ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 7, Issue – 5, October – 2024, Page No. : 92 - 100

Forensic Examination of Bitemarks; Distinguishing Human from Animal Impressions- A Narrative Review

[1]Dr.Barbee Mazumder, BDS, Goregaon Dental Centre, India

[2]Dr. Priyanka Bandi, BDS, Goregaon Dental Centre, India

[3]Dr.Anoli Agrawal, MDS, Assistant Professor, Department of Public Health Dentistry, ACPM Dental College, Dhule, Goregaon Dental Centre, India

[4]Dr. Naval Ghule, BDS, Goregaon Dental Centre, India

Corresponding Author: Dr. Barbee Mazumder, BDS, Goregaon Dental Centre, India

Citation of this Article: Dr. Barbee Mazumder, Dr. Priyanka Bandi, Dr. Anoli Agrawal, Dr. Naval Ghule, "Forensic Examination of Bitemarks; Distinguishing Human from Animal Impressions- A Narrative Review", IJDSIR- October – 2024, Volume –7, Issue - 5, P. No. 92 – 100.

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

A bitemark is the imprint left by teeth when a jaw closes on a surface. Similar to DNA or fingerprints, each person's bitemark is unique due to differences in tooth shape, size, and alignment. Bitemark comparison highlights dentistry's role in forensic science, specifically by aligning the bitemark pattern with a suspect's dental features and also it involves examining the distinct dental features of the suspected biter. Depending on the situation, a bitemark pattern might be found within food items, objects, or individuals who have been victims of assault or homicide. Overlays, made by hand tracing dental casts, wax impressions, xerographic images, or using computer-based methods, aid in this process. Animal bites differ from human bites in tooth size, arch alignment and tooth morphology. Human bitemarks typically have an oval or elliptical arch shape, while dog bitemarks are circular to oval, and cat bitemarks are circular. Human bitemarks typically occur when teeth are utilized as weapons, serving purposes such as expressions of anger, excitement, control, or destruction. Differences in incisor morphology are also noted: humans have rectangular shapes, dogs have oval to rectangular shapes, cats have circular shapes and bears have trapezoidal shapes. This study discusses the distinctive features of human and animal bitemarks and underscores the crucial contribution of forensic odontology in identifying potential perpetrators. The objective of this article is to furnish a thorough review encompassing the identification, differentiation, and comparison of bite marks.

Keywords: Forensic Odontology, Human Bitemark, Animal Bitemark, Bear Bitemark, Cat Bitemark

Introduction

Forensic odontology is a branch of dentistry that focuses on the collection, examination, and interpretation of dental evidence for legal cases. This field has been instrumental in identifying victims and suspects in various scenarios, including mass disasters, cases of abuse, and organized crime investigations. It encompasses all dental specialties, underscoring the necessity for a comprehensive, interdisciplinary approach in forensic dental work[1]. Forensic odontology is relatively new to law enforcement, with limited research on its effectiveness in criminal justice[2].

Dr. Oscar Amoedo, the Father of Forensic Odontology, pioneered the field in 1898 by identifying victims of a Paris fire, marking the discipline's inception in forensic science. Forensic odontology utilizes several techniques, such as rugoscopy (examining palatal rugae patterns), cheiloscopy (analyzing lip prints), Bitemarks, radiographs, photographic assessment, and molecular methods like polymerase chain reaction (PCR) for pulp DNA analysis. These days, DNA and protein analysis are crucial for identification. Extracting genomic and mitochondrial DNA from dental pulp, dentin, cementum, or saliva cells is essential in forensic identification[3].

The American Board of Forensic Odontology (ABFO) characterizes a bitemark as a "physical alteration or distinctive pattern imprinted in a surface, caused by the contact of human or animal teeth"[4]. Sorup is acknowledged as the first to conduct a detailed analysis of bitemarks. Bitemarks can be identified on a range of surfaces including food, flesh, cigars, pipes, and musical instruments [2].

Forensic odontologists assess suspected human bitemarks by confirming the lesion's origin and determining if it's from a child or adult. This involves measuring the inter-canine distance (ICD). Individual, racial, and gender variations can cause ICD overlaps between children and adults [5 6].

Bitemarks, from animals or humans, are significant practically and legally. The appearance of a bitemark depends on factors like the number of teeth, force, direction of the bite, dental health of the biter, and whether the victim was alive [6].

A human bitemark often features two opposing arcs from incisors, canines, and premolars, with lip and tongue compression causing bruising. Tooth edges cause lacerations, while tooth dragging leads to scrapes. Petechial hemorrhage may occur due to tongue suction. Animal bites, especially from dogs, cats, and rodents, are more frequent than human bites and typically cause tearing rather than compression of the flesh. Dog bitemarks often consist of pairs of triangular or rounded puncture wounds from the prominent canine teeth [5].

Thus this study aims to highlight about the Human and Animal bitemarks and analyze their impression patterns so that the recognition and examination of the bite marks and their subsequent comparison with suspects, may lead to criminal identification thereby resolving the crime.

Human Bitemark

An injury featuring a circular or oval pattern that consists of two opposing, symmetrical, U-shaped arches divided at their bases by open spaces is known as a classic human bite mark. The edges of these arches often exhibit abrasions, contusions, or lacerations, reflecting the distinct characteristics of the biting teeth's occlusal surfaces [7]. Mandibular anterior teeth stand out more in bite marks due to the lower jaw's movement. They create distinct impressions during closure, often accompanied by a suction effect on the skin from negative pressure. Tongue movements can also leave marks on the teeth, adding complexity to forensic analysis [7].

Bite marks are frequently seen on victims (from attackers), offenders (from victims defending themselves), or on items at crime scenes. Skin and delicate tissues all throughout the body often bear marks from human bites [7]. Female victims of bites typically have markings on their legs and breasts, which are commonly indicative of sexual assaults. Usually, male victims have bitemarks on their shoulders and arms, which are frequently the consequence of protective movements like lifting their arms to shield themselves. Bitemarks also appear frequently on children who have been abused [8]. The longevity of a bite mark hinges on the force and duration of the bite. Human bite marks typically appear as elliptical or circular injuries that document the unique features of the teeth, with diameters typically ranging from 25 to 40 mm. These marks often exhibit central bruising within the bite impression [8].

Human incisors exert around 11 kg of pressure, reaching up to 8 psi with tongue assistance. Biting also generates suction capable of producing a negative pressure of approximately 20 mmHg [9].

Figure 1: Bite mark measurement using American Board of Forensic Odontostomatology scale (ABFO Scale)[7]

Animal Bitemark

An animal bite refers to an injury inflicted by an animal's teeth, typically resulting in a puncture or laceration of the skin. Additionally, the force of the bite can cause contusions, which are bruises on body tissues even when the skin remains unbroken. Animal bites are notorious for causing severe infections that can prove fatal [10]. When an animal inflicts a bite, it typically leaves behind three distinct types of marks: nonfatal wounds sustained while the victim is alive, fatal wounds resulting in death, and postmortem lacerations occurring after death[10].

Carnivores have a specialized carnassials teeth, found as one of the posterior tooth in each quadrant, with a blade like upper tooth that slices against the corresponding lower tooth's outer surface, enabling efficient prey consumption through a scissor like cutting action [11]. There are few animals like dogs, closely associated with humans as pets, companions, and for tasks such as hunting and guarding, have brought the issue of dog bites into focus. There is growing concern over dog bites, which are the most common form of animal bites inflicted on humans [12]. In regions vulnerable to accidental or predatory carnivore attacks, correctly identifying the species responsible for bites is imperative for investigative purposes and ecological understanding. This identification helps in assessing risk factors, implementing appropriate safety measures, and maintaining ecological balance [13].

Comparison between Human Bite Marks and Animal Bite Marks

The process of bitemark analysis or bitemark comparison includes examining the unique dental characteristics of the suspected biter to establish any correlation between the two pieces of evidence [6]. The characteristics of a bitemark are influenced by several variables, including the number of teeth that make contact with the surface, the intensity, direction, and type of biting force applied, the occlusion and dental health of the biter, and whether the victim was living or deceased when bitten [6].

Dentition" pertains to the configuration and quantity of teeth types in animals, shaped by their dietary habits. Bite marks serve as pivotal clues for identifying the aggressor, whether animal or human, and can be evaluated through direct or indirect methods. Essential parameters for assessment encompass tooth width, orientation, inter-tooth spacing, and gap width. Teeth are the agents responsible for imprinting bite marks on the victim [12].

To mitigate diagnostic errors, researchers meticulously examine distinctive characteristics of animal and human bite marks. Through detailed scrutiny of dental traits, they seek to differentiate between self-inflicted injuries, aggression-induced bites, or those inflicted by animals. Central to their analysis is the measurement of the intercanine distance (ICD), as impressions left by anterior teeth are often conspicuous and quantifiable. This parameter plays a crucial role in determining the culpability of suspects or excluding them based on forensic bite mark analysis [12]. Bite mark analysis hinges on the assumption that dental patterns are distinctly individual and are accurately reflected in bite impressions. Consequently, this study aims to scrutinize one of the key factor to distinguish the bitemarks, that is the intercanine distance (ICD) in human and animal bitemarks, while also comparing these marks to assess their utility in Forensic Odontology.[12]

- Dental Features of Human Bite

  Different teeth produce different bitemarks such as Incisors produces rectangular marks, canine produces triangular or trapezoidal marks depending upon the amount of attrition whereas premolars and molars produces spherical or point shaped marks [9]. In humans the maxillary inter canine distance is larger than the mandibular inter canine distance. The inter canine distance measured on cast as per studies is 22-40mm with mean value of 33.2 and standard deviation of 5.0 [6].

- Dental Features of Dog Bite

  In the dog family (canidae), the incisors are having high central cusps with mesial and distal lobes adopted for specific functions such as holding, tearing and crushing. The canine is long, strong, sharp and very prominent teeth among all. The maxillary fourth premolar and mandibular first molar are adapted as carnassial teeth for shearing food [6]. The inter canine distance as measured on cast is 32-50mm with mean value of 34.64 and standard deviation of 4.1 [6].

Dental Features of Cat Bite

The cat family (Felidae), having a prominent dentition for grasping and killing the prey that can slice the flesh easily. Incisors poses almost same features as dog family but canines are more prominent and stronger than that of dogs [14]. They display short snout and incisors are arranged almost in a straight line across the front of the mouth and larger canines at the corners [6]. All felids can be categorized into three primary morphotypes, discernible in numerous skeletal traits, with the shape of their upper canines serving as the most defining characteristic [15]. Felines can be categorized into three morphotypes based on their upper canine structure:

1. **Conical-toothed cats** have short, round, unserrated canines.
2. **Scimitar-toothed cats** are identified by their broad, short canines with coarse serrations.
3. **Dirk-toothed cats** feature long, slender canines with fine serrations.

These types often inhabit the same environments but use different hunting strategies. Saber-toothed cats generally focused on large prey, likely targeting different animals. Scimitar-toothed cats, being long-limbed, likely pursued

their prey, whereas dirk-toothed cats, with shorter limbs, probably employed ambush tactics [15].

The inter canine distance as measured on cast is 11.80-18.24mm with mean value of 16.05 and standard deviation of 2.34 [6].

Dental Features of Bear Bite

The bear family (ursidae), poses different dental features from both canidae and felidae but their arch and dentition is more likely to the cat family. The Anterior portion of maxillary arch is slightly curved and the mandibular arch is very straight [16]. Bears have distinctive dentition reflecting their carnivorous diet, unlike most omnivorous ursids. Their small carnassial teeth lack advanced shearing adaptations, and smaller post-carnassial teeth indicate less reliance on grinding. Large canines are crucial for penetrating meat and for male competition during mating. Males have larger, more robust canines than females, showcasing sexual dimorphism, and tend to have longer molar rows as well [16].

Table 1: Comparative Characteristic features of Human bitemark, Dog bitemark, cat bitemark and bear bitemark [6 9 14 15 16].

CHARACTERISTIC FEATURES	HUMAN BITEMARK	DOG BITEMARK	CAT BITEMARK	BEAR BITEMARK
DENTAL ARCH SHAPE	ELLIPTICAL OR OVAL	CIRCULAR TO OVAL	CIRCULAR	TAPERED
DENTAL FORMULA	I2/2 C1/1 PM 2/2 M 3/3	I3/3 C1/1 P4/4 M2/3	I 3/3 C 1/1 PM 3/2 M 1/1	I3/3 C1/1 P4/4 M2/3
INCISOR MORPHOLODY	RECTANGULAR	ROUND TO OVAL	CIRCULAR (SMALL SIZE)	TRAPEZOIDAL
CANINE MORPHOLOGY	TRAINGULAR OR TRAPEZOIDAL	ROUND TO OVAL	CIRCULAR (LARGE SIZE)	TRIANGULAR
INTERCANINE DISTANCE	22-40mm	32-50mm	11.80-18.24mm	----------
TOOTH NUMBERING SYSTEM	FDI	Modified Triadan Numbering System	Modified Triadan Numbering System	Modified Triadan Numbering System
NO. OF TEETH	DECIDUOUS-20 PERMANENT-32	DECIDUOUS-28 PERMANENT-42	DECIDUOUS-26 PERMANENT-30	DECIDUOUS- PERMANENT-42

Cases

Case 1: The 'Nirbhaya' Case- Delhi Gang Rape 2013 (New Delhi)

On January 1, 2013, Delhi police Sought forensic odontology help from Dharwad to analyze bitemarks on the 'Nirbhaya' case victim. The next day, A Vasant Vihar Police Sub-inspector flew to SDM College of Dental Sciences & Hospital, delivering bitemark photos and dental models of five adult male suspects. Such marks, pivotal in sexual assault cases, can resemble the teeth that made them, like unique fingerprints [17].

The victim had 5-6 distinct bitemarks, analyzed against the dental records of five suspects using advanced 2D digital methods, after a thorough five-day investigation, a detailed report concluded two suspects' dental impressions matched several bitemarks [17].

Dr. Ashith Acharya was the chief Forensic Odontologist to investigate the bitemark analysis of this case. On May 6, 2013, Dr. Ashith Acharya, testified at Saket Court in New Delhi as an expert witness, facing rigorous cross-examination by defense lawyers. The Judge accepted his testimony and report, crucial in convicting two of the accused. The analysis was upheld by the Supreme Court of India on 5th of May, 2017 [17].

Case 2: The 'Ted Bundy' Case (Florida)

In one notable case involving bitemarks, Ted Bundy, the infamous serial killer, stands out. Dr. Richard Souviron, a forensic dentist, was summoned to examine evidence from a victim discovered at the Chi Omega Sorority House in Tallahassee, Florida, in January 1978. The evidence consisting of tissue from the breast and buttocks stored in fluid without retaining rings presented challenges due to its deteriorated state. Despite these limitations, Dr. Souviron identified that the perpetrator had misaligned teeth, a detail crucial in establishing probable cause for obtaining a search warrant. This

warrant facilitated the collection of dental impressions, bite records, and photographs of Ted Bundy's teeth, which become pivotal forensic evidence in the case [18].

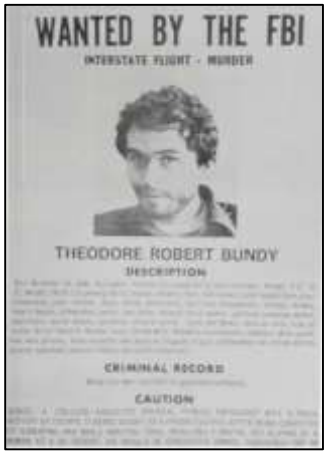

Figure 2: Ted Bundy "Wanted Poster'' [18].

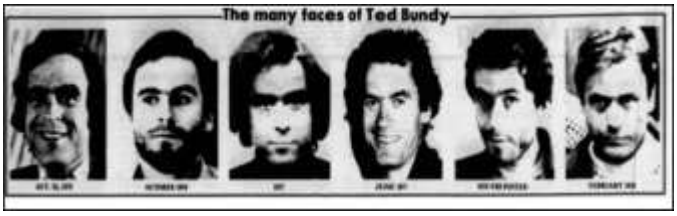

Figure 3: Various Makeover faces of Ted Bundy (Fort Myers News-Press) [18]

Figure 4: A Glimpse of Dr. Richard Souviron presenting evidence at Ted Bundy's appeal trial in Tallahassee, Florida [19]

Additionally, Dr. Lowell Levine and Dr. Norman Sperber independently examined the evidence and concluded that the bitemarks definitively linked Ted Bundy to the crime. Dr. Souviron then presented key slides to the grand jury and testified at the trial. Ted Bundy was convicted on seven counts and sentenced to death [18].

Case 3: A 7 Year Old Girl Dragged By Pet Pitbull (New Delhi)

A case in New Delhi, A girl playing outside her house on Friday evening was attacked and dragged by a pet dog but rescued by neighbors. She was taken to the nearby hospital where her condition got stable, according to the police. They reviewed the CCTV footage to clarify the sequence of events [20].

The dog owner, Shivanand Bhaskar, faces charges under Indian Penal Code sections 289 and 337 for negligence and causing harm [20].

Case 4: The Extensor Pollicis Longus Rupture (Epl) Case By Cat Bite

There's a case study done already, A 43-year-old woman who suffered a rare extensor pollicis longus tendon rupture after being bitten by her pet cat, marking the first reported occurrence of this type of injury. Animal bites, particularly from cats can lead to severe complications including tendon and bone damage. In this case, despite an initial absence of infection signs, the patient underwent successful EPL reconstruction using extensor indicis proprius (EIP) technique. Early treatment was needed to avoid lasting disability [21].

Figure 5: Pre-operative pictures of the cat bite mark [21]

Source: https://www.cureus.com/articles/162211-extensor-pollicis-longus-tendon-rupture-following-a-cat-bite-a-case-report-and-review-of-literature#!/

Case 5: A 4-Year Old Endures Extensive Surgery Following Vicious Attack By Neighbour's Dog

A 4-year-old girl in Dehradun underwent a three-hour surgery after being attacked by a neighbor's German shepherd while heading to a shop with her mother and sister. Her father filed a police complaint following the incident. The family is now focused on her recovery. Her father said the unleashed dog bit her face without warning. Fortunately, her mother intervened and pulled the dog away before it was taken inside by its owner. The girl was rushed to the hospital and underwent a three-hour surgery for her injuries. The father raised concerns about the dog's history of attacks, highlighting its danger. After the incident, the family had daily hospital visits for 15 days, and treatment will continue for six months, as the girl is still deeply affected [22].

Moreover, Sub-inspector Baldeep Singh confirmed charges have been filed against the dog owners. In a separate incident, a viral video captured a German shepherd attacking a girl in a Ghaziabad housing society while she rode her tricycle, even though it was on a leash[22].CCTV footage showed the owner struggling to control the aggressive dog while the girl's mother intervened, pushing it away and asking a security guard for help. In response, the family filed an FIR against the owner at Nangram police station[22].

Case 6: Extraordinary Bear Attack Resulting In Extensive Tissue Loss

A 53-year-old man underwent left eye enucleation following a bear attack in the jungle. He presented with significant hemorrhaging, a dislocated jaw, and multiple nasal fractures. Both eyelids were extensively damaged, yet the globe remained intact. The eyelids were embedded in the nasal fracture, and upon careful removal, no soft tissue loss was evident [23].

Figure 6a: Loss of outer structures of the left eyeball [23]

Figure 6b: Shows the loss of tissue and no sign of it anywhere [23]

Various techniques are utilized for extensive tissue loss, including tubed pedicle flaps and interpolation flaps. An interpolation flap is a two-stage procedure where the flap's base is not adjacent to the recipient site, suitable for cases with inadequate tissue or mobility for primary closure. These flaps, like transposition flaps, traverse normal skin to reach the defect [23].

Figure 7: Final Repair of The Lid and Other Structures (Post- Operative Picture)[23]

With increasing human encroachment into bear habitats, encounters are on the rise. Bear bites often result in postoperative infections; however, this patient exhibited no infections, and the wound healed appropriately. Unfortunately, he was lost to follow-up [23].

Conclusion

Bite marks represent a critical yet controversial facet of forensic odontology, capable of implicating suspects or

exonerating the innocent. When subjected to meticulous analysis, they offer a reliable and cost-effective means of identification. However, variables such as dermal elasticity and anatomical positioning can complicate forensic assessment. Animal dentitions exhibit variations from human dentition based on dietary adaptations, enabling bite mark analysis to identify the source. Comparative evaluation of bite marks involves parameters such as dental width, rotation, interproximal spacing, Tooth morphology, arch morphology, tooth anatomy, No. of teeth, alignment and many more. These unique impressions on victims serve as crucial identifiers. The increasing incidence of animal and human bite injuries requires detailed forensic analysis by odontologists. Emphasis should be on unique morphometric patterns and distinctive traits. Such evaluations are crucial for various forensic specialists. Recent advancements in forensic techniques aim to improve analytical precision and reduce error rates in bite mark identification. Whereas future advancements may utilize scanning electron microscopy (SEM) and 3D imaging techniques to enhance the comparative analysis of bite mark impressions and dental morphology.

References

1. Shamim T. Forensic odontology. J Coll Physicians Surg Pak. 2012 Apr 1;22(4):240-5.
2. Verma AK, Kumar S, Bhattacharya S. Identification of a person with the help of bite mark analysis. Journal of oral biology and craniofacial research. 2013 May 1;3(2):88-91.
3. Saxena S, Sharma P, Gupta N. Experimental studies of forensic odontology to aid in the identification process. Journal of forensic dental sciences. 2010 Jul;2(2):69.
4. Sauerwein K, Butler JM, Reed C, Reczek KK. A NIST Scientific Foundation Review. 2023
5. Sirakova MA, Debelle G. Identifying human bite marks in children. Paediatrics and Child Health. 2014 Dec 1;24(12):550-6.
6. Johnson A, Pandey A, Parikh PV. A comparative study on human and domestic animal bitemark patterns: An aid in forensic investigation. Indian Journal of Veterinary Research (The). 2018;27(2):1-6.
7. Rao DS, Ali IM, Annigeri RG. Bitemarks-A review. Journal of Dental Research and Review. 2016 Jan 1;3(1):31-5.
8. Vale GL, Noguchi TT. Anatomical distribution of human bite marks in a series of 67 cases. Journal of forensic sciences. 1983 Jan 1;28(1):61-9.
9. Shebah C, Sheethal A, Harshita BR, Preethi P, Prasanna RK. A review on bite marks in forensic dentistry. Austin J Dent. 2022;9(1):1167.
10. Fonseca GM, Mora E, Lucena J, Cantin M. Forensic studies of dog attacks on humans: a focus on bite mark analysis. Research and Reports in Forensic Medical Science. 2015 Oct 12:39-51.
11. Van Valkenburgh B. Carnivore dental adaptations and diet: a study of trophic diversity within guilds. In Carnivore behavior, ecology, and evolution 1989 (pp. 410-436). Boston, MA: Springer US.
12. Kashyap B, Anand S, Reddy S, Sahukar SB, Supriya N, Pasupuleti S. Comparison of the bite mark pattern and intercanine distance between humans and dogs. Journal of forensic dental sciences. 2015 Sep 1;7(3):175-9.
13. Bombieri G, Penteriani V, Almasieh K, Ambarlı H, Ashrafzadeh MR, Das CS, Dharaiya N, Hoogesteijn R, Hoogesteijn A, Ikanda D, Jędrzejewski W. A worldwide perspective on large carnivore attacks on humans. PLoS biology. 2023 Jan 31;21(1):e3001946.

14. Bellani GG. Felines of the world: discoveries in taxonomic classification and history. Academic Press; 2019 Sep 19.
15. Martin Larry D. Functional morphology and the evolution of cats. Nebraska Academy of Sciences;1980.
16. Loch C, Hemm L, Taylor B, Visser IN, Wiig Ø. Microstructure, elemental composition and mechanical properties of enamel and dentine in the polar bear Ursus maritimus. Archives of Oral Biology. 2022 Feb 1;134:105318.
17. Kattimani BF TNN. Nirbhaya Case: Dharwad College Helped with Forensic Analysis. The Times of India; 2013.
18. Terranova N. Impacts of a serial killer: Looking at the case of Ted Bundy then and now.
19. Mark Foley. Dr. Richard Souviron presents evidence at Ted Bundy's appeal trial - Tallahassee, Florida. Floridamemory.com. Mark Foley collection; Collection number N2006-6. Available from: https://www.floridamemory.com/items/show/133904;1987; [cited 2024 Jul 12].
20. Online ET. Seven-year-old girl dragged by pet pitbull in Delhi, dog owner booked under IPC charges [Internet]. Economic Times. 2024 [cited 2024 Jul 12]. Available from: https:// economictimes.indiatimes.com/news/new-updates/seven-year-old-girl-dragged-by-pet-pitbull-in-delhi-dog-owner-booked-under-ipc-charges/articleshow/108154645.cms
21. Singh S, Adamji S, Badge R. Extensor Pollicis Longus Tendon Rupture Following a Cat Bite: A Case Report and Review of Literature. Cureus. 2023 Aug;15(8).
22. Online ET. After vicious attack by neighbour's dog, 4-year-old undergoes three-hour surgery [Internet]. Economic Times. 2024 [cited 2024 Jul 12]. Available from: https:// economictimes.indiatimes.com/news/india/after-vicious-attack-by-neighbours-dog-4-year-old-undergoes-three-hour-surgery/articleshow/109748643.cms?from=mdr
23. Jethani J, Nagori R, Ghodadara B. An unusual case of bear bite with severe loss of tissue. Indian journal of ophthalmology. 2006 Oct 1;54(4):287-8.