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Optimal graft choices for tibial plateau fractures with joint depression

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Tibial plateau fractures are serious injuries which may result from high-energy trauma, often leading to joint surface disruption. These fractures can be particularly challenging, particularly when associated with joint depression due to metaphyseal fragmentation.[1] The primary goal in managing these fractures is to achieve anatomical reduction of the joint surface, thereby optimizing functional outcomes and reducing the incidence of post-traumatic arthritis.[2] Fractures with joint depression require elevation of the depressed fragments. Elevating these fragments often creates a subchondral void, which can lead to secondary collapse of the elevated parts. To prevent this complication and support bone growth the use of either bone grafts or substitutes is recommended.[3]

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ABSTRACT

Objectives: This study aims to provide insight into the advantages and disadvantages of autograft and synthetic graft use in the surgical treatment of tibial plateau fractures with joint depression by comparing the clinical and radiological outcomes of both graft types.

Patients and methods: Between February 2019 and September 2022, a total of 51 patients (23 males, 28 females; mean age: 45.3±13.5 years; range, 20 to 69 years) who underwent surgical treatment for Schatzker type 2 and type 3 tibial plateau fractures in our clinic were retrospectively analyzed. The patients were divided into two groups; 30 patients received autografts and 21 received tricalcium phosphate synthetic grafts. Demographic data, graft type, fracture classification, preoperative joint depression, body mass index (BMI), and smoking status were recorded. Postoperative evaluations included Lysholm and Visual Analog Scale (VAS) scores at two years.

Results: Similar clinical and radiological outcomes were observed in both graft groups in the short term ($p>0.05$). Smoking had a negative effect on graft stability, with a significantly higher postoperative depression rate in smokers ($p=0.026$). Patients with a BMI above 30 kg/m^2 also showed higher rates of postoperative depression ($p=0.004$). Clinical outcomes were worse in patients with joint depression compared to those without depression ($p=0.003$).

Conclusion: Autografts and synthetic grafts show similar efficacy in the mid-term treatment of tibial plateau fractures. High BMI and smoking may be associated with potential joint depression and worse clinical outcomes in the postoperative period.

Keywords: Autograft, beta-tricalcium phosphate, body mass index, tibial plateau fractures, smoking.

Both autografts and synthetic grafts are widely used to fill bone defects in this process. Autografts have been a preferred option for many years due to their biological compatibility and osteogenic

potential. However, autografts also have certain disadvantages, such as donor site morbidity.[4]

Synthetic grafts offer advantages such as reduced operative time, minimization of blood loss, and prevention of donor site complications. Studies examining the clinical and radiological outcomes of these grafts have shown that synthetic grafts provide healing results similar to those of autografts.[5] However, some controversies remain in the literature regarding long-term outcomes and the biological integration of synthetic grafts.

In the literature, although autografts and synthetic grafts have yielded similar short-term results, long-term data are still scarce.[6] In the present study, we, therefore, aimed to compare the clinical and radiological outcomes of patients treated with autografts and synthetic grafts for tibial plateau fractures with joint depression to better understand the advantages and disadvantages of each graft type.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Ankara Bilkent City Hospital, Department of Orthopedics and Traumatology between February 2019 and September 2022. Initially, a total of 82 patients aged between 18 and 60 years who underwent surgery for Schatzker type 2 and type 3 tibial plateau fractures were screened. Exclusion criteria were as follows: having prior injuries of the same extremity, having gonarthrosis of Kellgren-Lawrence Grade 4, having a diagnosis of rheumatic disease, having a follow-up period of less than 24 months, and having more than 2 mm of joint depression on radiographs on postoperative Day 0. Finally, a total of 51 patients (23 males, 28 females; mean age: 45.3±13.5 years; range, 20 to 69 years) were included in the study. A written informed consent was obtained from each patient. The study protocol was approved by the Ankara Bilkent City Hospital TABED Ethics Committee (date: 09.10.2024, no: TABED 1/629/2024). The study was conducted in accordance with the principles of the Declaration of Helsinki.

All patients were operated by a single surgical team. Open reduction and internal fixation of fracture fragments were achieved using a standard anterolateral approach with plates and locking or non-locking screws. To fill the voids created by the elevation of depressed fragments, ipsilateral iliac crest autografts were used for 30 patients, while tricalcium phosphate (TCP) (AdBone®; Medbone Biomaterials, Portugal) synthetic grafts were used for 21 patients. The choice of graft during surgery was determined based on the type of graft available under the hospital conditions at the time.

A standard postoperative protocol was applied for all patients who were followed for six weeks without weight-bearing in a locked knee brace. Gradual weight-bearing was, then, introduced and the brace was gradually loosened over the following three or four weeks until full range of motion was achieved.

Data recorded for all patients included demographic information, type of graft used, Schatzker classification, preoperative joint depression measurements in the coronal plane (mm), body mass index (BMI), and smoking status. Radiographs were taken and assessed at two-year follow-up visits and patients with joint depression were noted. The preoperative depressions of the patients and the measurements of joint depression during postoperative follow-up were performed once by a single specialist (Figure 1). Additionally, the Schatzker classification was also conducted by a single specialist.

Lysholm and Visual Analog Scale (VAS) scores were also recorded at the two-year postoperative follow-up to assess clinical outcomes.

Statistical analysis

Statistical analysis was performed using the SPSS version 26.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. Parametric tests were used for numerical variables that met the criteria for normal distribution, whereas non-parametric tests were applied for numerical variables that did not comply with normal distribution. The chi-square test was used to assess relationships between two categorical variables. The independent samples t-test and Mann-Whitney U test were employed to examine differences between two independent groups in terms of continuous variables. A p value of <0.05 was considered statistically significant.

RESULTS

A total of 51 patients who received either autografts or synthetic grafts for tibial plateau fractures were evaluated in this study. Based on fracture type, 33 (64.71%) cases were classified as Schatzker type 2, while 18 (35.29%) were classified as Schatzker type 3.

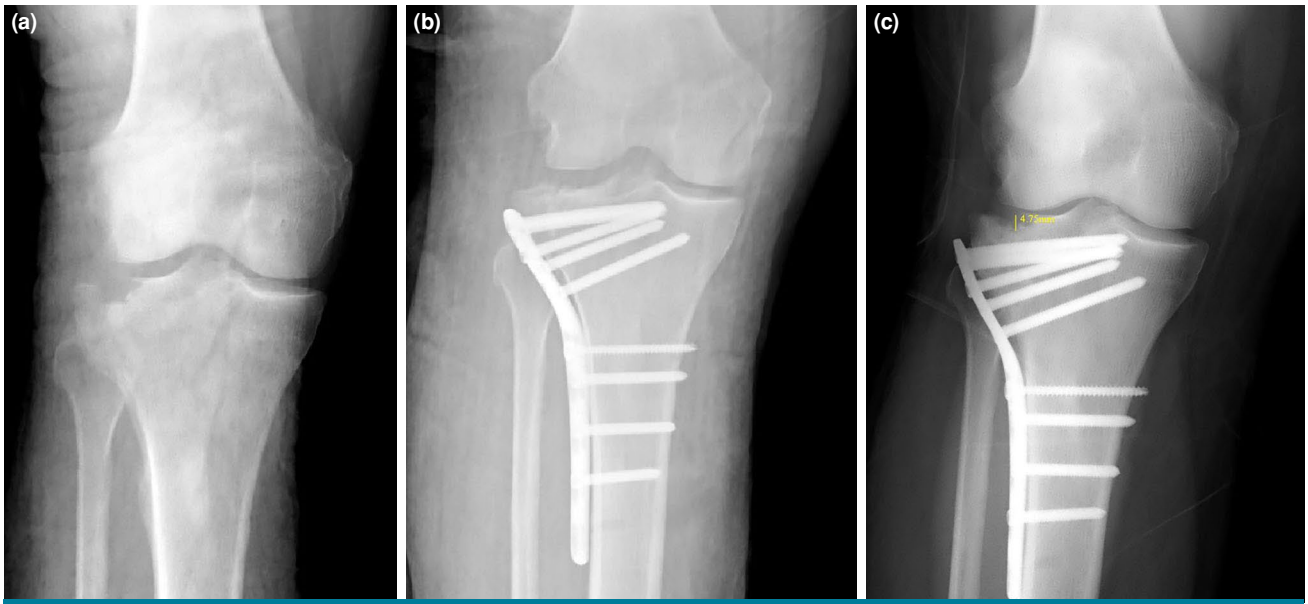

FIGURE 1. Radiographic images of a patient with recurrent joint depression during follow-up: **(a)** preoperative tibial plateau fracture with joint depression, **(b)** postoperative radiograph showing achieved reduction, **(c)** radiograph in the second postoperative year showing recurrent joint depression.

TABLE I
Relation of graft types with categorical variables

	Autograft		TCP		Total		
	n	%	n	%	n	%	*p*
Side							
Right	14	46.67	14	66.67	28	54.90	0.158
Left	16	53.33	7	33.33	23	45.10	
Sex							
Male	14	46.67	9	42.86	23	45.10	0.788
Female	16	53.33	12	57.14	28	54.90	
Schatzker type							
2	20	66.67	13	61.90	33	64.71	0.726
3	10	33.33	8	38.10	18	35.29	
Postoperative depression							
No	23	76.67	16	76.19	39	76.47	1.000
Yes	7	23.33	5	23.81	12	23.53	
Smoking							
No	16	53.33	14	66.67	30	58.82	0.341
Yes	14	46.67	7	33.33	21	41.18	
Body mass index (kg/m^2)							
<30	19	63.33	17	80.95	36	70.59	0.174
>30	11	36.67	4	19.05	15	29.41	

TCP: Tricalcium phosphate.

TABLE II
Differences between graft types according to continuous variables

	Autograft			TCP			Total			
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p*
Age (year)	45.1±14.4	44.0	20.0-69.0	45.7±12.5	43.0	25.0-69.0	45.3±13.5	43.0	20.0-69.0	0.868
Preoperative depression (mm)	8.33±3.398	8.5	3.0-14.0	8.8±2.564	10.0	4.0-14.0	8.53±3.063	8.5	3.0-14.0	0.591
Postoperative 2nd year depression (mm)	4.26±1.12	4.0	3.0-6.2	4.5±0.771	4.7	3.5-5.5	4.36±0.957	4.4	3.0-6.2	0.694
Lysholm score	82.7±5.615	82.0	72.0-92.0	83.76±4.949	86.0	79.0-92.0	83.14±5.325	82.0	72.0-92.0	0.785
Visual Analog Scale	2.13±0.73	2.0	1.0-3.0	2.19±0.75	2.0	1.0-3.0	2.16±0.731	2.0	1.0-3.0	0.772
Body mass index	28.57±3.15	29.1	23.2-35.8	25.28±4.564	24.8	18.2-33.5	27.22±4.095	26.6	18.2-35.8	0.004*

TCP: Tricalcium phosphate; SD: Standard deviation; * $p<0.05$.

Twenty-eight (54.90%) patients had fractures of the right leg and 23 (45.10%) patients had fractures of the left leg. There was no significant difference in the distribution of sex between the autograft and synthetic graft groups (p=0.788) (Table I).

According to the Schatzker classification, 66.67% of the autograft group had type 2 fractures and 33.33% had type 3 fractures, while in the synthetic graft group, 61.90% had type 2 and 38.10% had type 3 fractures. No statistically significant difference was found between graft types according to the Schatzker classification (p=0.726). In terms of postoperative depression, the two groups had similar results. No depression was observed in 76.67% of the autograft group and 76.19% of the synthetic graft group (p=1.000) (Table I).

In terms of smoking status, 53.33% of patients in the autograft group were non-smokers and 46.67% were smokers. In the synthetic graft group, these rates were 66.67% for non-smokers and 33.33% for smokers (p=0.341). Regarding BMI, 63.33% of patients in the autograft group had a BMI value of <30 kg/m², while 36.67% had a BMI value of ≥30 kg/m². In the synthetic graft group, 80.95% had a BMI value of <30 kg/m² and 19.05% had a BMI value of ≥30 kg/m² (p=0.174).

There was no statistically significant difference between the two groups in terms of mean age, preoperative depression, or postoperative depression (p>0.05; Table II). However, as shown in Figure 2, the mean BMI value of patients receiving autografts was found to be significantly higher than that of patients receiving synthetic grafts (p=0.004).

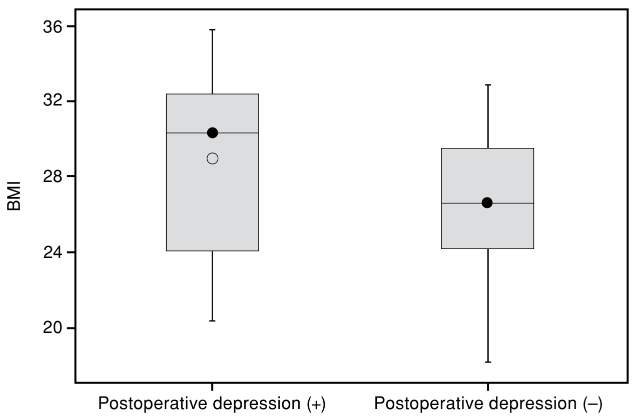

FIGURE 2. BMI distribution according to presence of postoperative depression.
BKI: Body mass index.

A significant association was found between postoperative depression and smoking status (p=0.026). The rate of postoperative depression was significantly higher among smokers than non-smokers. No other significant associations were observed between postoperative depression and graft type, Schatzker classification, or BMI groups (p>0.05).

In clinical evaluations, the Lysholm and VAS scores did not show a significant difference according to graft types (p>0.05). However, a statistically significant difference was found between Lysholm scores according to postoperative depression status (p=0.003). Lysholm scores were significantly higher among patients without postoperative depression compared to those with depression. No significant difference was observed in VAS scores between the different postoperative depression statuses (p>0.05) (Table III).

TABLE III
Differences in postoperative depression status according to Lysholm and VAS scores

	Postoperative depression (+)			Postoperative depression (–)			Total			
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p*
Lysholm	84.18±5.17	84	72-92	79.75±4.495	79	72-92	83.14±5.325	82	72-92	0.003*
VAS	2.18±0.79	2	1-3	2.08±0.515	2	1-3	2.16±0.731	2	1-3	0.573

VAS: Visual Analog Scale; SD: Standard deviation; * p<0.05.

DISCUSSION

In the present study, clinical and radiological outcomes following the use of autografts and synthetic grafts in tibial plateau fracture surgery were examined to analyze the similarities and differences between the two graft types in the medium-term healing process. Autografts are considered the gold standard of treatment due to their biological compatibility and osteogenic and osteoinductive properties; however, they have serious disadvantages including donor site morbidity.[7-9] Synthetic grafts, on the other hand, offer advantages such as reduced operative time, lower infection risk, and the elimination of additional donor site complications, although they may also be associated with risks such as wound infection.[10-12] There are studies indicating that autografts, despite some biological advantages, are not superior to synthetic grafts in terms of clinical outcomes.[13] In our study, we also found that the two graft types had similar clinical outcomes, although BMI and smoking were significant factors affecting postoperative depression rates.[14] The surgical procedure for harvesting grafts from the donor site can lead to complications such as infection, hematoma, nerve damage, and chronic pain.[7] These risks are particularly pronounced with grafts taken from the iliac crest. A study by Berkes et al.[8] revealed that donor site complications occurring in patients receiving autografts negatively impacted their quality of life and extended their recovery times. Given the high complication rates associated with autografts, there is a growing need to research alternative graft types with lower risk

profiles. The negative effects of synthetic grafts on wound healing and the potential risk of infection are subjects of ongoing discussion in the literature. In our study, two patients in the synthetic graft group developed prolonged wound drainage, which was managed with antibiotics. In a study conducted by Goff et al.,[15] the risk of wound infection in patients receiving synthetic grafts was noted to be significantly higher; however, this risk could be managed with postoperative antibiotics and infection control methods. A study by Rolvien et al.[16] highlighted the potential infection risks and challenges in the biological integration of synthetic grafts, particularly those made of beta-TCP (β-TCP), and discussed the possible negative effects on clinical outcomes. Considering the partial success of synthetic grafts in biological integration and other advantages during the healing process, these grafts offer promising options for the treatment of tibial plateau fractures.

The adverse effects of smoking on bone healing and graft stability are widely reported in the literature. Smoking reduces blood flow to the bone tissue, suppressing osteoblast activity and delaying the bone regeneration process. In our study, postoperative depression rates were significantly higher among smokers compared to non-smokers. Some studies have reported increased bone loss and graft failure rates among smokers.[11,17] This finding indicates that smoking can adversely affect graft stability in the treatment of tibial plateau fractures, suggesting that recovery should be closely monitored in patients who smoke.

The impact of BMI on graft stability is another important factor to be considered. Higher mechanical load on the bone surface in patients with high BMI can negatively affect graft stability. In a randomized study by Hofmann et al.,[10] bone healing was slower in patients with high BMI, making graft stability more challenging. Similarly, our study found higher postoperative depression rates in patients with BMI of >30 kg/m^2, although this was not statistically significant. This finding suggests that achieving graft stability may be more difficult and complication risks may increase in patients with obesity. Therefore, careful surgical planning and close postoperative monitoring are recommended for patients with high BMI. Although it is known that both smoking and high BMI can have negative effects on achieving graft stability, there are also studies showing that neither is a significant risk factor for graft stability.[18] Our study evaluated the relationship between joint line depression two years after surgery and factors such as smoking status, graft type, Schatzker classification, and BMI variables. However, factors that could potentially be associated with postoperative joint line depression, such as implant failure, nonunion of the fracture, avascular necrosis of bone fragments, or nonunion of the autograft or synthetic graft used to fill the void, were not assessed in these patients, which can be deemed as one of the limitations to our study.

A study examining postoperative follow-up of tibial plateau fracture surgery found no correlation between joint depression and functional outcomes.[19] However, in our study, a significant decrease in Lysholm scores was observed among patients with postoperative joint depression ($p=0.003$).[14] The measurements of joint depression were performed by a single specialist in our study, which is also another limitation.

Individual factors such as smoking and high BMI increase the risk of postoperative depression, negatively affecting graft stability and potentially increasing long-term complication risks. Ensuring graft stability may be more challenging in patients who smoke or have a high BMI, and these patients may require closer monitoring during recovery. Future studies with larger sample sizes and randomized-controlled trial designs assessing the long-term effects of these findings are warranted to provide important guidance in graft selection for the treatment of tibial plateau fractures.

In conclusion, our study results demonstrate that autografts and synthetic grafts yield similar clinical outcomes during a two-year follow-up. In addition, smoking and high BMI are associated with adverse effects on graft stability. Postoperative follow-up results indicate that patients with joint depression may have worse clinical outcomes compared to those without depression. Taken together, it should be considered that patients with high BMI values and those who smoke may have worse clinical outcomes after surgery, regardless of the type of graft, compared to patients without these individual risk factors. Further studies evaluating the long-term outcomes of both graft types in different patient groups are needed to contribute to the development of treatment methods.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Conception and design, collection and assembly of data, analysis and interpretation of the data: U.O., M.C.D.; Drafting of the article, critical revision of the article for important intellectual content: U.O., O.S.U, M.C.D, M.B, İ.B, İ.B, A.O. All authors read and approved the final manuscript.

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