**ARAŞTIRMA MAKALESİ /** *RESEARCH ARTICLE*

# Unpleasant Traumas of Orthopedics: Firearm Wounds

*Ortopedinin Sevimsiz Travmaları: Ateşli Silah Yaralanmaları*

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**ABSTRACT**

***Aim:*** *This study aimed to examine the clinical outcomes of patients presenting with gunshot wounds who were hospitalized in the orthopedic clinic in the last five years.*

***Material and Method:*** *The study is a retrospective study with 41 patients. Gender, age, length of hospitalization, injured extremities and regions, presence of fractures and distribution of fractured bones, need for surgery, need for other specialties, distribution of different specialties, additional injuries and complications, and their distribution were investigated.*

***Results:*** *The mean age of the patients was 39.76±12.77. 92.70% (n=38) of the patients were male, and 7.30% (n=3) were female. The mean duration of hospitalization among the patients was 5.68±3.38 days. It was observed that 80.50% (n=33) of the patients had the most injuries in the lower extremities. 70.70% (n=29) of the patients had a fracture accompanying the firearm injury. The femur was the most commonly fractured bone. Surgery was required in 82.90% (n=34) of the patients. 53.70% (n=22) of the patients had additional injuries and complications.*

***Conclusion:*** *Firearm injuries are an increasingly frequent and severe orthopedic injury, especially with the increase in individual armament. Therefore, emergency and orthopedic physicians should be equipped for early and effective intervention.*

**Key words:** *gunshot wounds; orthopedics; trauma*

**ÖZET**

***Amaç:*** *Bu çalışmada son beş yılda ortopedi kliniğinde yatarak tedavi gören ateşli silah yaralanması olan hastaların klinik sonuçlarının değerlendirilmesi amaçlandı.*

***Materyal ve Metot:*** *Araştırma 41 hasta ile yapılan tanımlayıcı bir çalışmadır. Hastaların cinsiyetleri, yaş ve hastanedeki yatış süreleri, yaralanan ekstremiteler ve bölgeler, kırık varlığı ve kırık tespit edilen kemiklerin dağılımları, cerrahi gereksinim varlığı, diğer branşlara gereksinim varlığı, gereksinim duyulan diğer branşların dağılımları, ek yaralanma ve komplikasyon durumları ve dağılımları incelenmiştir.*

***Bulgular:*** *Hastaların %92,70'i (n=38) erkek iken, %7,30'u (n=3) kadındır. Hastaların yaş ortalaması ve standart sapması 39,76±12,77 yıldır. Hastaların yatış sürelerinin ortalaması ve standart sapması 5,68±3,38 gündür. Hastalarda en fazla yaralanmanın %80,50'si (n=33) alt ekstremite bölgesinde olduğu görülmüştür. Hastaların %70,70'inde (n=29) ateşli silah yaralanmasına eşlik eden kırık mevcuttur. En fazla kırılan kemiğin femur olduğu görülmüştür. Hastaların %82,90'nında (n=34) cerrahi gereksinim duyulmuştur. Hastaların %53,70'inde (n=22) ek yaralanma ve komplikasyon mevcuttur.*

***Sonuç:*** *Ateşli silah yaralanmaları günümüzde özellikle bireysel olarak silahlanmanın artması ile sıklığı giderek artan ve ciddi ortopedik yaralanmaya sebep olan bir yaralanmadır. Bu sebeple acil servis ve ortopedi hekimleri erken ve etkili müdahale için donanımlı olmalıdır.*

**Anahtar kelimeler:** *ateşli silah yaralanmaları; ortopedi; travma*

## Introduction

Firearm injuries (FAI) are a preventable forensic public health issue worldwide, and since firearms are readily available, these types of injuries have significantly increased in recent years[1,2]. Firearms are frequently used for purposes such as hunting, defense, assault, terrorism, security, etc. in today's world. Firearms are classified as short-barreled and long-barreled, while injuries caused by them are categorized as low-energy and high-energy injuries. Firearm injuries that are contaminated and high-energy injuries are related to more excellent rates of death and disability. In the United States (US), these cases are the second most prevalent cause of mortality in the second decade of a person's life following traffic accidents[3]. In a similar epidemiological study, it is stated that the number of cases resulting in death after FI in the US reaches 100.000 annually, and nearly more than 50% of these cases have extremity injuries[4]. In Türkiye,

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FAI is a significant cause of deaths and morbidities as a result of the fight against terrorism and personal injuries. Every year in Türkiye, more than 2000 people die, and more than 3000 people are injured by firearm injuries[5]. Firearm injuries is most prevalently encountered in the extremities and most frequently in soft tissue injuries in the body[6]. Although they are not as mortal as head and neck injuries, the risk of causing sequella in extremities is higher. The severity of the injury can vary based on the type of firearm, the distance from which the shot was fired, and the characteristics of the bullet and the affected region. Depending on the severity of the injury, extensive soft tissue injuries, neurovascular injuries, joint injuries, and fragmented, segmental, or defective fractures may occur in the extremities. The treatment of FAI requires a multidisciplinary approach. Treating high-energy and contaminated FAI is very difficult, and the process may be lengthy and costly. The treatment aims to prevent bone and soft tissue infections, ensure union if there is a fracture, and promote early mobilization and functional recovery. Irrigation, debridement, and antibiotic prophylaxis are employed to prevent diseases, while external fixation methods are used in fracture fixation, but internal fixation methods are also applied. Complications may be inevitable in complex, high-energy, and contaminated cases, even with the most optimal treatment methods. Complications such as neurovascular injuries, osteomyelitis, pseudoarthrosis, osteoarthritis, amputation, and posttraumatic stress disorder may develop. This study aims to investigate the clinical outcomes of cases presenting with firearm injuries who have received in-patient treatment at the orthopedic clinic in the last five years.

## Materials and Methods

The research is a retrospective study conducted with 41 cases who were admitted to the Department of Orthopedics and Traumatology at the Medical Faculty Hospital of Kafkas University due to firearm injuries between January 2017 and January 2022. Forensic cases without firearm injuries, those not admitted to the Orthopedics and Traumatology Department, and the data of patients who died were not included in the analyses. The study examined the gender, age, and hospitalization of the patients, injured extremities and regions, presence of fractures and distribution of fractured bones, need for surgery, need for other branches, distribution of other branches needed, additional injuries, and the occurrence and distribution of complications.

The study utilized frequency (n) and percentage values for qualitative (categorical) variables. At the same time, mean, standard deviation, median, 1st and 3rd quartiles, and minimum and maximum values were used for quantitative (continuous) parameters. The statistical analyses were conducted with the Statistical Package for the Social Sciences (SPSS –IBM Statistical Package for Social Sciences program, version 21).

All patients gave informed consent. The Ethics Committee of Kafkas University Faculty of Medicine approved the study in session number 02, dated 23/02/2022, with protocol number 80576354-050-99/22. The study was conducted in compliance with the Declaration of Helsinki.

## Results

The study sample included 41 patients in total. While 92.70% (n=38) of the patients were male, 7.30% (n=3) were female. The mean age of the cases was 39.76±12.77, the median and 1st Quartile – 3rd Quartile was 39.00 [28.00–48.50] years, the youngest age was 21.00 years and the oldest age was 69.00 years. Of the hospitalization duration of the patients, the mean and standard deviation were 5.68±3.38 days, the median and 1st Quartile-3rd Quartile were 4.00 [3.00–7.00] days, the shortest one was 3.00 days, and the longest one was 17.00 days (Table 1).

80.50% (n=33) of the patients were injured in the lower extremity and 19.50% (n=8) in the upper extremity. When the injured regions were examined, it was observed that 36.60% (n=15) of the patients had injuries in the femur, 29.30% (n=12) in the cruris, and 12.20% (n=5) in the arm region (Table 2).

In 70.70% (n=29) of the patients, there was a fracture accompanying the firearm injury. In the examinations

***Table 1.*** *Characteristics of the patients who have received in-patient treatment due to firearm injuries*

| Variables | n (%) |
|---|---|
| **Gender** | |
| Female | 3 (7.30) |
| Male | 38 (92.70) |
| **Age (Years)** | |
| Mean ± Standard deviation | 39.76±12.77 |
| Median [1st Quartile-3rd Quartile] | 39.00 [28.00–48.50] |
| Minimum-maximum | 21.00–69.00 |
| **Duration of hospitalization (days)** | |
| Mean ± Standard deviation | 5.68±3.38 |
| Median [1st quartile – 3rd quartile] | 4.00 [3.00–7.00] |
| Minimum-maximum | 3.00–17.00 |
| Total | 41 (100.0) |

***Table 2.*** *Extremity injuries of the patients who have received in-patient treatment due to firearm injuries and the distribution of the injured regions*

| Variables | n (%) |
|---|---|
| **Injured extremity** | |
| Upper extremity | 8 (19.50) |
| Lower extremity | 33 (80.50) |
| **Injured regions*** | |
| Shoulder | 3 (7.30) |
| Arm | 5 (12.20) |
| Elbow | 2 (4.90) |
| Forearm | 3 (7.30) |
| Wrist | 1 (2.40) |
| Inguinal region | 1 (2.40) |
| Hip | 2 (4.90) |
| Gluteal region | 2 (4.90) |
| Femur | 15 (36.60) |
| Knee | 3 (7.30) |
| Cruris | 12 (29.30) |
| Ankle | 4 (9.80) |
| Foot | 2 (4.90) |

***Table 3.*** *Presence of accompanying fracture in the patients who have received in-patient treatment due to firearm injuries and distribution of bones with fractures*

| | |
|---|---|
| **Presence of fracture** | |
| Yes | 29 (70.70) |
| No | 12 (29.30) |
| **Bone with fracture*** | |
| Femur | 8 (19.50) |
| Tibia | 7 (17.10) |
| Fibula | 4 (9.80) |
| Calcaneus | 1 (2.40) |
| Talus | 1 (2.40) |
| Navicula | 1 (2.40) |
| Metatarsus | 1 (2.40) |
| Scapula | 1 (2.40) |
| Humerus | 7 (17.10) |
| Ulna | 2 (4.90) |
| Radius | 3 (7.30) |

* There are patients with fractures in more than one bone.

of bones with fractures, it was observed that the femur was affected in 19.50% (n=8) of the patients, tibia in 17.10% (n=7), and fibula in 9.80% (n=4) (Table 3).

Surgery was required in 82.90% (n=34) of the patients. Other branches were needed in 12.20% (n=5) of the patients. The most frequently required other branches were general surgery and cardiovascular surgery (Table 4).

There were additional injuries and complications in 53.70% (n=22) of the patients. In the examinations of these additional injuries and complications, it was seen that osteoarthritis developed in 29.30% (n=12) of the patients with firearm injury, joint injury caused by the firearm injury was detected in 24.40% (n=10), and nonunion was detected in 12.20% (n=5). Brachial artery injury was detected in one patient, and amputation was performed (Table 5).

***Table 4.*** *Need for surgery and other branches for the patients who have received in-patient treatment due to firearm injuries and distribution of other branches needed*

| Variable | n (%) |
|---|---|
| **Need for surgery** | |
| Yes | 34 (82.90) |
| No | 7 (17.10) |
| **Need for other branch** | |
| Yes | 5 (12.20) |
| No | 36 (87.80) |
| **Other branches needed*** | |
| General surgery | 3 (7.30) |
| Cardiovascular surgery | 3 (7.30) |
| Urology | 2 (4.90) |
| Plastic, reconstructive and aesthetic surgery | 2 (4.90) |
| Brain and nerve surgery | 1 (2.40) |

* There are patients with fractures in more than one bone.

***Table 5.*** *Additional injuries and complication distribution of the patients who have received in-patient treatment due to firearm injuries*

| Variables | n (%) |
|---|---|
| **Additional injury and complication** | |
| Yes | 22 (53.70) |
| No | 19 (46.30) |
| **Additional injuries and complications*** | |
| Tendon injuries | 2 (4.90) |
| Osteomyelitis | 2 (4.90) |
| Osteoarthritis | 12 (29.30) |
| Joint damage caused by the injury | 10 (24.40) |
| Non-union | 5 (12.20) |
| Arterial injury | 2 (4.90) |
| Ulnar nerve injury | 4 (9.80) |
| Median nerve injury | 3 (7.30) |
| Radial nerve injury | 3 (7.30) |
| Amputation | 1 (2.40) |

* There are patients with fractures in more than one bone.

## Discussion

Firearms have always attracted humankind's attention. Today, various types of weapons are used for defense, attack, and hunting[7]. As it becomes easier to obtain firearms, the cases of injuries and deaths caused by firearms are observed more frequently[8].

The gender, age, and hospitalization duration of the patients with firearm injuries who have received in-patient treatment at the orthopedic clinic in the last five years, injured extremities and regions, presence of fractures and distribution of fractured bones, need for surgery, need for other branches, distribution of other branches needed, additional injuries, and the occurrence and distribution of complications were examined in this study.

It has been reported that firearm injuries are observed chiefly in males and usually in the lower extremities[9]. In their study evaluating 112 cases of FAI over a decade of

experience, Dodge et al. reported that the most common etiological cause was suicide (31%), 20% of the cases resulted in death, and the rate of lower extremity injury (25%) was higher than that of upper extremity injury (25%)[10]. Halanski and Corden reported that orthopedic treatment was required in 79% of the cases, and 95% of the cases were male. Their study included 24 cases with ISS scores ranging from 1–50 about FAI during the hunting season[11]. In their study in which they evaluated 60 civilian patients regarding extremity FAI, Burg et al. reported that bone fractures were observed in 36 patients, and 75% of these fractures were in the lower extremities[12]. In their study in which they evaluated 38 FAI patients, Özerdemoğlu et al. reported that male patients (95%) were more common, and 56% of the injuries were in the lower and 46% in the upper extremities[13]. In our study, according to the literature, the patients were predominantly male (92.7%), and lower extremity injuries were more common (80.5%).

Depending on the type and severity of the injury, extremity FAI injuries are associated with isolated soft tissue injury, bone fracture, neurovascular injury, and complications up to amputation[14]. Type 3 injuries, which generally cause serious problems, are more frequently observed, and fractures and other associated injuries are often seen in type 3 injuries, usually resulting in poor functional recovery[12]. Özerdemoğlu et al. reported encountering infections in six cases and union-related problems in 12 cases among the 38 patients they studied[13].

The extremity preservation rate in the literature is reported to be between 81–97%[13]. Arterial injuries lead to high morbidity and amputation rates. In this type of injury, the presence of additional pathologies in patients, accompanying bone pathologies, and late delivery of patients to the hospital may increase these rates. It is reported that they lead to amputation by 27–54% in popliteal artery injuries[15]. On the other hand, aggressive wound debridement, irrigation, examination of the wound for pellet and stopper (plugs, felt), and adequate fracture fixation should be ensured in the early period due to the high incidence of infection and nonunion in FAI[13]. Esenkaya et al. emphasized the significance of removing the stopper in FAI[16].

Following the initial evaluation in the emergency department, we applied wound irrigation, broad-spectrum antibiotics, tetanus prophylaxis, and adequate debridement of devitalized tissues to all patients we followed in our study. It tried to explore and remove as many pellets, plugs, felt, and bullets as possible. Plugs were identified in two of the three cases where infections developed. The extremity preservation rate we found was 97.5%, higher than the one reported in the literature. On the other hand, one patient with an arterial injury was amputated at the elbow level. Additionally, the most significant factors that prolong the duration of hospitalization were identified as infections and arterial injuries.

Stucky et al. reported that there were 29 bone fractures in 37 cases injured by firearms; two of them developed superficial wound infections, and all patients recovered except those who encountered undesirable conditions[17]. In our study, 70.70% (n=29) of the patients had fractures accompanying firearm injuries. When the injured areas were examined, it was observed that the femur was affected in 36.60% (n=15) of the patients, the cruris in 29.30% (n=12), and the arm region in 12.20% (n=5) (Table 2). When the bones with fractures were examined, it was found that the femur was affected in 19.50% (n=8) of the patients, tibia in 17.10% (n=7), and fibula in 9.80% (n=4) (Table 3).

In firearm injuries, the high velocity of the arms creates problematic fractures in the human body. Many studies have reported favorable outcomes for treating fractures and pediatric extremity injuries[18]. In their research, Washington et al. reported that wound infection developed in only five patients, osteomyelitis did not occur, and all recovered, although one of the cases was grafted[17]. In our study, 53.70% (n=22) of the patients had additional injuries and complications. When these additional injuries and complications were examined, it was seen that osteoarthritis developed in 29.30% (n=12) of the patients with firearm injury, joint injury caused by the firearm injury was detected in 24.40% (n=10), and nonunion was detected in 12.20% (n=5). Brachial artery injury was detected in one patient, and amputation was performed (Table 5).

Advanced tissue damage may not be seen in injuries frequently encountered in the upper extremities. While fractures and joint damage are commonly observed in hand injuries, vascular and nerve injuries are relatively less common[19]. However, most of the amputations in the upper extremity are traumatic amputations[20]. In our study, one patient was amputated at the elbow level due to brachial artery injury.

In the study by Khatri et al. that included 29 patients, all cases were male patients with a mean age of 33 years (22–48). The mechanism of injury in all cases was

high-velocity firearm injury; 3 of 29 patients had arterial injuries (2 with popliteal artery, 1 with posterior tibial artery), and two patients had peroneal nerve injuries. Three patients underwent skin grafting. Union was achieved in all fractures, but secondary procedures were required to achieve union in 6 cases. In 23 patients, the union was completed between 16–22 weeks; the delayed union was detected in 5 patients at 6-month follow-up. An autologous iliac bone graft was applied to three patients without removing the implant (intramedullary nail in one patient, locking plate in two patients). Two patients received a carved nail, and an external fixator was applied to one patient. In 6 months, union was also achieved in these cases[21]. In our study, surgery was required in 82.90% (n=34) of the patients. Other branches were needed in 12.20% (n=5) of the patients. One of our patients had radial nerve symptoms and completely recovered in the follow-ups. The most frequently required other branches were general surgery and cardiovascular surgery (Table 4).

In a study conducted in Türkiye, 19.7% of 56 open tibial fractures were caused by FAI; 35 (68.6%) of the patients were male, 16 (31.4%) were female, and the average age of those male and female patients was 34.2 (ranging from 17 to 56 years)[22]. In our study, the mean age of the patients was 39.76±12.77, the median and 1st Quartile-3rd Quartile was 39.00 [28.00–48.50] years, the youngest age was 21.00 years, and the oldest age was 69.00 years. Of the hospitalization duration of the patients, the mean and standard deviation were 5.68±3.38 days, the median and 1st Quartile-3rd Quartile were 4.00 [3.00–7.00] days, the shortest one was 3.00 days, and the longest one was 17.00 days (Table 1).

The study's limitation is the relatively small sample size from a single center. Conducting multi-center studies with more patients could contribute more significantly to the literature.

## Conclusion

We often encounter FAI cases in orthopedic clinics. Especially in our region, due to the prolonged conflict environment, increasing firearm usage habits, and factors such as "terrorism, customs, and honor," it is observed that people, regardless of age, are exposed to firearm injuries and death incidents. In conclusion, as physicians, it would be prudent to minimize the damage that may occur by increasing our knowledge and expertise in the diagnosis, treatment, follow-up, and rehabilitation of FAI cases.

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