)
Hyperlipidemia	8 (36.4)
Cigarette smoking	6 (27.3)
Body Mass Index kg/m^2	28.7 ± 3.9
Peripheral artery disease	5 (22.7)
Osteoporosis treatment	13 (59.1)
Affected side (right/left)	13/9 (59.1/40.9)
Hip prosthesis	7 (31.8)
T-score	−3.3 ± 0.3

Table 2
The Su Classification for periprosthetic fracture.

SU CLASSİFİCATİON OF SUPRACONDYLAR PERİPROSTHETİC FEMUR FRACTURE'S	
Type I	Fracture is proximal to the femoral component
Type II	Fracture originates at the proximal aspect of the femoral component and extends proximally
Type III	Fracture originates at the proximal aspect of the femoral component and extends proximally

All statistical analyses were performed using the SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as mean ± standard deviation (SD) and categorical variables as percentages. The difference between postoperative and final valgus angles was tested using the paired-samples t-test. The Pearson test was used in evaluating correlations. A p value of <0.05, computed with two-tailed test in all analyses, was accepted statistically significant.

Results

The mean period from primary TKA to fracture was 18.3 ± 9.5 (range: 5 to 36) months. The fracture was associated with a minor trauma in 19 patients (86.4%) and with a major trauma in three patients (13.6%) (Table 3).

Patients had a mean body mass index (BMI) of 28.7 ± 3.9 (range: 23 to 32). The mean surgery time was 107 ± 18 (range: 85 to 165) minutes, hospitalization period was 3.7 ± 0.7 (range: 3 to 5) days, and follow-up period was 68.6 ± 15.5 (range: 39 to 90) months.

Radiological union was observed in a mean of 18.5 ± 4.3 weeks in 20 patients (90.9%). The valgus angle of the knee in relation to the anatomical axis was 5.2°±1.6° in the early postoperative period and 4.9°±1.5° at the final follow-up. The loss of correction was statistically significant ($p = 0.021$), however, the final values seemed to be within physiological limits. No genu varum deformity was detected in any patient due to correction loss at the final follow-up. Recurvation was observed in one patient (4.5%) due to 10° of malpositioning of the distal femoral fragment. According to the Tayside classification, two patients (9.1%) had Type 2 and two patients (9%) had Type 3 notching (Table 3).

At the final follow-up, the mean KSS was 81.8 ± 7.8 (range: 56 to 90), the mean WOMAC score was 78.1 ± 5.3 (range: 62 to 88) and the mean t-score was −3.3 ± 0.3. At the final evaluation of the operated knee, the mean ROM was 98.1°± 8.2° (range: 70°–110°) and the mean time to pain-free weight-bearing was 4.9 ± 1.1 (range: 4 to 8) months (Table 3).

In the evaluation of the correlation between KSS and WOMAC and clinical and radiological variables, a statistically significant and negative correlation with a moderate strength was found between KSS and time to pain-free weight-bearing. A statistically insignificant and negative correlation with a weak strength was found between KSS and t-score (Table 4). A statistically significant and negative correlation with a weak strength was found between the WOMAC score and the time to pain-free weight-bearing. A statistically insignificant and negative correlation with a weak strength was detected between the WOMAC score and t-score (Table 5). In evaluation of the correlations between ROM and the other variables, only a statistically significant and negative correlation with a moderate strength was found with the time to pain-free weight-bearing (Table 6).

Out of the total 22 patients, revision with constrained TKA was applied to one patient due to nonunion and to another due to

reduction loss (9.1%). Superficial infection developed in one case showed clinical recovery after four weeks of parenteral antibiotherapy (4 g/day cefazolin).

Discussion

In parallel with the increasing rates of primary and revision TKAs, the prevalence of PSFFs has also increased. The risk of fracture following primary TKA was reported as 0.6% and following revision TKA as 1.7%.[11] The main goal of the treatment is to achieve a return to the pre-trauma activity level in the shortest time possible. Therefore, in addition to appropriate positioning of the fracture and sufficient union, postoperative rehabilitation applied as early and effectively as possible is one of the main components of the treatment. A rigid, reliable and sustainable fixation is essential in achieving these conditions.

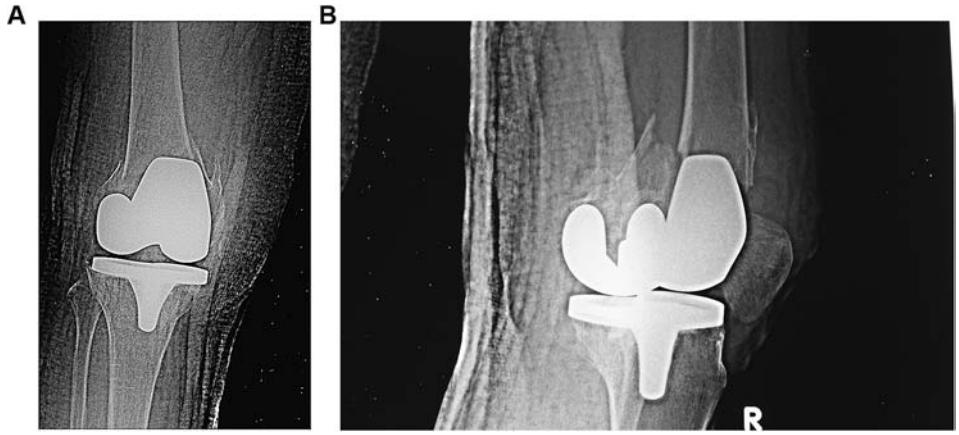

Fig. 1. A and B: Preoperative anterior posterior and lateral knee radiographs showing the course of the fracture line extending to the distal of the prosthesis

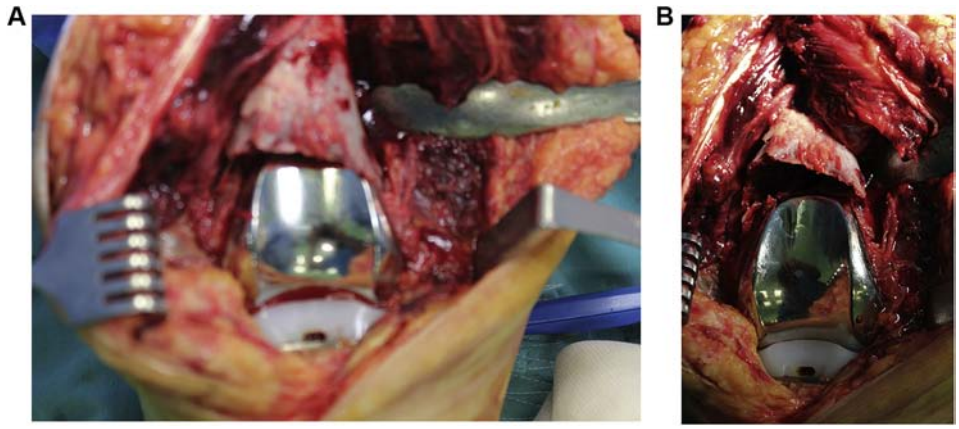

Fig. 2. A and B: Intraoperative image of the fracture line and exposure made with the medial parapatellar arthrotomy and midline incision.

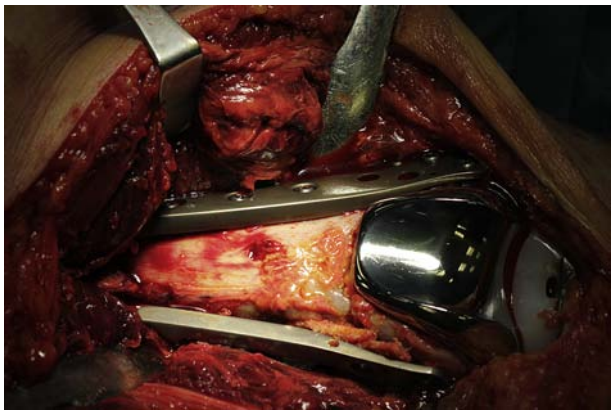

Fig. 3. After appropriate reduction osteosynthesis achieved with medial and lateral locking plate-screw combination and bridge grafting with corticospongeous iliac autograft.

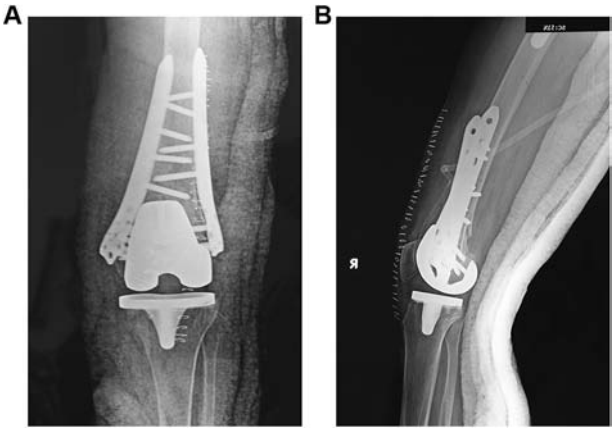

Fig. 4. A and B: Postoperative anteroposterior and lateral radiograph showing fracture reduction and osteosynthesis with medial and lateral locking plate.

Table 3
Operative and postoperative data.

Variable	n (%) mean ± SD
Operating time (mins)	107 ± 18
Graft use	13 (59.1)
autograft	13 (59.1)
allograft	5 (22.7)
Infection	1 (4.5)
Revision requirement	2 (9.1)
Postoperative valgus (degrees)	5.2 ± 1.6
Final valgus (degrees)	4.9 ± 1.5
Shortness	1 (4.5)
Recurvation	1 (4.5)
Hospitalisation period (days)	3.7 ± 0.7
Notching (Tayside)	4 (18.2)
Time to pain-free weight-bearing (months)	4.9 ± 1.1
Time to radiological union (weeks)	18.5 ± 4.3
KSS	81.8 ± 7.8
WOMAC	78.1 ± 5.3
Range of motion (degrees)	98.1 ± 8.2
Time from primary TKA to fracture (months)	18.3 ± 9.5
Major trauma	3 (13.6)
Minor trauma	19 (86.4)
Follow-up period (months)	68.6 ± 15.5

Table 4
Evaluations of correlations between KSS and other variables.

	r	p
T-score	−0.11	0.613
Time to pain-free weight-bearing (months)	−0.54	0.010
Time to radiological union (months)	−0.1	0.659
Time from primary TKA to fracture (months)	0.19	0.388
Final Valgus, °	0.28	0.185
Range of motion, °	0.73	<0.001
WOMAC	0.42	0.051

Table 5
Evaluations of correlations between WOMAC and other variables.

	r	p
T-score	−0.27	0.252
Time to pain-free weight-bearing (months)	−0.43	0.044
Time to radiological union (months)	0.19	0.395
Time from primary TKA to fracture (months)	0.18	0.213
Final Valgus, °	−0.10	0.497
Range of motion, °	0.69	<0.001
KSS	0.42	0.051

Table 6
Evaluations of correlations between range of motion and other variables.

	r	p
T-score	−0.10	0.963
Time to pain-free weight-bearing (months)	−0.51	0.014
Time to radiological union (months)	−0.11	0.808

In order to provide the abovementioned requirements in Su Type 3 PSFF patients with difficulties that emerge in providing and protecting stabilization in presence of distal osteoporosis, we employed a technique using a strong construct of titanium double locking plate and screw combination. To better understand the subject, the data compared within this study population were also compared with the data from the literature.

There were several factors related to the technique that caused some concern. Since the exposure used the previously used midline incision, there was much more contact with open air during the arthroplasty and medial parapatellar arthrotomy. The increased implant density of the double plate used could have increased the risk of postoperative implant infection and osteonecrosis could have developed due to insufficient feeding in the limited distal bone stock. Successful results in double plate application in the complicated distal femur fractures partially rid our hesitations concerning this subject.[12,13]

Other than the application in our study, Gurava et al applied double locking plate to a patient with PSFF extending distally in bilateral implants and reported successful results in their case report.[14] With a more extensive patient series in our study, the results of Gurava et al's case report could be confirmed. An advantage of the technique is the reduced risk of arthrofibrosis as no second incision was performed around the knee. Another advantage is the gaining of sustainable physiological valgus correction since the second medial plate provides resistance against varus stress. In addition, the risk of genu varus due to postoperative correction loss is reduced, thus providing a strong fixation and thereby allowing a more rapid and reliable rehabilitation program.

Despite the various advantages provided, this technique should not be recommended in routine PSFF cases. Nevertheless, it can be considered as a more biological alternative in advanced revision arthroplasty in a narrow patient group of Su Type 3 fractures with problems in the fracture line reaching the distal of the implant and in presence of accompanying osteoporosis where the implant stability is preserved.

In treatment of PSFFs following TKA, two methods are generally used. Those are conservative treatment applied with skeletal traction or the application of a cast brace without traction and surgical treatment using different implants and techniques. Recently, there have been various discussions on the efficacy of conservative treatment. Loss of ROM has been reported in 50% of the patients treated this way[15] and 20.4%–35% of the patients require conversion to surgical treatment.[4,16] In addition, the long period of immobilization creates a risk of secondary problems in this geriatric patient group.

With the recent implant developments, the treatment of supracondylar femoral fractures on the basis of TKA has achieved higher success rates compared to conventional methods.[17] Therefore, surgical treatment is considered as the primary treatment modality for most cases. However, in surgical applications, rates of nonunion have been reported as 50% in the application of conventional plate and screws, and despite successful intraoperative reduction, up to 70% of the patients may experience varus malposition during the follow-up period.[8]

Successful results have been reported with the use of retrograde supracondylar femoral nails.[18–20] In another study related to those two techniques, nonunion rates were relatively high in femoral plate applications and refracture with the application of retrograde supracondylar femoral nails.[21]

Those fractures, which are generally encountered in geriatric patients, are accompanied by additional complications. In majority of the cases, there is concomitant clinical osteoporosis. In patients who had undergone TKA, the presence of osteoporosis causes additional local osteoporosis and/or osteolysis around the implant postoperatively. This situation develops most rapidly between the first three months and first year postoperatively; studies have shown that it can continue for up to seven years.[22–24] These studies have shown that there is continuing bone loss around the implant in the knee.

In the event of PSFF, it is difficult to provide intraoperative rigid fixation in the treatment thus leading to delayed union, and problems in preserving correction.[25] In addition, the localization and course of the fracture line creates another problem in the

treatment of PSFFs. The treatment algorithm changes and becomes more limited when the fracture extends towards the distal of the femoral component, as in Su Type 3. At this point, the stability of the femoral component is important. In case of instability, reconstruction with long femoral stem semi-constrained or constrained revision implants is considered a valid treatment option. However, in this case, complication rates of up to 31% have been reported, especially with constrained type implants.[26,27] This may sometimes be a treatment option in cases where stability has been preserved between the bone and implant, and in Type 3 cases where bone stock is not of a sufficient amount and quality in the distal.[28]

It has been reported that monolateral plates have been used, even if there is more distal placement, in PSFF cases where this type of implant stability has been preserved. This may be considered more advantageous as it is a less invasive and more biological application compared to revision arthroplasty. However, in one study, delayed union was reported in 6%, nonunion in 15% and failure in 9% of the patients.[29] In the current study, nonunion was observed in one patient (4.5%) and reduction loss in another (4.5%). In our current study of PSFF cases, which extended to the distal of the femoral component, with the application of titanium double locking plates and screws, and auto or allograft application where necessary, more successful clinical results with lower complication rates were achieved compared to the applications of constrained and semi-constrained revision TKAs and the application of single axis locking plate. This shows that even if a rigid fixation is obtained, clinical results can be improved. Even when successful rates of union are achieved in the treatment of PSFF, a prolonged rehabilitation program creates a significant negative effect on the patient's movement and quality of life.[30]

The more rigid fixation obtained with double locking plate and screw application also provides advantages to the patient in postoperative rehabilitation. Early mobilization and rehabilitation of the patient is important with respect to ROM.

The absence of a patient group with the application of monolateral locking plate for comparing the advantages and disadvantages of double locking plate application in PSFF cases and the absence of long-term follow-up results may be considered as the limitations of our study. On the other hand, our alternative technique using a strong construct of titanium double locking plate and screw combination has yielded promising results in the treatment of Su Type 3 PSFFs in the geriatric population.

In conclusion, in our small geriatric patient group with osteoporotic Type 3 PSFFs, the rigid fixation obtained with the double locking plates and screws resulted in reductions in complication rates, reduction loss and implant failure and allowed early mobilization and rehabilitation and earlier weight-bearing, thus providing advantages that may improve the patient's quality of life.

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