

Chapter 4

Injury Assessment, Documentation, and Interpretation

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1. INTRODUCTION

The ability to appropriately assess, document, and interpret injuries that have been sustained is a key part of the work of any forensic physician or forensic pathologist. Crimes of violence are increasing throughout the world. Nonjudicial assault, such as torture, has also become more widely recognized (1). It has been suggested that the definition of physical injury in the forensic medical context should be “damage to any part of the body due to the deliberate or accidental application of mechanical or other traumatic agent” (2). This chapter specifically addresses the issues of physical assault and the assessment and documentation of wounds or injury.

The purpose of assessment and documentation is to assist in establishing how a wound or injury is caused, which may often be at issue in courts or tribunals of law. These two skills should be within the remit of any doctor, although they are rarely done fully and appropriately. The interpretation of the causes of wounds and injuries is probably best undertaken by those with forensic expertise, because there may be many factors involved in such interpretation. Because interpretation of wounds and injuries may be undertaken by review of documents, for example written descriptions, body chart mapping, or photographs, it is imperative that the descriptions are comprehensible to all. For

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example, the term *wound* has specific meaning in certain jurisdictions, for example relating to whether the skin or mucosa is completely breached. It is more appropriate for those who are documenting injuries to ensure that they have documented them in detail and unambiguously so that the courts can then make the decision regarding the most appropriate judicial interpretation of the injury or injuries described and their relevance to the case.

In many cases, the initial examination and assessment may have been undertaken for purely therapeutic purposes, and the forensic significance of the injuries may not become apparent until several weeks or months later. Scrutiny of the doctor's notes at a later stage, possibly in court, may reveal serious deficiencies, which not only bring discredit on the individual practitioner and the profession as a whole but also can seriously prejudice the legal proceedings. Pediatricians and emergency medicine specialists are typical of those nonforensic practitioners who may encounter patients with injuries that may be contentious within court proceedings.

2. ASSESSMENT AND DOCUMENTATION

Assessment and interpretation of injury depends on establishing a good history and undertaking an appropriate physical examination and recording the findings contemporaneously, clearly, and unambiguously. Such documentation (whether notes, body charts, or computer records) may be reviewed by other doctors, legal advisers, and the courts. Consent for the examination and for subsequent production of a medical report should be sought from the individual being examined. It should also be remembered that vexatious or frivolous accusations of assault can be made, and the examiner should be aware that false allegations and counter allegations do occur, which may only become obvious at a later date.

2.1. Key Factors

Table 1 identifies key factors that may be relevant in the examination of anyone with injuries and that, if relevant, should be determined when the history is taken from the injured person.

It is important to document the time at which the injury was said to have occurred. Injuries heal, and thus the appearance of an injury after assault is time dependent. Assaults may not be reported for days or weeks after the incident. There may be several injuries from different incidents. Specific times should be sought for each. If more than one type of assault has occurred, clear records must be made of which injury was accounted for by which implement. Document the handedness (left, right, or both) of both the victim and

Table 1
Potential Relevant Factors to Determine From History

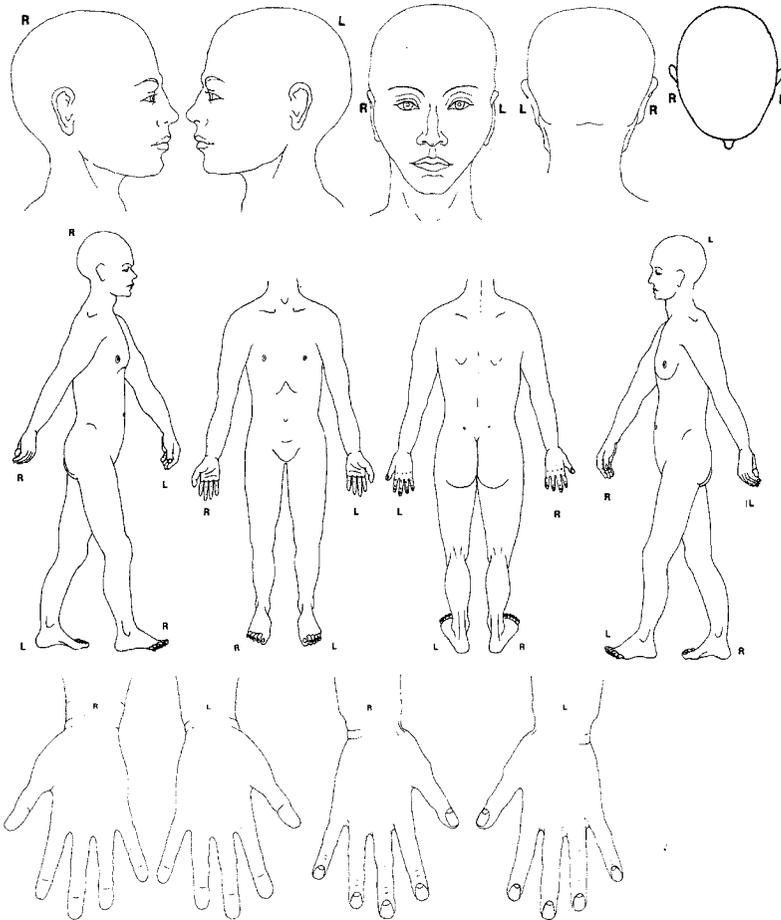
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- How was the injury sustained?
 - Weapon or weapons used (is it [are they] still available?)
 - What time was the injury sustained?
 - Has the injury been treated?
 - Pre-existing illnesses (e.g., skin disease).
 - Regular physical activity (e.g., contact sports).
 - Regular medication (e.g., anticoagulants, steroids).
 - Handedness of victim and suspect.
 - Use of drugs and alcohol.
 - Clothing worn.
-

Table 2
Potential Relevant Information Required When Assessing Injury

-
- | | |
|---|--|
| <ul style="list-style-type: none"> • Location
(anatomical—measure distance from landmarks) • Pain • Tenderness • Stiffness • Causation • Handedness | <ul style="list-style-type: none"> • Type (e.g., bruise, cut, or abrasion) • Size (use metric values) • Shape • Color • Orientation • Age • Time • Transientness (of injury) |
|---|--|
-

the assailant, if known, because this may affect the interpretation of injury causation. Witnesses may give different accounts of the incident; it is the forensic physician’s role to assist the court in determining the true account. These accounts may also be influenced by the effect of drugs and/or alcohol, and it is appropriate to assess the influence that these may have in each case. Knowledge of the type of weapon used can be important when assessing injury because particular implements can give identifiable injuries. The type of clothing worn (e.g., long-sleeved shirts or armless vests) should be noted. When examining any individual for injury, all these features should at least be considered to see whether they may have relevance to the case; others may become relevant as the examination progresses or as other accounts of any assault are given.

Documentation of injuries can be in several formats, including hand-drawn notes, annotated pro forma diagrams, and photographic. [Figure 1](#) illustrates one form of body chart and note system (3). [Table 2](#) lists the characteristics of each injury that may be needed for appropriate documentation.



No other injuries observed or complained of

Specimens taken

.../1-

.../2-

.../3-

.../4-

.../5-

.../6-

.../7-

.../8-

.../9-

Handed to:

At time:

I consent to a full examination and/or taking of samples and am aware that formal reports/statements may be prepared from these notes for police and court purposes, and I consent to such reports/statements being made:

Name

Witness (name and signature)

Signed

.....

ADDITIONAL COMMENTS:

Fig. 1. Body chart and note system.

Table 3
Classification of Injuries

• Wheals and erythema (reddening)	• Bruises (contusion or ecchymosis)
• Hematoma	• Petechiae
• Abrasions (grazes)	• Scratches
• Scuff/brush abrasions	• Point abrasion
• Lacerations	• Incisions
• Slash	• Chop
• Stab wounds	• Firearms
	• Bites

Digital images have now become an appropriate way of documenting injury, and the digital image evidence should be supported by contemporaneous written and hand-drawn notes. Ensure at the time of examination that each injury is accounted for by the account given. If an injury is not consistent with the account given, question it at the time. In many cases, individuals who have been involved in fights or violent incidents are simply unaware of the causation of many sites of injury. It may be appropriate (particularly with blunt injury) to reexamine injuries 24–48 hours later to see how injuries evolve and whether bruises have appeared or other sites of injury noted. Pretreatment and posttreatment examination and photography may be useful.

2.2. Types of Injury

It is important that anyone who is involved in injury assessment understand the range of terms that can be applied to different injury, and this may depend on certain factors, such as country of origin or medical specialty. Thus, each practitioner should have a system of his or her own that ensures that the nature of each injury is described clearly, reproducibly, and unambiguously in note form, using accepted terms of classification. The most common reason why medical evidence on injuries given in court is contentious is the confusing assortment of terms used by doctors and the inappropriate or inaccurate description of a wound, for example, using the term *laceration* to describe a clean-cut wound caused by a bladed weapon, such as a knife, when the wound was, in fact, an incision (4). It is therefore essential that for medicolegal purposes a standard nomenclature be adopted when describing injuries. The following classification is one that is appropriate and clear, and most visible injuries will fall into one of the groups listed in Table 3. These injuries type are explained in the following paragraphs.

Deliberate injury may be divided into two main types: blunt impact or blunt force injury and sharp implement injury. Blunt force injury describes the cause of injuries not caused by instruments or objects with cutting edges. The injury may be caused by traction, torsion, or shear stresses. The body may move toward the blunt object (e.g., a fall or push against a wall), or the blunt object may move towards the body. Examples of objects that cause blunt impact injuries include fists, feet, baseball bats, and police batons. A blunt force blow can cause a range of symptoms or signs, and the resultant injuries depend on numerous factors, including force, location, and impacting surface, which range from no visible evidence of injury to tenderness or pain at the impact sites, reddening, swelling, bruising, abrasions, cuts (lacerations), and broken bones. Each injury type may be present alone or in combination. Such injuries are seen at the point of contact of the impacting object on the body. Bruises may migrate from the point of contact by gravity after a period of time. Abrasions give a clear indication of the impact site. In some cases, injury patterns may indicate whether a particular impacting object was involved. Blunt impact injuries can be described in terms of force applied as being weak, weak/moderate, moderate, moderate/severe, or severe.

Sharp injuries are those caused by any implement with cutting edges (e.g., knives, scissors, or glass). The injuries may be of varied types, including incised, where the cutting edge runs tangentially to the skin surface cutting through skin and deeper anatomical structures, or stab, where the sharp edge penetrates the skin into deeper structures. An incised wound is generally longer than it is deep, whereas a stab wound is generally deeper than it is wide. Forces required to cause sharp injuries and the effect of such injuries are variable because a sharp pointed object may penetrate vital structures with minimal force. Special types of cutting injuries included slash- or chop-type injuries from weapons such as machetes.

Many impacts may cause initial pain and discomfort, which resolves within a few minutes, and tenderness, which may still be elicited hours or days later, with no visible sign of injury. The lay person must be aware that the absence of visible injury does not imply that no assault or injury has occurred.

Wheals and erythema are also nonpermanent evidence of trauma caused by initial vasodilatation and local release of vasoactive peptides after an injury, such as a slap, scratch, or punch, which will leave no mark after a few hours. The classic features of the triple reaction are present, but no specific damage is done to any tissues. Thus, an initial reddening associated with pain with possible subsequent development of local swelling may be present initially, but after a few hours has completely resolved, unlike bruising, which will still be present after 24 hours or more.

2.3. Size and Shape of the Injury

Even though the size of an injury is perhaps the easiest measurement to ascertain, it is probably the most common omission from medical records. It should be ascertained using a ruler or a pair of calipers and recorded in centimeters or millimeters. Because measurements given in imperial units may be easier for some individuals to understand, it is also acceptable to include the equivalent size of an injury in inches. The shape of the wound should also be noted; simple terms, such as circular, triangular, V-shaped, or crescent-shaped, best express this characteristic, but if the wound shape is irregular or complex, then it is possibly easier to record this feature on a body chart. Wounds may also have depth, but it is often not possible to determine this accurately in the living.

2.4. Position of the Injury

The best method of pinpointing the location of an injury is to use fixed anatomical landmarks. On the head, one can use the eyes, ears, nose, and mouth; on the neck, the prominence of the thyroid cartilage and the sternocleidomastoid muscles can be used; and on the trunk, the nipples, umbilicus, and bony prominences can be used as points of reference. The advantages of using simple anatomical diagrams and body charts for locating the injury are self-evident. It is a simple process to record the position of an injury accurately, yet when medical records are reviewed, it is both surprising and disappointing to find only a vague indication of location.

2.5. Aging Injuries

Allotting a specific time or time frame to the infliction of an injury is one of the most frequently requested and most contentious of issues in forensic medicine. Injuries inflicted shortly before examination (both of the living and the dead) show no sign of healing. The healing process depends on several variables, including the site of injury, the force applied, the severity of tissue damage, infection, treatment, etc., and these all make assessment of the age of a wound extremely difficult and inaccurate. Bruises often become more prominent a few hours or even days after infliction because of diffusion of blood closer to the skin surface; on occasion, a recent deep bruise may be mistaken for an older, more superficial lesion. Bruises resolve over a variable period ranging from days to weeks; the larger the bruise, the longer it will take to disappear. The colors of a bruise can include (dependent on the examiner) blue, mauve, purple, brown, green, and yellow, and all tints and hues associated with these. Many bruises exhibit multiple colors. The only sub-

stantial study that looks at bruise evolution by color showed that a bruise with a yellow color was more than 18 hours old and that red, blue, and purple/black could occur anytime within 1 hour of bruising to resolution (up to 21 days in the study) (5). Thus, coloration of bruises and the progress and change of color patterns cannot, with the exception of a yellow bruise, which may be considered to be more than 18 hours old, be used to time the injury. It should be emphasized that estimation of bruise age from color photographs is also imprecise and should not be relied on because the color values are not accurate (6). This has recently been confirmed in another study (7) that identified great interobserver variability in color matching both in vivo and in photographic reproductions. Other specific information (e.g., a witnessed blow) is the only way of reliably timing a bruise.

Abrasions sustained during life are usually red-brown and exude serum and blood, which hardens to form a scab. This scab organizes over a period of days before detaching to leave a pink, usually intact, surface.

In the absence of medical intervention, lacerations tend to heal with scarring, usually over a period of days or weeks, whereas incisions, the edges of which may be apposed, can heal within a few days, although some may scar significantly.

2.6. Transient Lesions

Swelling, redness, and tenderness, although frequently caused by trauma, are not specific signs of injury. Although it is important to record whether these features are present, it must be remembered that there also may be nontraumatic causes for these lesions (e.g., eczema/dermatitis or impetigo).

Red marks outlining an apparent injury, for example, the imprint of a hand on the slapped face or buttock of a child, should be photographed immediately because such images may fade within an hour or so and leave no residual marks.

3. TYPES OF INJURY

3.1. Bruises

The terms *contusion* and *ecchymosis* have been used to differentiate between different types of injury that can more simplistically be called bruising. These terms have been used variously to describe different injury sizes but do not enhance understanding of either causation or mechanism of injury and should no longer be used. A hematoma is best used to refer to a collection of blood forming a fluctuant mass under the skin and may be associated with substantial trauma. The difference between that and a standard bruise is that a hematoma may be capable of being aspirated in the same way a collection of

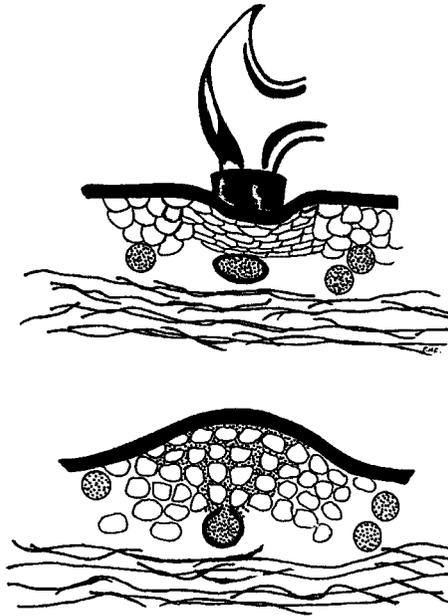


Fig. 2. Production of bruising.

pus is aspirated. Bruising is caused when an impact damages blood vessels so that blood leaks into the perivascular tissues and is evident on the skin surface as discoloration. Such discoloration changes in color, shape, and location as the blood pigment is broken down and resorbed. In some cases, although blood vessels may be damaged, there may be no visible evidence on the skin. In certain cases, it may take hours or days for any bruise to become apparent because the blood diffuses through damaged tissue. The blunt force ruptures small blood vessels beneath the intact skin, and blood then escapes to infiltrate the surrounding subcutaneous tissues under the pumping action of the heart (*see Fig. 2*). Thus, theoretically at least, bruising is not produced after death. In fact, severe blows inflicted after death may cause some degree of bruising, although this is usually only slight. Bruises may be associated with other visible evidence of injury, such as abrasions and lacerations, and these lesions may obscure the underlying bruise.

Bruising may need to be differentiated from purpura, which develop spontaneously in those with a hemorrhagic tendency and in the elderly and tend to be rather blotchy, are less regular in outline, and are usually confined to the forearms and lower legs. Bruises vary in severity according to the site and nature of the tissue struck, even when the force of the impact is the same.

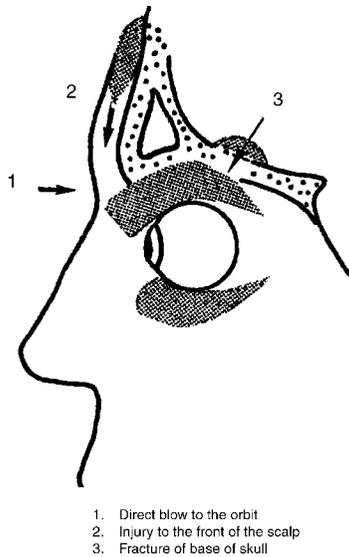


Fig. 3. Production of a black eye. (1) Direct blow to the orbit. (2) Injury to the front of the scalp. (3) Fracture of base of skull.

Where there is an underlying bony surface and the tissues are lax, as in the facial area, a relatively light blow may produce considerable puffy bruising. The orbit is the most vulnerable, giving rise to the common “black eye.” However, remember that there are other mechanisms for the production of a black eye, such as an injury to the front of the scalp draining down over the supraorbital ridge or a fracture of the base of the skull allowing blood to escape through the roof of the orbit (*see Fig. 3*).

Bruises can enlarge over a variable period of time, which can be misleading regarding the actual site of injury. Because a bruise is a simple mechanical permeation of the tissues by blood, its extension may be affected by movement and gravity. Thus, bruising of the face can result from an injury to the scalp. Further difficulties arise if a bruise, as it extends, tracks along tissue planes from an invisible to a visible location. Bruising of this kind may not become apparent externally for some time and then some distance from the site of the original impact. This delay in the appearance of bruising is of considerable significance because absence of apparent injury at an initial examination is not necessarily inconsistent with bruising becoming apparent 24–48 hours later. Thus, in cases of serious assault, it is often advisable to conduct a further examination a day or so later.

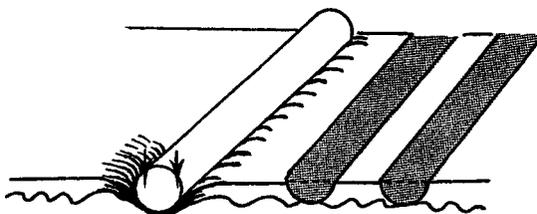


Fig. 4. Tramline bruising caused by a blow from a rod-like implement.

Generally, bruises, unless superficial and intradermal, tend to be nonspecific injuries, and it is usually not possible to offer any detailed opinions on the agent responsible. However, some bruises may have a pattern (a patterned bruise), or because of their shape or size or location, may have particular significance. Common patterning types include petechial bruising reproducing the texture of clothing, the ridge pattern from the sole of a shoe or tire, or the streaky linear purple bruising seen on the neck, wrists, or ankles caused by the application of a ligature. Beating with a rod-like implement often leaves a patterned bruise consisting of an area of central pallor outlined by two narrow parallel bands of bruising, so-called tramline bruising (*see Fig. 4*).

Other bruises of particular medicolegal significance are the small circular or oval bruises, usually approx 1–2 cm in diameter, characteristic of fingertip pressure from either gripping or grasping with the hand, prodding with the fingers, or the firm impact of a knuckle. They may be seen on the limbs in cases of child abuse when the child is forcibly gripped by the arms or legs and shaken or on the abdomen when the victim is poked, prodded, or punched. However, such nonaccidental injuries must be differentiated from bruises seen on toddlers and children associated with normal activities, play, or sports. Bruises may be seen on the neck in cases of manual strangulation and are then usually associated with other signs of asphyxia.

When sexual assault is alleged, the presence of bruising on the victim may help support the victim's account and give an indication of the degree of violence that was used. For example, grip marks or "defense" injuries may be present on the upper arms and forearms, whereas bruising on the thighs and the inner sides of the knees may occur as the victim's legs are forcibly pulled apart. Bruising of the mouth and lips can be caused when an assailant places a hand over the face to keep the victim quiet. Love bites ("hickeys") may be present often in the form of discrete areas of ovoid petechial bruising on the neck and breasts. However, it is important to recognize that the latter may be the sequelae of consensual sexual encounters.

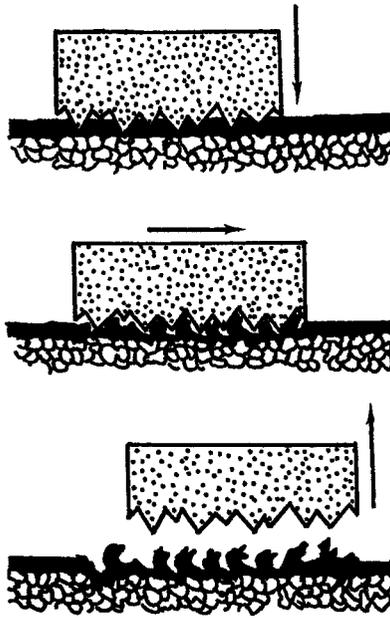


Fig. 5. Production of an abrasion.

3.2. Abrasions

An abrasion (or a graze) is a superficial injury involving only the outer layers of the skin and not penetrating the full thickness of the epidermis. Abrasions exude serum, which progressively hardens to form a scab, but they may also bleed because occasionally they are deep enough to breach the vascular papillae that corrugate the undersurface of the epidermis in which case frank bleeding may be present at an early stage. More superficial abrasions that barely damage the skin with little or no exudation of serum (and thus little or no scab formation) may be termed *brush* or *scuff* abrasions. Scratches are linear abrasions typically caused by fingernails across the surface of the skin. Pointed but noncutting objects may also cause linear abrasions and to differentiate them from fingernail scratches may be termed “point abrasions.”

Abrasions often result from movement of the skin surface over a rough surface or vice versa (see Fig. 5). Thus they may have a linear appearance, and close examination may show ruffling of the superficial epidermis to one end, indicating the direction of travel of the opposing surface. Thus, a tangential blow could be horizontal or vertical, or it may be possible to infer that the victim had been dragged over a rough surface.

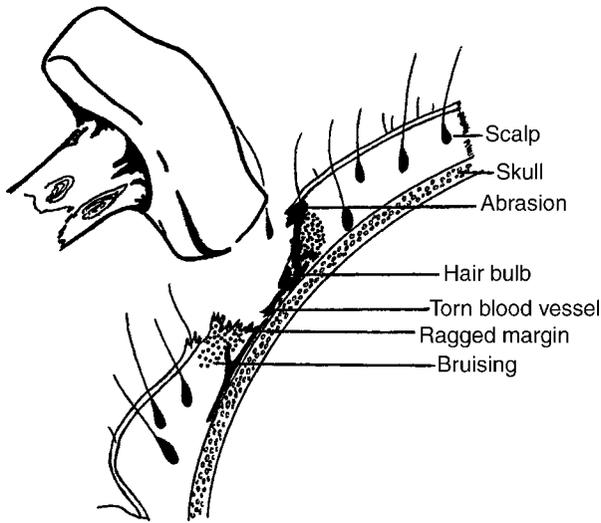


Fig. 6. Laceration of the scalp.

The patterning of abrasions is clearer than that of bruises because abrasions frequently take a fairly detailed impression of the shape of the object causing them and, once inflicted, do not extend or gravitate; therefore, they indicate precisely the area of application of force. In manual strangulation, small, crescent-shaped abrasions caused by the fingernails of the victim or assailant may be the only signs visible on the neck. A victim resisting a sexual or other attack may claw at her assailant and leave linear parallel abrasions on the assailant's face. Some abrasions may be contaminated with foreign material, such as dirt or glass, which may have important medicolegal significance. Such material should be carefully preserved for subsequent forensic analysis. In such cases, consultation with a forensic scientist can ensure the best means of evidence collection and preservation.

3.3. Lacerations

Lacerations are caused by blunt force splitting the full thickness of the skin (see Fig. 6) most frequently when the skin and soft tissues are crushed between impacting force and underlying bone. Boxers classically develop lacerations when a boxing glove presses on the orbital rim. As with abrasions, the injury site is indicative of the impact site. Lacerations can bleed profusely, particularly on face and scalp. When inflicted deliberately, the force may cause the assailant and weapon to be contaminated with blood.

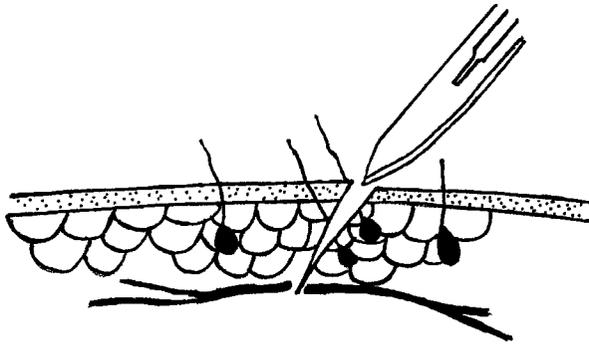


Fig. 7. Cross-section of an incision.

Lacerations have characteristic features but often mimic incised wounds (or vice-versa), particularly where the skin is closely applied to underlying bone, for example, the scalp. Close examination of the margins of the wound, which are usually slightly inverted, normally resolves the issue. Lacerations are ragged wounds caused by crushing and tearing of the skin. They tend to gape open, and their margins are often bruised and abraded. Blood vessels, nerves, and delicate tissue bridges may be exposed in the depth of the wound, which may be soiled by grit, paint fragments, or glass.

The shape of the laceration may give some indication regarding to the agent responsible. For example, blows to the scalp with the circular head of a hammer or the spherical knob of a poker tend to cause crescent-shaped lacerations. A weapon with a square or rectangular face, such as the butt of an axe, may cause a laceration with a Y-shaped split at its corners.

3.4. Incisions

These wounds are caused by sharp cutting implements, usually bladed weapons, such as knives and razors, but sharp slivers of glass, the sharp edges of tin cans, and sharp tools, such as chisels, may also cause clean-cut incised injuries. Axes, choppers, and other similar instruments, although capable of cutting, usually cause lacerations because the injury caused by the size of the instrument (e.g., axe head) overrides the cutting effect of the tool. Mixed wounds are common, with some incised element, some laceration, bruising, and swelling and abrasion also present. Each element of the injury must be documented. Machetes and other large-blade implements are being used, producing large deep cuts known as slash or chop injuries.

The features of an incision contrast with those of a laceration (*see Fig. 7*). The margins tend to be straight, unbruised, unabraded, and not inverted. They

gape, and the deeper tissues are all cut cleanly in the same plane. Hemorrhage tends to be greater than from similarly located lacerations. If the blade of the weapon is drawn across the skin while it is lax, it may cause a notched wound if the skin creases. The direction of travel of the blade of the weapon is not always easy to decide, but usually the deeper part of the wound is near the end that was inflicted first, the weapon tending to be drawn away toward the end of the wound.

The head and neck are usual targets when an assailant inflicts incised wounds. In an attempt to ward off the assailant, the arms are often raised in a protective gesture and incisions are then often seen on the ulnar borders of the forearms. If the blade of the weapon is grasped, then incised wounds are apparent on the palmar surfaces of the fingers. Such injuries are known as *defense wounds*.

Incised wounds may be a feature of suicide or attempted suicide (*see* Subheading 3.6.). They are usually located on the wrists, forearms, or neck, although other accessible areas on the front of the body may be chosen. The incisions usually take the form of multiple parallel wounds, most of them being tentative and superficial; some may be little more than simple linear abrasions.

3.5. Stab Wounds

Stab wounds are caused by sharp or pointed implements and wounds with a depth greater than their width or length. They are usually caused by knives but can also be inflicted with screwdrivers, pokers, scissors, etc. Although the external injury may not appear to be particularly serious, damage to vital structures, such as the heart, liver, or major blood vessels, can lead to considerable morbidity and death, usually from hemorrhage. In those individuals who survive, it is common for little information to be present about the forensic description of the wound because the priority of resuscitation may mean that no record is made. If operative intervention is undertaken, the forensic significance of a wound may be obliterated by suturing it or using the wound as the entry for an exploratory operation. In such cases, it is appropriate to attempt to get a forensic physician to assess the wound in theatre or subsequently.

Stab wounds are rarely accidental and occasionally suicidal, but usually their infliction is a result of criminal intent. In the case of suicide, the wounds are usually located on the front of the chest or upper abdomen and, as with self-inflicted incisions, may be associated with several superficial tentative puncture wounds (*see* Subheading 3.6.). When deliberately inflicted by an assailant, stab wounds may be associated with defense injuries to the arms and hands.

The appearance of the skin wound will vary depending on the weapon used and can easily be distorted by movement of the surrounding skin. Typi-

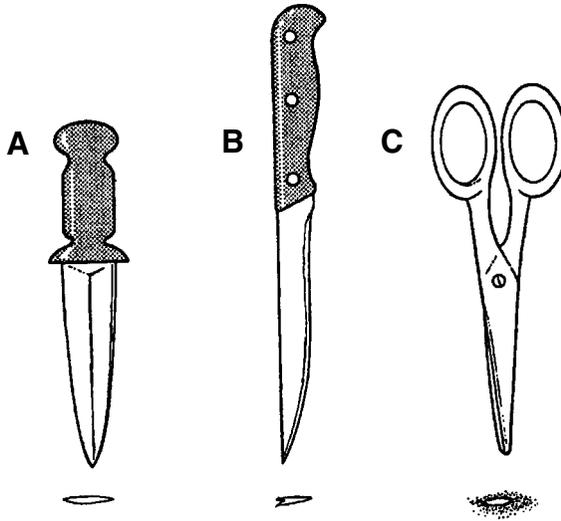


Fig. 8. Elliptical (A), fish-tailed (B), and bruised ovoid (C) stab wounds.

cally, when inflicted with a knife, the wound is usually elliptical because the natural elasticity of the skin causes its length to shrink. If the blade is double-edged, such as that of a dagger, the extremities of the wound tend to be equally pointed. A stab wound from a single-edged blade, such as a kitchen knife, will usually have one extremity rounded, squared-off, or fish-tailed (caused by the noncutting back of the blade). When blunt weapons are used—a pair of scissors, for example—the wound tends to be more rounded or oval, with bruising of its margins (*see Fig. 8*). Scissor wounds can sometimes have a cross-shape caused by the blade screws or rivets. Notched wounds are often caused by the blade of the weapon being partially withdrawn and then reintroduced into the wound or twisted during penetration.

It is rarely possible from an inspection of the skin wound alone to comment usefully on the width of the blade because the skin retracts and the knife is unlikely to have been introduced and removed perfectly perpendicularly. Surprisingly, long skin wounds may be caused with quite narrow-width blades.

3.6. Deliberate Self-Harm

Deliberate self-harm refers to any attempt by an individual to harm himself or herself. When assessing injuries, it is important to understand which factors may indicate the possibility that an injury was caused by deliberate

Table 4
Indicators of Possible Deliberate Self-Harm Injuries

-
- Must be on an area of body accessible to the person to injure themselves.
 - Superficial or minor.
 - Regular with an equal depth at the beginning and end (for cuts).
 - Regular and similar in style or shape (for scratches, burns, etc.).
 - Multiple.
 - Parallel or grouped together.
 - In right-handed persons, the injuries are predominantly on the left side (and the converse for left-handed individuals).
 - There may be lesser injuries where initial attempts at self-harm are made (tentative scars).
 - There may be old scars of previous self-harm.
 - There may be a psychiatric history.
-

From ref. 2.

self-harm. Individuals injure themselves for numerous reasons, including psychiatric illness and others, such as attempting to imply events took place that did not or for motives of gain. Self-inflicted injuries have several characteristics, which are not diagnostic but that together may give an indication of self-infliction. Table 4 lists features that may assist in the recognition or suspicion that cuts or other injury, such as scratches, are self-inflicted—all or some may be present—their absence does not preclude self-infliction nor does their presence necessarily imply self-infliction (2).

4. FIREARM INJURIES

The examination of fatal firearm injuries should be left to an experienced forensic pathologist; however, it is not unusual in cases of nonfatal injuries for a hospital clinician or forensic physician to be asked to comment on the nature of the wound or wounds (8). As with all injuries within the forensic setting it is essential in these nonfatal cases that the initial appearances of the injuries be accurately described and the wounds photographed. This is particularly important because subsequent surgical treatment may distort or completely obliterate the wound characteristics. Furthermore, any fragments, bullets, or pellets found within the wounds must be carefully removed and handed over to the appropriate authorities.

There are two main types of firearm: smooth bore and rifled. Injuries occurring from both are discussed in the following subheadings.

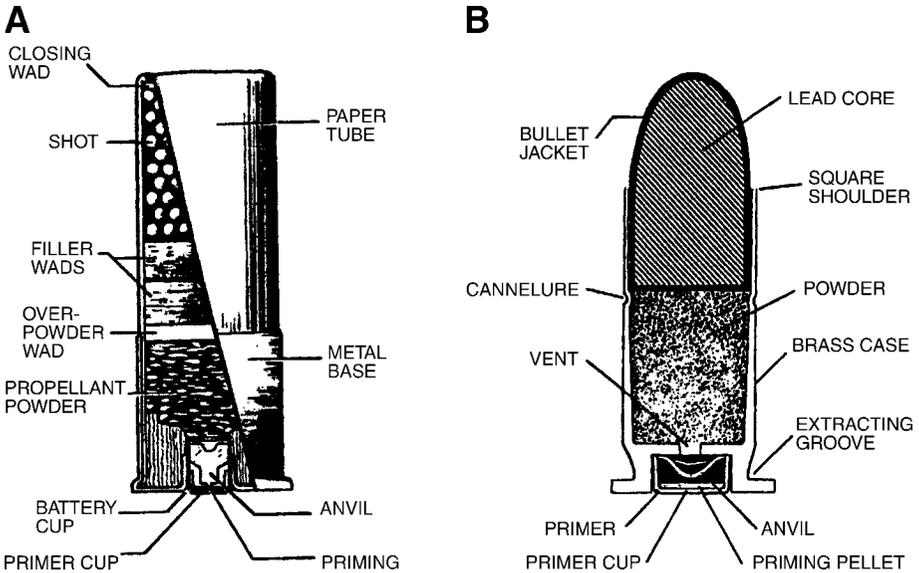


Fig. 9. Components of a shotgun cartridge (A) and a rifled bullet (B).

4.1. Smooth-Bore Weapons

Shotguns, which fire a large number of small projectiles, such as lead shot, are the most common type of smooth-bore weapons. They are commonly used in sporting and agricultural activities and may be either single or double-barreled. The ammunition for these weapons consists of a plastic or cardboard cartridge case with a brass base containing a percussion cap. Inside the main part of the cartridge is a layer of propellant, plastic, felt, or cardboard wads and a mass of pellets (lead shot of variable size) (see Fig. 9A). In addition to the pellets, the wads and/or cards may contribute to the appearance of the wounds and may be important in estimating range and possible direction.

4.2. Rifled Weapons

Rifled weapons are characterized by having parallel spiral projecting ridges (or lands) extending down the interior of the barrel from the breach to the muzzle. This rifling causes the projectile, in this case a bullet (see Fig. 9B), to spin as it is ejected from the weapon and thus impart gyroscopic stability along its flight path. The rifling also leaves characteristic scratches and rifling marks that are unique to that weapon on the bullet surface. There are three common types of rifled weapons: the revolver, the pistol, and the rifle. The

revolver, which tends to have a low muzzle velocity of 150 m/s, is a short-barreled weapon with its ammunition held in a metal drum, which rotates each time the trigger is released. The spent cartridge case is retained within the cylinder after firing. In the self-loading pistol, often called “semi-automatic” or erroneously “automatic,” the ammunition is held in a metal clip-type magazine under the breach. Each time the trigger is pulled, the bullet in the breach is fired, the spent cartridge case is ejected from the weapon, and a spring mechanism pushes up the next live bullet into the breach ready to be fired. The muzzle velocity of pistols varies between 300 and 360 m/s. The rifle is a long-barreled shoulder weapon capable of firing bullets with velocities up to 1500 m/s. Most military rifles are “automatic,” allowing the weapon to continue to fire while the trigger is depressed until the magazine is empty; thus, they are capable of discharging multiple rounds within seconds.

4.3. Shotgun Wounds

When a shotgun is discharged, the lead shot emerges from the muzzle as a solid mass and then progressively diverges in a cone shape as the distance from the weapon increases. The pellets are often accompanied by particles of unburned powder, flame, smoke, gases, wads, and cards, which may all affect the appearance of the entrance wound and are dependent on the range of fire. Both the estimated range and the site of the wound are crucial factors in determining whether the wound could have been self-inflicted.

If the wound has been sustained through clothing, then important residues may be found on the clothing if it is submitted for forensic examination. It is absolutely essential that the advice of the forensic science team and crime scene investigator is sought when retrieving such evidence. When clothing is being cut off in the hospital, staff should avoid cutting through any apparent holes.

Contact wounds are caused when the muzzle of the weapon is held against the skin. The entrance wound is usually a fairly neat circular hole, the margins of which may be bruised or abraded resulting from impact with the muzzle. In the case of a double-barreled weapon, the circular abraded imprint of the nonfiring muzzle may be clearly seen adjacent to the contact wound. The wound margins and the tissues within the base of the wound are usually blackened by smoke and may show signs of burning owing to the effect of flame. Because the gases from the discharge are forced into the wound, there may be subsidiary lacerations at the wound margin, giving it a stellate-like shape. This is seen particularly where the muzzle contact against the skin is tight and the skin is closely applied to underlying bone, such as in the scalp. Carbon monoxide contained within the gases may cause the surrounding skin and soft

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tissues to turn pink resulting from the formation of carboxyhemoglobin. Contact wounds to the head are particularly severe, usually with bursting ruptures of the scalp and face, multiple explosive fractures of the skull, and extrusion or partial extrusion of the underlying brain. Most contact wounds of the head are suicidal in nature, with the temple, mouth, and underchin being the sites of election. In these types of wounds, which are usually rapidly fatal, fragments of scalp, skull, and brain tissue may be dispersed over a wide area.

At close, noncontact range with the muzzle up to about 15 cm (6 in) from the skin, the entrance wound is still usually a single circular or oval hole with possible burning and blackening of its margins from flame, smoke, and unburned powder. Blackening resulting from smoke is rarely seen beyond approx 20 cm; tattooing from powder usually only extends to approx 1 m. The wads and cards rarely travel more than approx 2 m.

As distance increases, the pellets begin to diverge. Up to approx 1 m they are still traveling as a compact mass, but between approx 1–3 m, the pellets start to scatter and cause variable numbers of individual satellite puncture wounds surrounding a larger central hole. At ranges greater than 8–10 m, there is no large central hole, only multiple small puncture wounds, giving the skin a peppered appearance.

Exit wounds are unusual with shotgun injuries because the shot is usually dispersed in the tissues. However, the pellets may penetrate the neck or a limb and, in close-range wounds to the head, the whole cranium may be disrupted.

4.4. Rifled Weapon Wounds

Intact bullets penetrating the skin orthogonally, that is, nose-on, usually cause neat round holes approx 3–10 mm in diameter. Close examination reveals that the wound margin is usually fairly smooth and regular and bordered by an even zone of creamy pink or pinkish red abrasion. A nonorthogonal nose-on strike is associated with an eccentric abrasion collar, widest at the side of the wound from which the bullet was directed (*see Fig. 10*). Atypical entrance wounds are a feature of contact or near contact wounds to the head where the thick bone subjacent to the skin resists the entry of gases, which accumulate beneath the skin and cause subsidiary lacerations to the wound margins, imparting a stellate lacerated appearance. Contact wounds elsewhere may be bordered by the imprint of the muzzle and the abraded margin possibly charred and parchmented by flame. Punctate discharge abrasion and sooty soiling are usually absent from the skin surface, but the subcutaneous tissues within the depth of the wound are usually soiled. The effects of flame are rarely seen beyond 10 cm (4 in), with sooty soiling extending to approx 20 cm (8 in).

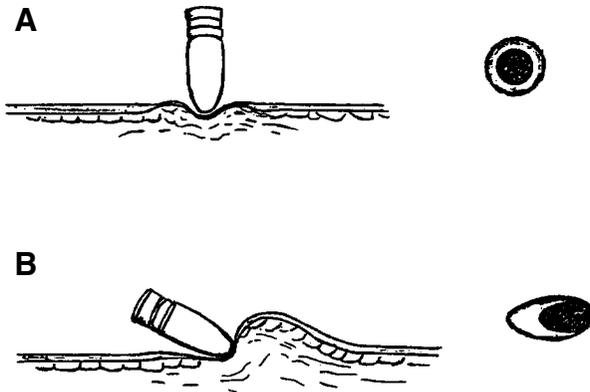


Fig. 10. Entrance wounds caused by perpendicular (A) and tangential (B) bullet strikes.

Punctate discharge abrasions, which may be particularly heavy with old revolver ammunition, are often present at ranges up to approx 50 cm (20 in). It is important to remember that sooty soiling of the skin surrounding a wound is easily removed by vigorous cleaning carried out by medical or nursing staff. The soiling of contact close-range entrance wounds may be absent if clothing or other material is interposed between the skin surface and the muzzle of the weapon.

Bullet exit wounds tend to be larger than entrance wounds and usually consist of irregular lacerations or lacerated holes with everted, unabraded, and unbruised margins. When the skin at the site of an entrance wound has been supported by tight clothing, eversion of the margins of the wound may be absent and the margins may even be abraded, albeit somewhat irregularly, but nevertheless making differentiation from entrance wounds more difficult.

Entrance wounds caused by damaged or fragmented bullets may be so atypical that it may not be possible to offer a useful opinion as to their nature. It is inappropriate to offer an opinion on the caliber of a bullet based on the size of an entrance wound, and it is not possible to state whether the bullet was fired from a revolver, pistol, or rifle by only the appearance of the wound.

5. DEFENSE INJURIES

Certain types of injuries may be described as defense injuries. These injuries typically are seen when an individual has tried to defend himself or herself against an attack and are the result of instinctive reactions to assault. Some

individuals, for example, the very young and the very old, are less capable of offering much defense against the perpetrators of assault. When attacked with blunt objects, most individuals will attempt to protect their eyes, head, and neck by raising their arms, flexing their elbows, and covering their head and neck. As a result, the exposed surfaces of the arms become the impact point for blows. Thus, the extensor surface of the forearms (the ulnar side), the lateral/posterior aspects of the upper arm, and the dorsum of the hands may receive blows. Similarly, the outer and posterior aspects of lower limbs and back may be injured when an individual curls into a ball, with flexion of spine, knees, and hips to protect the anterior part of the body.

In sharp-blade attacks, the natural reaction is to try and disarm the attacker, often by grabbing the knife blade. This results in cuts to the palm and ulnar aspect of the hand. Occasionally, the hands or arms may be raised to protect the body against the stabbing motion, resulting in stab wounds to the defense areas.

In blunt-force attacks, the injuries sustained usually take the form of bruises if the victim is being punched or kicked, but there may also be abrasions and/or lacerations depending on the nature of the weapon used. If the victim is lying on the ground while being assaulted, he or she will tend to curl up into a fetal position to protect the face and the front of the trunk, particularly from kicks. In these circumstances, defensive bruising is likely to be seen on other surfaces of the trunk and limbs.

The absence of defense injuries in persons otherwise apparently capable of defending themselves against an assault may be particularly significant if it is believed that other injuries found on the victim could have been self-inflicted or if it is believed that they were incapacitated through alcohol, drugs, or other injury.

6. TORTURE

The World Medical Association's Declaration of Tokyo in 1975 defined torture as "the deliberate, systematic or wanton infliction of physical or mental suffering by one or more persons acting alone or on the orders of any authority, to force another person to yield information, to make a confession, or for any other reason" (9). The declaration also established guidelines for doctors when faced with cases of suspected torture. Clinicians view torture in two main contexts: first, torture that is perpetrated by criminals and terrorist organizations, and second, torture that is carried out, or allegedly carried out, by the police or other security force personnel during the detention and interrogation of prisoners and suspects. Nonjudicial justice is now meted out worldwide in several ways.

Criminal groups and paramilitary organizations may torture their captives for numerous reasons. It may be to extract information from an opposing gang or faction, to discipline informants and others engaged in unsanctioned criminal activity, or simply to instill fear and division within a community. The methods used are crude and barbaric. The victim is usually bound, blindfolded, and gagged, and the wrists and ankles may bear the pale streaky linear bruises and abrasions caused by ligatures. "Beating up" is typical, with extensive bruises and abrasions scattered on the head, trunk, and limbs. Black eyes, fractures of the nose and jaws, and dislodgment of the teeth are all fairly typical. Cigarette burns, usually seen as discrete circular areas of reddish-yellow, parchmented skin, are also quite common. Patterned injuries resulting from being struck with the butt of a gun or tramline bruising owing to blows with a truncheon or baseball bat may be seen; in Northern Ireland, shooting through the lower limbs ("knee-capping") is a favored method of punishment by paramilitary organizations.

Systematic torture by security personnel, usually during interrogation of suspects, ranges from the subtle use of threats and intimidation to physical violence. Hooding, prolonged standing, and the use of high-pitched sound have all been used, as have attempts to disorientate prisoners by offering food at erratic times, frequent waking up after short intervals of sleep, and burning a light in the cell 24 hours a day. Physical abuse includes beating of the soles of the feet, so-called *falanga*, which, although extremely painful and debilitating, does not usually cause any significant bruising. Repeated dipping of the victim's head under water, known as *submarining*, may prove fatal if prolonged, as can the induction of partial asphyxia by enveloping the head in a plastic bag.

Electric torture is well documented and carries the risk of local electric shocks and fatal electrocution. *Telefono*, as it is known in Latin America, consists of repeated slapping of the sides of the head by the open palms, resulting in tympanic membrane rupture.

Doctors who have access to prisoners in custody have a heavy responsibility to ensure that they are properly treated during detention and interrogation. In all cases of suspected or alleged ill-treatment of prisoners, it is essential that the doctor carry out a methodical and detailed "head-to-toe" examination. All injuries and marks must be accurately recorded and photographed, and the appropriate authorities must be informed immediately. Increasingly, forensic physicians are involved in assessments of refugees and asylum seekers to establish whether accounts of torture (both physical and psychological) are true. This role is likely to expand in the future, and the principles of independent assessment, documentation, and interpretation are, as with other

areas discussed, vital in ensuring that courts and tribunals have the appropriate information to allow fair judgments to be reached (1).

7. BITE MARK INJURIES

7.1. Introduction

The term *bite mark* has been described as “a mark caused by the teeth alone, or teeth in combination with other mouth parts” (10).

Biting is a dynamic process, and bite marks are complex injuries. Recognition, recording, analysis, and interpretation of these injuries are the most intriguing challenges in forensic dentistry. Biting can establish that there has been contact between two people—the teeth being used for offense or defense. When individual tooth characteristics and traits are present in the dentition of the biter and are recorded in the biting injury, the forensic significance of the bite mark is greatly increased. Early involvement of the forensically trained dentist, with experience in biting injuries, is essential to ensure that all dental evidence from both the victim and any potential suspect(s) is appropriately collected, preserved, and evaluated. There may be insufficient evidence to enable comparisons to be made with the biting edges of the teeth of any particular person, but, if the injury can be identified as a human bite mark, it may still be significant to the investigation. It is important that the forensic dentist discusses with investigators the evidential value of the bite mark to enable resources to be wisely used. Clearly, conclusions and opinions expressed by the forensic dentist often lead him or her into the role of the expert witness subject to rigorous examination in court.

The forensic physician will mostly be involved with biting injuries to human skin and any secondary consequences, including infection and disease transmission, but should be aware that bites in foodstuffs and other materials may be present at a crime scene and be easily overlooked. It is essential that a human bite can be distinguished from an animal bite, thus exonerating (or incriminating) the dog or cat next door. The following sections will consider issues surrounding bites to human skin caused by another human. Early recognition of a patterned injury (suspected of being caused by biting) by medical personnel, social services, and other investigating agencies is extremely important; the injury may be the only physical evidence and must not be lost. Ideally, the forensic dentist should be contacted sooner rather than later when a possible biting injury is discovered to ensure that all evidence is collected appropriately. All too often the dentist is brought in at a later date, when there has been incorrect recording of the bite mark and the injury is partly healed and distorted or fully healed and no longer visible. Reliance may then have to be placed on ultraviolet photography to demonstrate the “lost” injury (11).

Bites can be found on the victim or the assailant (living, deceased, child, or adult). It is well known that biting is often a feature in nonaccidental injury to children (*see* Chapter 5). We must all beware of the so-called “amorous” bite and self-inflicted bite. If a bite mark is found on an anatomical site that is accessible to the victim, it becomes necessary to exclude him or her from the investigation.

7.2. Bite Mark Information

7.2.1. Initial Considerations

1. Is it a biting injury?
2. Is it human?
3. What should I do?

If the answer to the first question is “don’t know,” “possibly,” or “yes,” then request the assistance of the forensic dentist. Ensure that swabs are taken from the injured site (with controls) and photographs should be taken. Make sure that you know which forensic dentists are available in your area; this will prevent delays and frustration. You will need to know whether your local forensic dentist has experience and training in bite mark-analysis or whether he or she focuses mainly on identifications.

The forensic dentist will examine the suspected biting injury and consider the following:

- Whether the injury is oval or round.
- Whether the injury has central sparing or discoloration from suction or nipping between teeth.
- Whether the mark is made by two dental arches. However, note that a mark from only one arch does not mean that it is not a biting injury.
- Are marks made by individual teeth within the dental arch clearly visible?
- If so, is detail of that individual tooth visible? Characteristics, such as tooth size, shape, displacement, rotations, wear facets, etc. will be considered. Individual tooth absences from the arch will be noted.
- Is there sufficient detail for comparisons to be made with the biting edges of the teeth of any particular person or persons?
- Does the appearance of the injury fit the alleged time frame of the incident?

7.2.2. Differential Diagnosis

It is important to remember that other injuries can mimic bite marks. The following have all been queried as biting injuries:

- Dermatological conditions.
- Marks made by electroencephalogram electrodes.
- Heel marks.

- Patterned door knobs.
- Burns.

7.2.3. *Range of Bite Mark Appearance*

- Erythema.
- Laceration.
- Bruising.
- Avulsion of tissue.
- Abrasion.

In a single bite mark, one or any combination of several or all of these components may be present, and they may be discrete or superimposed. Furthermore, scrape marks made by tooth movement over the skin may be present. However, the complex situation may become even more complicated when there are multiple bite marks at a single location where they may overlap as a result of the biter trying to get a better “grip;” all this leads to interpretation difficulties.

7.2.4. *Helpful Information From Bitten Person (When Possible)*

- When were they bitten?
- How many bites were there?
- What was the victim’s position?
- What was the assailant’s position?
- Has the injury been washed?
- Was the victim clothed over the bitten area?
- Did the victim bite the assailant?

In attempting to get answers to these questions, a clearer picture of the incident may develop.

7.2.5. *Anatomical Distribution of Bitten Sites*

It can be seen from the anatomical distribution of the bite marks studied by the author (see Fig. 11) that no part of the body is spared. This graph does not distinguish between male and female, child or adult, or whether there were multiple bites to one person, but serves purely to illustrate that it is essential for medical personnel to thoroughly examine the body for biting injuries and carefully document the findings. Record the anatomical location and nature of the injury and its size, shape, and color. However, photographic documentation is essential for bite mark analysis. In many cases, there are multiple bite marks on the body, some that the victim may not be aware of or recall. Multiple bite marks on the body, produced by the same perpetrator, may vary

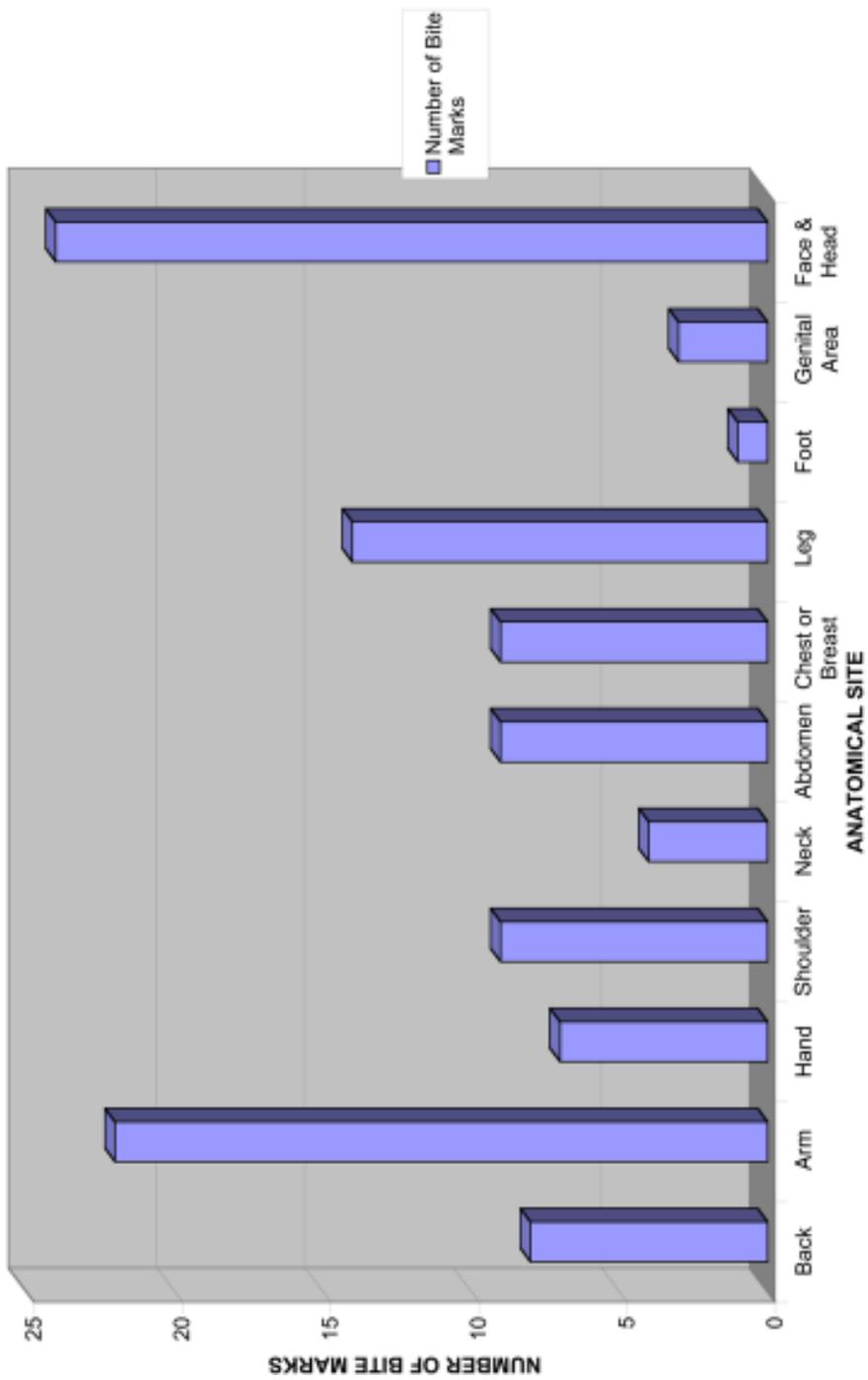


Fig. 11 . Anatomical distribution of last 110 bite marks studied by the author (Hinchliffe).

considerably in appearance depending on several factors; these include the site bitten, number of teeth involved, thickness of the skin, elasticity of the skin, force involved, relative movement between biter and victim, etc.. In short, do not jump to the conclusion that there are multiple biters or vice-versa. Nor should it be assumed that a small biting injury has been caused by a child; it may be an incomplete adult bite. Where bruising is diffuse or confluent, size is not always easy to determine. If the marks on the skin can be identified as being made by the smaller deciduous (baby) teeth, it would suggest the mark has been inflicted by a young child. It is widely appreciated that it is easy to miss bruising on dark skins.

7.3. Evidence Collection

As soon as it has been established that the injury has been caused by biting, the injury should be photographed and swabbed for saliva. In addition, it may be necessary to take an impression of the injured site to preserve any possible indentations. Clearly, the taking of forensic samples is not always possible when the injured party needs urgent medical attention. Often, the forensic dentist is provided with photographs taken some time after the incident date and after medical intervention (*see* Fig. 12); by this time dental evidence has been lost, but it may still be possible to identify the injury as a possible biting injury.

7.3.1. Saliva

Saliva is deposited on the skin (and clothing, if present) during biting and sucking. The quantity and quality of this may enable DNA analysis after swabbing of the unwashed injury site. The double-swab technique is effective for this procedure (12). Please note that salivary DNA has been reported as having been recovered from the bitten breast of a young deceased woman found submerged in water (13). The saliva swabs (with controls) must be clearly and correctly labeled and stored appropriately (*see* Chapter 3).

Oral saliva samples will be needed from any potential suspect, and the victim of an assault if there is a possibility that the victim bit the assailant (or self-infliction is suspected).

7.3.2. Photography

Photographs should be taken when the bite mark is first discovered. It is essential for correct photographic procedures to be followed to minimize distortions. Police photographers experienced in crime scene and other injury photography may still find the assistance of the forensic dentist useful, because



Fig. 12. Photograph showing biting injury to right ear after medical intervention. © Northumbria Police. Used with permission.

complications arise from curved surfaces and the correct positioning of the camera and scales. The American Board of Forensic Odontology no. 2 scale, being small and “L” shaped, is very effective (14) and is now used by many police forces.

Skin is not the best impression material, and various papers and reports have shown the importance of photographing the victim in the same position as when bitten in an attempt to minimize distortion (15,16). However, this is not always possible. Changes in the injury with time (in both the living and the deceased) may mean that the injury pattern appears clearer after a day or two. There is no reliable way of knowing when an injury will reveal the most detail, and, therefore, repeat photography (e.g., every 24 hours for 3–5 days) can prove useful.

7.3.3. *Photograph Protocol*

- Anatomical location of bite mark (and identification of bitten person).
 - Victim in same position as when bitten (when possible).
 - Close up of bite mark without scales (nothing is being hidden) in color and black and white (in addition, black and white with a green filter may be useful).
 - Close up of bite mark with scales in color and black and white (in addition, black and white with a green filter may be useful). Scales should be close to injury but not so close as to obscure the injury.
- Note:** scales should be in the same plane as the bite mark.
- Photograph with the scales and injury parallel to the film plane (right angles to injury).
 - Each dental arch may need to be photographed separately when on a curved surface.
 - Repeat at intervals.
 - Consider ultraviolet photography for older injuries that may no longer be visible.

Ultimately, the forensic dentist will select the best photographs and have them reproduced to life-size (1:1) for analysis and comparison work. At the time of writing, conventional film photography is still widely used, but the use of digital photography is progressing rapidly. Whatever the future brings, it is essential that standards, protocols, and appropriate training are in place.

7.3.4. *Dental Impressions*

Dental impressions taken from the potential biter by the dentist (or appropriately qualified person) after a thorough dental examination will be cast into hard dental models. Dental impressions taken of an individual in custody are intimate samples and require the appropriate authority and consent for your jurisdiction. Transparent overlays of the biting edges of the



Fig. 13. Photograph showing bite mark on back, with scales. Individual tooth detail is visible. © Northumbria Police. Used with permission.

teeth from the dental models will be produced to facilitate physical comparisons. Currently, the best method for overlay production to achieve accuracy and reproducibility is the computer-generated method (17).

The importance of following the correct procedures for evidence documentation, collection, preservation, and storage with continuity of evidence cannot be overstressed.

7.4. Summary

The biting injury demonstrating plenty of detail (see Fig. 13) that has been carefully examined, recorded, analyzed, and interpreted can be useful to the justice system. It can establish contact between two people or, of equal importance, exclude an innocent party. *Early suspicion and recognition by personnel involved with the investigation, followed by prompt and appropri-*

ate action, will help maximize the opportunity to collect evidence. Awareness by all concerned and early referral to the forensically trained dentist with experience in this field promote teamwork and best practice.

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