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ORIGINAL ARTICLE

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AO type 43C tibial pilon fractures: what factors influence functional outcomes?

Fraturas de pilão tibial tipo AO 43C – o que influencia o resultado funcional?

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ABSTRACT

Objective: The objective of this study was to prospectively evaluate operated cases of AO type 43C tibial pilon fracture and assess which factors might influence functional outcomes during the late postoperative period.

Methods: Patients were classified according to the OTA/AO Classification using X-ray and computed tomography (CT) scans. Patients with type 43C fractures were included in this study. A total of 98 tibial pilon osteosynthesis surgeries were performed, and 35 cases were selected for this study based on the inclusion criteria. The treatment protocol established was based on the Tscherne Classification.

Results: We observed that immediate skin complications might be a prognostic factor for the late removal of osteosynthesis material (mean=2 years postoperation) because an association was found between skin complications and the removal of osteosynthesis material. We observed a high incidence of late arthritis complications in both groups, which indicates that the post-traumatic arthritis associated with 43C pilon fractures is practically certain.

Conclusion: No differences were found between the groups when correlating the American Foot and Ankle Score (AOFAS), the degree of arthritis, and skin complications; therefore, complications did not determine the outcomes of tibial pilon fracture. Although the cartilage damage that occurs at the time of injury is a significant mediator of the clinical outcome, more important factors affect the final treatment outcome. In our study, these factors were the treatment protocol based on soft tissue involvement, the anatomical reconstruction of the joint, and rigid internal fixation with early range of motion.

Level of Evidence II; Therapeutic Studies; Comparative Prospective.

Keywords: Tibial fractures; Intra-articular fractures; Fibula; Open fracture reduction; Surveys and questionnaires.

RESUMO

Objetivo: O objetivo deste estudo foi avaliar prospectivamente os casos operados de fratura do pilão tibial tipo AO 43C e avaliar quais os fatores que podem influenciar no resultado funcional no pós-operatório tardio.

Métodos: Os pacientes foram classificados de acordo com a Classificação da OTA/AO através de exames de raio X e tomografia computadorizada e incluídos os do tipo 43C. Foram realizadas 98 cirurgias de osteossíntese do pilão tibial e, segundo os critérios de inclusão, foram selecionados para o estudo 35 casos. O protocolo de tratamento estabelecido foi baseado na Classificação de Tscherne.

Resultados: Com relação às complicações imediatas de pele observamos que ela pode ser um fator prognóstico para a retirada de material de síntese tardio (média de 2 anos de pós-operatório), pois houve associação entre as complicações de pele e a retirada do material de síntese. Com relação à complicação tardia relacionada à artrose obtivemos uma elevada incidência em ambos os grupos, o que denota que a artrose pós-traumática das fraturas de pilão 43C é praticamente certa.

Conclusão: Não houve diferença entre os grupos ao relacionarmos escore AOFAS e grau de artrose e complicações de pele e, portanto, as complicações não foram fatores que determinaram um desfecho na fratura de pilão tibial. Apesar de o dano à cartilagem, que ocorre no momento da lesão, ser um mediador significativo do resultado clínico, existem mais fatores importantes que afetam o resultado final do tratamento. Em

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nosso estudo esses fatores foram: o protoloco de tratamento baseado em acometimento de partes moles, reconstrução anatômica da articulação e fixação interna rígida com movimento precoce.
Nível de Evidência II; Estudos Terapêuticos; Prospectivo Comparativo.

Descritores: Fraturas da tíbia; Fraturas intra-articulares; Fíbula; Redução aberta; Inquéritos e questionários.

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INTRODUCTION

In 1968, Ruedi et al. published a study detailing the mechanism of tibial pilon fracture, previously suggested by Bohler[1] in 1951, in which the type of fracture is related to the position of the foot at the time of injury and varies across the plantar flexion, neutral, and dorsiflexion positions[2]. In this same article, Ruedi proposed a classification system of tibial pilon fractures based on the degree of comminution between the articular surface and the deviation of the fragments, divided into three types[3]. Another proposed system is the AO classification[4,5], in which these fractures belong to group 43. These two classifications are similar. The interobserver reproducibility of the AO classification[6], based on X-ray, is “moderate” (Kappa=0.41-0.60). The use of computed tomography (CT)[7] improves this reproducibility.

Complete tibial pilon fractures are rare, and their treatment is difficult. Their pathophysiology includes three groups: (A) high-energy traumas (e.g., injuries from motor vehicle accidents and falls from heights greater than 2 metres) with severe joint and soft tissue lesions, (B) rotational trauma (e.g., skiing accidents and falls from heights below 2 metres) with mild joint and soft tissue damage, and (C) low-energy trauma amongst the elderly[8]. These three groups lead to different problems and complications based on the soft tissue injury described by the Tscherne classification[9].

The fractures of patients with high-energy trauma should be stabilised within the first 6 hours of injury to avoid secondary damage, and external fixation is indicated. The second stage can be applied after the soft tissue heals using internal osteosynthesis or a definitive external fixator. In patients with moderate and low-energy trauma, however, the initial stage is unnecessary, and treatment can be started at the second stage. According to a meta-analysis evaluating the two osteosynthesis treatment options available for the second stage, current evidence shows that both treatments have a similar incidence of postoperative complications[10].

Despite the standardisation in the literature of the classification and pathophysiology of trauma, many factors influence the surgical treatment outcomes of pilon fractures, including the procedure time, surgical technique, access route, and individual patient factors. In addition, the vast majority of articles available in the literature are retrospective case reviews[11].

The objective of the current study was to prospectively evaluate the operated cases of AO type 43C tibial pilon fracture and assess which factors might influence the functional outcomes during the late postoperative period.

METHODS

This study was approved by the Ethics Committee and registered in the Brazil Platform under CAAE number: 46127215.4.0000.5463.

The foot and ankle surgery group of our institution treated the patients included in this study between January 2007 and February 2017. All patients were recruited consecutively after signing the informed consent form and obtaining the approval of the Brazil Platform.

The patients were classified according to the OTA/AO Classification[5], through X-ray examinations and CT. The inclusion criterion was type 43C tibial pilon fracture. The exclusion criterion was loss to postoperative follow-up.

The patients were divided into two groups based on intensity of trauma: moderate-energy trauma (e.g., rotational trauma and falls from heights below two metres, with mild joint and soft tissue damage) and high-energy trauma (e.g., injuries from motor vehicle accidents and falls from heights greater than 2 metres, with severe joint and soft tissue injuries)[8].

The surgical management was standardised according to the Tscherne classification[9] as follows:

- high-energy group with two surgeries: First, surgery was performed in an emergency setting in the initial hours after trauma, with a uniplanar external fixator in the medial delta and lateral access route to reduce the fibula fracture and osteosynthesis using 3.5-mm plate and screws. After 2 weeks, a second surgery was performed to remove the external fixator through an anteromedial access route to reduce the pilon fracture and place a 3.5-mm anatomic compression and locking plate on the distal third of the tibia.

- moderate-energy group with one surgery: Elective surgery was performed during the first days after the trauma via the lateral access route for osteosynthesis of the fibula using a 3.5-mm plate and screws as well as the anteromedial access route to place a 3.5-mm anatomic compression and locking plate on the distal third of the tibia.

The same surgical team operated on all of the patients, and osteosynthesis materials from the same company were used each patient.

The same physiotherapy team provided postoperative care, which started the day after the surgery. The patient was kept without any load on the operated limb, with emphasis on rehabilitation for ankle joint range of motion. After 8 weeks, an X-ray was performed, and fracture healing was evaluated. Once the fracture had healed, the patients began walking with full loads on the operated limbs. The patients continued undergoing rehabilitation with the same team.

Routine outpatient postoperative follow-up visits took place at 1 week to assess ankle joint range of motion and local skin conditions; at 8 weeks for radiographic confirmation of fracture healing; at 24 weeks to evaluate rehabilitation and return to work; and at 48 weeks to evaluate subjective and functional scores. Afterwards, annual follow-up assessments were performed.

The patient data evaluated were gender, age, injured side, weight, height, chronic disease, smoking, alcohol consumption, education level, employment status, and time absent from work.

The fracture-related data of the evaluated patients were mechanism of trauma, fracture classification, presence of fibula fracture, recent complications (e.g., skin lesions), late complications (e.g., removal of the osteosynthesis material performed in cases of skin lesions), and post-traumatic arthritis.

Post-traumatic arthritis was classified based on late postoperative X-ray analysis and classified according to the Kellgren-Lawrence radiographic score[12], where

- Grade 0: preserved bone structure and joint space
- Grade 1: marginal osteophyte formation without joint space narrowing
- Grade 2: marginal osteophyte formation and subchondral bone changes without joint space narrowing
- Grade 3: marginal osteophyte formation and subchondral bone changes with joint space narrowing
- Grade 4: bone changes and ankylosis

An objective (functional) questionnaire, the American Foot and Ankle Score (AOFAS-BR 2008)[13], and a subjective survey that measured personal satisfaction through an adaptation of Johnson et al.'s (1988) scale[14] were used.

Data analyses were performed using Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL), version 23.0. Means, medians, and standard deviations (SDs) were calculated for the continuous variables, and we used descriptive statistics for the categorical variables. The Mann-Whitney U test[15] and the Kruskal-Wallis test were used to compare the distributions of the categorical variables. The chi-square test and Fisher's exact test were used to compare the categorical variables between the two mechanism of trauma groups. An analysis of variance (ANOVA) of linearity was used to analyse whether a direct or inverse proportional association existed between the factors.

RESULTS

A total of 98 tibial pilon osteosynthesis surgeries were found, and 35 cases were selected for this study based on the inclusion criteria. The mean age of the patients was 51 years, and the mean postoperative follow-up time was 5.2 years, with a SD of 2.4 years. The patients were divided into two groups based on the intensity of the trauma, and the epidemiological characteristics of the groups are described in Tables 1 and 2.

A difference in age between the groups with (mean=56.12 years) and without chronic disease (mean=46.44 years) was observed, $p=0.038$. No difference in body mass index (BMI) between the groups with and without chronic disease was found ($p=0.883$).

The AO type 43C classification was distributed among the study groups as shown in figure 1. No association was found across the AO classification distribution (C1, C2, and C3) and the mechanism of trauma ($p=0.352$).

Fibula fracture combined with tibial pilon fracture was found in 10 cases in the high-energy group (77%) and in 18 cases in the moderate-energy group (82%), with no significant difference between the groups ($p=0.525$).

The distributions of recent and late postoperative complications are shown in table 3.

Table 1. Epidemiological characteristics of the numerical variables

	High-energy group (n=13): mean and SD	Moderate-energy group (n=22): mean and SD	Total (n=35): mean and SD	*p* (≤0.05)
Age at surgery (years)	47.92 (SD=14.88)	53.05 (SD=10.93)	51.14 (SD=12.58)	0.389
Weight (kg)	81.69 (SD=16.45)	77.00 (SD=18.78)	78.74 (SD=17.85)	0.408
Height (metres)	1.72 (SD=0.08)	1.67 (SD=0.09)	1.69 (SD=0.09)	0.079
BMI (weight/height x height)	27.50 (SD=5.37)	27.42 (SD=5.22)	27.45 (SD=5.19)	0.987
Time of absence from work (months)	6.09 (SD=3.75)	5.40 (SD=2.16)	5.65 (SD=2.78)	0.951
Postoperative follow-up time (years)	4.77 (SD=2.24)	5.45 (SD=2.50)	5.20 (SD=2.39)	0.353

Source: SAME.

Table 2. Epidemiological characteristics of the categorical variables

	High-energy group (n=13)	Moderate-energy group (n=22)	*p* (≤0.05)
Gender			0.482
Female	5	10	
Male	8	12	
Injured side			0.625
Right	6	10	
Left	7	12	
Personal history			
Chronic disease	3	14	**p<0.023**
Smoking	1	2	0.694
Alcohol use	0	1	0.629
Type of employment			0.709
Active	10	15	
Retired	3	7	
Education level			0.178
Elementary	1	7	
Secondary	5	7	
Higher	0	2	
Postgraduate	7	6	

Source: SAME.

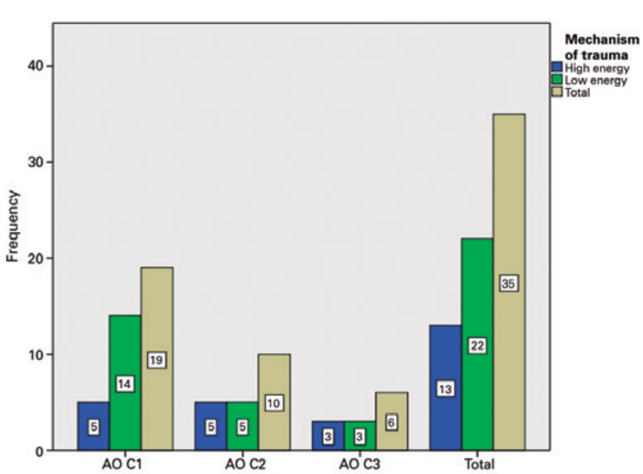

Figure 1. Distribution of 43C fractures between the study groups.
Source: SAME.

The removal of osteosynthesis material was performed at a mean postoperative time of 2 years, and an association was found between skin complications and the removal of osteosynthesis material (p=0.050).

The frequency of post-traumatic arthritis and its distribution by group are shown in figure 2. The scores distribution are shown in table 4.

The distribution of the AOFAS score, relative to the Johnson score, differed between the groups (p=0.042), and the ANOVA revealed a linear relationship (Figure 3).

No difference was found between the groups regarding the AOFAS based on the presence of chronic disease (p=0.757), the presence of mild or severe arthritis (p=0.054), the removal of the osteosynthesis material (p=0.149), or skin complications (p=0.113).

DISCUSSION

The mean age of the 35 patients evaluated was 51 years; when we divided this sample into high- and moderate-energy groups, these groups were balanced with regard to gender, injured side, age, BMI, employment status (active or retired), and education level. Therefore, the groups were homogeneous and could be compared with each other.

Table 3. Distribution of recent and late postoperative complications

	High-energy group (n=13)	Moderate-energy group (n=22)	*p* (≤0.05)
Skin complication	6	7	0.480
Removal of osteosynthesis material	5	4	0.243
Post-traumatic arthritis	12	19	0.522
Loss of reduction	0	0	0
Non-healing	0	0	0

Source: SAME.

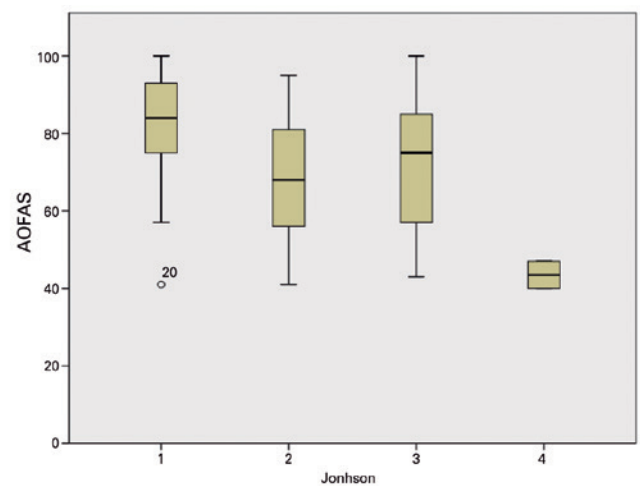

Figure 3. Analysis of variance test for linearity.
Source: SAME

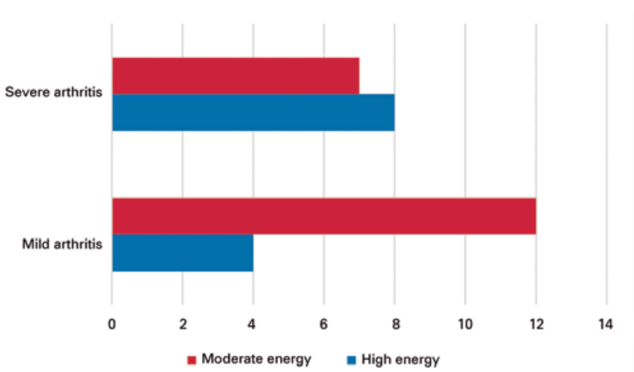

Figure 2. Distribution of 43C fractures between the study groups.
Source: SAME

Table 4. Distribution of subjective and functional scores

	High-energy group (n=13)	Moderate-energy group (n=22)	*p* (≤ 0.05)
Personal satisfaction (Johnson Score)	1: 07	1:10	0.128
	2: 06	2: 05	
	3: 00	3: 05	
	4: 00	4: 02	
AOFAS	mean=67.69	mean=78.18	0.149
	SD=19.66	SD=18.45	
	median=57.00	median=84.00	

Source: SAME.

The only significant difference found between the groups was the presence of chronic disease. This difference is explained by the higher ages found in the moderate-energy group, which predispose these patients to the development of chronic disease. However, the presence of chronic diseases did not affect the functional outcomes evaluated by the AOFAS (p=0.757); therefore, this variable was not a factor that determined the outcomes of tibial pilon fracture.

Certain factors (e.g., the mechanism of trauma, presence of comminution, soft tissue involvement [based on the Tscherne Classification], and the presence of fibula fracture) serve as clues to understand the amount of energy absorbed by the trauma[16-18]. The presence of fibula fracture is typically associated with higher-energy traumas; however, if the mechanism of injury has a high-energy aetiology, then the presence of the fracture contributes to elucidate only the direction of the mechanism (typically, a varus axial load)[17]. Busel et al. state that the plate should be placed in such a way as to withstand the original deforming forces; thus, medial plates should be used on tibia fractures with varus deformation[18]. On the other hand, the absence of fibula fracture or fibular tension failure is associated with a pattern of varus, axial load injury, and low-energy trauma[16]. All of the fractures in our study presented with varus deformation; therefore, the medial plate was placed on the tibia. When assessing the presence of fibula fracture and correlating these data across the moderate- and high-energy groups, we did not find a significant difference (p=0.525).

Therefore, we infer that in type 43C fractures, the amount of energy absorbed by the trauma was high, regardless of the mechanism of trauma. If the trauma did not result in fibula fracture, then it might be that the energy was absorbed by the metaphyseal region of the tibia due to insufficient bone architecture. Thus, it is possible to correlate these fractures with bone metabolism changes such as osteoporosis.

We observed that immediate skin complications might be a prognostic factor for the late removal of osteosynthesis material (mean=2 years postoperation) because an association was found between skin complications and the removal of osteosynthesis material (p=0.050). However, these complications did not affect the functional outcomes evaluated by the AOFAS (p=0.113 for skin complications and p=0.149 for the removal of osteosynthesis material); therefore, these factors do not determine the outcomes of tibial pilon fracture.

We found a high incidence of late arthritis complications in both groups, which indicates that post-traumatic arthritis is practically certain after 43C pilon fracture. However, no difference was found between the groups with regard to the correlation between the AOFAS and mild or severe arthritis (p=0.054); therefore, this factor does not determine the outcomes of tibial pilon fracture. The treatment of intra-articular fractures, through anatomical reduction to preserve joint cartilage metabolism and progressive chondrocyte damage along fracture lines, might eventually mitigate the risk of post-traumatic osteoarthritis[19,20]. However, high-energy impact fractures lead to significant and possibly irreversible joint cartilage damage[21].

The distribution of the AOFAS relative to personal satisfaction differed between the groups (p=0.042), such that better function was associated with higher personal satisfaction. A relevant variable is time absence from work or daily life activity (mean=5.14 months), which did not significantly differ between the groups.

Despite protocols and gradual technical advances, combined with the technological evolution of implants, the original principles regarding the management of pilon fracture remain unchanged. The basis of ideal management continues to be the restoration of the ankle joint length with fibular fixation, the reconstruction of the anatomical articular surface, and bone grafting (when necessary) to buttress metadiaphyseal reconstruction. Current modifications include the importance of soft tissue management with a particular focus on tissue oedema and pelvic floor resolution. In addition, preoperative planning strategies through the use of CT and the selection of adequately interconnected surgical incisions that, when combined, provide for better perioperative and postoperative periods reach the functional outcome desired[22]. Our team obtained functional results that did not differ between the groups using the established treatment protocol based on the Tscherne Classification[23] to minimise postoperative complications (i.e., skin complications, the removal of osteosynthesis material, and post-traumatic arthritis), and the same result was observed with regard to time absent from work. We believe that a thorough understanding of the anatomy, nature of the fracture established by CT, and complete preoperative planning with the design and knowledge of different surgical approaches will help to ensure a satisfactory outcome, even in the most difficult cases[24,25].

CONCLUSIONS

No difference was found between the groups when correlating the AOFAS, the degree of arthritis, and skin complications; therefore, complications did not determine the outcomes of tibial pilon fracture. Although the cartilage damage that occurs at the time of injury is a significant mediator of the clinical outcome, more important factors affect the final treatment outcomes. In our study, these factors were the treatment protocol based on soft tissue involvement, the anatomical reconstruction of the joint, and rigid internal fixation with early range of motion.

Authors' contribution: Each author contributed individually and significantly to the development of this article: VQB *(https://orcid.org/0000-0001-7889-8090) interpreted the study results and wrote the article; LVMM *(https://orcid.org/0000-0002-2657-012X) performed the literature review and participated in the review process; GFF *(https://orcid.org/0000-0001-8032-3077) interpreted the study results and participated in the review process; KCS *(https://orcid.org/0000-0003-1534-9654) designed and planned the study activities, participated in the review process and approved the final version. *ORCID (Open Researcher and Contributor ID).

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