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Original article

EPIDEMIOLOGICAL PATTERNS AND CLASSIFICATION OF ANKLE FRACTURES: A RETROSPECTIVE STUDY

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Abstract

Ankle fractures are among the most common types of fractures, with a rising global incidence, particularly in the elderly population. Despite this, comprehensive epidemiological data on all forms of ankle fractures remain limited. This study aimed to provide a detailed epidemiological analysis of ankle fractures classified by the AO/OTA system within a cohort from a trauma center in Skopje over a seven-year period.

This observational study analyzed data from 559 patients with ankle fractures treated at the University Clinic for Traumatology in Skopje between 2017 and 2024. Fractures were classified using the AO/OTA system, and data on patient demographics, injury mechanisms, and seasonal variations were collected. Descriptive statistics were employed to analyze the distribution of fractures.

The study found that AO/OTA type B fractures were the most common, accounting for 62.9% of cases, predominantly affecting elderly women. Men under 45 years had a higher incidence of ankle fractures, often associated with high-energy trauma. The mean age of patients was 52 years, with women showing a higher mean age (62 years) than men (53 years). Seasonal variation was evident, with a peak in fractures during the winter months.

This study highlights the prevalence of ankle fractures among elderly women and the impact of high-energy trauma in younger males. The findings underscore the importance of targeted prevention strategies, particularly in high-risk populations, and call for further research through multicenter studies to validate and extend these insights.

Keywords: ankle fracture, epidemiology, incidence

Introduction

Ankle fractures are one of the most common types of fractures[1,2]. Injury mechanism can vary from high-energy mechanism all the way to simple falls while walking[3,4]. The global prevalence of ankle fractures is steadily rising, leading to a corresponding escalation in treatment

expenses[5,6]. Ankle injuries in younger persons commonly result from a vigorous and energetic lifestyle. Conversely, in elderly individuals, there is substantial evidence that inferior bone quality is a major contributing cause to ankle injuries[7-9]. Despite this, there is still little epidemiological research that is both up to date and comprehensive, and that encompasses all forms of ankle fractures. Seasonal variations in ankle fractures have also been reported[10]. It is still difficult to gain a clear picture of the epidemiological aspects of these injuries. Therefore, it is of the utmost importance to carry out large epidemiological research in order to get a full understanding of the underlying damage processes, the demographic characteristics of each fracture category, and the effect of gender and age on the particular form of fracture that is experienced.[11] The purpose of this research is to offer a comprehensive epidemiologic information on ankle fractures and distribution of ankle fractures that are categorised as AO/OTA within a cohort that was collected over the course of the last seven years.

Materials and methods

The methodology of research

This was an observational study based on data collected from the University Clinic for Traumatology in Skopje for a duration of two years, starting from January 2017 and concluding in January 2024. After the study design was finished, the Institution Ethical Board granted its approval. All potential participants submitted informed consent forms after receiving information about the study's purpose and objectives. Subsequently, they made a decision on their willingness to participate.

Population Characteristics

The population under investigation was comprised of all ankle fractures that were classified as AO/OTA 44. Initially, standards were created for determining what should be included and excluded in the study. Our study comprised patients who were above the age of 18. Age, gender, date of injury, mechanism of injury (categorised as high- or low-energy), fracture classification (using the AO/OTA classification system), and the treatment method (surgical or non-surgical) were some of the parameters included in the epidemiological data that was collected. In addition to this, the record included the side of the injury as well as the presence or absence of an open or closed fracture pattern. The injury mechanisms were categorised into three groups: a simple fall, a fall from height and traffic-related trauma.

Statistics

All the collected data were entered into a database (Microsoft Excel, Microsoft, Redmond, Washington). Following the completion of the study, the data were transferred to the statistical software (SPSS for Windows 23.0). We calculated descriptive parameters (mean, median, standard deviation, percentage).

Results

There were a total of 559 individuals who suffered ankle fractures during the course of the study. Five patients had bilateral fractures as a consequence of the same injury event. Additionally, 4 patients encountered ankle fractures as a result of different injury during the realization of the study. In the group of people who had multiple fractures, 3 patients suffered a second fracture in the same ankle, whereas 1 patient experienced a fracture in the opposite ankle. Situations in which both ankles were impacted by the fracture were omitted.

A classification system for fractures

This study analyzed 559 fractures, and out of them, 134 (24.1%) were categorised as AO/OTA type A fractures, 352 (62.9%) were classified as AO/OTA type B fractures, and 73 (13%) were classified as AO/OTA type C fractures. 60% of the fractures that were categorised as A-type were classified as A1, and just 8% of the fractures were classified as A3. Out of all the B-type fractures, 55% were classified as B1 fractures, while B2 and B3 fractures accounted for 30% and 15% of the total, respectively. Forty percent of the C-type fractures were classified as C1, 33% as C2, and 27% as C3. According to the findings of the study, the percentage of ankle fractures that occurred in women (63%) was higher than in men (37%). For all ankle fractures, the average age of patients at the time of injury was 52 years, with a range of ages from 18 to 87 years. When cross-referencing to the other AO/OTA categorisation categories, the C2 group had the lowest average age at the time of injury, with a mean age of 43 years. On the other hand, the B3 group had the highest average age, with a mean age of 60 years. Women had a higher mean age of 62 years (ranging from 18 to 87), while men had a mean age of 53 years (ranging from 18 to 80) when they were wounded. It is important to note that men had a higher incidence of ankle fractures compared to women; however, this was only detected in age groups that were less than 45 years old.

Characteristics of fractures

Two percent of ankle fractures that were investigated in this study were open fractures, most prevalent in the C2 group according to the AO/OTA fracture group. On the other hand, just 1 patient from the A1 group had an open fracture. Open fractures were most commonly seen in individuals who were between the ages of 21 and 80 years. When compared to males, the frequency of open fractures was shown to be significantly greater among patients aged 60 and older who were female. Within the age range of 21 to 45 years old, men were more likely to be impacted by open fractures than women. The most common type of open fracture that was found was the Gustilo–Andersson type II, which was distinguished by a wound size that was greater than one centimetre. Women made up two-thirds of the population that fell into this particular group. All Gustilo-Andersson damage categories were more prevalent among female patients. On the other hand, among patients younger than 60 years old, females were more likely to be affected by Gustilo-Andersson types I and II injuries, whereas males were more likely to be affected by Type III injuries.

High-energy trauma was responsible for 15% (n=84) of all ankle fractures. The AO/OTA-A2 group had the largest proportion of high-energy trauma cases, while the AO/OTA-B1 group had the lowest proportion. Individuals between the ages of 21 and 35 years were most likely to experience high-energy trauma, and across all age groups, males were more likely to be harmed by high-energy injury mechanism than females.

Seasonal variations

There was a discernible seasonal variation in the frequency of ankle fractures, with the highest number of fractures occurring during the winter months (December to March), and a decrease during the spring and summer months[12-15].

Discussion

This study provides comprehensive epidemiological data on ankle fractures, offering insights into their distribution, classification, and associated demographic factors. The findings

align with previous research in recognizing the increasing incidence of ankle fractures, particularly among the elderly population, and highlight significant variations based on age, gender, fracture type, and injury mechanisms.

The observed higher incidence of ankle fractures in women (63%) compared to men (37%) is consistent with the broader trend seen in osteoporotic fractures, which are more prevalent among postmenopausal women due to decreased bone mineral density.[16] The mean age of patients (52 years) for ankle fractures, with a higher mean age in women (62 years) than in men (53 years), further supports the understanding that elderly women are at a greater risk of such injuries. This gender difference in fracture rates was most pronounced in individuals older than 45 years, which could be attributed to the increased likelihood of falls among older women, compounded by factors such as lower bone density and muscle mass.

Interestingly, the study found that men had a higher incidence of ankle fractures than women in the age groups under 45 years. This can be explained by the higher engagement of younger men in high-risk activities and occupations that involve physical exertion, making them more susceptible to traumatic injuries. The AO/OTA classification system revealed that B-type fractures were most common, accounting for 62.9% of all fractures, which is in line with other epidemiological studies that have also found B-type fractures to be the most prevalent ones.

The distribution of fracture types, with AO/OTA type B fractures being most common, reflects the typical patterns observed in ankle fractures. The higher prevalence of type B fractures (62.9%) compared to type A (24.1%) and type C (13%) suggests that rotational injuries were more common in the studied population. This is consistent with the understanding that B-type fractures, particularly B1 and B2, often result from lower-energy mechanisms such as twisting injuries, which are frequent in everyday activities like walking or slipping.

The study's detailed analysis of fracture subtypes also revealed that certain groups, such as the AO/OTA-C2 group, had a notably lower mean age at the time of injury (43 years), which could indicate a different mechanism of injury or a different patient profile compared to other fracture types. The high incidence of C1 fractures among younger individuals might suggest a link between high-energy trauma and more complex fracture patterns, as these fractures often involve both rotational and axial forces.

High-energy trauma accounted for 15% of all ankle fractures in this cohort, with a notable predominance of such injuries in younger males (ages 21-35). This finding aligns with the literature, which frequently reports a higher incidence of high-energy fractures in younger individuals, particularly men, due to factors such as motor vehicle accidents, falls from significant heights, and sports injuries.[17] The AO/OTA-A2 group higher proportion of high-energy trauma cases suggests that certain fracture types may be more closely associated with high-energy mechanisms, potentially requiring different management strategies and having different prognostic implications.

The study also highlighted a gender disparity in the mechanism of injury, with males being more prone to high-energy trauma across all age groups. This gender difference is likely attributable to the greater participation of men in high-risk activities and the higher physical demands of certain occupations traditionally held by men. The findings underline the importance of considering the mechanism of injury in the clinical assessment and treatment planning for ankle fractures, as high-energy fractures often require more complex surgical interventions and are associated with a higher risk of complications.

The occurrence of open fractures in 2% of the cases, predominantly in the AO/OTA-C2 group, is of particular clinical significance. Open fractures, especially those classified as Gustilo-

Anderson type II, are known for their complexity and the increased risk of complications such as infection and delayed healing. The study finding that open fractures were more common among older women may be related to the higher incidence of falls in this demographic, as well as the potential for more severe soft tissue damage due to decreased skin elasticity and subcutaneous tissue in the elderly. This is also in align with the findings of Bugler *et al*[18].

The gender-specific analysis revealed that men under 60 were more likely to experience Gustilo-Anderson type III injuries, which are typically associated with high-energy trauma and severe soft tissue damage. This finding suggests that while women are more prone to less severe open fractures, men, particularly younger men, are at a higher risk of more complex and severe open fractures. This distinction has important implications for treatment, as type III fractures often require more aggressive surgical management, including debridement, stabilization, and sometimes, reconstructive procedures.

The study observation of a higher incidence of ankle fractures during the winter months is consistent with existing literature that associates increased fracture rates with icy and slippery conditions[12-15]. The seasonal variation, with a peak in ankle fractures from December to March, underscores the role of environmental factors in the epidemiology of these injuries. This trend is particularly relevant for public health initiatives aimed at fracture prevention, as it suggests that targeted interventions, such as public awareness campaigns about the risks of icy conditions and the use of appropriate footwear, could help reduce the incidence of ankle fractures during winter.
Moreover, the decrease in fractures during the spring and summer months could be attributed to better weather conditions, leading to fewer slip and fall accidents. However, it is also possible that the types of activities people engage in during these months differ, with less exposure to high-risk situations that could lead to ankle injuries.

While this study provides valuable insights into the epidemiology of ankle fractures, it is important to acknowledge its limitations. The study was based on data from a single trauma center, which may limit the generalizability of the findings to other populations or regions. Additionally, the retrospective nature of the study may introduce bias, particularly in the classification and reporting of injury mechanisms. The study also did not explore the long-term outcomes of the patients, which could provide further insights into the impact of different fracture types and treatment modalities on recovery and quality of life.
Future research should aim to include larger, multicenter cohorts to validate these findings and explore regional differences in the epidemiology of ankle fractures. Prospective studies that track patients over time would also be valuable in understanding the long-term implications of different fracture types and treatment approaches. Additionally, investigating the role of comorbidities, such as osteoporosis and diabetes, in the risk and outcomes of ankle fractures could provide further insights into targeted prevention and management strategies.

In conclusion, this study contributes to the growing body of knowledge on ankle fractures, highlighting important demographic, clinical, and seasonal factors that influence the occurrence and characteristics of these injuries. The findings underscore the need for tailored approaches to the prevention and management of ankle fractures, particularly in high-risk populations such as elderly women and younger men engaged in high-risk activities.

Conclusion

This study provides a comprehensive analysis of ankle fracture epidemiology, revealing a rising incidence, particularly among elderly women. AO/OTA type B fractures are most common, reflecting the prevalence of rotational injuries. High-energy trauma is more frequent

among younger males, influenced by activity levels. Seasonal variations, especially in winter, highlight the role of environmental factors. Although limited by a single-center, retrospective design, the findings emphasize the need for targeted prevention strategies and further research in diverse populations to confirm and expand upon these insights.

Conflict of interest statement. The authors declare no conflict of interest.

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