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Profile of individuals with unstable ankle fractures surgically treated in the Jequitinhonha Valley, Minas Gerais

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Abstract: During the adult life stage, the most frequent cause of ankle fractures is road-traffic accidents and sports activities. Over the past 20 years, the number of these fractures has increased in young and active patients, especially in younger men. This study aimed to describe the profile of individuals who suffered unstable ankle fractures treated surgically, through open reduction and internal fixation (ORIF), in the Jequitinhonha Valley region, in Minas Gerais. Eighty-six patients (n=57, men; n=29, women) with unstable ankle fracture surgically treated was included in this study. They were prospectively admitted from July 2015 to November 2016 at two hospitals in region of Jequitinhonha Valley - Brazil. A sociodemographic 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. Out of 86 patients, young men predominated in all variables researched. The commonest injury cause seen was motorcycle crash followed by soccer accidents ($p \leq 0.001$). Regarding the sociodemographic variables of the study, we verified significant differences in the variables smoking ($p \leq 0.05$); racial composition ($p \leq 0.001$) work category ($p \leq 0.01$) and educational level ($p \leq 0.05$) of the patients. Thus, according to the results presented, we conclude that the profile of individuals who suffered unstable ankle fractures treated surgically, through open reduction and internal fixation

(ORIF), in the Jequitinhonha Valley region, in Minas Gerais, are mostly adult men, brown, salaried employees, have a smoking habit and have a low level of education.

Keywords: ankle fracture, adult, motorcycles, soccer, surgical procedures.

Introduction

In adults, the occurrence of malleolar fractures of the ankle are relatively common, accounting for more than 10% of all fractures (Elsoe; Ostgaard; Larsen, 2018). During the adult life stage, the most frequent cause of ankle fractures (AFs) is road-traffic accidents (Ahmad *et al.*, 2011; Dhameliya; Prashanth, 2016) and sports activities (Elsoe; Ostgaard; Larsen, 2018; Robertson *et al.*, 2014). Over the past 20 years, the number of these fractures has increased in young and active patients (Jain; Mantri; Mahajan, 2018) especially in younger men (Ratna Kanth; Gautham Varma, 2018; Shekhar; Reddy, 2017). The consequences of these injuries do not only include pain and disability but can also result in long-term physical, psychological, and social impacts (McPhail *et al.*, 2012).

The incidence of ankle fracture is estimated at 101 fractures per 100,000 inhabitants per year in Europe (Court-Brown; Caesar, 2006; Jensen *et al.*, 1998) to 184 fractures per 100,000 inhabitants per year in the United States (Daly *et al.*, 1987). We found no studies reporting the incidence of ankle fractures in Brazil. One study conducted in Denmark (Elsoe; Ostgaard; Larsen, 2018) showed an increase in AF incidence when compared to other studies (Ávila *et al.*, 2018; Pakarinen *et al.*, 2011). The mean incidence of AF was 169 fractures per 100,000 inhabitants per year. Young adults dominated the demographics, and the study shows an incidence peak of 157 fractures. Some studies have reported that ankle fractures require surgical treatment in up to 50% of cases (Beerekamp *et al.*, 2017; Manoukian; Leivadiotou; Williams, 2013).

Few studies have verified the socioeconomic diversity of patients who undergo surgical AF. In one large study conducted in China, the authors investigated the population-based incidence rate of AF and associated risk factors in terms of demographics, socioeconomics, and lifestyle. However, this study was limited since it collected only basic fracture and demographic data (e.g., age, gender, and fracture time), without any information on bone location, fracture type, injury mechanism, and related risk factors (geographic location, socioeconomic status, and lifestyle) (Song *et al.*, 2018).

Although many AFs can be treated non-operatively, open reduction and internal fixation (ORIF) remains the gold standard treatment for unstable and displaced AFs (Boni *et al.*, 2019). These operative methods ensure the union, anatomical joint restoration, biomechanics, and recuperation of the loading contact of ankle (Patil; Kore, 2017; Vem *et al.*, 2017). Additional advantages include early rehabilitation and mobilization without a cast, along with earlier weight bearing (Rupp *et al.*, 2018; Shekhar; Reddy, 2017).

In this perspective, the aim of this study is to describe the profile of individuals who suffered unstable ankle fractures treated surgically, through open reduction and internal fixation (ORIF), in the Jequitinhonha Valley region, in Minas Gerais.

Materials and Methods

Design

We conducted a prospective study with a team of seven orthopedic surgeons who performed the surgeries under the blinded condition for the purpose of the research. The study was conducted in the orthopedics department of Our Lady of Health Hospital and the House of Charity Santa Tereza. Both are in the Jequitinhonha Valley in Brazil. The sample was adult patients admitted to this department with AF from July 2015 to November 2016. On admission, the patients' medical records were analyzed to understand the nature of their injuries, in addition to detailed and systematic examinations to rule out associated injuries.

All the 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 instrument includes the following variables: gender, age, age range, skin color, marital status, fracture of cause, fracture classification, medical comorbidities at the time of AF, smokers, health insurance, accommodation, degree of schooling, mesoregion who lives in the state of Minas Gerais, region (rural or urban), category at work, individual monthly income, family monthly income.

Patients

The present study comprised 86 cases (n=57, men; n=29, women) of unstable AF treated with ORIF. All the patients were treated as inpatients. They written informed consent

before surgery in accordance with the departmental and university ethical procedures, with the protocol number Doc14A/CE/2015.

Inclusion criteria were the following: age between 18 and 65 years; unstable AF only of one lower limb without any type of amputation. Exclusion criteria included 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.

Procedures

All radiographs were reviewed by an orthopedic surgeon to minimize diagnostic error. The AFs were defined according to the criteria of Müller *et al.* (1991) their morphology was analyzed according to the AO *Foundation and Orthopaedic Trauma Association* (AO/OTA) classification system, based on the location of the line of the fracture in the fibula in relation to the level of syndesmosis (Müller *et al.*, 1991). Fractures of the medial malleolus and the posterior margin of the tibia, which could not be classified by the AO/OTA system, were also recorded.

Statistical analysis

After collection, data were analyzed using version 23.0 of the Statistical Package for Social Sciences (SPSS) program. The result of quantitative variable (age) was presented as mean, standard deviation (SD), minimum, and maximum. Qualitative variables (gender, age range, cause of fracture, skin color, marital status, fracture classification, medical comorbidities at the time of AF, smokers, health insurance, accommodation, degree of schooling, mesoregion who lives in the Minas Gerais state, region (rural or urban), category at work, individual monthly income, family monthly income) were expressed as frequencies and percentages. The relationship between the gender variable and the variables age range, skin color, smokers, health insurance, accommodation, region (rural or urban) were verified by an asymptotic chi-squared test (χ^2), with its respective degree of freedom (gl) and result of the coefficient Phi (ϕ). The relationship between the gender variable and the variables marital status, cause of fracture, classification of fracture, degree of schooling, mesoregion who lives in the Minas Gerais state, category at work, individual monthly income, and family monthly

income were verified by a Monte Carlo simulation for the chi-squared test (χ^2), with its respective degree of freedom (gl) and result of the contingency coefficient (C Pearson). A value of p less than 0.05 was considered significant.

Results

During the survey period, 86 residents of the Jequitinhonha Valley region of Brazil suffered unstable AFs that required hospitalization. Of these, 57 (66.3%) were men and 29 (33.7%) were women. The mean age of the subjects was 37.9 years (SD=14.05), and the age ranged from 18 to 65 years. On average, men were eight years younger than women, at 35 (SD=13) vs. 43 (SD=16) years. Of the men, 49 (86%) were under 49 years old, and of the women, 11 (38%) were over 50 years old [$\chi^2(1)=6.377$, $\phi=0.272$, $p=0.012$].

Table 1 shows the most frequent causes of AF by gender. Of the 26 patients who suffered their injuries in a road-traffic accident, 25 (96.2%) were due to motorcycles crashes and one (3.8%) was due to a car crash; the latter patient was men. In sports injuries, 16 (94.1%) occurred during soccer practice and one occurred as a result of falling off a bike; the latter patient was men [$\chi^2(8)=36.850$, C Pearson=0.655, $p=0.000$].

Table 1: Cause of the fracture by gender

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 own 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

*** $p \leq 0.001$; %, percentage; B, bike fall; Cc, car crash; Mc, motorcycle crash; n, number of patients; S, soccer.

The breakdown into different AO/OTA 44 groups is presented in Table 2. This table shows that 3.5% of the fractures were AO/OTA 44 type A fractures, 53.5% were AO/OTA 44 type B fractures, 32.6% were AO/OTA 44 type C fractures, and 10.4% could not be classified through the AO/OTA system. The number of patients with an AO/OTA 44 type B fracture

was almost equal in men and women, at 25 (29%) and 21 (24.5%), respectively. The number of patients with an AO/OTA 44 type C fracture was much higher among men than among women, at 22 (25.6%) and 6 (7%), respectively [$\chi^2(3)=6.882$, C Pearson=0.272, $p=0.076$].

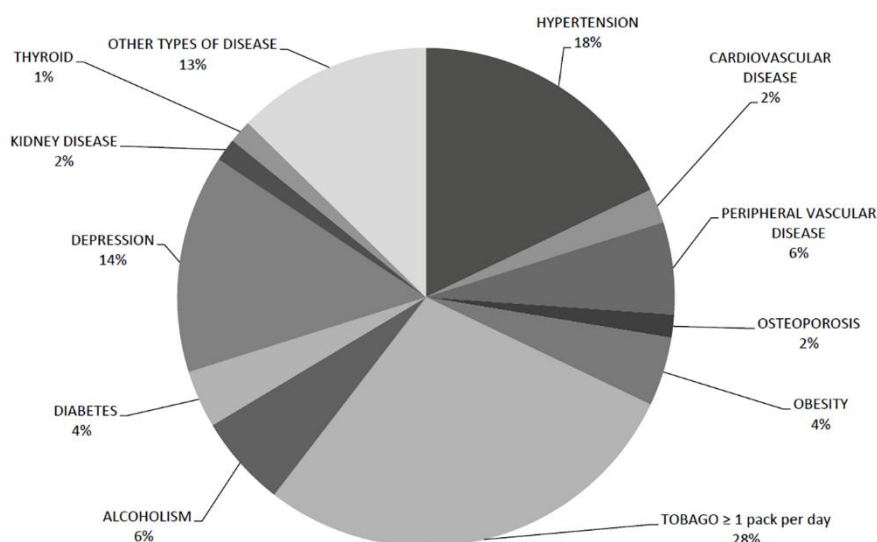
Table 2: Fracture classification according to the AO/OTA 44 by gender

Classification	Men		Women		Total	
	n	%	n	%	n	%
AO/OTA A	2	2.3%	1	1.2%	3	3.5%
AO/OTA B	25	29.1%	21	24.4%	46	53.5%
AO/OTA C	22	25.6%	6	7%	28	32.6%
Without classification	8	9.2%	1	1.2%	9	19.4%

Abbreviations: AO/OTA, AO *Foundation and Orthopaedic Trauma Association*; AO/OTA 44, classification AO/OTA to malleolar fractures of the tibia and fibula calls 44; AO/OTA A, fibular fracture syndesmotic infrastructure; AO/OTA B, fibular fracture trans-syndesmotic; AO/OTA C, fibular fracture supra-syndesmotic.

Figure 1 demonstrates the mean percentage of presence of comorbidities, alcoholism and smoking at the time of AF. The smoking habit predominated in this study with 28% of the total. Of all the patients (N=86), 23 (26.7%) were smokers; of these, the majority (n=19, 83%) were men [$\chi^2(1)=3.746$, $\phi=-0.209$, $p=0.050$].

Figure 1: Mean percentage of presence of comorbidities, alcoholism and smoking at the time of AF



In terms of the sociodemographic variables of the study (Tab. 3), we verified significant differences in the variables of racial composition [$\chi^2(1)=11.574$, $\phi=-0.367$,

$p=0.001$], work category [$\chi^2(5)=15.217$, C Pearson=0.421, $p=0.009$] and educational level [$\chi^2(7)=13.604$, C Pearson=0.370, $p=0.050$]. The other variables did not show significant results.

Table 3. Relationship between gender and sociodemographic variables

Sociodemographic Variables	Men		Women		Of the Total		<i>p</i> value
	n	%	n	%	n	%	
Racial composition							
Brown	43	75.4	11	24.6	54	62.8	0.01**
Marital status							
Single	30	76.9	9	23.1	39	45.3	0.213
Regarding the financial part							
Funded by SUS	49	65.3	26	34.7	75	87.2	0.628
Regarding type hospitalization							
Ward office	54	67.5	26	32.5	80	93	0.382
Category of work							
Salaried employee	19	65.5	10	34.5	29	33.7	0.009**
Regarding the monthly individual income							
One minimum wage [#]	22	61.1	14	38.9	36	41.9	0.325
Regarding the monthly family income							
One to two minimum wage [#]	27	65.9	14	34.1	41	47.7	0.717
Level of schooling							
Incomplete elementary school	22	68.8	10	31.3	32	37.2	0.050*
Region where lived in the MG state							
Jequitinhonha Valley	43	61.4	27	38.6	70	81.4	0.346
Lived in rural ou urban area							
Rural area	25	75.8	8	24.2	33	38.4	0.142

Abbreviations: ** $p \leq 0.01$; * $p \leq 0.05$; %, percentage; #, around 250 dollars; MG, Minas Gerais; n, number of patients; SUS, Unified Health System.

Discussion

This study aimed to describe the profile of individuals who suffered unstable ankle fractures treated surgically, through open reduction and internal fixation (ORIF), in the Jequitinhonha Valley region, in Minas Gerais. We found a bimodal distribution between men and women, with peaks in younger men and older women, and with an overall uneven gender distribution. Regarding the sociodemographic variables of the study, we verified significant differences in the variables of racial composition, work category and educational level. Most fractures occurred in brown men, who declared themselves to be salaried employees and had

incomplete primary education. Among the comorbidities and lifestyle habits studied in our research, the greatest concern was the prevalence of male smokers. In both genders, the most common cause of AF was road-traffic accident (mainly motorcycle crashes) followed by sports injury (mainly soccer) with young and active men significantly predominating in both. We found a much higher number of AO/OTA 44 C fractures among men than among women, indicating the severity of the fractures.

The study found a demographic and mechanism of injury profile that is similar to previously published studies (Elsoe; Ostgaard; Larsen, 2018; Oluwadiya *et al.*, 2008). The results of the bimodal distribution in the age range between genders are in line with the study by Ávila *et al.* (2022), which found a predominance of AFs in young men with a mean age of 35 years, on average eight years younger than women. Consequently, the results indicate that adult men are more likely to suffer AFs requiring surgical treatment than adult women.

The majority of fractures in this study occurred in brown men. A recently published study sought to assess racial disparities in postoperative surgical and medical management of patients after tibial shaft fracture fixation and found the following findings: racial differences were observed in age, gender, and fracture severity of patients with tibial fractures; black patients with surgical tibial fractures tend to be younger, more often male, have higher rates of open fractures that are more severe fractures, and are less likely to meet postoperative prescriptions compared to white patients (DeBaun *et al.*, 2024). Other studies have highlighted the need for interventions that address the disparities that exist between different races and ethnicities in the outcomes of foot and ankle surgeries. These disparities may result from multifactorial socioeconomic factors (Buchanan *et al.*, 2024; Driesman *et al.*, 2017).

Regarding the employment category, the majority reported being salaried employees. Bullock *et al.* (2021), aimed to assess whether income status affects the timing of presentation for orthopedic care, surgical treatment, or continuity of care after a closed AF. They concluded that low-income patients are more susceptible to multiple delays in accessing acute orthopedic surgical treatment, with socioeconomic status being considered a vital condition for the outcome of this patient. In addition, another study cited that economic disparities were associated with a higher risk of infection after AF surgery (Kamalapathy; Dunne; Yarboro, 2022).

Regarding the level of education, the majority stated that they had incomplete primary

education. De Ávila *et al.* (2024) cited in their study that low educational level and surgery after 48h may have negatively influenced the quality of life, mainly of men. These findings are in agreement with other studies (Bhandari *et al.*, 2004; Nilsson *et al.*, 2009). Patients with educational disparities had higher rates of complications and hospital readmission after treatment of ankle and hip fractures compared to those without disparities, due to higher risks of infection and revision after surgery (Kamalapathy; Dunne; Yarboro, 2022).

Among the comorbidities and lifestyle habits studied in our research, the greatest concern was the prevalence of male smokers. Two studies related to AF (Nåsell *et al.*, 2011; Pearson *et al.*, 2016) concluded that smokers face twice the risk of suffering a non-union after fracture, increasing their risk of postoperative complications after AF is surgically treated. Smoking prolongs reparative and inflammatory cellular functions and has a transient effect on the tissue microenvironment, leading to complications and delayed healing after surgery. However, after 4 weeks of smoking cessation, the tissue microenvironment and inflammatory cellular functions were rapidly restored (Sørensen, 2012). To address this issue, smokers should be encouraged to participate in smoking cessation programs or nicotine replacement therapy that should be initiated prior to surgery to improve their outcomes after these orthopedic treatments (Cropley *et al.*, 2008). They should be advised to quit smoking before and after the surgical procedure (Jerjes; Tan; Giannoudis, 2014; Cropley *et al.*, 2008).

Fracture classification AO/OTA 44 B was the main type of AF found here, which was also seen in most of the studies surveyed (de Ávila *et al.*, 2024; Elsoe; Ostgaard; Larsen, 2018). Furthermore, the sequence AO/OTA 44 B (most common), AO/OTA 44 C (relatively common), and AO/OTA 44 A (less common), which we found in our research, was also seen in these other studies (de Ávila *et al.*, 2024; Vem *et al.*, 2017). However, although the difference was not significant, we found a much higher number of AO/OTA 44 C-type fractures among men than women. Treatment of this type of fracture is more complex than AO/OTA 44 B-type, because it is a fibular fracture with syndesmosis injury (Sakaki *et al.*, 2014). According to Court-Brown *et al.* (1998), AO/OTA 44 C-type fractures are often the result of high-speed injuries, such as road-traffic accidents, certain sports activities, and fall from own height.

In both genders, the most common cause of AF was road-traffic accident (mainly motorcycle crashes) followed by sports injury (mainly soccer) with young and active men

significantly predominating in both. Most of the studies surveyed found that road-traffic accidents were the main cause of AF (Ávila, 2023; Ratna Kanth; Gautham Varma, 2018); a study by Ahmad Hafiz *et al.* (2011) also found that the majority of road-traffic accidents were motorcycle crashes. Among sports injuries, Jensen *et al.* (1998) and Court-Brown *et al.* (1998) also found that the main cause was soccer.

People aged 21-50 years are more prone to accidents, due to their professions and increased use of vehicles, with men being even more vulnerable because they are overrepresented in jobs involving high-risk tasks, such as working at great height, driving, and traveling more for work (Jain; Mantri; Mahajan, 2018). In this age range, traffic accidents were associated with a high mortality rate—around 19.8% (Debieux *et al.*, 2010). AF is considered severe when it involves road-traffic accidents, falls from great heights, and sports trauma (Daly *et al.*, 1987). One-third of patients are no longer able to perform their favorite sport due to problems in performing basic activities, such as climbing stairs, squatting, and running (Nilsson *et al.*, 2005; Van der Sluis *et al.*, 1998). Motorcycles went from being leisure objects to becoming work tools; thus, motorcycle accidents are considered both work accidents and road-traffic accidents (Orsati *et al.*, 2004).

Van Son *et al.* (2013) suggested at the end of their article that further research needs to be conducted that focuses on sociodemographic as well as clinical and psychosocial predictors regarding quality of life. These should be considered as part of the main measurements in evaluating AF results, making the patients' perspective more prominent.

Our study was limited by several factors. First, our participants were selected from two hospitals in the interior of Brazil, with low financial resources and financed by Unified Health System (SUS); as a result, recurrent delay was encountered in carrying out the surgeries, due to lack of beds and surgical materials. Second, recurrent strikes (more than thirty days in one of the hospitals) led to a loss of many patients, who were transferred to other hospitals outside the region under research. Thus, at the end of the data collection phase, the sample we obtained was relatively small. In addition, future studies should investigate the short-term financial consequences and return to work after salaried employees undergo surgically treated AF.

Conclusion

Our results indicate that adult men are more likely to suffer AFs requiring surgical treatment than adult women. Most fractures occurred in brown men. They reported being salaried employees, having a smoking habit, and having a low educational level. In both sexes, the most common cause of AF was traffic accident (mainly motorcycle accidents), followed by sports injury (mainly soccer), with young and active men predominating in both. We found a much higher number of AO/OTA 44 C fractures among men than among women, indicating the severity of the fractures. Thus, according to the results presented, we conclude that the profile of individuals who suffered unstable ankle fractures treated surgically, through open reduction and internal fixation (ORIF), in the Jequitinhonha Valley region, in Minas Gerais, are mostly adult men, brown, salaried employees, have a smoking habit and have a low level of education.

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Declarations of interest

None.

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Processo de Avaliação por Pares: (*Blind Review* - Análise do Texto Anônimo)

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