



Original article

Analysis of the characteristics of patients with open tibial fractures of Gustilo and Anderson type III[☆]



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ABSTRACT

Objective: To analyze the characteristics of patients with Gustilo–Anderson Type III open tibial fractures treated at a tertiary care hospital in São Paulo between January 2013 and August 2014.

Methods: This was a cross-sectional retrospective study. The following data were gathered from the electronic medical records: age; gender; diagnosis; trauma mechanism; comorbidities; associated fractures; Gustilo and Anderson, Tscherne and AO classifications; treatment (initial and definitive); presence of compartment syndrome; primary and secondary amputations; MESS (Mangled Extremity Severity Score) index; mortality rate; and infection rate.

Results: 116 patients were included: 81% with fracture type IIIA, 12% IIIB and 7% IIIC; 85% males; mean age 32.3 years; and 57% victims of motorcycle accidents. Tibial shaft fractures were significantly more prevalent (67%). Eight patients were subjected to amputation: one primary case and seven secondary cases. Types IIIC (75%) and IIIB (25%) predominated among the patients subjected to secondary amputation. The MESS index was greater than 7 in 88% of the amputees and in 5% of the limb salvage group.

Conclusion: The profile of patients with open tibial fracture of Gustilo and Anderson Type III mainly involved young male individuals who were victims of motorcycle accidents. The tibial shaft was the segment most affected. Only 7% of the patients underwent amputation. Given the current controversy in the literature about amputation or salvage of severely injured lower limbs, it becomes necessary to carry out prospective studies to support clinical decisions.

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Análise das características dos pacientes com fratura exposta de tibia grau III de Gustilo e Anderson

R E S U M O

Palavras-chave:

Fraturas da tibia

Amputação/epidemiologia

Amputação/métodos

Objetivo: Analisar as características dos indivíduos com fratura exposta de tibia tipo III de Gustilo e Anderson, tratados em um hospital de nível terciário em São Paulo, entre janeiro de 2013 e agosto de 2014.

Métodos: Estudo transversal retrospectivo. Foram coletados dos prontuários eletrônicos: idade, gênero, diagnóstico, mecanismo de trauma, comorbidades, fraturas associadas, classificações de acordo com Gustilo e Anderson, Tscherne e AO, tratamento (inicial e definitivo), presença de síndrome compartimental, amputações primárias e secundárias, índice de MESS, índices de mortalidade e infecção.

Resultados: Foram incluídos 116 pacientes, 81% com fratura tipo IIIA, 12% IIIB e 7% IIIC, 85% do gênero masculino, média de 32,3 anos e 57% vítimas de acidente de motocicleta. A fratura da diáfise da tibia foi significativamente mais prevalente (67%). Oito pacientes foram submetidos à amputação, uma primária e sete secundárias. Houve predomínio dos tipos IIIC (75%) e IIIB (25%) entre os pacientes com amputação secundária. O índice de MESS obteve pontuação maior do que 7 em 88% dos amputados e em 5% dos pacientes com o membro salvo.

Conclusão: O perfil dos pacientes com fratura exposta de tibia de tibia tipo III de Gustilo e Anderson envolveu principalmente indivíduos jovens do gênero masculino, vítimas de acidentes de motocicleta. A diáfise da tibia foi o segmento mais acometido. Apenas 7% dos pacientes foram submetidos à amputação. Diante da controvérsia existente na literatura sobre a amputação ou o salvamento do membro inferior gravemente lesionado, tornam-se necessários mais estudos prospectivos para apoiar a escolha clínica.

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Introduction

Exposed fractures comprise any injury pattern that causes tearing of the soft-tissue envelope and results in direct communication between the bone and the environment.^{1,2} Epidemiological data from Europe have demonstrated that the rate of occurrence of exposed fractures is approximately 4% per year, which is similar to the rates in other developed countries. It is believed that this rate is equivalent to around 250,000 fractures per year in the United States.¹

The degree of severity of exposed fractures is often classified in accordance with the system of Gustilo and Anderson.^{2,3} This takes into account the wound size, fracture pattern and degree of soft-tissue contamination. Type III of this classification corresponds to fractures due to high-energy trauma, with extensive injury to soft tissues, and is divided into three subtypes: types IIIA, IIIB and IIIC, according to the severity of the injury.¹⁻³

The extensive damage seen in types IIIB and IIIC may be a veritable challenge, even for surgeons with greater experience. It may require a clinical decision between attempts to salvage the limb and amputation. Clinical advances within orthopedic, plastic and vascular surgery have provided the means for reconstructing injuries to limbs that, around 20 years ago, would have resulted primarily in amputation. However, some studies have reported that limb salvage is not always the best

solution and that early amputation with prosthetic treatment should be recommended in some cases.⁴⁻⁷

Some classification scores are used to complement the detailed clinical assessment on the affected limb and aid in making clinical decisions.^{8,9} Helfet et al.⁷ established the use of the Mangled Extremity Severity Score (MESS), which grades injuries based on the clinical findings and takes into consideration the characteristics of the injury, the duration of ischemia, the shock and the patient's age. Scores greater than or equal to seven have predictive value for limb amputation.⁴ According to Tufescu,⁶ evaluation scores predict limb salvage, and not amputation or the functioning of the salvaged limb. For this reason, they cannot be used as the only tool for choosing the treatment. Rather, they should be used in conjunction with the clinical assessment and the grading of lower-limb impairment.

Attempts to salvage a limb may present high complication rates and failure over the long term. They may require multiple high-cost procedures without any guarantee of success. However, at the time that the decision needs to be made, 92% of the patients opt for attempts to salvage and reconstruct the affected limb. The economic impact also needs to be taken into consideration before the treatment is defined. Some of the sociodemographic factors relating to the patient may be predictive of unfavorable clinical outcomes, both for amputation and for limb salvage: advanced aged, low educational level, poverty, smoking and low motivation.⁶

Although much has been now reported regarding exposed fractures, there is a gap in the literature in relation to studies presenting a high level of evidence that have compared outcomes between limb salvage and amputation. This gap exists because of ethical concerns regarding randomization of patients between these two procedures.¹⁰⁻¹³ Thus, many of the recommendations that are incorporated into the treatment routines for patients with exposed fractures of the tibia and fibula are based on specialists' opinions. Thus, further scientific studies are needed in order to provide scientific backing for surgeons' and patients' choices before the operation. The objective of this study was to analyze the characteristics of individuals with exposed fractures of the tibia that were classified as Gustilo and Anderson type III. These patients were treated in a tertiary-level hospital in São Paulo, between January 2013 and August 2014.

Materials and methods

This retrospective cross-sectional study was conducted in the Mandaqui Hospital Complex in São Paulo, Brazil. After approval had been granted by the institution's Research Ethics Committee (no. 745.737), the electronic files of patients with a diagnosis of exposed fractures of the tibia that were classified as Gustilo and Anderson type III, and who were treated at this service between January 2013 and August 2014, were identified. The data were gathered by means of the HospGestor software, which is available at <https://www.hgresidencia.com.br>. The data in this system are updated every day by the traumatology team of this hospital. The following characteristics were analyzed: number of amputations (primary and secondary) and number of salvage procedures on the limb affected; degree of severity of the exposed fractures, classified in accordance with Gustilo and Anderson,^{2,3} classification of Oestern and Tschern¹³ for evaluating the condition of the soft tissue; MESS index,^(x) age; gender; diagnosis (type of fracture and classification in accordance with AO/OTA)¹⁴; injury mechanism; multiple trauma (more than one organ affected); associated fractures; presence of complications (compartment syndrome and infection) and mortality rate.

The data were analyzed statistically and the mean was calculated (with minimum and maximum values) for the continuous outcomes; and frequency and percentage for the dichotomous data (95% confidence interval).

Patients with incomplete medical files and/or lack of radiographic examinations, and those who had transferred to other services, were excluded. The statistical analysis on the data consisted of descriptive analysis on the continuous data, with calculation of means, standard deviations and 95% confidence intervals. Student's t test and analysis on relative frequencies with a 95% confidence interval were used for the dichotomous data.

Results

The initial selection included 126 patients who fulfilled the inclusion criteria. However, ten were excluded because their treatment was transferred to another service. Thus, the

Table 1 – Characteristics of the sample.

Characteristics	n (%)	95% CI
<i>Gender</i>		
Male	99 (85%) ^a	77.68% to 90.74% ^a
Female	17 (15%)	9.26% to 22.32%
<i>Side affected</i>		
Right	51 (44%)	35.27% to 53.05%
Left	65 (56%)	46.95% to 64.73%
<i>Location of the fracture</i>		
Diaphyseal fracture of the tibia	78 (67%) ^a	58.25% to 75.13% ^a
Fracture of the tibial plateau	13 (11%)	6.54% to 18.36%
Fracture-dislocation of the ankle	10 (9%)	4.59% to 15.31%
Tibial pilon fracture	5 (4%)	1.60% to 9.95%
Ankle fracture	5 (4%)	1.60% to 9.95%
Distal fracture of the tibia (extra-articular)	3 (3%)	0.5% to 7.66%
Proximal fracture of the tibia (extra-articular)	2 (2%)	0% to 6.46%
<i>Trauma mechanism</i>		
Motorcycle accident	66 (57%) ^a	47.80% to 65.55% ^a
Being run over by a car	20 (17%)	11.37% to 25.21%
Falling from a height	8 (7%)	3.34% to 13.21%
Being run over by a motorcycle	4 (3%)	1.06% to 8.82%
Gunshot wound	4 (3%)	1.06% to 8.82%
Occupational accident	4 (3%)	1.06% to 8.82%
Bicycle accident	4 (3%)	1.06% to 8.82%
Fall	3 (3%)	0.5% to 7.66%
Car accident	2 (2%)	0% to 6.46%
Stab wound	1 (1%)	0% to 5.20%
Total	116 (100%)	

^a Statistically significant difference.

sample was composed of 116 patients with a diagnosis of exposed fracture of the tibia of Gustilo and Anderson type III. Among these, 81% presented type IIIA (95% CI, 73% to 87%), 12% IIIB (95% CI, 7% to 19%) and 7% IIIC (95% CI, 3% to 13%). There was significant predominance of the male gender (85%; 95% CI, 78% to 91%) and the mean age of the sample was 32.3 years (\pm 15.70). The left side was affected more frequently, but without a significant difference (56%; 95% CI, 46.95% to 64.73%). Traffic accidents were the injury mechanism in 84% of the cases, with a significant difference in relation to accidents involving motorcycles: 57%; 95% CI, 47.80% to 65.55%). Fractures of the tibial diaphysis were significantly more prevalent and were diagnosed in 78 patients (67% of the total sample; 95% CI, 58.25% to 75.13%), followed by 13 patients with fractures of the tibial plateau (11%; 95% CI, 6.54% to 18.36%) (Table 1). In relation to the AO/OTA classification, 20% of all the fractures were type 42-A3 and 13%, 42-B3 (Fig. 1).

Out of the total sample (116 patients), eight (7%) underwent amputation of the limb affected: one as a primary procedure and seven as secondary procedures. The patient who underwent primary amputation was a 17-year-old male who was a victim of a motorcycle accident, with a diagnosis of fracturing of the tibial plateau (AO 41-A2), of Gustilo and Anderson type

Table 2 – Characteristics of the patients who underwent secondary amputation.

Age/Gender	Trauma mechanism	AO fracture type/classification	Gustilo	Tscherne	MESS	Initial treatment	Mortality	Infection
32/M	Motorcycle accident	Tibial plateau (41-C3)	IIIC	III	10	Linear external fixation	–	–
21/M	Gunshot wound	Tibial plateau (41-B1)	IIIC	III	10	Transarticular external fixation, anastomosis of popliteal artery and fasciotomy	–	–
54/M	Motorcycle accident	Tibial plateau (41-C1)	IIIB	III	10	Transarticular external fixation	–	–
39/M	Motorcycle accident	Extra-articular distal tibia (43-A3)	IIIC	III	10	Linear external fixation and fasciotomy	–	–
47/M	Run over by car	Tibial diaphysis (42-C2)	IIIC	III	10	Surgical cleaning and splint	Yes	–
84/F	Run over by motorcycle	Tibial diaphysis (42-C2)	IIIC	III	11	Linear external fixation and fasciotomy	–	Yes
42/M	Motorcycle accident	Extra-articular distal tibia (43-A3)	IIIB	III	5	Linear external fixation	–	Yes

M, male; F, female.

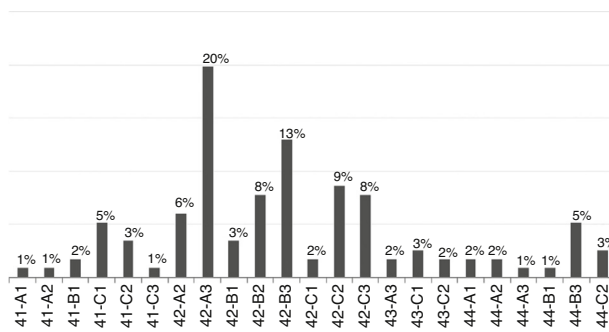


Fig. 1 – Sample distribution according to the AO/OTA classification system.

IIIC, Tscherne type III and MESS index 11, and who presented irreversible injury to the popliteal artery.

Among the seven patients who required secondary amputation, three presented fracturing of the tibial plateau, two of the tibial diaphysis, one of the proximal tibia (extra-articular) and one of the distal tibia (extra-articular). In relation to the Gustilo and Anderson classification, type IIIC fractures predominated (five patients), while two patients presented type IIIB. The scores in the MESS index were similar among the patients (mean of 9.5). The mean time that elapsed between the initial treatment and the secondary amputation was 17.5 days (range: 5–40). The main reasons for reaching this decision were problems with reperfusion (four patients) and infection of soft tissues with purulent secretion and extensive areas of necrosis (three patients). Among the seven patients who underwent secondary amputation, two presented infection that was treated and one died due to complications relating to reperfusion and multiple organ failure (Table 2).

The 108 patients whose affected limb was salvaged presented characteristics that differed from those of the

amputees. A significant majority of these individuals (87%; 95% CI, 79% to 92%) presented the Gustilo type IIIA classification, while in the group of amputees there were only fractures of type IIIB (25%; 95% CI, 6% to 60%) and type IIIC (75%; 95% CI, 40% to 94%) and no significant difference could be seen. The mean age among the amputees was 42.62 (± 22.26) years and it was 31.57 (± 14.96) years in the other group ($P = 0.0543$). There was also a difference between the amputees and the patients whose limbs were salvaged in relation to the MESS index, such that 88% of the amputees had scores greater than seven (95% CI, 51% to 99%), compared with 5% in the other group (95% CI, 2% to 11%). The same was observed regarding the number of multiple trauma patients, such that the frequency of this condition was 50% among the amputees (95% CI, 22% to 78%), whereas it was 9% among those whose limb was salvaged (95% CI, 4% to 15%); regarding associated fractures, 50% (95% CI, 22% to 78%) versus 19% (95% CI, 13% to 28%), respectively; and regarding diagnoses of compartment syndrome, 38% (95% CI, 13% to 70%) versus 6% (95% CI, 3% to 13%), respectively. The infection rate was significantly different, comprising 62% among the amputees (95% CI, 30% to 87%) and 17% among those whose limb was salvaged (95% CI, 11% to 25%) (Table 3).

Discussion

This study had the objective of analyzing the characteristics of patients with diagnoses of grade III exposed fractures of the tibia who were treated at a tertiary-level hospital in São Paulo, Brazil. Male patients showed significant predominance (85%); the mean age was 32.3 years and the left lower limb was affected more frequently. Fodor et al.¹⁵ reported that modernization, industrialization and increasing rates of violence within society had contributed toward the growing incidence of severe traumatic injuries to the lower limbs. The

Table 3 – Distribution of the characteristics of amputated patients compared with those whose limb was salvaged.

	Amputation % (95% CI)	Salvaged limb % (95% CI)	Total % (95% CI)
Male (%)	88% (51% to 99%) ^a	85% (77% to 91%) ^a	85% (78% to 91%) ^a
Gustilo and Anderson (%)			
IIIA	0% (0% to 37%)	87% (79% to 92%) ^a	81% (73% to 87%) ^a
IIIB	25% (6% to 60%)	11% (6% to 19%)	12% (7% to 19%)
IIIC	75% (40% to 94%)	2% (0% to 7%)	7% (3% to 13%)
Tscherne classification (%)			
I	0% (0% to 37%)	2% (0% to 8%)	3% (1% to 8%)
II	0% (0% to 37%)	80% (71% to 86%) ^a	74% (65% to 81%) ^a
III	100% (63% to 100%) ^a	18% (11% to 26%)	23% (16% to 32%)
MESS (%)			
<7	12% (0% to 49%)	95% (89% to 98%) ^a	90% (83% to 94%) ^a
≥7	88% (51% to 99%) ^a	5% (2% to 11%)	10% (6% to 17%)
Multiple trauma (%)	50% (22% to 78%)	9% (4% to 15%)	11% (6% to 18%)
Associated fractures (%)	50% (22% to 78%)	19% (13% to 28%)	22% (15% to 30%)
Compartment syndrome (%)	38% (13% to 70%)	6% (3% to 13%)	9% (5% to 15%)
Infection (%)	62% (30% to 87%)	17% (11% to 25%)	20% (13% to 28%)
Mortality (%)	12% (0% to 49%)	1% (0% to 6%)	2% (0% to 6%)
Total (n)	8	108	116

^a Statistically significant difference.

higher incidence among young men of productive age that was demonstrated in the present study correlates directly with these factors, especially with regard to the injury mechanism.

The main injury mechanisms for exposed tibial fractures are traffic accidents, violence, occupational accidents and serious gunshot wounds.¹⁵ The analysis on the data gathered in this study corroborates this description: 84% of the exposed fractures were caused by traffic accidents, especially those involving motorcycles (57%).

Several scoring systems for assisting in making decisions regarding amputation or salvage of the wounded limb have been described.⁵ The MESS index is perhaps the one most used, both in clinical practice and in scientific circles, although controversy still exists in relation to its sensitivity and specificity.

In the present study, MESS scores greater than or equal to seven were observed in 88% of the amputation cases, but in only 5% of the limb salvage cases. Furthermore, among the patients subjected to amputation, 75% of their fractures were classified as type IIIC and 25% as type IIIB of Gustilo and Anderson. Fagelman et al.¹⁶ evaluated the correlation between fractures of Gustilo and Anderson types IIIB and IIIC and the MESS index for exposed fractures of the lower limbs and found results that significantly predicted treatment, for 93%. On the other hand, Sheean et al.¹⁷ did not find any significant difference in MESS values between amputees and patients whose limbs were salvaged. Both of these authors highlighted the importance of the presence of vascular lesions as a factor predictive of amputation. Slauterbeck et al.¹⁸ reported that early use of a scoring system such as MESS would possibly reduce the morbidity associated with prolonged hospital stay and with the various surgical procedures performed in these cases.

Dua et al.¹⁹ conducted a retrospective cross-sectional study and demonstrated that better control over harm to patients, evolution of surgical techniques and shorter duration

of ischemia were benefits that contributed toward reducing the morbidity and mortality rates. However, even with the advances in these techniques, deciding whether to reconstruct and salvage a limb or to amputate it remains a matter of controversy in cases of complex exposed fractures with associated injuries to adjacent tissues.

Sgarbi et al.²⁰ emphasized that it was important that patients with exposed tibial fractures of Gustilo and Anderson type III should be treated at hospital services that have full resources available for ensuring that salvage of the limb affected might be possible. However, salvage of lower limbs affected by crushing and extensive soft-tissue injuries, in multiple trauma victims, may result in severe metabolic alterations and the risk of sepsis through systemic dissemination of infection. Thus, such injuries need to be carefully assessed by the team.

According to Slauterbeck et al.,¹⁸ preservation of a limb with several attempts to salvage it may be shown to be unviable, given that the limb becomes insensitive and incapable of functional recovery and there is greater risk of morbidity and mortality due to the prolonged hospitalization and various surgical procedures.

It is also important to take into consideration the high costs and the financial, personal and social expense that may result from amputations that are theoretically “unavoidable” but which are often postponed. The absolute indications for primary amputation of the lower limbs include complete avulsion of the limb, injury to the popliteal artery, ischemia lasting more than six hours, neurological injuries, gaseous gangrene and impossibility of restoring the circulatory flow.²⁰

Durham et al.²¹ reported a primary amputation rate of 41% among 21 limbs with MESS scores greater than seven and a secondary amputation rate of 11.7% with a mean MESS score of 8.8. The data gathered for the present study demonstrated that out of the eight patients subjected to amputation, only one case was a primary intervention and the other seven

cases required secondary intervention because the attempts to salvage the limb failed. Among the main reasons that led to secondary amputation were soft-tissue infection, presence of extensive areas of necrosis and vascular and reperfusion-related complications.

Dua et al.¹⁹ reported that historically, the high mortality rates relating to the need for revascularization of severely injured limbs made it more acceptable to make the decision to amputate the injured segment. In the present study, two cases of death relating to severe deficit of perfusion were recorded (2.4% of the total sample): one patient who underwent secondary amputation (47-year-old man who was a victim of being run over, with an exposed fracture of the tibial diaphysis of type IIIC and MESS index of 10 points); and another, for whom the treatment decision was limb salvage (88-year-old woman who was a victim of falling down stairs, with an exposed tibial pilon fracture of type IIIC and MESS index of 7).

The final decision regarding the treatment for patients with a diagnosis of an exposed fracture of the tibia needs to take into account future functionality, availability of recovery, the patient's profile and the surgeon's expertise. The criteria for indicators such as the MESS score and the fracture classification need to be carefully analyzed so that the limb salvage can be done in an effective manner and so that amputation is done in precisely selected cases.^{15,16}

The retrospective data-gathering of this study can be considered to be a limitation. Thus, there is an evident need for prospective studies, especially given the lack of studies of good methodological quality. The informed consent statement for amputations that is used in hospital services attending trauma patients needs to include the detailed orthopedic and vascular evaluation, along with predictive factors such as the MESS index, the Gustilo and Anderson classification and the Tscherne classification. It should also include the evolution of the treatment and quality scientific evidence, so that such studies can contribute toward better treatment for patients who are victims of severe trauma to the lower limbs.

Conclusion

As shown by the sample analyzed in this study, the patient profile among these individuals with exposed tibial fractures of Gustilo and Anderson type III mainly involved young males of productive age who were traffic accident victims, especially relating to motorcycles. A significant majority (81%) presented fractures of the tibial diaphysis of type IIIA. Only 7% of these patients underwent amputation: 75% with Gustilo and Anderson type IIIC and 25% with type IIIB. A MESS index with scores greater than or equal to seven was observed in 88% of the cases of amputation, compared with 5% of the cases of limb salvage. In the light of the scarcity of studies and the controversy that exists in the literature regarding amputation versus salvage for severely injured lower limbs, prospective studies that provide good-quality scientific evidence regarding the criteria for making treatment choices in cases of complex exposed tibial fractures become necessary. Through this, better functional prognoses and reductions in morbidity and mortality rates may be achieved.

Conflicts of interest

The authors declare no conflicts of interest.

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