Tibial Plateau Fractures Schatzker Type II–III Treated With Impacted Bone Allograft or Rafting Technique: Is Filling the Void Necessary? A Comparative Cohort Study of 80 Patients

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ABSTRACT

Introduction: Schatzker type II and III tibial plateau fractures require techniques that stabilize and maintain the articular surface. The objective of this study was to compare the use of impacted bone allograft and the rafting technique, evaluating secondary displacement and postoperative function. **Materials and Methods:** We conducted a retrospective, comparative review of all patients with Schatzker type II and III tibial plateau fractures consecutively treated between January 2015 and December 2020 using either the rafting technique (RT) or impacted bone graft (IBG). Loss of articular reduction (defined as >2 mm of secondary depression) was assessed, along with clinical and radiographic outcomes using the Rasmussen score and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). **Results:** Eighty patients were included: 39 treated with RT and 41 with IBG. Two patients in each group experienced loss of articular reduction during follow-up. The Rasmussen clinical score was excellent or good in 93.75% of the series, with no significant differences between groups; likewise, no significant differences were found in the WOMAC score. The radiological Rasmussen score was excellent or very good in 96.25% of patients, again with no differences between groups. **Conclusion:** The results suggest comparable performance between impacted bone allograft and the rafting technique in maintaining reduction and achieving functional outcomes in Schatzker type II–III tibial plateau fractures.

Keywords: Tibial plateau fracture; tibial plateau depression; rafting technique; bone allograft.
Level of Evidence: III

Fracturas de platillo tibial tipo II-III de Schatzker tratadas con aloinjerto óseo impactado o técnica de rafting. ¿Es necesario llenar el vacío? Estudio de cohortes comparativo en 80 pacientes

RESUMEN

Introducción: Las fracturas de platillo tibial tipos II y III requieren técnicas que estabilicen y mantengan la superficie articular. El objetivo de este estudio fue comparar el uso de aloinjerto óseo impactado con la técnica de *rafting*, evaluando el desplazamiento secundario y la función posoperatoria. **Materiales y Métodos:** Se evaluó, de forma retrospectiva y comparativa, a todos los pacientes con fracturas de platillo tibial tipos II y III de Schatzker tratados consecutivamente con la técnica de *rafting* o injerto óseo impactado, entre enero de 2015 y diciembre de 2020. Se analizaron la pérdida de reducción articular (definida como hundimiento >2 mm) y los resultados clínicos y radiológicos mediante las escalas de Rasmussen y WOMAC. **Resultados:** La serie tenía 80 pacientes, 39 tratados con técnica de *rafting* y 41, con injerto óseo impactado. Dos pacientes del grupo con técnica de *rafting* y 2 del otro grupo tuvieron una pérdida de reducción articular durante el seguimiento. El puntaje clínico de Rasmussen fue excelente o bueno en el 93,75% de la serie, sin diferencias significativas entre los grupos. Tampoco hubo diferencias significativas en el

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puntaje WOMAC. El puntaje radiológico fue excelente o muy bueno en el 96,25% de los pacientes, sin diferencias entre los grupos.
Conclusión: Los resultados sugieren un rendimiento similar en el mantenimiento de la reducción y los resultados funcionales utilizando aloinjerto óseo impactado o la técnica de *rafting* en fracturas de la meseta tibial tipos II y III de Schatzker.
Palabras clave: Fractura de la meseta tibial; fractura-depresión; técnica de *rafting*; aloinjerto óseo.
Nivel de Evidencia: III

INTRODUCTION

Tibial plateau fractures account for 1% of all fractures in adults and between 5–8% of lower limb fractures.[1] Joint depression is an important component of lateral tibial plateau fractures.[2] According to the Schatzker classification, the main types are II (fracture plus depression) and III (pure depression).[3] Effective treatment includes elevation of the osteochondral fragment and stable fixation to provide structural support.[4]

Traditionally, autologous bone grafting is recommended to fill the subchondral bone defect and prevent collapse of the osteochondral fragment after initial joint reduction.[5,6] However, this procedure requires a second surgical approach, causing pain in a previously uninjured area and increasing the risk of infection.[7-11] Alternative strategies, such as bone allografts, bone substitutes, or subchondral graft screws, have reduced donor-site morbidity.[2,11-15]

While bone allografts and substitutes support the joint surface by filling the defect, the rafting technique maintains the articular surface through subchondral screw placement.[2,15] To date, biomechanical studies have not found significant differences in overall construct stiffness, nor has the superiority of any technique been confirmed.[2]

Therefore, the aim of this study was to analyze secondary fragment displacement and functional outcomes following surgery using either impacted bone allograft or rafting techniques without bone grafting for Schatzker type II and III tibial plateau fractures. Our hypothesis was that none of the techniques would demonstrate superior results.

MATERIALS AND METHODS

The databases of three referral centers were retrospectively reviewed to identify all tibial plateau fractures treated with open reduction and internal fixation using either impacted bone allograft or a rafting technique between January 2015 and December 2020.

The study was conducted after approval by the institutional and ethics review boards of each participating institution.

Inclusion criteria were: age >18 years, tibial plateau articular depression ≥3 mm, and Schatzker type II or III fractures.

Exclusion criteria were: open fractures, subacute fractures (>3 weeks after injury), fractures with isolated posterolateral involvement requiring a posterolateral plate, concomitant lower-limb injuries affecting rehabilitation, and postoperative follow-up of less than 12 months.

Preoperative evaluation included anteroposterior and lateral radiographs, as well as a CT scan of the injured knee. Fractures were classified according to the Schatzker system.[3]

The following data were collected: sex, age, diabetes, obesity (body mass index >30), smoking status, fracture type (Schatzker II or III), implants used (cortical or cannulated screws, plates), bone union, and postoperative complications.

Surgical Technique

Patients were operated on a radiolucent table under spinal anesthesia. The anterolateral approach to expose the lateral tibial plateau was performed with the patient in the supine position. A submeniscal arthrotomy was used to visualize the lesion and directly assess the reduction. In fractures with pure depression, the osteochondral fragment was reduced with forceps through a cortical window. For type II fractures, the cortical fracture line was opened and the depressed fragment was elevated en bloc using an osteotome. Fracture reduction was monitored with fluoroscopy in all cases.

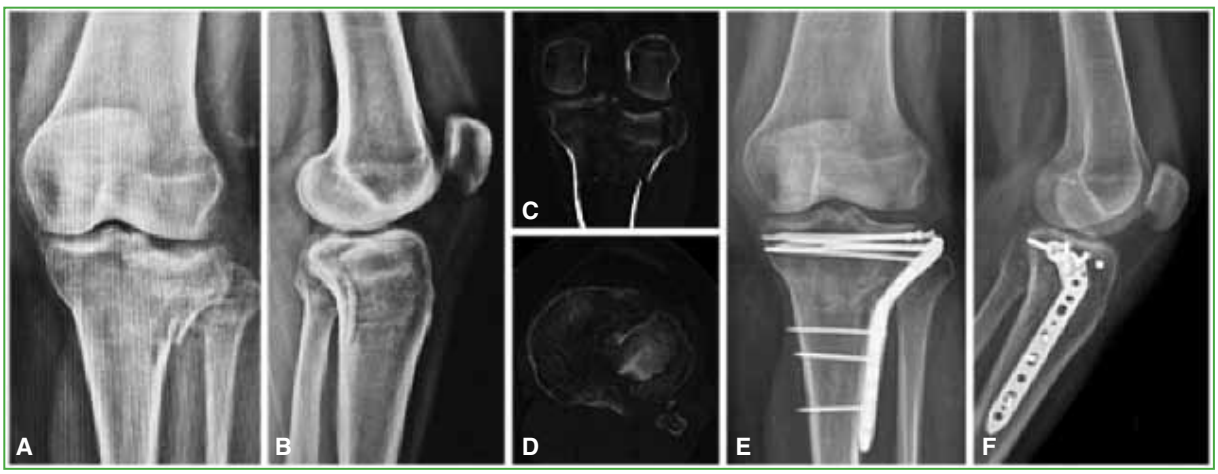

Figure 1. A and B. Schatzker type II fracture in a 56-year-old woman. **C and D.** Computed tomography of the knee showing a centrally depressed fragment associated with a shear component. **E and F.** After open reduction, the depressed fragment was fixed with three 3.5-mm subchondral screws (rafting technique) placed proximal to the precontoured anti-shear plate.

After reduction, preliminary fixation was performed with Kirschner wires. In the rafting technique group (Figure 1), definitive fixation was achieved with 3.5-mm subchondral screws placed through the plate when its design allowed adequate subchondral positioning. When this was not possible, the screws were placed proximally outside the plate.

In the other procedure, the articular surface was restored with impacted bone allograft introduced through a distal window; two cannulated screws (4.5 or 6.5 mm) were then inserted, followed by additional impaction and filling with allograft to occupy the metaphyseal defect (Figure 2).

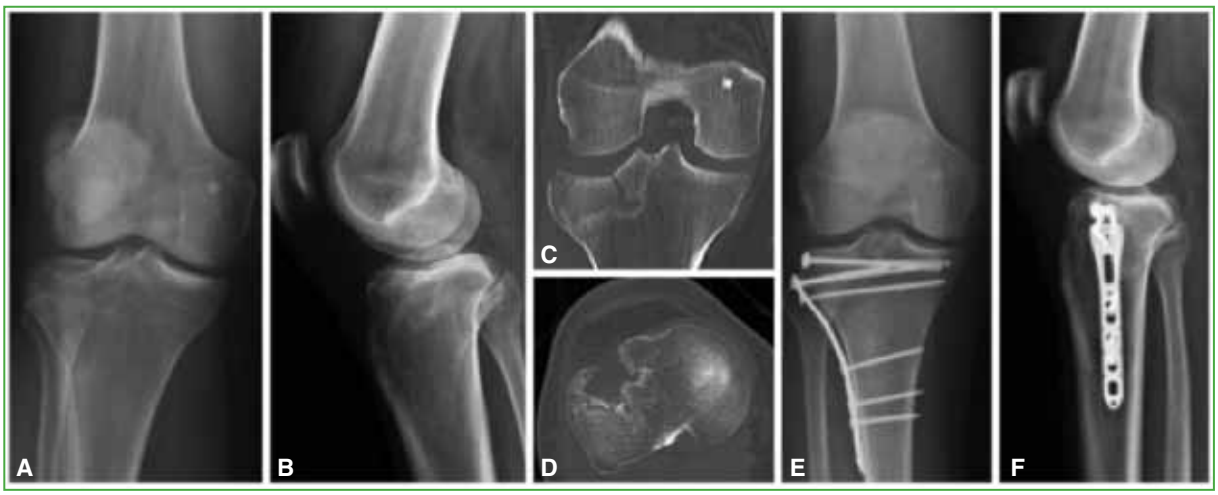

Figure 2. A and B. Schatzker type III fracture in a 61-year-old man. **C and D.** Computed tomography of the knee demonstrating anterolateral joint depression. **E and F.** The depressed fragment was reduced through a cortical window and fixed with two cannulated screws. Impacted allogeneic bone graft was used to fill the defect, and an anti-shear plate was applied.

In type II fractures, a low-profile locking plate was used as a buttress, whereas in type III fractures its use was left to the discretion of the operating surgeon.

All patients followed the same postoperative rehabilitation protocol. Beginning on postoperative day 2, knee and ankle flexion–extension exercises were initiated. Weight bearing was restricted for 4 weeks, followed by partial weight bearing and progression to full weight bearing at approximately 8–10 weeks postoperatively. Clinical and radiological follow-up visits were scheduled at 3 and 6 weeks, 3, 6, and 12 months, and annually thereafter.

For analysis, patients were divided into two groups according to treatment: rafting technique or impacted bone allograft.

Clinical and Radiological Analysis

At the last postoperative follow-up, the Rasmussen criteria were used for the clinical and radiological assessment.[16] This system evaluates clinical outcomes (pain, walking ability, range of motion, and stability) and rates them as excellent (≥27 points), good (26–20 points), fair (19–10 points), or poor (9–6 points). Functional outcomes were determined using the WOMAC (*Western Ontario and McMaster Universities Arthritis Index*) questionnaire through a telephone interview at the end of the study.[17]

Radiological findings (articular depression, alignment, widening, and osteoarthritis) were classified as excellent (18 points), good (17–12 points), fair (11–6 points), or poor (<6 points). Articular depression was measured by drawing the tibial anatomical axis and a perpendicular line at the level of the medial plateau, determining the height difference with the injured plateau at the point of greatest depression. Measurements were performed using the Fujifilm Pack digital system. This assessment was carried out both in the immediate postoperative period and at the final radiological follow-up, with particular attention to significant loss of reduction (>2 mm).

Statistical Analysis

Quantitative variables are reported as mean and standard deviation or median and range, depending on their distribution. Qualitative variables are expressed as frequency and percentage. Comparative analyses between treatment groups were conducted using Fisher's exact test, the Mann–Whitney U test, or the χ^2 test, according to the nature of the variable. A p-value <0.05 was considered statistically significant.

All analyses were performed using SPSS software, version 23 (IBM; Chicago, Illinois, USA).

RESULTS

Of the 92 patients identified, 12 were excluded (3 with open fractures, 1 with a non-acute fracture, 3 with isolated posterolateral involvement, 2 with ipsilateral femur or tibia fractures, and 3 lost to follow-up). The final cohort consisted of 80 patients: 39 (48.75%) treated with the rafting technique and 41 (51.25%) with impacted bone allograft. The general characteristics of the overall sample and each treatment group are presented in Table 1.

Table 1. General characteristics, complications, and follow-up

	Total (n = 80)	*Rafting* (n = 39)	IBA (n = 41)	p
Male, n (%)	47 (58.75)	28 (71.79)	19 (46.34)	0.01
Age, mean (range)	49.6 (25-85)	49.3 (25-77)	51.7 (28-85)	0.12
Diabetes, n (%) BMI >30, n (%) Smokers, n (%)	14 20 13	7 11 7	7 9 6	0.99 0.60 0.76
Schatzker type, n (%) II III	 48 (60.0) 32 (40.0)	 19 (48.72) 20 (51.28)	 29 (70.73) 12 (29.27)	0.07
Complications (%)	4 (5)	2 (5.13)	2 (4.87)	0.99
Follow-up, mean (range)	24.9 (12-51)	24.6 (12-44)	25.2 (12-51)	0.23

BMI = body mass index.

Among preoperative variables, a significant difference was found only in sex distribution between groups (p = 0.01). In the rafting group, a median of 3 screws outside the plate was used. In the impacted bone allograft group, the median graft volume was 45 cc (range 35–75).

Clinical Outcomes

A total of 93.75% (n = 75) of patients achieved excellent or good outcomes according to the Rasmussen clinical score, with no significant differences between groups (Table 2).

Table 2. Clinical outcomes - Rasmussen

	Total	*Rafting* (n = 39)	IBA (n = 41)	p
Excellent, n (%) Good, n (%) Fair, n (%) Poor, n (%)	62 (77.50) 13 (16.25) 5 (6.25) 0	31 (79.48) 6 (15.38) 2 (5.12) 0	31 (75.6) 7 (17.1) 3 (7.3) 0	0.08
Pain, SD	4.21 ± 0.64	4.05 ± 0.75	4.36 ± 0.69	0.07
Gait, SD	4.45 ± 0.63	4.43 ± 0.59	4.46 ± 0.67	0.84
Range of motion, SD	4.49 ± 0.73	4.30 ± 0.59	4.63 ± 0.76	0.76
Stability, SD	4.92 ± 0.47	5.0 ± 0.0	4.85 ± 0.65	0.16

SD = standard deviation.

Sixty-eight of the 80 patients were successfully contacted by telephone (84.6% of the rafting group and 82.9% of the allograft group) to complete the WOMAC questionnaire. The mean WOMAC score was 14.3 ± 2.64 in the rafting group and 15.1 ± 1.98 in the impacted allograft group, with no significant difference between them (p = 0.25).

Radiological Outcomes

Overall, 96.25% (n = 77) of patients obtained excellent or good radiological outcomes. No significant differences were found in any of the radiographic parameters assessed.

Four patients (5%), two in each group, presented loss of articular reduction between the immediate postoperative period and the final follow-up (defined as >2 mm depression) (Table 3).

Table 3. Radiological outcomes - Rasmussen

	Total	*Rafting* (n = 39)	IBA (n = 41)	p
Excellent, n (%) Good, n (%) Fair, n (%) Poor, n (%)	50 (62.5) 27 (33.7) 3 (3.7) 0	24 (61.5) 14 (35.9) 1 (2.6)	26 (63.4) 13 (31.7) 2 (4.9)	0.76
Joint depression, SD	2.40 ± 0.57	2.33 ± 0.57	2.43 ± 0.53	0.43
Varus-Valgus, SD	3.85 ± 0.48	3.92 ± 0.27	3.78 ± 0.61	0.18
Condylar widening, SD	3.81 ± 0.47	3.87 ± 0.33	3.75 ± 0.58	0.28
Osteoarthritis, SD	3.60 ± 0.73	3.51 ± 0.85	3.68 ± 0.60	0.30
Loss of reduction, n (%)	4 (5.0)	2 (5.12)	2 (4.87)	0.86

SD = standard deviation.

DISCUSSION

The main finding of this study was that neither technique proved superior for the treatment of Schatzker type II and III tibial plateau fractures with respect to postoperative loss of reduction or functional outcomes. These results support our initial hypothesis.

Over the past decade, additional factors, such as joint stability, meniscal preservation, and coronal alignment, have been identified as critical determinants of outcomes in tibial plateau fractures, partly due to their relationship with joint congruency.[18] However, recent studies have shown that even a 2-mm articular collapse may correlate with increased knee stiffness and poorer clinical outcomes.[19, 20] Thus, anatomical reduction of the joint surface and stable fixation remain the cornerstones of treatment.[19, 20]

Traditionally, in cases of pure depression or fracture-depression patterns, elevation of the depressed fragment followed by filling the metaphyseal defect with autologous bone graft has been recommended to prevent secondary collapse.[5,6] Nevertheless, donor-site morbidity associated with autologous graft harvesting is well documented. In response, alternative strategies, such as the use of allograft or bone substitute, have been developed, with excellent reported outcomes.[7-11]

Conversely, some authors have demonstrated that filling the void is not essential for construct stability.[2] Mechanical support of the reduced osteochondral fragment via subchondral screw placement ("rafting technique") represents a viable option to prevent collapse.[21] Various technical modifications have been described, including the "trapped screw configuration," "magic screw," interferential "metaphyseal screw," and subchondral plating.[21-26] Regardless of the technique, screws must be positioned sufficiently close to the joint to ensure intimate contact with the osteochondral fragment.[22]

Kulkarni et al.[27] reported outcomes in 38 patients with Schatzker type II fractures treated with rafting fixation using 3.5-mm screws placed through a locking plate. After a mean follow-up of 22.8 months, 94% of patients achieved excellent or very good Rasmussen scores, and only one patient experienced loss of reduction, findings consistent with those in our series.

In the present study, comparison between allograft impaction and rafting demonstrated that both methods effectively maintained articular reduction, with excellent or good radiological outcomes based on Rasmussen criteria.

Although pure depression patterns occur more frequently in osteoporotic bone and therefore are more prevalent in older individuals, the mean age in both groups of our series was similar and consistent with previous reports.[1,19,22,23]

A statistically significant difference favoring male patients was found in the rafting technique group. This may be explained by the fact that one of the centers predominantly treats patients who sustain work-related injuries.

To our knowledge, this is the first study in our setting to compare a series of patients with Schatzker type II and III fractures treated either with impacted bone allograft or with the rafting technique without bone graft or any other substitute.

We acknowledge the limitations of this study. The first is its retrospective design, in which patients were not randomized to one technique or the other, a factor that would have strengthened our findings. Another limitation is the relatively small number of patients per group, which may have affected the analysis and contributed to the lack of statistical significance; however, compared with previous reports, this represents one of the largest cohorts per group. Additionally, the number, direction, and position of screws, whether through or outside the plate, were not standardized. Finally, the follow-up period was insufficient to assess the potential development of post-traumatic osteoarthritis.

CONCLUSIONS

The results suggest comparable performance between impacted bone allograft and the rafting technique in maintaining reduction and functional outcomes in patients with Schatzker type II and III tibial plateau fractures. Depending on fracture characteristics, patient factors, and local resources, these findings allow the surgeon to choose either of the two fixation strategies with the expectation of achieving similarly favorable radiological and clinical outcomes.

Conflicts of interest: The authors declare no conflicts of interest.

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