

Cost-effectiveness Analysis of Schatzker V Tibial Plateau Fractures Treated with Locking Plate in a University Hospital

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Abstract: This study analyzes the cost-effectiveness of the locking plate in grade V tibial plateau fractures in a university hospital. A retrospective study was conducted in patients with Schatzker V tibial plateau fracture. Patients were randomly divided into control (conventional plate, n = 10) and study (locking plate, n = 10) groups. Visual analog scale for pain intensity and WOMAC index were assessed. Total cost of surgery paid by the hospital and the amount paid by the public healthcare system for hospitalization were studied. Among the studied patients, 75% were males, 15% had exposed fracture, 70% used external fixator prior to osteosynthesis, and 10% presented infection. A significant difference in pain intensity was found between the groups (p = 0.0047), with less pain in the study group. WOMAC index was significantly lower in the study group (p = 0.0170). Mean surgery time and mean hospital stay were greater in the control group, but the differences were non-significant (p = 0.2051 and 0.8065, respectively). Total cost of surgery paid by the hospital was lower in the control group. Amount paid by the public healthcare system was higher in the control group. Total cost was lower in the control group. Two of the patients (control group) were reoperated within 30 days of the postoperative period. Thus, total cost of treatment was higher in the control group. Treatment for grade V tibial plateau fractures with a lateral locking plate proved to be more cost effective than treatment with a conventional a double plate and two access points.

Keywords: Tibial Plateau Fracture, Bone Plates, Treatment, Costs and Costs Analysis

Introduction

Tibial plateau fracture with joint involvement accounts for 1.6% of all fractures in adults. Schatzker IV, V, and VI types are common in high-impact trauma and are generally associated with soft tissue injuries. These fractures are difficult to treat and have a high incidence of complications, as infection occurs in 9.9% of cases.^{1,2}

Besides requiring further surgical procedures and increasing the length of hospital stay, infection of the surgical site contributes to a poor functional result and a higher mortality rate.² The risk factors for infection following osteosynthesis of a tibial plateau fracture include open fractures, which cannot be prevented by surgeons, and compartment syndrome, which is directly related to the infection rate of the surgical site due to the need for prior fasciotomy,¹ ranging from 11.8% when the fasciotomy is closed prior to osteosynthesis to 50% when osteosynthesis is performed prior to the closure of the fasciotomy.³ The duration of the surgical procedure is a relevant aspect, as the risk of infection of the surgical site in the postoperative period increases by approximately 78% for each additional hour of surgery time.^{4,5} External fixation prior to definitive osteosynthesis is another

factor that increases the rate of infection of the surgical site, but it is not yet clear whether this increase occurs due to the presence of wires near the fracture or because fractures that require an external fixator are more serious.¹ The number of incisions and quantity of osteosynthesis material are related to an increase in cases of infection due to the increase in surgery time and handling of soft tissues, which are directly related to the infection rate.⁵

Surgical site infection leads to an average increase in hospitalization of two weeks and, consequently, the cost of treatment can increase by as much as 300%.⁶ According to Metsemakers et al.,⁷ surgical site infection increases the cost of treatment 6.5 fold, mainly due to the increase in hospitalization stay and the use of antimicrobials.

The use of locking plate on the tibial plateau with single approach achieves better results compared to the use of external fixator and conventional plates.⁸ The stability of this method enables supporting a physiological load, resulting in satisfactory clinical outcome, avoiding the use of several incisions, and, consequently, reducing the risk of infection.⁸ However, the higher cost of the locking plate in



comparison to a conventional plate may render its use unviable when treatment is sought through the public healthcare system.

This study is justified by the need for cost-effectiveness analysis regarding osteosynthesis of tibial plateau fractures, as this type of fracture is common in high-impact trauma and is generally associated with soft tissue injuries. Studies on the cost effectiveness of the locking plate for the treatment of patients with grade V tibial fractures are scarce. From the medical standpoint, this single-plate fixation method contributes to a reduction in postoperative complications, thereby diminishing the hospital stay and improving the quality of life of these patients. The cost-effectiveness analysis at a university hospital funded by the public healthcare system will compare costs to clinical outcomes, enabling a review of medical conduct and the establishment of a protocol. The aim of the present study was to analyze the cost effectiveness of the locking plate for the treatment of patients with grade V tibial plateau fracture.

Materials and Methods

A retrospective study was conducted involving data from patients with Schatzker V tibial plateau fracture submitted to surgical treatment between January and December 2019 at a high-complexity university hospital in Brazil, and affiliated with the public healthcare system. This study was approved by an institutional ethics committee (CAAE 30195620.3.0000.5415).

The patients were randomly divided into two groups: control (conventional plate through two surgical incisions, $n = 10$) and study (lateral locking plate through a single incision, $n = 10$). All individuals were operated by the same surgical team and submitted to the same preoperative protocol. Gustillo grade III exposed fractures were previously treated with a transarticular linear external fixator. When the culture results demonstrated no signs of infection, the patients underwent definitive osteosynthesis after improvement of the soft tissues. Individuals without exposed fractures but with soft tissue injuries were initially treated with a transarticular linear external fixator and submitted to definitive osteosynthesis after seven days. Postoperatively, patients identified with surgical site infection were readmitted and submitted to mechanical cleaning, the collection of a bone sample for culture analysis, and directed antibiotic therapy for the period necessary to control the infection.

The patients were evaluated upon discharge from hospital as well as seven, 14, 30, and 90 days after surgery by the same team. The protocol was the same for both groups: return visits, removal of stitches, onset of physiotherapy, onset of partial load, and definitive load based on radiological follow-up at one, two, and three months. The clinical assessment involved the visual analog scale (VAS) for pain intensity, degree of joint mobility [range of motion (ROM)], residual deformities (in degrees), and the Western Ontario and McMaster Universities (WOMAC) index for knee osteoarthritis.

The evaluation of the treatment costs in both groups considered the cost of the synthesis materials, length of hospital stay, material used in the surgical ward, surgery time, and the cost of hospitalization for the treatment of infection, which was added to the total hospital cost. Factors not related to the cost of the treatment of tibial plateau fracture itself, such as the external fixator and osteosynthesis of other bones beyond tibial plateau fracture, and readmissions for the osteosynthesis of other bones or any other procedure not related to tibial plateau surgery were excluded from the calculation.

Amounts paid for the osteosynthesis by the institution to the supplier were considered. The supplier was the same for both groups. The public healthcare payment table, all materials used at the surgical ward, and the daily hospitalization cost for the patients were also the same in both groups.

Statistical analysis

Descriptive statistics were performed using measures of central tendency and dispersion as well as frequency counts. For the inferential statistical analysis of the quantitative variables, the Kolmogorov-Smirnov test was used to determine the normality of the data. Student's t-test and Mann-Whitney test were used for comparisons between groups. Chi-squared test was used for the comparison of frequencies. Data were analyzed using the Statistical Package for the Social Sciences (SPSS, IBM Corp., Armonk, NY, US) software, version 23.0, and a significance level of 5% was adopted.

Results

Mean age of the patients with Schatzker grade V proximal tibial fracture submitted to surgical treatment ($n = 20$) was 44.05 ± 10.65 years. The sample was composed of adult males (75%), non-smokers (95%), with exposed fracture (15%), use of transarticular external fixator prior to osteosynthesis (70%), and infection (10%) (Table 1).

Table 1: Characterization of patients with grade V proximal tibial fracture submitted to surgical treatment with conventional plates (control group, n = 10) and locking plates (study group, n = 10) until discharge from hospital.

Variables	Control group	Study group
Sex		
Female	1 (10)	4 (40)
Male	9 (90)	6 (60)
Smoking	0 (00)	1 (10)
Compartment syndrome	0 (00)	0 (00)
Exposed fracture	0 (00)	3 (30)
Use of external fixator	8 (80)	6 (60)
Infection	2 (20)	0 (00)
Death	0 (00)	0 (00)

Percentages in parentheses

Table 2 displays clinical data of the patients with grade V proximal tibial fracture submitted to surgical treatment with conventional and locking plates. No significant difference between groups was found regarding to age (p = 0.3170). A significant difference between groups was found regarding pain intensity using the VAS (p = 0.0047), with lower pain in patients treated with locking plate (study group). WOMAC index was significantly lower in the study

group (p = 0.0170) compared to the control group. No significant differences between groups were found regarding flexion, extension, or valgus and varus deformities. Mean surgery time and mean hospital stay were greater in the control group compared to the study group, but these differences were non-significant (p = 0.2051 and 0.8065, respectively).

Table 2: Means of clinical variables of patients with grade V proximal tibial fracture submitted to surgical treatment with conventional plates (control group, n = 10) and locking plates (study group, n = 10) at hospital.

Variables	Control group	Study group	p
Age (years)	41.6 ± 10.6	46.5 ± 10.7	0.3170
VAS	3.3 ± 1.8	1 ± 1.3	0.0047*
WOMAC	27.6 ± 16.1	11.2 ± 10.7	0.0170*
Flexion (°)	109 ± 15.2	110 ± 13.3	0.8777
Extension (°)	-3.5 ± 4.1	-1 ± 2.1	0.1390
Valgus deformity (°)	2.4 ± 2.0	3 ± 2.4	0.5484
Varus deformity (°)	0.8 ± 1.7	0.2 ± 0.6	0.5032
Surgery time (min)	184.5 ± 35.4	160.8 ± 36.5	0.2051
Hospital stay (d)	4.6 ± 5.2	3.3 ± 2.6	0.8065

VAS = visual analog scale; min = minutes; d = days; * significant difference

Total cost of surgery paid by the hospital was lower in the control group. The amount paid by the public healthcare system for hospitalization was higher in the control group. The total cost was R\$ 25,077.15

for the control group and R\$ 32,826.30 for the study group, which is a difference of R\$ 7,749.15 (Table 3).

Table 3: Total cost of surgery (R\$), total paid by public healthcare system, and deficit related to patients with grade V proximal tibial fracture submitted to surgical treatment with conventional plates (control group, n = 10) and locking plates (study group, n = 10) at hospital.

Variables	Control group	Study group	Difference
Total cost of surgery (R\$)	36,088.08	39,103.01	3,014.93
Total paid by public healthcare for hospitalization (R\$)	11,010.10	6,276.71	4,733.39
Deficit (R\$)	- 25,077.15	- 32,826.30	7,749.15

Two (20%) of the patients in the control group were reoperated within 30 days of the postoperative period. Table 4 displays the reoperation time, hospital stay

related to reoperation, total cost of surgery and treatment, and total received by the public healthcare system.

Table 4: Data related to two patients with grade V proximal tibial fracture submitted to surgical treatment with conventional plates (control group) who were reoperated within 30 days of postoperative period at hospital.

d = days; min = minutes; R\$ = Brazilian currency

Patient	Reoperation time (min)	Hospital stay (d)	Amount received from public system (R\$)	Total cost of surgery + treatment (R\$)	Difference (R\$)
1	150	19	1,534.70	9,874.26	8,339.56
2	100	11	1,606.99	8,100.75	6,493.76
Total	250	30	3,141.69	17,975.01	-14,833.32

Discussion

The present study demonstrate that treatment for grade V tibial plateau fractures with a lateral locking plate proved to be more cost effective than treatment with a conventional a double plate and two access points in patients treated through the Brazilian unified health system at a high-complexity university hospital.

Tibial plateau fractures compromise the joint surface, requiring surgical treatment with reduction and the reestablishment of the joint surface as well as rigid stabilization of the fracture to enable early rehabilitation, which is a determinant of a good prognosis.

Besides compromising the joint surface, Schatzker types V and VI compromise the medial and lateral condyle, requiring fixation with two or three plates and two surgical access points, which accentuates the tissue injury and increases the surgery time, triggering complications, such as infection.¹ Surgical site infection occurs in 9.9% of cases of osteosynthesis of tibial plateau fractures¹ and is a determinant of an unsatisfactory result, prolonging the hospital stay and increasing the cost by more than 300%⁶ at public healthcare services.

Main risk factors for infection in this type of surgery are exposed fractures, compartment syndrome, extended surgery time, smoking, and the presence of an external fixator prior to osteosynthesis.¹ Exposed fractures and smoking contribute to the emergence of infection, but cannot be controlled by the medical team.

Surgery time exerts an influence on the occurrence of surgical site infection, as the risk of infection increases by 78% for every additional hour of surgery.⁴ Besides prolonging the surgery time, surgeries involving two access points for the fixation of two or three plates increase tissue ischemia, with consequent necrosis and an increase in the incidence of infection. In the present study, the mean surgery time for fixation with a conventional plate was 184.8 minutes, which was longer than that for fixation with a single lateral locking plate (160.8 minutes).

Although this difference was not statistically significant, the mean increase in surgery time for osteosynthesis with a conventional plate was 24 minutes, with the occurrence of greater surgical aggression, the devitalization of tissues, and, consequently, an increased risk of infection.⁴

The use of a transarticular external fixator to control damage is another possible risk factor for infection.¹ A fixator was used in 60% of the patients in the study group and 80% in the control group. Moreover, two of the patients in the control group who used an external fixator presented infection.

Regarding the clinical findings, pain in the postoperative period was mild in both groups but was significantly lower in the study group (1 ± 1.3) compared to the control group (3.3 ± 1.8). No significant difference in ROM was found between groups, although the study group had better flexion and extension in comparison to the control group. No significant differences between groups were found regarding residual deformity. This finding is contrary to the concept that fixation with a single lateral plate leads to greater residual varus deformity in comparison to fixation with a double lateral and medial plate, but is compatible with biomechanical findings that a lateral plate with a rigid angle promotes sufficient stability for these fractures.⁹ Assessment using the WOMAC questionnaire revealed a significant improvement in the study group (11.2 ± 10.7) compared to the control group (27 ± 16.1), indicating that post-trauma osteoarthritis was lower in the group submitted to treatment with a locking plate.

Some authors have found no clinical or functional advantage with the use of locking plates for the treatment of tibial plateau fractures.¹⁰ However, the authors cited used locking plates in 28% of cases of grade I to IV fractures, for which there is no medial instability. In the present investigation, locking plates were only used for grade V fractures, in which rigid lateral fixation stabilizes the fracture of the medial plateau without the use of an additional plate.

Although a locking plate is more costly than a

conventional plate, infection occurred two patients in the control group (fixation with a double plate and access points) within 30 days of the postoperative period, requiring reoperation with surgical cleaning and antibiotic therapy. With this, the total cost of treatment was higher in the control group (R\$ 39,910.47) than the study group (R\$ 32,826.30). Thus, the use of the locking plate was more cost effective for grade V fractures.

Conclusion

The present findings show that treatment for Schatzker grade V tibial plateau fractures with a lateral fixation using a locking plate proved to be more cost effective than treatment with a conventional a double plate and two access points.

Conflict of Interests

The authors have no conflict of interests to declare.

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