

## Original Article

# Comparative result between adult men and women with ankle fractures surgically treated

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## Abstract

**Objective:** Compare the results between adult men and women treated with open reduction and internal fixation after unstable ankle fractures.

**Methods:** Prospective study including 86 patients (n=57, men; n=29, women) with unstable ankle fractures surgically treated. A socio-demographic and clinical questionnaire with 48 items was applied. The morphology of ankle fractures was analyzed according to the AO Foundation and Orthopaedic Trauma Association (AO/OTA) classification system.

**Results:** Among the 86 patients, young men predominated all variables researched. The most common injury was motorcycle crashes, followed by soccer accidents ( $p \leq 0.001$ ) caused by high-energy trauma ( $p \leq 0.05$ ). Other factors are fractures on the right side ( $p \leq 0.05$ ), more fractures AO/OTA 44-B2 and C1 ( $p \leq 0.05$ ), and malleolus lateral and bimalleolar fractures ( $p \leq 0.01$ ).

**Conclusion:** The results indicate that adult men are more likely to suffer ankle fractures requiring surgical treatment than adult women. We suggest that the anatomical reduction of displaced malleolar fractures, especially restoring the fibula length and maintaining reduction until the fracture is healed, appears to be highly favorable for the surgical treatment of unstable ankle fractures.

**Level of Evidence II; Prognostic Studies; Prospective Study.**

**Keywords:** Ankle fractures; Adult; Open fracture reduction.

## Introduction

Fractures involving the ankle mortise are among the most common joint injuries in the lower extremity treated by orthopedic surgeons<sup>(1,2)</sup>. Moreover, these fractures are relatively common and exceed 10% of all fractures<sup>(3,4)</sup>, thereby representing an important cause of morbidity among younger populations<sup>(5,6)</sup>.

Since 1950, there has been an increase in the number and overall incidence of ankle fractures (AFs)<sup>(7,8)</sup>, ranging from 101-184 fractures per 100,000 inhabitants per year<sup>(9)</sup>, with a peak incidence among young men estimated at 157.1 fractures per 100,000 inhabitants per year<sup>(3)</sup>. Of these, approximately 53% are unstable fractures requiring surgical treatment<sup>(10)</sup>.

In adult age, the most frequent cause of AFs has been road-traffic accidents<sup>(11,12)</sup> and sports activities<sup>(13,14)</sup>. However, in the last two decades, the prevalence of such fractures has increased among young, active patients, particularly younger men<sup>(2,15)</sup>. Among youth, there are more AFs in men than women, but after 50 years of age, the rate per gender reverses<sup>(6,16)</sup>.

Since the mid-1970s, there has been a general trend toward surgical intervention to treat more-severe ankle injuries<sup>(17)</sup>. Several studies have shown that better results are obtained with surgical than non-surgical treatment<sup>(18,19)</sup>. Although non-surgical treatment was used for many years, open reduction and internal fixation (ORIF) has become the gold standard surgical treatment for AF<sup>(20,21)</sup>.

Study performed at the Hospital Nossa Senhora da Saúde (HNSS), Diamantina, Minas Gerais, Brazil and Casa de Caridade Santa Tereza, Serro, Minas Gerais, Brazil.

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The key to success in this surgical treatment is the anatomical reduction of displaced malleolar fractures, especially restoring the fibula length and maintaining reduction until the complete union of the fracture, which is almost impossible with non-surgical treatment<sup>(13,22)</sup>. In addition, there is a concern that a non-surgical approach may fail to produce an anatomical reduction of the mortise, leading to ankle instability, nonunion, and post-traumatic osteoarthritis of the ankle<sup>(22)</sup>.

Considering this information, the hypothesis of this study is to learn whether adult men are more likely to suffer AFs that are surgically treated than adult women. Therefore, this study was conducted to compare the results between adult men and women treated with ORIF after unstable AFs.

## Methods

### Patients

The study included 86 patients (n=57, men; n=29, women) with unstable AF treated with ORIF. All patients were treated as inpatients. They signed the informed consent form before surgery following the institution's ethical procedures under the number Doc14A/CE/2015.

Inclusion criteria were age between 18 and 65 and unstable AF only of one lower limb without amputation. Exclusion criteria were cranial-encephalic and spinal cord injury, pathological fracture, cognitive conditions that would interfere with providing accurate responses to a questionnaire, and previous motor disease that would alter lower-limb performance.

### Design

A prospective study was conducted in the orthopedics department, including seven orthopedic surgeons who performed the surgeries under the blinded condition. The sample included adult patients admitted to this department with AF from July 2015 to November 2016. On admission, the patient's medical records were analyzed to understand the nature of their injuries, in addition to detailed and systematic examinations to rule out associated injuries.

All patients were interviewed in person at hospital admission or, at most, within two weeks post-surgery, using a sociodemographic and clinical questionnaire with 48 items elaborated according to the research purpose. This theoretical questionnaire includes the following variables: gender, age, age range, cause of fracture, fracture subclassification, type of trauma, fractured side, characteristic of fracture, pattern of fracture, number of days waiting for surgery, delay in surgery, number of days from post-surgery to hospital discharge, surgical procedures, and complications following surgery.

### Procedures

An orthopedic surgeon reviewed all radiographs to minimize diagnostic errors. The AFs were defined according to the criteria of Müller et al.<sup>(23)</sup>, and their morphology was analyzed according to the AO Foundation and Orthopaedic Trauma Association (AO/OTA) classification system based on the line

location of the fracture in the fibula to the level of syndesmosis<sup>(23)</sup>. In addition, fractures of the medial malleolus and the posterior margin of the tibia, which the AO/OTA system could not classify, were recorded.

### Statistical analysis

After collection, data were analyzed using the Statistical Package for Social Sciences (SPSS) program, version 23 (IBM Corp., Armonk, New York, USA). The results of quantitative variables (age, number of days waiting for surgery, number of days from post-surgery to hospital discharge) were presented as mean, standard deviation (SD), minimum, and maximum. Qualitative variables (age range, gender, cause of fracture, fracture subclassification, type of trauma, fractured side, characteristic of fracture, pattern of fracture, delay in surgery, surgical procedures, complications following surgery) were expressed as frequencies and percentages. Normal and asymmetric distribution was observed using the Kolmogorov-Smirnov test on age, number of days waiting for surgery, and number of days from post-surgery to hospital discharge. The relationship between the gender variable and the variables age range, type of trauma, fractured side, characteristic of fracture, and complications following surgery were verified by an asymptotic chi-squared test ( $\chi^2$ ), with its respective degree of freedom (gl) and the result of the coefficient Phi ( $\phi$ ). The relationship between the gender variable and the variables causes of fracture, subclassification of fracture, pattern of fracture, and delay in surgery were verified by a Monte Carlo simulation for the chi-squared test ( $\chi^2$ ), with its respective degree of freedom (gl) and the result of the contingency coefficient (C Pearson). Comparisons between the gender variable and the variables number of days waiting for surgery and post-surgical period (until hospital discharge) were performed using the Mann-Whitney U test. A p-value less than 0.05 was considered to be significant.

### Results

During the study period (July 2015 to November 2016), 86 adult patients who suffered ankle fractures surgically treated were included in this study following inclusion criteria: age between 18 and 65 and unstable AF only of one lower limb without amputation. On the other hand, patients with the following criteria were excluded from this study: cranial-encephalic and spinal cord injury, pathological fracture, cognitive conditions that would interfere with providing accurate responses to a questionnaire, and previous motor disease that would alter lower-limb performance. On admission, the patient's medical records were analyzed to understand the nature of their injuries, in addition to detailed and systematic examinations to rule out associated injuries, thus classifying whether the patients would be under the inclusion and exclusion criteria.

Among the total, men were predominant, with 57 (66.3%) and 29 (33.7%) were women. The mean age of the patients was 37.9 (SD=14.05), and their ages ranged from 18 to 65.

The mean age the men were younger than women was eight years, 35 (SD=13) vs. 43 (SD=16). Forty-nine men (86%) were under 49, and 11 women (38%) were over 50 [ $\chi^2(1)=6.377$ ,  $\phi=0.272$ ,  $p=0.012$ ].

As shown in Table 1, the most frequent causes of AF were motorcycle crashes and soccer accidents. In both types of accidents, this represented a predominance of more than 94% of men to the total of AFs related to motorcycle crashes and soccer accidents by gender [ $\chi^2(8) = 36.850$ , C Pearson=0.655,  $p=0.000$ ].

The breakdown into different AO/OTA 44 subgroups is presented in Figure 1. The AO/OTA 44-B2 and C1 fractures were the more frequent, with 51 cases; of these, 32 (63%) were men [ $\chi^2(9)=17.157$ , C Pearson = 0.408,  $p=0.046$ ].

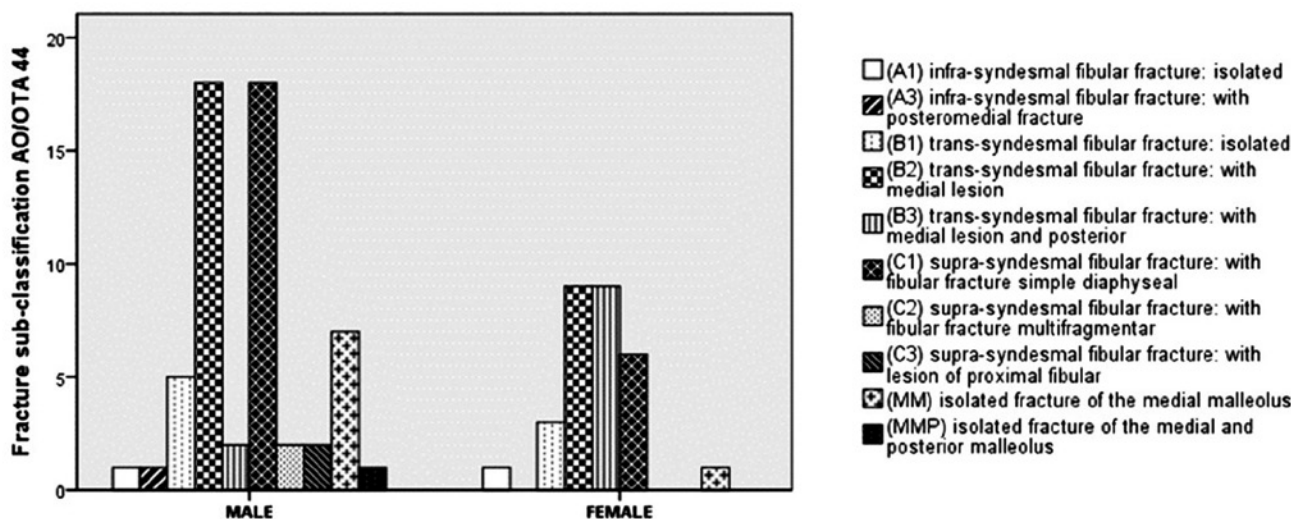
The dominant type of AF in our series was the low-energy type 50 (58.1%), but men presented with the AFs of the high-energy type 29 (80.6%) in the total of 36 patients [ $\chi^2(1)=5.647$ ,  $\phi=0.256$ ,  $p=0.017$ ]. Of the total number of patients, the fractured side was 50% to both sides (n=43 right side; n=43 left side); men had 33 (76.7%) right side fractures [ $\chi^2(1)=4.214$ ,  $\phi=0.221$ ,  $p=0.040$ ]. Regarding the fracture's characteristics, closed fractures were predominant, with 75 cases (n=47 men; n=28 women). Only 11 patients suffered open fractures (12.8%), of which 90.9% (n=10) were men [ $\chi^2(1)=3.424$ ,  $\phi=0.200$ ,  $p=0.064$ ].

Table 2 shows the division of AF patterns by gender. Most patients had lateral malleolus fractures, followed by bimalleolar fractures; in both cases, the majority were men [ $\chi^2(4)=15.115$ , C Pearson = 0.387,  $p=0.004$ ].

**Table 1.** Cause of the fracture by genre

Cause Fracture	Men		Women		Total	
	n	%	n	%	n	%
Road-traffic accident	22 (Mc21, Cc1)***	25.6	4	4.7	26 (Mc25, Cc1)	30.2
Fall of horse	3	3.5	0	0	3	3.5
Fall from their height	1	1.2	10	11.6	11	12.8
Fall of height	3	3.5	0	0	3	3.5
Fall of stairs	1	1.2	4	4.7	5	5.8
Twist or sprain	6	7.0	6	7.0	12	14
Running over	3	3.5	1	1.2	4	4.7
Fall in slope	2	2.3	3	3.5	5	5.8
Sports injury	16 (S15, B1)***	18.6	1	1.2	17 (S16, B1)	19.8

\*\*\*  $p<0.001$ ; B = bikefall; Cc = car crash; Mc = motorcycle crash; n = number of patients; S = soccer.



**Figure 1.** Fracture subclassification according to AO/OTA 44 by gender.

\* $p<0.05$ ; AO/OTA = AO Foundation and Orthopaedic Trauma Association; AO/OTA 44 classification AO/OTA of malleolar fractures of the tibia and fibula is 44.

**Table 2.** Pattern of fracture by gender

	LMF		MMF		BMF		TMF		TMF1	
	n	%	n	%	n	%	n	%	n	%
Men	25**	29.1	8	9.3	19**	22.1	4	4.7	1	1.2
Women	7	8.1	1	1.2	10	11.6	11	12.8	0	0
Total	32	37.2	9	10.5	29	33.7	15	17.4	1	1.2

\*\* p<0.01; LMF = lateral malleolus fracture; MMF = medial malleolus fracture; BMF = bimalleolar fracture; TMF = trimalleolar fracture; TMF1 = trimalleolar fracture with small posterior fracture, lesion of deltoid ligament.

The total mean of the variable, the number of days waiting for surgery, was (X=7.67, SD=5.81); there were no significant differences between men (X=7.70, SD=5.77) and women (X=7.62, SD=6.00) (U=812.000, p=0.894). Only 16 patients (18.6%) were submitted to surgery within 48 hours post-AF [ $\chi^2(1)=0.126$ ,  $\phi=-0.038$ , p=0.723]. The transfer was the main reason for the delay of 32 patients (20 men (23.3%); 12 women (14.0%)) because there were no beds available in the hospital where they would have surgery. Other reasons for the delay pointed out by the patients (16 men (18.6%); 7 women (8.1%)) were related to elective surgery, the need for other professionals, and/or additional tests or exams [ $\chi^2(7)=3.951$ , C Pearson=0.210, p=0.785].

Regarding the period (in days) between post-surgery and hospital discharge (1.76, SD=5.25), there was no significant difference between men and women (U=805.000; p=0.750). In our study, there were no cases of bone-graft procedures; however, there were 26 (30.2%) cases of clinical problems following surgery (17 men (19.8%); 9 women (10.4%)) [ $\chi^2(1)= 0.013$ ,  $\phi=0.012$ , p=0.908].

All surgeries were performed using the ORIF method, and only in one case was there a need to remove the screws. Later, an external fixator was placed following several debridements to mitigate a serious infection in the wound.

## Discussion

The aim of the study was to compare the results between adult men and women who were treated with ORIF after unstable AF. In all variables studied, young men were predominant. The most common cause of AFs was road-traffic accidents (mainly motorcycle crashes), followed by sports injuries (mainly soccer). Similarly, road-traffic accidents were found to be the main cause of AFs in most of the studies surveyed<sup>(1,11,24)</sup>, and the study by Ahmad et al.<sup>(11)</sup> found that the majority were motorcycle crash related. Among sports injuries, Jensen et al.<sup>(16)</sup> and Court-Brown et al.<sup>(25)</sup> found that the main cause of AFs was soccer. People between 21 and 50 years are more prone to accidents due to their jobs and the increased use of vehicles. Men are even more vulnerable because their work is more likely to involve risks such as working at heights, driving more, and traveling more for their work<sup>(18)</sup>.

The results regarding the fracture subclassification in our study were very similar to Sakaki et al.<sup>(26)</sup>. They found 37% of AO/OTA 44-C fractures and stated that the treatment for this type of fracture is more complex than for AO/OTA 44-B

because it is a fibular fracture with a syndesmosis injury. The reason is the difficulty of reducing fibular fractures and the need for a perfect restoration of the tibiofibular connexion at the syndesmosis level. According to Court-Brown et al.<sup>(25)</sup>, AO/OTA 44-C fractures are often high-speed injuries such as road-traffic accidents, some sports activities, and falls from any height.

The most common fracture pattern found was lateral malleolus fracture, and the least common was medial malleolus fracture. In general, most authors agree that lateral fractures of the ankle are the most common<sup>(3,18)</sup>. In this sense, the second major cause of AF pattern was bimalleolar fracture. Daly et al.<sup>(27)</sup> claimed that there had been an increase in bimalleolar fractures in young, active men over the last two decades.

The number of days after surgery to hospital discharge in most patients ranged from 1 to 2 days, but one 32-year-old men patient was hospitalized for 49 days. This patient had an unfavorable outcome because the AF did not present with anatomical reduction of the lateral malleolus. The patient had a closed bimalleolar fracture of the right side resulting from a fall from a height of more than five meters. The ORIF was performed, followed by several debridements, which resulted in a serious infection progressing to screw removal due to rejection. Our study suggests that the lateral malleolus is the key to the anatomical reduction of bimalleolar fractures. In this sense, Mahesh and Venkataramana<sup>(13)</sup> found that the accurate anatomical reduction of AF is not enough; it is also necessary to maintain this reduction until a complete fracture union is reached. This is supported by Mitchell et al.<sup>(22)</sup> study, which affirmed that the anatomical reduction of the displaced malleolar fracture, especially restoring the fibula length and maintaining the reduction, is almost impossible using the closed conservative method. There is a concern that a non-operative approach may fail to produce an anatomical reduction of the mortise, leading to ankle instability, nonunion, and post-traumatic osteoarthritis of the ankle.

Regarding the predominant side of the fracture, our results align with Dhameliya and Prashanth<sup>(12)</sup> and agree with the gender of other studies<sup>(15,28)</sup>. The right side predominance in our study, and several other studies, can be explained by the dexterity of the dominant side of the patient so that, in the case of an accident, they first support the dominant side if it is the right side. This is a limitation of our study that was not researched and is, therefore, a research suggestion for new studies.

The most common type of trauma found was low-energy, following the studies of Court-Brown et al.<sup>(25)</sup> and Dhameliya and Prashanth<sup>(29)</sup>; however, men had a higher frequency of high-energy trauma. Although the study by Larsen et al.<sup>(30)</sup> reported that men had a higher frequency of high-energy trauma due to sports activities, this finding contrasts with our study. There were only four cases of high-energy trauma due to sports activities; the remainder were due to road-traffic accidents, falls from any height, and falls from horses. This difference may have been because this study<sup>(30)</sup> investigated AO/OTA 42 fractures (fibular and tibial diaphysis fractures).


In our research, only 16 patients were submitted to surgery within 48 hours of AF. Several studies noted that the best results were seen in patients who underwent surgery 24 to 48 hours after AF<sup>(15)</sup>. However, Patil and Kore<sup>(19)</sup> reported that although most of the fractures in their study were treated within 24 hours, this did not change the outcome. In our study, this delay in performing surgery may be justified by the region's low income. Since the hospitals where the data were collected were financed by the Unified Health System (SUS), the lack of beds available for transferring patients who resided in another city was the main reason for this delay.

Our study has limitations due to several factors. First, our participants were selected from two hospitals with low resources financed by the SUS. Consequently, there were recurrent delays in performing surgeries due to a lack of beds

and surgical materials. Another reason was recurrent strikes (more than 30 days in one of the hospitals) and the related loss of many patients who were transferred to other hospitals outside the region of our research. Thus, by the end of our research, we had obtained a relatively small sample. Therefore, future studies should investigate unstable AFs with a larger sample, and the results should be followed over a longer period. Finally, we reinforce the above suggestion regarding the patient's dominant dexterity.

## Conclusion

The results showed a predominance of AFs in young men with a mean age of 35, a mean of eight years younger than women. Despite the younger age, there is a predominance of high-energy accidents related to motorcycle crashes and soccer accidents. Other factors that can be mentioned are the fractures that are predominant on the right side, and more AO/OTA 44-B2 and C1, malleolus lateral, and bimalleolar fractures. All these indicate the severity of AFs. Accordingly, the results indicate that adult men are more likely to suffer AFs that require surgical treatment than adult women. Lastly, we suggest that the anatomical reduction of the displaced malleolar fracture, especially restoring the fibula length and maintaining the reduction until the fracture has healed, appears to be highly favorable for the surgical treatment of unstable AFs.

**Author's contributions:** Each author contributed individually and significantly to the development of this article: VRA \*(<https://orcid.org/0000-0003-3875-250X>) Conceived and planned the activities that led to the study, interpreted the results of the study, wrote the article, participated in the reviewing process; SAS \*(<https://orcid.org/0000-0002-3187-3416>) Interpreted the results of the study, participated in the reviewing process; WFG \*(<https://orcid.org/0000-0001-9555-0790>) Interpreted the results of the study, wrote the article; JCL \*(<https://orcid.org/0000-0003-1798-2496>) Interpreted the results of the study, participated in the reviewing process and approved the final version; NFS\*(<https://orcid.org/0000-0002-7904-7631>) Participated in the reviewing process and approved the final version. All authors read and approved the final manuscript. \*ORCID (Open Researcher and Contributor ID) .

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