ORIGINAL ARTICLE

The epidemiology of adult fractures according to the AO/OTA fracture classification

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ABSTRACT

BACKGROUND: The epidemiology of adult fractures has been changing timely, in a multifactorial fashion. The aim of this study was to put forward a recent 5-year epidemiological analysis of adult fractures, according to the current AO/OTA fracture classification, in the current decade of action for road safety.

METHODS: 5324 adult patients who were diagnosed with at least one fracture related with orthopedics and traumatology in a level-one trauma center were included in this retrospective, epidemiological descriptive study. The patients were grouped according to their ages as; 18–35, 36–55, 56–69, and ≥70. The fractures were examined according to the AO/OTA classification.

RESULTS: 5865 fractures were present in 5324 patients. The mean age of the patients was 48.6±21.5. The number of patients according to the age groups was as follows; 1947 (36.6%), 1636 (30.7%), 881 (16.5%), and 860 (16.2%), respectively. The most frequent three fractures according to the AO/OTA fracture classification were; 7 (hand 19.6%), 23 (distal forearm, 12.1%), and 8 (foot, 11.8%). About 54.4% and 45.4% of the patients were treated non-surgically and surgically, respectively. About 0.2% of the patients preferred an alternative treatment. Overall mortality rate was 0.4%.

CONCLUSION: To the best of our knowledge, this study represents the first analysis of adult fractures according to the AO/OTA classification, over a 5-year period. As a future prospect, further multi-centric epidemiological studies are warranted to constitute a sustainable action plan for the prevention of major traumas.

Keywords: Adult fractures; AO/OTA classification; epidemiology.

INTRODUCTION

Traumatic injuries of the musculoskeletal system have been commonly and increasingly encountered. They constitute a global socioeconomic burden of public health problem, which may lead to significant morbidities and mortalities.[1,2] Among all traumatic musculoskeletal injuries, fractures constitute relatively a significant portion of this increasing burden over time.[3,4] In general, it is a necessity to define fractures correctly to share a relevant common language. An appropriate classification system should be used for this purpose. Regarding the classification systems of fractures; being reliable, valid, accurate, relevant, and repeatable are the most importantly accepted prerequisites.[5–7] Although, some administrative classifications (e.g., International Disease Classification) are commonly used in the hospital settings, the most consistent and commonly used classification of adult fractures is the AO/OTA classification.[8] This comprehensive classification system, which has been accepted worldwide, has been reported to be reliable, accurate, and valid.[8–11]

In addition, the well understanding of the epidemiological features and injury mechanisms of fractures is of utmost importance and should be the first step to develop or ameliorate

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the relevant prevention and treatment strategies, and subsequently to avoid of the preventable causes and to diminish their frequencies as much as possible. Considering these facts, the conduction of descriptive epidemiological studies in a large number of patients using the most frequently used and recent fracture classification system has gained importance. On one hand, studies on the frequencies of fractures for specific age and gender groups are relatively scarce in the developing countries, mainly due to the deficiencies of nationwide databases. On the other hand, the epidemiological data change timely and in a multifactorial fashion; so, the regular repetition of these studies are also required both to observe the time trends and socioeconomic impacts of fractures in adults.

In this context, the aim of the current study was to put forward a recent 5-year epidemiological analysis of adult fractures, in the current decade of "Action for Road Safety." To the best of our knowledge, this is the first epidemiological study that presents data on adult fractures, according to the current AO/OTA classification.

MATERIALS AND METHODS

Following the ethical approval of the institutional review board, 5324 adult patients who were diagnosed with at least one fracture related with orthopedics and traumatology in a level-one trauma center, between the dates January 1, 2010, and December 31, 2014, were included in this retrospective, epidemiological descriptive study. This study was conducted as one part of a large epidemiological investigation, which also included a pediatric counterpart.

The demographic data related with all fractures related with orthopedics and traumatology that were encountered on an in-patient and outpatient basis, in patients older than 18-year-old were investigated. The patients included in this cohort were grouped into four age ranges; 18–35 years, 36–55 years, 56–69 years, and ≥70 years. The main demographic data, which were investigated included, age, gender, mechanism of injury, anatomical fracture sites, open fracture rate, pathological fracture rate, and overall mortality rate.

The AO/OTA classification was used to record and examine the data of the fractures.[8] As this analysis was performed on the musculoskeletal fractures, which were only related with orthopedics and traumatology, fractures at the skull, maxillofacial, and chest wall were excluded from the study. The cervical vertebral fractures were also excluded, due to the extensive management of these fractures by the department of neurosurgery in the present trauma center. In addition, nonunion and malunion of previous fractures were excluded from the study.

The mechanism of injury related with the fractures was recorded under 11 titles; out-vehicle accident, in-vehicle accident, simple fall, fall height (>2 m.), firearm, occupational and instrument-related, sports-related, self-harm, minor and other traumas, sprain, and finally pounding injuries. Second, the weekly, monthly and yearly admission times of all patients were given in detail. Third, the management of the fractures was also recorded as non-surgical, surgical, and other ways, and among surgically treated patients, the time from admission to surgery was recorded. Finally, open and pathological features of each fracture type and the overall mortality rate of adult fractures were also presented.

The descriptive statistics of all variables were calculated and given as frequencies/percentages in categorical variables; as mean±SD or median (minimum, maximum) for numerical variables of normally distributed and skewed data, respectively. Statistical analyses were performed by using the SPSS with version 20.0.

RESULTS

During the 5-year study period, 5864 fractures were present in 5324 patients, who were managed in the Department of Orthopaedics and Traumatology Necmettin Erbakan University Meram Faculty of Medicine Hospital. This number constituted 37% of a total number of 14408 hospitalized patients (including elective surgeries), and 62% of a total number of 8585 patients, who were diagnosed with and managed for at least one relevant fracture in the adulthood. Table 1 shows the 5-years demographic features of adult fractures, compared with pediatric fractures. The mean age of the patients was 48.6 (range 18–100). The male to female ratio was 2.2. About 92% of the fractures were isolated and the rest was multiple fractures. Most of the patients admitted to the hospital during weekdays (68.7%) and were managed non-surgically (54.4%).

Table 2 demonstrates the comparative epidemiological characteristics of the fractures, according to each age group. The most common mechanism of injury was observed as simple fall at all age groups. It is also interesting that the patient number decreases and that the male to female ratio decreases, as the age increases.

Figure 1 demonstrates overall and gender-specific frequencies of all fractures, according to the AO/OTA classification. The overall and gender-specific frequency distribution curves are depicted in Figure 2. Figure 3 demonstrates that frequency distribution of fractures was steady, on a yearly basis, over 5 years, in both genders. In addition, summer months was the time, when fractures were most frequently encountered and winter months, being the lowest. The frequency distribution curves of fractures, which were encountered in the upper extremity, lower extremity, and axial skeleton, according to the pre-defined age groups, are demonstrated in Figure 4.

Table 1. Summary of five-years' comparative demographic features in adult versuspaediatric fractures

	Adult	Paediatric
Number of patients	5324	3261
Number of fractures	5865	3396
Mean age±SD (Range)	48.6±21.5 (18–100)	9.8±4.6 (1–17)
Male/female ratio	2.2	2.6
Fractures		
Isolated (%)	92	97
Multiple (≥2) (%)	8	3
Time of admission		
Weekday	68.7	68.9
Weekend	31.3	31.1
Anatomical site		
Upper limb (%)	48.8	73.7
Lower limb (%)	43.7	25
Axial skeleton (%)	7.5	1.3
The most common		
Fracture type (AO/OTA) (%)	7 (19.6)	23 (22.9)
Mechanism of injury (%)	Simple fall (38.6)	Simple fall (60.5)
Season (%)	Summer (32.5)	Summer (39)
Management		
Non-surgical	54.4	68.8
Surgical	45.4	31.2
Other	0.2	–
Open fracture rate (%)	11.6	5.8
Pathological fracture rate (%)	1.8	1
Overall mortality rate (%)	0.4	0.1

Overall, the most and the least common AO/OTA fracture types were 7 (hand/carpal bones) (19.6%) and 14 (scapula) (3.4%), as demonstrated in Table 3. Nearly all of the fractures were observed in males more than in females, except 11 (humerus proximal). On the one hand, the AO/OTA 7 (hand/carpal bones) fractures were observed in younger patients (mean age: 37.1±15.3); on the other hand, the AO/OTA 31 (femur proximal) fractures were observed in elderly patients (mean age: 68.7±20.0). The open fracture rate was the highest in AO/OTA 33 (femur distal) (39.2%). The percentage of operative treatment was the highest and the lowest in AO/OTA 32 (femur diaphysis) (92.9%) and in AO/OTA 14 (scapula) (3.2%), respectively.

It was striking that 50.1% of all fractures occurred after simple fall and traffic accidents (Table 4). The most frequent fracture types, which were encountered by these mechanisms, were 42 (tibia diaphysis) and 23 (radius/ulna distal), respectively. It was also interesting that the following mechanisms; firearm, occupational and instrument-re-

Table 2. The epidemiological characteristics of all fractures according to the age groups

Age groups (years)	n	Frequency (%)	Male/Female ratio	Mean age (years)	Most common mechanism of injury	Open fracture (%)	Most frequent AO/OTA fracture type
18–35	1947	36.6	4.6	25.5±5.2	Simple fall	13.0	7 (Hand/Carpal bones)
3–55	1636	30.7	2.4	44.1±6.0	Simple fall	13.8	7 (Hand/Carpal bones)
56–69	881	16.5	1.5	61.5±4.3	Simple fall	9.6	23 (Radius/Ulna distal)
≥70	860	16.2	0.9	79.6±6.2	Simple fall	5.9	31 (Femur proximal)

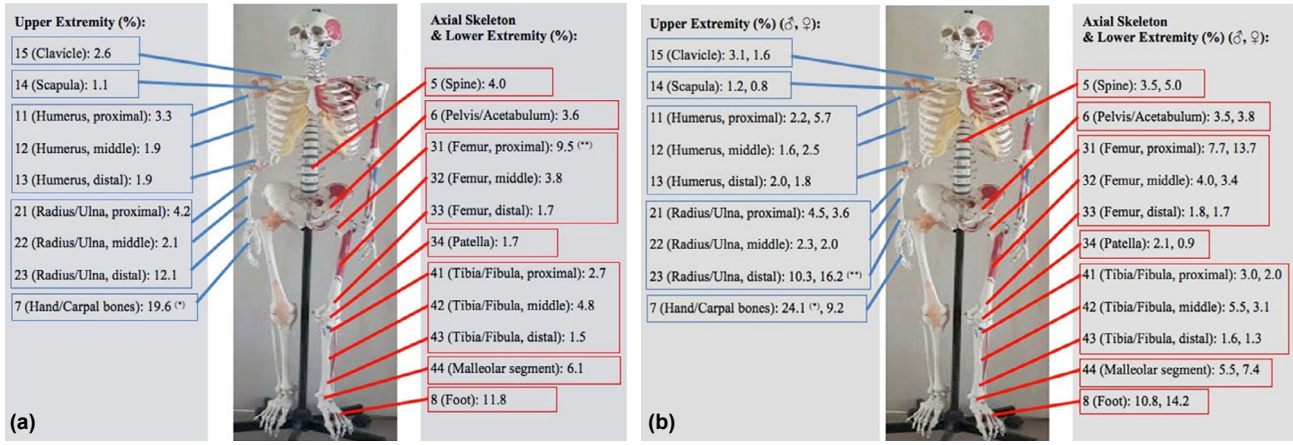

Figure 1. Demonstration of the fractures' frequencies on the human skeleton, according to the AO/OTA classification. **(a)** Overall, (*: The most frequent upper extremity fracture, and **: The most frequent lower extremity fracture), and **(b)** gender-specific, (*: The most frequent fracture in males, **: The most frequent fracture in females) values.

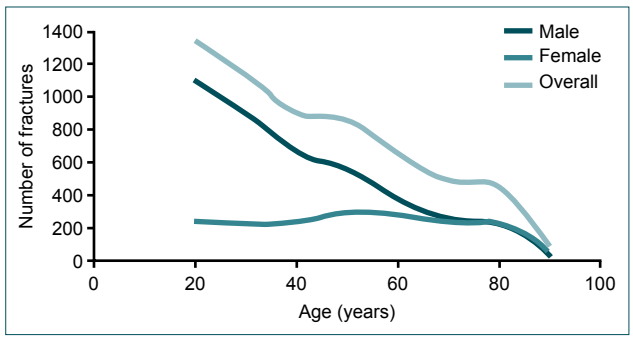

Figure 2. The frequency distribution curves of adult fractures (overall and gender-specific).

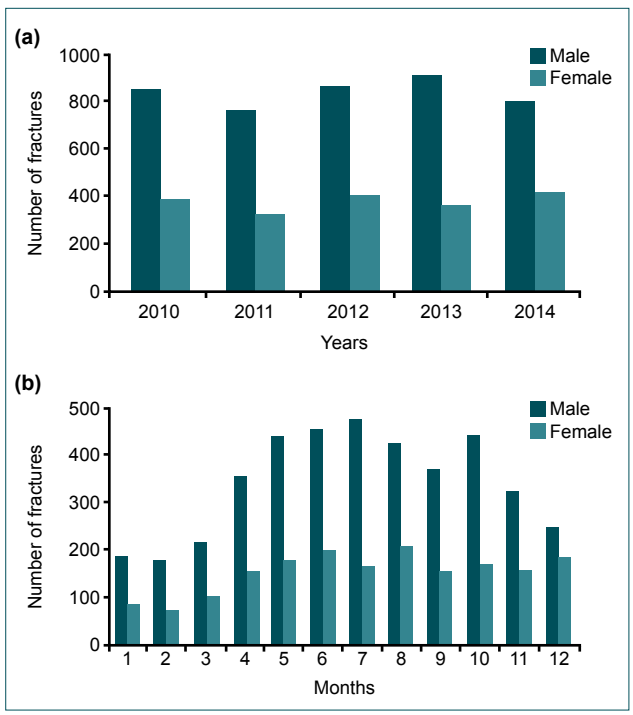

Figure 3. The yearly **(a)** and monthly **(b)** frequency distribution curves of fractures in males and females.

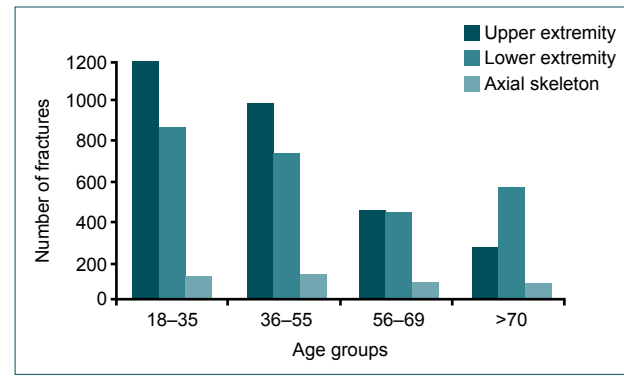

Figure 4. The frequency distribution curves of fractures, in the upper extremity, the lower extremity and axial skeleton, according to the age groups.

lated, sports-related, and self- harm injuries, were at least 10 times more commonly observed in males than in females.

DISCUSSION

The most important result of the present study was that the epidemiological analysis of a large number of fractures in adults, according to the AO/OTA classification was reported first in the literature, over a 5-year of period in a level-one trauma center. The fracture and demographic characteristics were mostly different from that of the pediatric age group, which was also investigated as a counterpart of the present study, simultaneously (Table 1).

The comprehensive AO/OTA classification, which was reported to be reliable, accurate, valid, and user-friendly, was used in this study.[8–11] According to this system; the most frequently encountered fractures were 7 (hand/carpal bones), 23 (distal radius/ulna), and 8 (foot) in the present study. In the previous studies, the most frequent site of adult fractures was reported as distal radius/ulna, which ranks the second place

Table 3. The summary of data on adult fractures according to the AO/OTA classification, in order of decreasing frequency

AO/OTA fracture type	n	Frequency (%)	Male/Female ratio	Mean age (±SD)	Open fracture (%)	Operative treatment (%)
7	1149	19.6	6	37.1±15.3	27.7	40.1
23	709	12.1	1.5	46.8±18.0	1.3	19.2
8	694	11.8	1.7	39.2±16.1	6.8	13.7
31	559	9.5	1.3	68.7±20.0	2.5	92
44	356	6.1	1.7	46.9±18.3	8.4	54.8
42	280	4.8	4	41.4±17.6	30.7	85
21	246	4.2	2.8	40.2±16.9	2.4	41.5
5	232	4	1.6	52.1±19.0	0.4	40.1
32	224	3.8	2.7	40.5±21.9	20.1	92.9
6	210	3.6	2.1	47.4±21.0	2.9	41
11	191	3.3	0.9	61.6±16.8	1.6	31.4
41	157	2.7	3.5	47.1±17.8	8.3	66.2
15	154	2.6	4.3	37.3±15.2	2.6	25.3
22	126	2.1	2.7	41.1±17.1	16.7	83.3
13	114	1.9	2.5	44.2±21.6	10.5	77.2
12	109	1.9	1.4	45.3±18.1	8.3	65.1
33	102	1.7	2.4	49.6±20.6	39.2	85.3
34	101	1.7	5.3	45.6±16.9	4	45.5
43	90	1.5	2.8	50.5±15.4	12.2	66.7
14	62	1.1	3.4	51.7±18.8	1.6	3.2

Table 4. The epidemiological data related with the mechanisms of injury of adult fractures, with decreasing order

Mechanism of injury	n	Frequency (%)	Male/Female ratio	Mean age (years)	Most frequent fracture type
Simple fall	2263	38.6	1.3	53.4±21.4	23 (Radius/ulna distal)
Minor and other traumas	892	15.2	2.4	43.6±19.0	7 (Hand/Carpal bones)
In-vehicle traffic accident	766	13.1	4.3	40.5±19.2	42 (Tibia diaphysis)
Out-vehicle traffic accident	490	8.4	3.0	40.8±15.6	42 (Tibia diaphysis)
Occupational and instrument-related	435	7.4	10.4	30.1±15.0	7 (Hand/Carpal bones)
Fall height (>2 m.)	377	6.4	4.1	41.3±14.8	23 (Radius/ulna distal)
Sprain	246	4.2	1.8	47.6±17.5	8 (Foot)
Sports-related	153	2.6	21.0	28.4±10.4	7 (Hand/Carpal bones)
Self-harm	103	1.8	33.3	30.1±9.2	8 (Foot)
Firearm injury	76	1.3	14.2	40.3±12.6	32 (Femur diaphysis)
Pounding	64	1.1	4.8	40.5±15.4	32 (Femur diaphysis)

in our study.[3,12–14] Moreover, although the most frequent fracture type in males was 7 (hand/carpal bones, 24.1%), 23 (radius/ulna distal, 16.2%), was the most frequent fracture in females, concordant with aforementioned studies. A variety of factors may play a role in the difference of fractures' frequencies; for example, socioeconomic, demographic, seasonal, geographical, and geopolitical. The difference in the present study compared with previously published studies may be explained due to relatively higher frequency of jobs related with farming and industry in the geographical region investigated, leading to higher exposure of hands to injuries, including fractures.

In general, the predominance of most fractures in males was consistent with previous studies.[3,13–15] Conversely, it was demonstrated that males aged 39 and younger had 135% greater fall risk than females in the same age category and that no sex differences were observed for fracture risk.[16] However, the results of this study may be challenged by their report being in a much smaller population in a limited geographical region, compared with other studies. The only female predominance was in proximal humerus (AO/OTA 11) fractures in our study. Anyway, the overall predominance in males may be explained by a combination of genetic and environmental factors; biological and hormonal differences, risk taking behavioral differences between genders, activity/occupation-related gender differences, higher risk of exposure to major trauma, etc. Although it is actually hard to identify these factors in the setting of trauma, this issue may open a new frontier to investigate the people who are prone to fractures and to help to minimize their exposure to the trauma, possibly with education.

Another issue with age was that the fragility fractures, which were observed predominantly in patients over 75 years, were reported to have an equal or lower male/female ratio of 1.3.[12,14,17] In the present study, contrary to the fall of overall fracture frequency from a peak at second decade in males, the frequency followed a steady course over decades until the eighth decade, where a sharp fall was observed in both genders. Considering these changes, the male/female ratio was equalized at around the seventh decade and fractures predominated in females after the eighth decade. This finding was also consistent with the aforementioned relevant studies. Considering the age groups; fractures were encountered in the upper extremity, lower extremity and axial skeleton, with decreasing frequencies, before the seventh decade. After the seventh decade, lower extremity fractures predominated over other sites. This indirectly also demonstrates that the lower extremity bones (especially proximal femur and distal tibia and fibula) are more susceptible to fractures, as they are weight bearing. These findings were consistent with the previous relevant study of Court-Brown and Clement.[18] In general, the frequency of fractures in the upper extremity and axial skeleton decreased over decades and stayed steady after the past decade, respectively. The relative increase of lower extremity fractures' frequency after the age of seventy may be explained by the exponential increase in hip fractures, which was previously reported to occur due to a variety of factors: Decreased bone quality, impaired neuromuscular responses, and increased risk of falling.[3,16,19]

On the one hand, the rates of open and pathological fractures were also reported in the present study, as 11.6% and 1.8%, respectively. On the other hand, the overall mortality rate related with adult fractures was also found as 0.4%. The epidemiological studies on adult fractures mainly focused on body regions (e.g., tibia diaphysis, hip, distal radius) or on separate special topics (e.g., open fractures, osteoporotic fractures), and a number of large population-based studies were also published till now. However, the rates of open and pathological fractures, and fracture-related mortality rate were lacking. To the best of our knowledge, this info was also presented here, first in the relevant literature.

The present study showed that the frequency distribution of the factures was steady, on a yearly basis, over 5 years, in both genders. This finding indirectly reflects the consistency of the data and findings in this study. Simple fall and traffic accidents were found to be the leading two mechanisms of injuries for fractures in adults. This finding is consistent with the previous reports.[17,18] This finding is important because; falls as mechanism of injury, fall-related fractures, fall-related costs, and deaths especially in elderly patients have been increasing over years.[20–23] In this context, it was important to perform this study. Musculoskeletal disorders, especially fractures, have constituted a large component of socioeconomic impairments of individuals in the working and geriatric population.[24–26] The socioeconomic health burden and costs of especially osteoporotic fractures are expected to rise, as a future prospect.[27–29] Because of the significant impacts of fractures on both personal and public health and on socioeconomic values, sufficiently prepared good statistical data are extremely important and essential, to observe the time trends of fractures, and to prepare efficient and sustainable action plans for preventing or minimizing their preventable causes, at least.

Although the main strengths of this study include the relatively large sample size, and the documentation of novel data over a long period of time, in a level-one trauma center, it possesses some limitations to discuss. First, the data belongs to a single medical center. Although the results of this study can be applied to a specific population, our center is the oldest and the largest, major referral university trauma center in the investigated geographical region. Second, the info related with the associated injuries of other body parts, the medical comorbidities of the patients, the time from admission to surgery and the time of hospital stay were not reported in this study. These info and their effects will be reported in the subsequent epidemiological studies on the fractures of each anatomical region separately, as the next part of this main study, in the near future. Third, the subgroups of each fracture type of AO/OTA classification were not given in detail. Because, these details are out of scope of this study and they will be presented in separate subsequent investigations of each anatomical regions' fractures. Fourth, we are not able to report neither incidence nor prevalence related with adult fractures for now, because of the presence of other smaller scale hospitals in the same geographical region. Ultimately, this main study would serve as a kernel to expand the scope of our efforts to perform a larger, multi- center, epidemiological study on adult fractures.

Conclusion

To the best of our knowledge, this study represents the largest and the first epidemiological evaluation of adult fractures

according to the AO/OTA classification, in a level- one trauma center, over 5 years. The present study warrants further multi-centric, descriptive epidemiological studies, to constitute a sustainable action plan for the prevention of major traumas and fractures in adults. As a future prospect, this study would ultimately serve as an initial relevant baseline database of adult fractures according to the AO/OTA classification, to compare their time trends and to constitute or ameliorate national and/or international registries and preventive health-care strategies.

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ORİJİNAL ÇALIŞMA - *ÖZ*

AO/OTA sınıflamasına göre yetişkin kırıklarının epidemiyolojik çalışması

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AMAÇ: Yetişkin kırıklarının epidemiyolojisi, çok faktörlü bir şekilde, zamanla değişmektedir. Bu çalışmanın amacı, mevcut AO/OTA kırık sınıflamasına göre, yol güvenliği için mevcut on yıllık eylem planı kapsamında yetişkin kırıklarının son beş yıllık epidemiyolojik analizini ortaya koymaktır.
GEREÇ VE YÖNTEM: Bu geriye dönük, epidemiyolojik tanımlayıcı çalışmaya birinci düzey bir travma merkezinde ortopedi ve travmatoloji ile ilişkili en az bir kırık tanısı almış 5324 erişkin hasta dahil edildi. Hastalar yaşlarına göre; 18–35, 36–55, 56–69 ve ≥70 olmak üzere gruplandırıldı. Kırıklar AO/OTA kırık sınıflamasına göre incelendi.
BULGULAR: 5324 hastada 5865 kırık vardı. Hastaların ortalama yaşı 48.6±21.5 idi. Yaş gruplarına göre hasta sayıları sırasıyla 1947 (%36.6), 1636 (%30.7), 881 (%16.5) ve 860 (%16.2) idi. AO/OTA kırık sınıflamasına göre en sık görülen üç kırık; 7 (el, %19.6), 23 (distal önkol, %12.1) ve 8 (ayak, %11.8) idi. Hastaların %54.4'ü ameliyatsız ve %45.4'ü ameliyatla tedavi edildi. Hastaların %0.2'si alternatif bir tedaviyi tercih etti. Toplam ölüm oranı %0.4 idi.
TARTIŞMA: Bildiğimiz kadarıyla bu çalışma, beş yıllık bir dönem boyunca AO/OTA sınıflandırmasına göre yetişkin kırıklarının analiz eden ilk çalışmadır. Geleceğe yönelik olarak, major travmaların önlenmesi için sürdürülebilir bir eylem planı oluşturmak amacıyla daha fazla çok merkezli epidemiyolojik çalışma yapılması gerekmektedir.
Anahtar sözcükler: AO/OTA Sınıflaması; epidemiyoloji; erişkin kırıkları.

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