ANNALS OF MEDICINE
2025, VOL. 57, NO. 1, 2556251
https://doi.org/10.1080/07853890.2025.2556251

RESEARCH ARTICLE

OPEN ACCESS Check for updates

Approach and treatment algorithm to animal bites the role of plastic surgery in animal bites: injury profiles and treatment approaches

Emrah Işıktekin and Emre Babaarslan

Faculty of Medicine, Department of Plastic, Reconstructive and Aesthetic Surgery, Balıkesir University, Balıkesir, Turkey

ABSTRACT

Introduction: Injuries sustained by animals are now common. A review of cases shows that injuries usually manifest as penetrating injuries, lacerations, crushing and tissue rupture. These can lead to severe complications, including infection, deformity, zoonotic diseases and, in extreme cases, death.

Materials and Methods: From January 2020 to February 2025, 981 patients were admitted to Balıkesir University Health Practice and Research Hospital due to animal-related injuries. A detailed investigation was performed. The investigation analysed demographic data, animal-related injury mechanisms, trauma sites, plastic surgery interventions, patient outcomes and complications. A decision tree model was constructed to identify predictors of complication risk among patients who underwent surgery following an animal bite.

Results: The patient sample's demographics: 54.2% female, 45.8% male. The most common reasons for admission: dog (83.9%), cat (9.0%), rodent (5.4%). The most prevalent intervention is primary suturing, accounting for 55.05% of cases. Patients who were referred to the Plastic Surgery Department constituted 14.07% of the total. 62.1% of these patients were discharged, while 24.8% were admitted to hospital. The mean duration of hospitalisation for dog, cat, rodent and equine bite patients is 4, 2, 6 and 7 days respectively. Patients were observed at the outpatient clinic two, four, four and six times on average.

Conclusion: The risk predictive model shows that antibiotic therapy, animal type and injury location can predict complications. Older age and lack of vaccination were also identified as risk factors. This helps clinicians to make more informed decisions.

ARTICLE HISTORY
Received 11 June 2025
Revised 12 August 2025
Accepted 28 August 2025

KEYWORDS
Animal; bite; reconstruction

Introduction

The issue of animal bites represents a substantial public health problem on a global scale, with these incidents constituting a considerable proportion of emergency room visits [1]. A thorough investigation of such cases reveals that the injuries sustained typically manifest in the form of penetrating injuries, lacerations, crushing, and tissue rupture, which can lead to severe complications. These range from minor injuries to infection and deformity, as well as the development of zoonotic diseases, and in extreme cases, death.

Such injuries, it must be noted, can occasion physical impairment and also present a multitude of consequences. Such consequences may include an increased susceptibility to infection, psychological effects [2,3] and the need for reconstructive surgery [4,5].

According to Fein et al. (2019), as well as Baddour and Harper (2022), the prevalence of such bites varies depending on the age of the individual, environmental factors, and the frequency of contact with animals [6,7]. In addition to dogs and cats, rodents and, albeit rarely, other mammals, have also been implicated as the cause of such bites. As reported by Fein et al. it is imperative to note that children, the elderly, and individuals with compromised immune systems are particularly vulnerable to such injuries [6].

CONTACT Emrah Işıktekin emrah.isiktekin@balikesir.edu.tr Faculty of Medicine, Department of Plastic, Reconstructive and Aesthetic Surgery, Balıkesir University, Balıkesir, Turkey.

As plastic surgeons, our remit encompasses the surgical and reconstructive management of soft tissue injuries, neurovascular injuries, and musculotendinous injuries across all anatomical regions. However, it is imperative to acknowledge our limitations in domains such as wound infections, systemic infections, immunoprophylaxis management, in the treatment of trauma. For this reason, it is essential to establish a multidisciplinary approach and systematic framework for the effective management of animal bites. This study, which adopts a comprehensive approach to the treatment of animal bites with the approach of plastic surgery, is based on five years of experience in a single center. The aim is to minimize complications by managing the process from diagnosis to treatment and follow-up.

Materials and methods

Study design and patient recruitment

The present study was designed as a retrospective observational study. The present study was conducted on patients who applied to Balıkesir University Faculty of Medicine Health Practice and Research Hospital for treatment as a result of animal bites between January 2020 and February 2025. A comprehensive examination was conducted to analyse the following: demographic data, trauma sites, animal-related injury mechanisms, plastic surgery interventions, and patient outcomes. Patients with injuries due to animal bites who were admitted to the hospital and who had complete clinical records were included in the study. Patients who did not consent to participate in the study, had incomplete records and examinations, refused treatment of their own accord, and did not attend at least one follow-up appointment were excluded from the study.

All human participants gave their informed consent before being included in the study. Written informed consent was obtained from adult patients. In cases involving minors, written informed consent was obtained from their legal guardians, and where appropriate, from the children themselves. Additionally, permission was obtained from all individuals (or their legal guardians in the case of minors) for the publication of any identifying images or clinical details. The study was conducted in accordance with the ethical standards of the relevant institutional and/or national research committee, as well as the 1964 Declaration of Helsinki and subsequent amendments. Appropriate documentation is available upon request.

The present study was conducted in accordance with the Declaration of Helsinki and received approval from the Non-Interventional Research Ethics Committee of Balıkesir University Health Sciences. (Date 11/03/2025 and decision no 2025/125).

Baseline data collection

The demographic information of patients (age, gender), the reasons for admission, the mechanisms of injury, the interventions performed, and the patient outcomes (discharge, hospitalisation, referral, etc.) were recorded. The average length of hospital stay and follow-up period were added, and complications, infections and additional conditions were noted. The data were obtained through the utilisation of a scanning process of the hospital automation system and patient files.

Statistical analysis

A total of 976 animal bite cases (excluding 'other animals' for homogeneity) were statistically analyzed. All statistical analyses were conducted using IBM SPSS Statistics version 29. Categorical variables were analyzed using the Chi-square test or Fisher's exact test when appropriate. Pairwise z-tests with Bonferroni correction were applied for post hoc comparisons. The independent samples t-test or the Mann-Whitney U test was employed for continuous variables. A p-value < 0.05 was considered statistically significant. Mean, standard deviation and percentage distributions were used to provide a comprehensive descriptive analysis.

Construction and key findings of decision tree model

A decision tree model was developed using the CART (Classification and Regression Tree) algorithm with a maximum depth of 4, providing balance between interpretability and predictive performance.

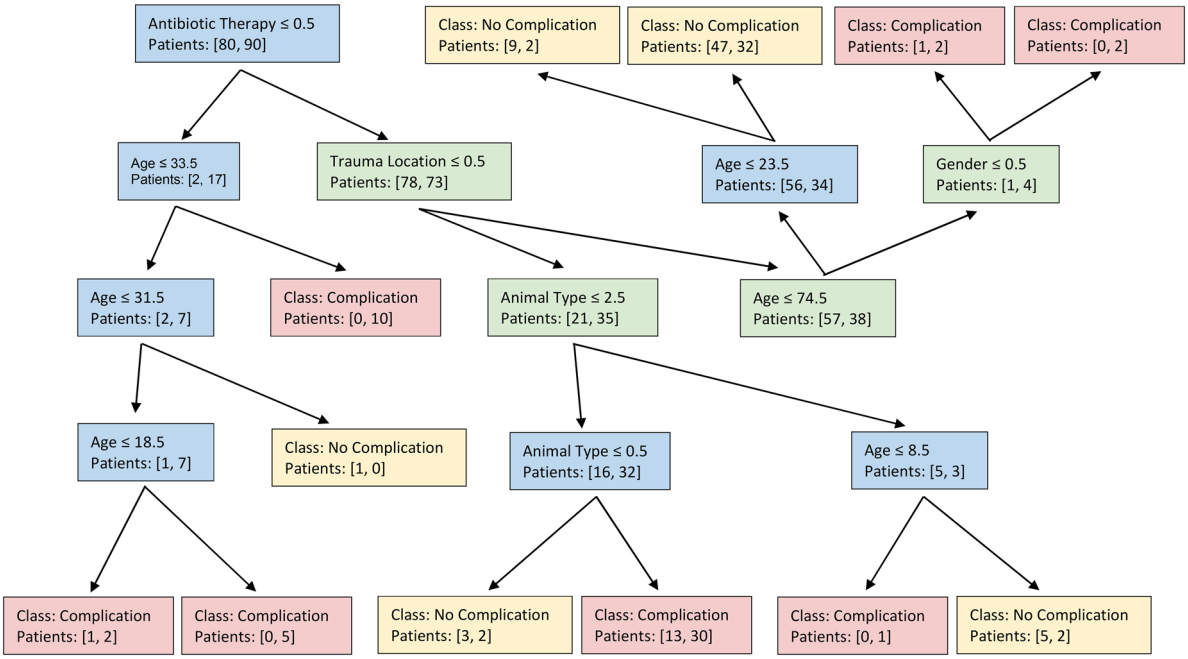

Figure 1. Flow chart of decision tree algorithm developed to predict the risk of complications in patients referred to plastic surgery due to animal bite injuries. The model was constructed using data from 170 patients and incorporates key clinical variables including type of animal, injury location, patient demographics, antibiotic and vaccination status.

The model included six categorical predictors: animal type, injury location, gender, age group, prophylactic antibiotic administration, and vaccination status. All categorical variables were labelled to prepare them for modelling. The analysis demonstrated that the animal type was the most significant variable, with dog and rodent bites being more frequently associated with complications in specific contexts. Furthermore, the location of the injury was found to be a critical factor in the study's results. Specifically, wounds affecting the face and extremities were found to be more susceptible to adverse outcomes, particularly in the absence of antibiotic prophylaxis. Older age and lack of vaccination were identified as independent risk factors for complications. Notably, patients who did not receive antibiotics after high-risk injuries—such as rodent bites to the face or hands—had a significantly increased incidence of clinical complications. These results highlight the model's utility in identifying high-risk patients (Figure 1).

Statistical summary of model

The model utilised a Decision Tree Classifier with a maximum depth of 4, incorporating six categorical predictors: animal type, injury location, patient gender, age group, use of prophylactic antibiotics, and vaccination status. The model demonstrated robust performance, with an overall accuracy of 81.8%, sensitivity of 78.4%, specificity of 84.2%, and an area under the ROC curve (AUC) of 0.86, as determined by 5-fold cross-validation. The findings suggest that the model is both sensitive and specific in identifying high-risk cases and may serve as a practical clinical decision support tool.

Results

A total of 976 patients were included in this study, four of whom were shared as cases. The study population comprised patients ranging in age from 1 to 92 years, with an average age of 34.1 years. A further breakdown of the data by age revealed that the group most affected among the population were individuals between the ages of 19 and 30 (Figure 2). The analysis revealed a statistically significant association between age category and the type of animal involved ($\chi^2(28) = 121.28$, $p < 0.001$). This indicates that the distribution of animal bite types varies significantly across different age groups.

Of the patients who presented with complaints of injury caused by an animal bite, 54.2% were female ($n = 529$), and 45.8% were male ($n = 447$). No significant association was found between animal type and patient gender ($\chi^2(3) = 0.007$, $p = 0.9998$), indicating a balanced gender distribution across animal types.

The data also indicates that 73% (n: 712) of the applications were submitted by outpatient applicants, while 27% (n: 264) were made by individuals who had been transported to the hospital by ambulance (Figure 3). There was no statistically significant difference between animal species, complications and infections in terms of how they arrived at the hospital ($p > 0.05$).

As demonstrated by the data, the months in which the highest number of applications were received were July (15.6%), June (15.3%) and September (13.1%). The months in which the lowest number of applications were received were January (2.5%), March (3.1%) and February (3.3%) (Figure 4). There was no statistically significant difference between animal species, complications and infections in terms of months.

A closer examination of the distribution of patient applications to the hospital by year reveals that 3.2% (n: 121) were made in 2020, whereas this figure increased substantially to 41.7% (n: 297) in 2024 (Figure 5).

When the applications are examined according to the day of submission, Monday (19.1%) and Tuesday (16.4%) were found to be the days when hospital applications are made most frequently. It was observed that Saturdays (10.3%) and Sundays (10.8%) were the days on which the lowest number of applications were received (Figure 6). A Chi-square test revealed a significant association between the day of presentation and animal type ($\chi^2(18) = 83.71$, $p < 0.001$), with cat and rodent bites being relatively more common on weekends.

An analysis of the procedures and interventions performed on patients admitted to our hospital with injuries caused by animal bites reveals that primary suturing is the most prevalent intervention, accounting for 55.05% (n: 540) of the cases. Of these patients, 14.07% (n: 138) were consulted to the Plastic Surgery Department (Figure 7). A significant association was found between animal type and the need for plastic surgical intervention ($\chi^2(3) = 32.73$, $p < 0.001$). Pairwise z-tests showed that bites from rodents and equines were significantly more likely to require plastic surgery than those from dogs or cats ($p < 0.05$).

An examination of the records of patients who had sustained injuries due to animal bites and who had applied to our hospital revealed that 62% of them (n: 605) were discharged. 24.8% (n: 242)

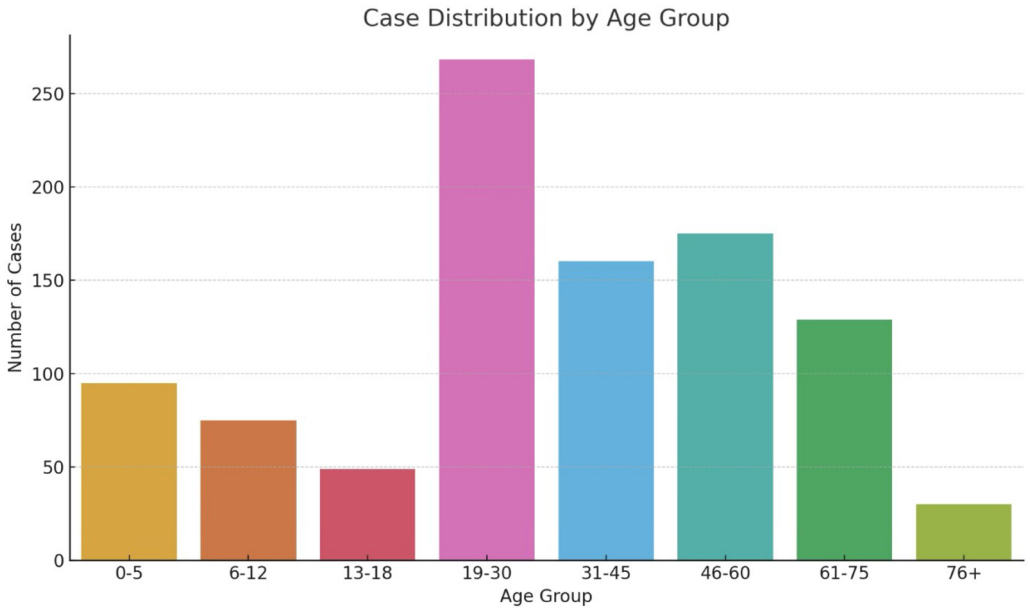

Figure 2. Distribution of cases by age group.

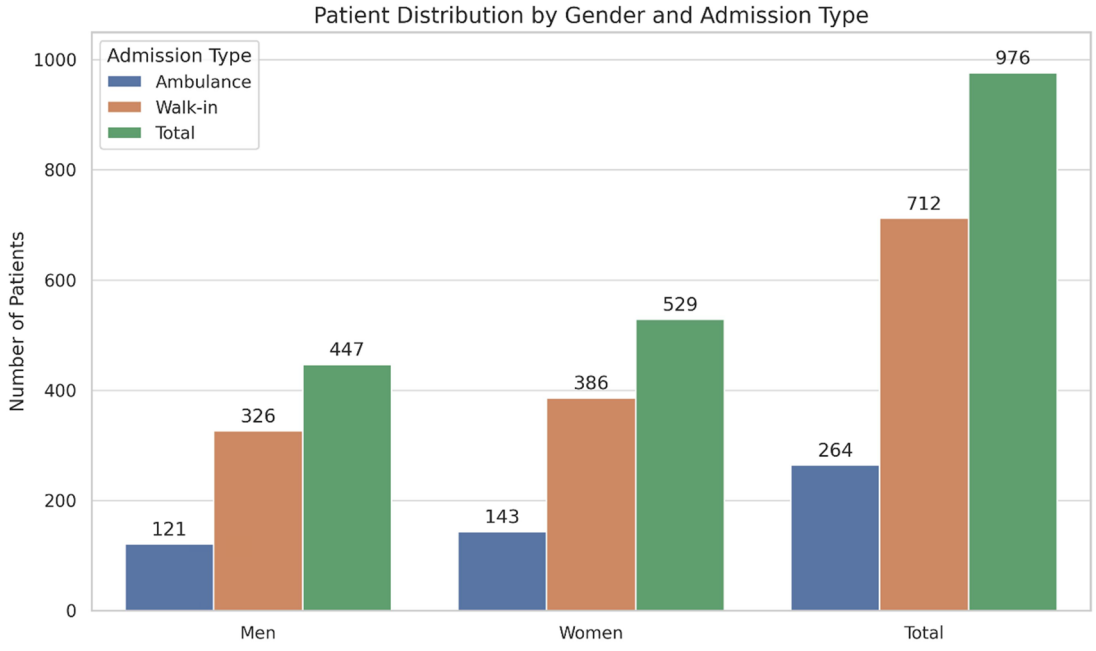

Figure 3. Distribution of applications by gender and admission type.

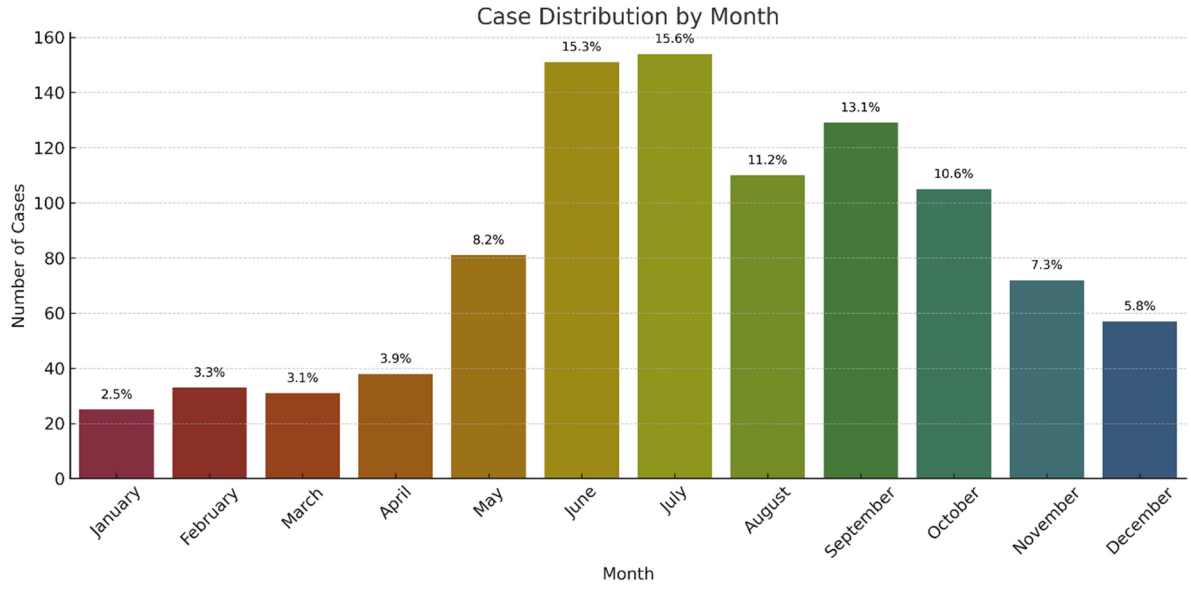

Figure 4. Patient applications by month.

of the patients were admitted to hospital. Of these patients, 9.9% (n: 97) were discharged from hospital care due to a refusal of treatment, and the remaining 3.3% (n: 32) were referred to other medical facilities for a variety of reasons, including the need for intensive care, a multidisciplinary approach to treatment, and a lack of specialisation. Final patient outcomes (discharge, admission, refusal, referral) also differed significantly by animal type ($\chi^2(9) = 135.69$, $p < 0.001$). Equine and rodent bites had higher referral rates, while dog bites were more often associated with admission or treatment refusal.

The most common cause of admission was dog bites, accounting for 83.9% (n: 823) of all cases. The data indicates that dog bites are followed by cat bites, which constitute approximately 9% (n: 88) of all cases. A total of 5.4% (n: 53) of the applications were attributable to rodent bites, while 1.2% (n: 12) of

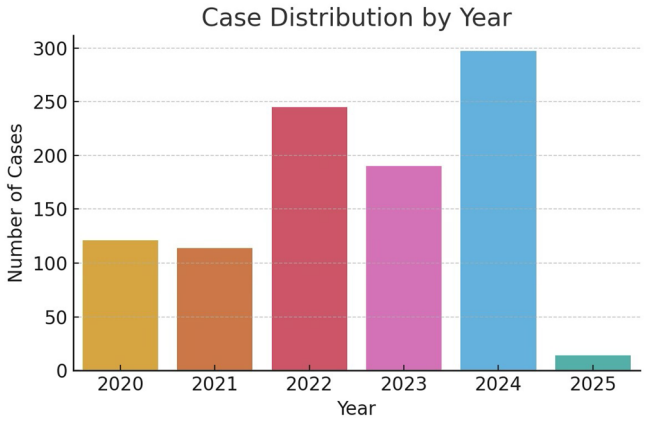

Figure 5. Patient applications by year.

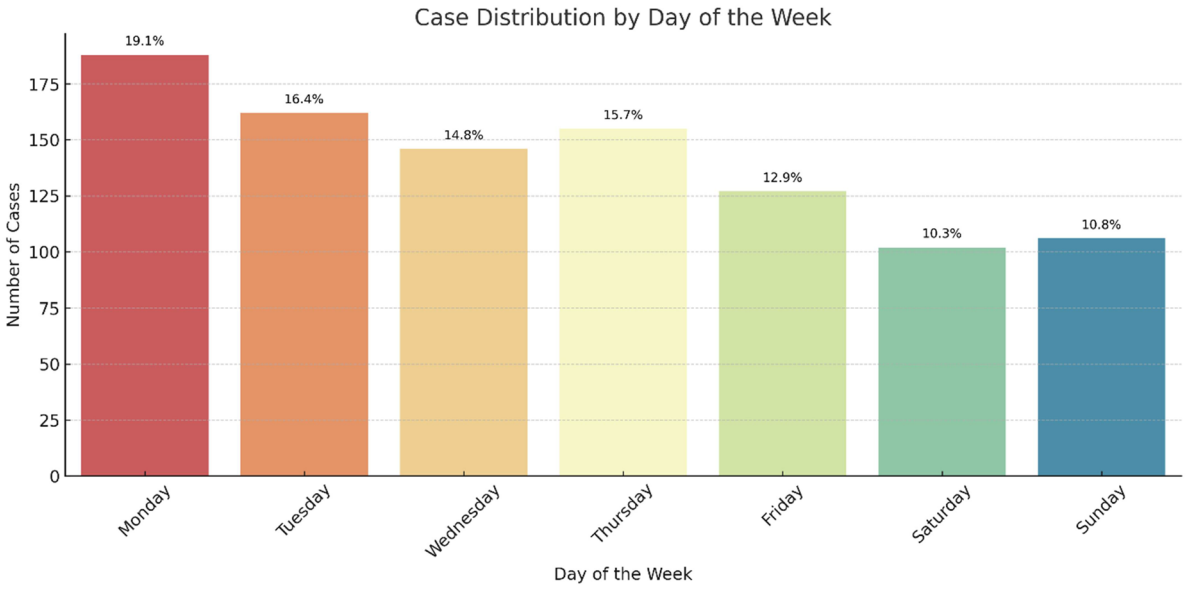

Figure 6. Patient applications by day.

cases were attributable to equine. The frequency of bites inflicted by other animals, is comparatively low (Figure 8). Injury location was significantly associated with animal type ($\chi^2(12) = 187.53$, $p < 0.001$). Rodent bites disproportionately affected the face and scalp, while dog bites commonly involved extremities (Figure 9).

A significant association was found between hospital admission and complication type ($\chi^2(3) = 54.46$, $p < 0.001$). Systemic infections and functional loss were more common in admitted patients, whereas localized infections and wound healing issues were prevalent in discharged patients. Pairwise z-tests showed that functional loss was significantly more frequent in equine bites compared to other animals ($p < 0.05$). Systemic infections were more common in equine and rodent bites than in dog bites ($p < 0.001$).

Antibiotic therapy differed significantly by age group ($\chi^2(7) = 157.79$, $p < 0.001$). Antibiotic therapy significantly affected the type of complication ($\chi^2(3) = 31.74$, $p < 0.001$); systemic infections and functional loss were more common in patients who did not receive antibiotics. However, antibiotic therapy did not show a significant relationship with the type of complications in any age group ($p > 0.05$).

Vaccination rates varied significantly by age group ($\chi^2(7) = 401.10$, $p < 0.001$).

No statistically significant difference was found between complications and infections in terms of average hospital stay and total follow-up frequency ($p > 0.05$).

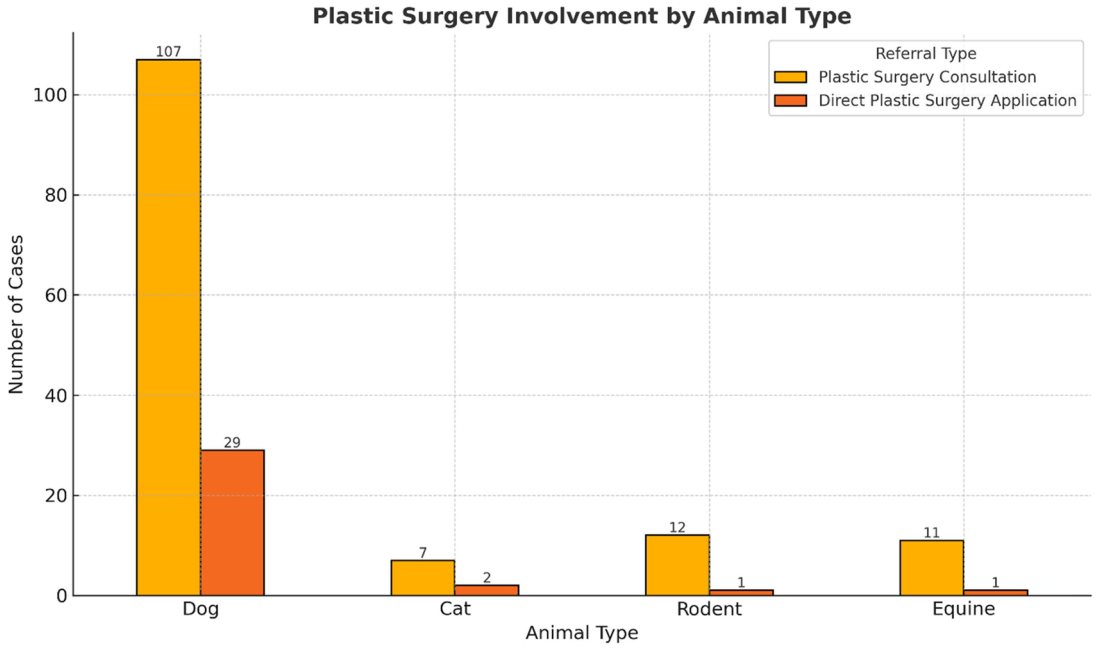

Figure 7. Plastic surgery involvement by animal type.

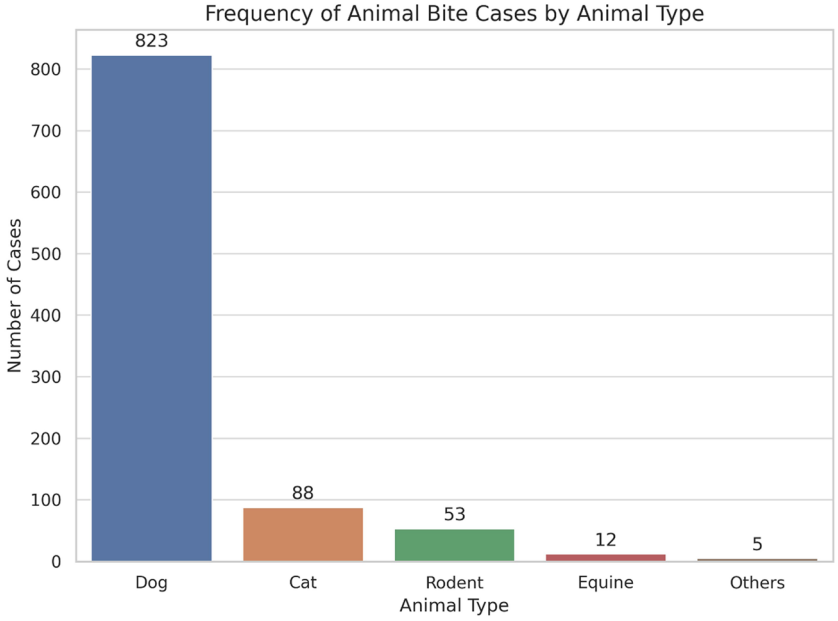

Figure 8. 5-year prevalence of bites from different animal species.

Clinical management and decision

In this study, a decision tree model was developed to predict complications in patients with animal bite injuries evaluated by the plastic surgery department. The model was built using the CART (Classification and Regression Tree) algorithm, which works by repeatedly splitting the data based on variables that best separate patients with and without complications. The tree was limited to a maximum depth of four to maintain clinical interpretability while preserving predictive accuracy. The model used six categorical variables: animal type, injury location, gender, age, use of prophylactic antibiotics, and vaccination status. At each decision point, the algorithm selects the most informative variable to divide the patient population, eventually leading to terminal nodes that classify the risk of complications. For example, the model might first separate patients by animal type, identifying rodent bites as higher risk. It may then

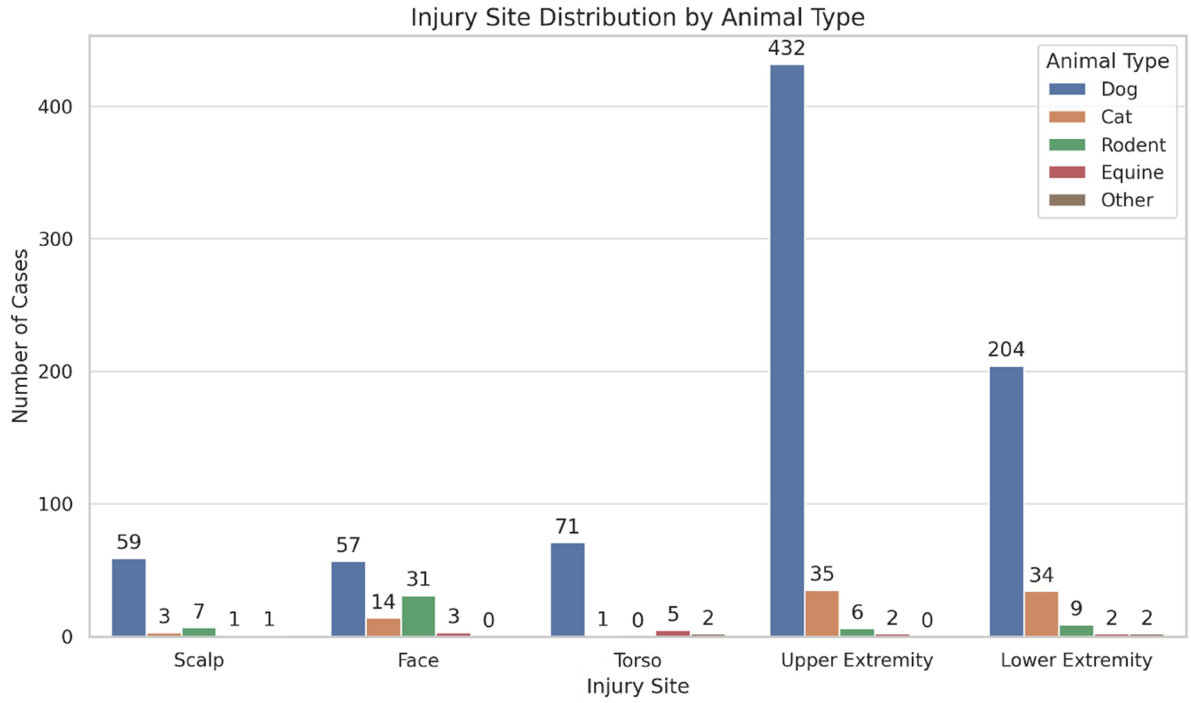

Figure 9. Distribution of anatomical injury sites by animal type among patients presenting with animal bites.

further split those cases based on injury location (e.g. face or hand), and whether antibiotics were administered. Patients in high-risk branches—such as unvaccinated individuals with facial rodent bites who did not receive antibiotics—were found to have a significantly increased complication rate. Clinically, this algorithm provides a simple, structured tool to guide decisions in emergency or surgical settings. It enables frontline clinicians to stratify patients at the point of care, helping identify those who may benefit from aggressive prophylaxis, surgical follow-up, or inpatient observation. This is particularly valuable in settings with limited access to plastic surgery consultation. The model showed strong performance with an accuracy of 81.8% and an AUC of 0.86, supporting its potential for clinical integration.

Cases

Case-1

A 46-year-old female patient submitted an application to our clinic after sustaining an injury from a dog bite inflicted by her friend's canine. On examination, a tissue loss was identified extending from the upper lip midline to the left, measuring approximately 3×4 cm, including the vermiculite line and lip epithelium (Photo 1).

Written informed consent for publication was of their details was obtained from the patient.

The wound was meticulously irrigated using a substantial quantity of saline solution. The application of approximation sutures to the oral mucosa was subsequently undertaken. Silver wound dressing was applied to the defect area extending to the dermis in the upper lip area. The tetanus vaccination was given in five doses as per the guidelines [8]. These were given at intervals of 0–4 weeks, 6 months, 1 year and 1 year. Rabies immunoglobulin (IG) and rabies vaccine prophylaxis were administered on days 0, 3, 7 and 14 [9]. The silver wound dressing was replaced every three days, and secondary healing of the affected area was observed during the follow-up period (Photo 2). Following completion of the six-month healing process, scar revision using the Z-plasty technique was planned to minimise the appearance of the scar.

Case-2

A 22-year-old male patient presented to us after being bitten by a horse he tried to ride during a farm visit. A thorough examination revealed several epidermo-abrasions on the face, along with two

Photo 1. Preoperative appearance.

Photo 2. Postoperative appearance.

distinct incisions: one measuring 2 centimetres in length, located 2 centimetres above the right eyebrow on the lateral side, and another measuring 3 centimetres, situated laterally on the left zygomatic region (Photo 3). During the motor examination, it was found that he could not raise his right eyebrow.

Written informed consent for publication was of their details was obtained from the patient.

The wound was meticulously irrigated using a substantial quantity of saline solution. It was recommended that the abrasions be dressed with antibiotic ointment. Partial lacerations of the right facial nerve and frontal branch, as well as the frontal muscle, were observed during exploration. His cuts were primarily restored. Tetanus prophylaxis was started in five doses, administered at intervals of 0–4 weeks, 6 months, 1 year and 1 year [8]. The patient was commenced on outpatient antibiotic therapy. In this particular case, the decision was taken to initiate antibiotic prophylaxis with amoxicillin-clavulanate tablets (875-125 mg, twice daily or 500-125 mg, three times daily) on the basis of the existing injury to the facial region. The patient is undergoing postoperative follow-up.

Case-3

A 5-year-old child patient presented to our clinic following a dog bite. A thorough physical evaluation reveals an 8 centimetre long deep incision on the lateral side of the right eyebrow, a 2 centimetre vertical incision in the frontal midline, and an obliquely angled bone exposure incision situated just below the hairline, again in the frontal midline (Photo 4). The patient exhibited signs of periorbital inflammation, including right-eye oedema and ecchymosis, as well as subconjunctival haemorrhage. Upon rigorous examination of the motor, it was determined that the patient is unable to elevate the right eyebrow. The tomographic images reveal the presence of superficial free bone fragments.

Written informed consent for publication was of their details was obtained from her guardian.

Photo 3. Preoperative appearance.

Photo 4. Intraoperative appearance.

The wound was meticulously irrigated using a substantial quantity of saline solution. During the course of the exploration procedure, lacerations were observed to the right facial nerve, the frontal branch of the nerve, and to the periosteum. Her cuts were primarily restored. Rabies immunoglobulin (IG) and rabies vaccine prophylaxis were administered on days 0, 3, 7 and 14 [9]. The patient was hospitalised and initiated on dual antibiotic therapy. In the present clinic, the following intravenous (IV) medications are administered to paediatric patients: Ampicillin-Sulbactam (200 mg/kg/day, every 6 h) and Clindamycin (30 mg/kg/day, every 8 h). The patient is undergoing postoperative follow-up.

Case-4

In this case study, a 69-year-old female patient presented to our clinic after sustaining an injury from a stray dog bite to the face in her local village. On physical examination, the following lesions are observed: firstly, a 3 cm deep incision in the left nasolabial sulcus, and secondly, a horizontal skin incision of approximately 8 cm on the right cheek. In addition to these, a vertical incision is present in the middle of the upper lip, passing through the vermiculitis-cutaneous line (Photo 5). A thorough facial examination was conducted, which revealed a loss of left upper lip elevation.

Written informed consent for publication was of their details was obtained from the patient.

The wound was meticulously irrigated using a substantial quantity of saline solution. The application of antibiotic ointment to abrasions was recommended. As a result of the exploration procedure, it was determined that the left facial nerve's buccal branch was subject to laceration. Her cuts were primarily restored. Tetanus prophylaxis was started in five doses, administered at intervals of 0–4 weeks, 6 months, 1 year and 1 year [8]. Rabies immunoglobulin (IG) and rabies vaccine prophylaxis were administered on days 0, 3, 7 and 14 [9]. In light of the patient's injury to the facial area, antibiotic prophylaxis was initiated with Amoxicillin-Clavulanate tablets (875-125 mg twice daily or 500-125 mg thrice daily). The patient is undergoing postoperative follow-up.

Photo 5. Preoperative, intraoperative and postoperative appearance.

Discussion

The findings obtained in this investigation are largely consistent with the existing literature data concerning animal bites admitted to hospital, but some differences are also worthy of note.

The mean age of patients evaluated in the study was found to be 34.1. The finding that 54% of the patients in this study were female is at odds with the conclusions of certain studies which have asserted that the male gender is more prevalent in cases of animal bites [2,10,11]. However, this finding is consistent with the results reported in the study by Cameron et al. [12].

The prevalence of dog bites is higher in children; however, there is a higher incidence of dog bite in boys than in girls. Furthermore, the age ranges most affected vary between studies [4,6]. In this study, it was observed that individuals between the ages of 19 and 30 were most affected. Consequently, complication rates were found to be comparatively elevated in this age group. The finding that age is not a key factor in the predictability of complications in the decision tree model enhances its clinical applicability.

In this study, an examination was conducted of the distribution of hospital applications by year. The results showed that the rate was 12.4% in 2020, 11.8% in 2021 and 24.8% in 2022.

The marked increase observed in 2022 can be ascribed to a decrease in contact with stray animals, consequent to the restrictions that were imposed after the first case was documented in Turkey in March 2020, and an increase in contact between people and stray animals following the substantial lifting of restrictions in 2022, subsequent to the initiation of vaccination programmes that commenced in 2021. In 2024, this rate was 41.7% (n: 297), and this significant increase can be associated with the uncertainties in the implementation process of the articles regarding the collection of stray animals in the Animal Protection Law No. 5199. The Turkish Grand National Assembly accepted this law on 30 July 2024 and it entered into force upon publication in the Official Gazette on 2 August 2024. The transition period also resulted in uncontrolled contact conditions with stray animals. In contrast, the increasing trend in animal bites observed over recent years may be attributed to an increased awareness of the necessity of seeking treatment at designated rabies prevention centres. Alternatively, this phenomenon could indicate a genuine increase. This increase, which was also emphasised in the study of O'Hara (2024), should be specifically investigated in future studies [13].

The months which demonstrate the highest number of applications according to the data collected in the present study are July (15.60%) and June (15.29%). This phenomenon can be attributed to increased levels of outdoor activity, including picnics, hiking and gardening. Furthermore, it has been observed that a greater number of individuals tend to migrate from urban to suburban areas during the holiday season. The present data align with the findings of McLoughlin et al. who reported an increase in aggression by canines during the summer months [14].

An examination of hospital applications in the present study reveals that Monday (19.07%) and Tuesday (16.41%) are the days when hospital applications are most frequent, while Saturday (10.30%) and Sunday (10.71%) are the days when they are least frequent. The increase in hospital admissions observed on Monday and Tuesday may be attributed to the increased number of bite cases presented

to healthcare institutions on the first working days of the week following the weekend events. Conversely, the decline observed on Saturday and Sunday may be attributed to a reduced tendency of patients to present themselves to hospitals, due to the limitations in outpatient services on weekends and inadequate public transportation in rural areas. Our study revealed differences in aggressions of animals according to days, in addition to months, as reported by McLoughlin et al. and Quezeda et al. [14,15]. This study contributes to the literature identifying temporal changes in animal bite risk. To our knowledge, this is the first study to use day-related data.

Depending on the nature of the bite and the type of animal concerned, animal bites can cause either simple or complex injuries. According to Williams et al. bruises, abrasions, avulsions, skin tears, lacerations, puncture wounds and/or damage to deep body structures are among those possible injuries. Williams et al. also reported that the most prevalent types of injury are penetrating wounds, lacerations and avulsion injuries [16]. In the present study, consistent with the extant literature, the majority of cases exhibited penetrating injuries and lacerations, and the majority were treated with vaccination and primary suturing at emergency department. As plastic surgery department, a comprehensive patient assessment performed in the emergency department or in the context of referral for post-traumatic emergencies using smartphone-based device cameras has resulted in the application of advanced surgical procedures to restore function to the musculotendinous system, neurovascular repairs and soft tissue closure in complex cases. This highlights the complexity of this type of injury and emphasizes the need for a systematic approach.

As reported by Hurt and Maday, dog bites represent the most prevalent category of animal bites, accounting for 85% to 90% of all cases, with approximately 4.5 million cases being reported annually [17]. The study indicated that dog bites are followed by cat bites, which accounted for approximately 10% of all cases (approximately 400,000 cases per annum). Finally, the incidence of rodent-biting has been documented to reach up to 20,000 cases per annum, whereas bites from other mammalian creatures, such as ferrets, raccoons and skunks, along with farm animals, occur at a reduced frequency [1,17]. In the present study, 83.9% of cases were attributed to dog bites, a finding that aligns with the extant literature, which corroborates the assertion that the preponderance of animal bites is attributable to canines. Equıne bites constitute 1.2% (n: 12) of cases, a figure that appears to exceed the data reported in the relevant literature. This high rate can be attributed to two main factors. Firstly, the proximity of the hospital's current location to the rural areas of Balıkesir province. Secondly, the high rate of horse ownership in rural areas. Darwishi et al. emphasized in their study that this rate increases significantly when moving towards the east; horses were shown to be the cause of 17% of the bite injuries caused by animals in eastern Turkey [18].

Brown and DeMaria reported that the overall infection rate resulting from dog bite injuries is approximately 10%, with this figure rising to as high as 20% in cases involving child victims [19]. Cat bites have been shown to have a higher infection rate, with reported figures ranging from 20% to 80% [1,20,21]. Conversely, the risk of infective complications remained comparatively low in the subgroup of patients who received antibiotics and were bitten by cats in our study and framework. These findings in our study should be supported by other studies with a larger number of cat bite patients.

In order to establish which factors increase the risk of infection in cases of animal bites, it is first necessary to consider the patient-related risk factors. These include diabetes, peripheral vascular disease, asplenia (absence of spleen), liver disease, the presence of prosthetic valves or joints, and immunosuppression. In addition to these, there are risk factors related to the nature of the bite. As documented by Baddour et al. the risk of infection is elevated in cases of bites to the hand or foot, bites to limbs with venous or lymphatic insufficiency, bites near prosthetic joints or vascular grafts, in instances where the bite constitutes a crushing injury or a penetrating injury, and in applications within the first 12 h for the extremities and within the first 24 h for the face following the bite [7]. The manifestation of signs of infection may occur within 12 h post-bite. Serious infections, including cellulitis, abscess, osteomyelitis, tenosynovitis, septic arthritis, and necrotising soft tissue infection, may ensue [22]. The reason for the higher incidence of systemic infections and loss of function in inpatients and higher incidence of local infections and wound healing problems in discharged patients in our study is that hospitalized patients are exposed to more serious and complication-prone injuries than outpatients. A limitation of our study

is that the patients did not have statistically significant comorbidities, and where such conditions were present they were not documented.

Baddour et al. also emphasized that the management of animal bite wounds necessitates diagnostic imaging in the appropriate cases to rule out or confirm complications such as foreign body retention or fractures. Standard radiography is most frequently employed, while hand bites and bites involving joint spaces require targeted imaging. In cases of bite injuries affecting the head or face, computed tomography (CT) is the preferred modality [7]. In cases of infected bite wounds and suspected deep tissue infections (e.g. abscesses or osteomyelitis), ultrasound, magnetic resonance imaging (MRI), or a CT scan with intravenous contrast may be indicated (with angiography if vascular injury is suspected) [7]. A further limitation of the present study is that additional imaging methods were not utilised with greater frequency, particularly in cases where recommendations from other departments were not sought. In addition, antibiotic therapy, meticulous debridement and tissue reconstruction led to a substantial reduction in the prevalence of deep tissue infection and abscess development.

With regard to the administration of immunoprophylaxis, it is imperative to evaluate the tetanus and rabies immunity status of every patient who has sustained a bite from an animal. Patients who have previously completed a full tetanus vaccination series and have received their last tetanus toxoid-containing vaccine (DTaP, Tdap, or Td) within the last five years are considered immune. Nonetheless, in the event that a period of five years has elapsed, the patient's immune status will no longer be effective. It follows that the administration of a tetanus toxoid vaccine is required. Ideally, this should be administered within a 72-hour period [23,24].

Individuals who have not received the relevant vaccinations at the time of injury should be administered the appropriate tetanus series in accordance with the CDC vaccination schedule [23]. It is crucial to consider the administration of tetanus immune globulin (TIG) for individuals who have not completed the primary tetanus vaccination series or who have never been vaccinated. In our study, tetanus vaccine and immunoglobulin were administered as per guidelines, and follow-up was carried out as standard, with no complications. It is important to note that none of the patients declined the vaccine, and the compliance of all patients during follow-up was also effective in this regard.

The rabies virus is transmitted to the nervous system through contact with infected animal saliva after a bite. Rabies prophylaxis must be considered for those bitten by a mammal or who have come into contact with an animal's saliva or tissue. Rabies prophylaxis must also be given to individuals who have had contact with bats, where injury may be possible.

Brown et al. stated that in the context of animals that necessitate rabies prophylaxis, species such as bats, raccoons, skunks, foxes, coyotes, bobcats and woodpeckers have been identified as high-risk categories for rabies infection [19]. In the event of a bite from one of these animals, and if the animal is available for testing, rabies post exposure prophylaxis (PEP) should be initiated if the animal tests positive. In the event that the animal is not available for testing, the PEP should be initiated without delay. It is considered that animals such as squirrels, groundhogs, rodents and rabbits pose a low risk of rabies infection. Consequently, bites from these animals generally do not require administration of rabies prophylaxis. Pets (canines, felines and ferrets) should be quarantined for a period of 10 days after the bite. In instances where the animal cannot be tracked, the initiation of PEP should be undertaken without delay [19,25]. In light of the prevalence of stray animals in rural regions, the challenges associated with tracking the bitten animal, and the accessibility of the patient to the hospital, the administration of rabies immune prophylaxis was conducted in accordance with established standards, independent of the animal group in our study. This represented a significant limitation of our study, given that the number of vaccinated patients was too large to allow for statistical significance.

For individuals who have not received a vaccination, it is recommended that human rabies immune globulin (HRIG) and rabies vaccine be administered on day 0, with subsequent doses given on days 3, 7, and 14. The HRIG dosage is calculated as 20 units per kilogram of the patient's body mass and should be administered around and into the wound as much as possible. The remaining dose should be administered by intramuscular injection in a location that is distant from the site of the bite. For individuals who have already received a vaccine against rabies, the primary vaccination is composed of the rabies vaccine, administered on days 0 and 3, and no further HRIG is required [26]. In our study, our patients

were administered vaccine and immune globulin in accordance with this guideline and followed up. In the decision tree model analysis, lack of vaccination and advanced age were therefore found to be risk factors, emphasizing the importance of vaccination in such patients.

The rationale behind leaving bite wounds open is to reduce the risk of infection. Nonetheless, primary closure may be performed for cosmetic reasons. It is imperative that these situations are confined to superficial wounds on the face or scalp, non-broken wounds, and patients with normal immune systems [17]. Our study demonstrated that wounds were less often left open with sharp debridement and reconstruction, indicating a reduced infection risk when combined with antibiotic therapy.

It is imperative that all closed bite wounds are examined for signs of infection within 48–72 h [27]. Furthermore, all patients are contacted within 48 h for a follow-up consultation, during which the presence of any infectious findings is investigated. In our study, the surgical approach employed, in conjunction with the high number of inpatients, facilitated the early detection of infections during the follow-up period.

Cui et al. emphasized that, despite the controversy surrounding the utilisation of prophylactic antibiotics for dog bites, there are circumstances in which their administration is recommended [28]. It has also been established that animal bites frequently exhibit polymicrobial characteristics in the study of Kisaka et al. [29]. The presence of aerobic bacteria, including Pasteurella, Streptococcus, and Staphylococcus/MRSA, as well as anaerobic bacteria such as Fusobacterium, Bacteroides, Prevotella, Peptostreptococcus, and Porphyromonas, has been observed by Darvishi et al. [18]. Consequently, antibiotic therapy should be broad-spectrum. The primary treatment option is frequently amoxicillin-clavulanate [30,31]. In our medical facility, amoxicillin clavulanate is selected as the initial antibiotic therapy for outpatient patients. The study by Garber et al. recommends a combination of different antibiotic options and trimethoprim/sulfamethoxazole if the patient has a documented history of MRSA or a history of bites with non-domestic animals [32]. In our study, we confirmed that the preferred antibiotic diversity was in this direction and that initiation of antibiotic therapy plays a key role in the prevention of complications. This is exemplified by a decision tree model based on the observed infection and complication rates in patients who started treatment during the follow-up period.

In this study, all patients requiring plastic surgery intervention were evaluated in WHO Classification of Animal Bite Wounds (Table 1.) 'Category-III' and managed accordingly [33]. In the present study, as in the Meek et al. study, head and facial area bites were encountered with a high frequency as wound site localisation, especially in paediatric patients, and scar revisions and fat injections were scheduled in the late period to achieve an optimal cosmetic appearance [34]. In our study, the most commonly affected trauma site was the upper extremity contrary to the existing literature [35,36]. This can happen for two reasons. Firstly, people often try to protect themselves with their hands when they are attacked by an animal. Secondly, children's contact with animals (especially dogs and cats) in leisure time is often through activities that use the hands, such as petting, feeding and playing. In cases where bites occur close to a bone or joint cavity, the pain experienced tends to increase with movement. Therefore, joint examination was an important part of the examination in our study, especially upper extremity and hand injuries requiring fine motor skills were carefully evaluated. In addition, signs of infection (erythema (redness), discharge and/or temperature increase), neurovascular examination and systemic general condition were noted and evaluated at each visit as in the literature [7]. This recorded data have helped standardise the management of animal bite injuries, making treatment more predictable and effective.

The most significant strength of this study is that it has developed an approach and a valuable risk predictive model for anımal bites, with including antibiotic therapy, vaccination, animal type and trauma sites. The principal limitation of this study is that, given its retrospective nature, the potential for incomplete or inaccurate records pertaining to animal bite patients may result in misclassification, consequently leading to suboptimal data quality.

Table 1. WHO classification of animal bite wounds.

WHO ANIMAL BITE CATEGORIES	
CATEGORY	DESCRIPTION
CATEGORY-I	Touching or feeding of animals, or licks on intact skin
CATEGORY-II	Nibbling of uncovered skin, minor scratches or abrasions without bleeding
CATEGORY-III	Single or multiple transdermal bite sor scratches, licks on broken skin, contamination of mucous membranes with saliva from licks

Conclusions

In the contemporary context, animal-related traumas have become a prevalent patient group in clinical settings. A multidisciplinary approach involving emergency medicine, infectious diseases, plastic surgery, dermatology and psychiatry departments is required for the management of these patients. In some cases, combining plastic, reconstructive and aesthetic surgery skills is necessary. But a systematic approach is needed to manage patients with a wide variety of injuries. The study's framework shows that the key to complications is antibiotic therapy, vaccination, animal species and the location of the injury. The model lets clinicians categorize patients into different risk groups to help inform their decisions about observation, intervention and follow-up.

Acknowledgments

Emrah Işıktekin: Having an idea/view or contributing to the emergence and continuation of the study, plan, design or pattern, revision, supervision, review; conception and design of the data, revising it critically for intellectual content, the final approval of the version to be published, agree to be accountable for all aspects of the work. Emre Babaarslan: Data collection or processing of collected data to prepare for analysis, data analysis or interpretation of analysis, review of literature; conception and design of the data, , the drafting of the paper, the final approval of the version to be published, agree to be accountable for all aspects of the work.

Author contributions

CRediT: **Emrah Işıktekin**: Conceptualization, Investigation, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing; **Emre Babaarslan**: Conceptualization, Formal analysis, Supervision, Writing – original draft, Writing – review & editing.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

ORCID

Emrah Işıktekin http://orcid.org/0000-0001-6068-9899
Emre Babaarslan http://orcid.org/0009-0005-6628-8785

Data availability statement

Raw data were generated at Balıkesir University, Faculty of Medicine. Derived data supporting the findings of this study are available from the corresponding author [Işıktekin, E.] on request.

References

[1] Bula-Rudas FJ, Olcott JL. Human and animal bites. Pediatr Rev. 2018;39(10):490–500. doi: 10.1542/pir.2017-0212.
[2] Khazaei S, Karami M, Veisani Y, et al. Epidemiology of animal bites and associated factors with delay in post-exposure prophylaxis; A cross-sectional study. Bull Emerg Trauma. 2018;6(3):239–244. doi: 10.29252/beat-060309.
[3] Kumar R, Deleyiannis FW, Wilkinson C, et al. Neurosurgical sequelae of domestic dog attacks in children. J Neurosurg Pediatr. 2017;19(1):24–31. doi: 10.3171/2016.7.PEDS1646.
[4] Boyd LC, Chang J, Ajmera S, et al. Pediatric dog bites: a review of 1422 cases treated at a level one regional pediatric trauma center. J Craniofac Surg. 2022;33(4):1118–1121. doi: 10.1097/SCS.0000000000008209.
[5] Chang W, Zhang H. Reconstructive surgery after facial trauma: advances in flap techniques. Facial Plast Surg Clin North Am. 2019;27(2):195–205.
[6] Fein J, Bogumil D, Upperman JS, et al. Pediatric dog bites: a population-based profile. Inj Prev. 2019;25(4):290–294. doi: 10.1136/injuryprev-2017-042621.

[7] Baddour L, Harper M. ; 2022. Animal bites (dogs, cats, and other animals): Evaluation and management. UpToDate. https://www.uptodate.com.
[8] WHO. Essential programme on immunization. [accessed 2024 July 30]. https://www.who.int/teams/immunization-vaccines-and-biologicals/essentialprogramme-on-immunization.
[9] Kuduz Profilaksi Rehberi TC. Sağlık Bakanlığı Halk Sağlığı Genel Müdürlüğü Zoonotik ve Vektörel Hastalıklar Dairesi Başkanlığı 1134. Ankara;2019.
[10] Murphy J, Qaisi M. Management of human and animal bites. Oral Maxillofac Surg Clin North Am. 2021;33(3):373–380. doi: 10.1016/j.coms.2021.04.006.
[11] Mallikarjuna S, Jeshanah MS. Epidemiological profile and awareness regarding animal bite management in an urban area. Cureus. 2024;16(9):e69159. doi: 10.7759/cureus.69159.
[12] Cameron O, Al-Himdani S, Oliver DW. Not a plastic surgeon's best friend: dog bites an increasing burden on UK plastic surgery services. J Plast Reconstr Aesthet Surg. 2017;70(4):556–557. doi: 10.1016/j.bjps.2016.12.007.
[13] O'Hara N. Dog bites are increasing in frequency and severity - a sustained effect following the COVID-19 pandemic. J Plastic, Reconstruct Aesthetic Surg: JPRAS. 2024;95:21–23. doi: 10.1016/j.bjps.2024.05.049.
[14] McLoughlin RJ, Cournoyer L, Hirsh MP, et al. Hospitalizations for pediatric dog bite injuries in the United States. J Pediatr Surg. 2020;55(7):1228–1233. doi: 10.1016/j.jpedsurg.2019.06.025.
[15] Quezada-Nolasco JL, Galarde-López M, Sánchez-Zamorano LM, et al. Spatial patterns and risk of aggression of dogs and cats in a central township of Mexico City. Acta Trop. 2023;239:106814. doi: 10.1016/j.actatropica.2023.106814.
[16] Williams A, Peterson B, Martinez S. Rabies and tetanus vaccination protocols in animal bite victims. Clin Infect Dis. 2021;52(4):109–115.
[17] Hurt JB, Maday KR. Management and treatment of animal bites. JAAPA. 2018;31(4):27–31. doi: 10.1097/01.JAA.0000531049.59137.cd.
[18] Darvishi M, Nava AO, Karimi E, et al. Human and animal bites. Caspian J Environ Sci. 2023;21(2):445–456.
[19] Brown CM, DeMaria A. Indications for post-exposure rabies prophylaxis; 2023. UpToDate. https://www.uptodate.com/contents/indications-for-post-exposure-rabies-prophylaxis.
[20] Greene SE, Fritz SA. Infectious complications of bite injuries. Infect Dis Clin North Am. 2021;35(1):219–236. doi: 10.1016/j.idc.2020.10.005.
[21] Barrett J. Human bites: background, pathophysiology, etiology. Medscape; 2021. https://emedicine.medscape.com/article/218901-overview.
[22] Johns Hopkins Medicine. Necrotizing soft tissue infection. HopkinsMedicine.org; n.d. [accessed 2024 Jan 18]. https://www.hopkinsmedicine.org/health/conditions-and-diseases/necrotizing-soft-tissue-infection.
[23] Centers for Disease Control and Prevention. Tetanus: for clinicians. | CDC; 2023. https://www.cdc.gov/tetanus/clinicians.html.
[24] American College of Emergency Physicians. Animal bites. EmergencyPhysicians.org; 2024. https://www.emergencyphysicians.org/article/know-when-to-go/animal-bites.
[25] Cunningham A, Camilon T, Chao S. Surgical management of pediatric dog bites: a systematic review and treatment guideline. J Pediatr Surg. 2025;60(2):161984. doi: 10.1016/j.jpedsurg.2024.161984.
[26] Centers for Disease Control and Prevention. Medical care: rabies vaccine rabies. CDC; 2024. https://www.cdc.gov/rabies/medical_care/vaccine.html.
[27] Beam JW. Tissue adhesives for simple traumatic lacerations. J Athl Train. 2008;43(2):222–224. doi: 10.4085/1062-6050-43.2.222.
[28] Cui M, Jia Y, Chen Z, et al. Primary closure and prophylactic antibiotics for treatment of traumatic wounds caused by mammals, a systematic review and meta-analysis. World J Emerg Surg. 2025;20(1):48. doi: 10.1186/s13017-025-00619-1.
[29] Kisaka S, Makumbi FE, Majalija S, et al. The potential for the double risk of rabies and antimicrobial resistance in a high rabies endemic setting: detection of antibiotic resistance in bacterial isolates from infected dog bite wounds in Uganda. Antimicrob Resist Infect Control. 2022;11(1):142. doi: 10.1186/s13756-022-01181-0.
[30] Bennett JE, Dolin R, Blaser MJ. (Eds.). Mandell, Douglas, and Bennett's principles and practice of ınfectious diseases. 9th ed. Elsevier, Philadelphia; 2020.
[31] Di Mita O, Rosa M, Ruggiero L, et al. Emergency management of animal-related ınjuries in children: an observational multicenter Italian study. Pediatr Emerg Care. 2025;41(6):443–447. doi: 10.1097/PEC.0000000000003358.
[32] Garber B, Glauser J. Mammalian bites: ınfection prevention and management. Curr Emerg Hosp Med Rep. 2023;11(3):103–110. doi: 10.1007/s40138-023-00269-0.
[33] World Health Organization. WHO guide for rabies pre and post exposure prophylaxis in humans; Geneva: World Health Organization 2014.
[34] Meek E, Lewis K, Hulbert J, et al. Who let the dogs out? A 10-year review of maxillofacial dog bite injuries. Br J Oral Maxillofac Surg. 2024;62(9):831–835. doi: 10.1016/j.bjoms.2024.07.012.
[35] Thangaraj JWV, Krishna NS, Devika S, Human Rabies Study Collaborators, et al. Estimates of the burden of human rabies deaths and animal bites in India, 2022-23: a community-based cross-sectional survey and probability decision-tree modelling study. The Lancet Infect Dis (Auckl). 2025;25(1):126–134. doi: 10.1016/S1473-3099(24)00490-0.
[36] Briotti DJ, Cransberg DJ, Chidambaram DR, et al. A two-year retrospective cohort study investigating the occurrence and short-term outcomes of dog-bite injures in regional Western Australia. Injury. 2024;55(6):111588. Epub 2024 Apr 25. PMID: 38718712. doi: 10.1016/j.injury.2024.111588.