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INTRODUCTION

Injuries from three main types of firearms are encountered by forensic pathologists: wounds caused by handguns, rifles, or shotguns. Other weapons, such as zip guns, are also rarely encountered.^{1,2} Handguns can be small, medium, or large caliber, with 0.22, 0.38, and 0.45 caliber handguns respective examples of the three types. While some authors recommend describing handguns and rifles with their exact velocity,³ for the purpose of basic review, rifles can be high-velocity/high-powered (eg, 30-06) or low-velocity/low-powered (eg, 0.22). Shotguns that are encountered are commonly 0.410 gauge, 12 gauge, and 20 gauge, and can shoot variable types of projectiles (eg, slugs, buckshot, and birdshot).

The overall evaluation for wounds sustained from each of the three types of weapons is similar, comprising radiography, external examination to (1) identify the wound itself, (2) distinguish entrance from exit, and (3) determine a relative range, and internal examination to identify the pathway of the projectile through the body, including direction of the projectile and organs injured. The interpretation of the pattern of the radiographic findings, the skin changes, and the injuries to the body allows the pathologist to identify the general weapon type, an entrance wound vs an exit wound, a relative range of fire, and the injuries caused. The term “relative range” is used in this chapter to indicate the general proximity of the weapon to the body (eg, contact or close) and not a specific range (eg, 6 inches or 2 feet). Interpretation of the overall pattern of autopsy findings in context with the scene investigation allows the pathologist to determine the cause and manner of death in individuals who have died as the result of a firearm injury.

As a component of the external examination, examination of the clothing and its collection for evidentiary purposes is performed and, as a component of the internal examination, the projectile and/or projectile fragments are recovered for evidentiary purposes.

CHECKLIST for Evaluation of a Firearm Injury (in addition to those for a general forensic autopsy)

- ☐ Radiographs of the body to identify projectiles and associated changes (eg, fractures, blood accumulation in body cavities).
 - ☐ If requested by investigators or per office policy, collection of gunshot residue kit.
 - ☐ Removal and examination of the clothing and retention as evidence when requested by investigators (or as per office policy).
 - ☐ Examine the wounds to determine entrance and exit and relative range of the firearm injury based upon skin and other changes.
 - ☐ Determine pathway of the projectile(s) through the body and identify the injuries caused.
 - ☐ Collect projectile(s) both within the body and outside the body (ie, within the clothing).
-

RADIOGRAPHY

BASICS OF RADIOGRAPHY IN FIREARM INJURIES

Radiographs of the body of a decedent with a firearm injury serve several useful purposes: (1) potential identification of the weapon type, sometimes with very specific correlation (eg, one form of 0.25 ACP (Automatic Colt Pistol) ammunition, a Winchester Expanding Point); (2) identification of the location of the projectile to aid in recovery; (3) identification of injuries and other findings associated with the firearm wound, such as fractures, air embolus, pneumothorax, or hemothorax (Figure 11.1); and (4) potential assistance as to determination of the pathway of the projectile. For small-caliber handguns (eg, 0.22 and 0.25) and for some forms of larger-caliber projectiles (eg, wadcutter and semi-wadcutter), the projectile

is often lead or lead with a copper gilding, with no separate copper jacket present. For larger-caliber weapons, the projectile most often consists of a lead core and a copper jacket. Copper and lead have two distinct appearances on a radiograph (Figure 11.2). Lead is more radio-dense than copper and thus will appear more white on a radiograph, whereas copper is less radio-dense than lead and will appear more transparent on a radiograph. If a copper jacket, specifically from the base of the projectile, is present, it should be recovered, as the copper jacket will have the rifling marks that will potentially allow a firearm examiner to match the projectile recovered from the body to the firearm that was used. If no copper jacket is present, then the lead or copper-gilded lead projectile will have the rifling marks.

SPECIFIC RADIOGRAPHIC FINDINGS ASSOCIATED WITH CERTAIN TYPES OF WEAPONS

Certain types of handgun/rifle ammunition and the three basic types of shotgun ammunition can each produce characteristic patterns on the radiograph. For shotguns, the three main types of ammunition are slugs, buckshot, and birdshot. A slug is one large projectile, which can fragment, and, on radiograph, will most characteristically have a C shape (Figure 11.3). Buckshot is large pellets, often present in multiples of three, with some newer ammunition having eight instead of nine pellets (Figure 11.4). Birdshot is smaller pellets than buckshot, with numerous tiny pellets present (Figure 11.5). High-powered rifles will most often produce a “lead snowstorm” pattern, with the projectile often partially breaking up into numerous tiny fragments but with a bulk of the projectile still usually contained within one fragment (Figure 11.6). Ratshot or snakeshot (essentially a small shotgun shell but fired by a handgun or rifle) will have numerous small pellets (Figure 11.7). A 0.25 ACP Winchester Expanding Point round will have a main projectile fragment, similar to a handgun or rifle projectile but also a single pellet (Figure 11.8). A Glaser round will have a main projectile fragment, which is a copper jacket, and numerous small pellets (Figure 11.9). Frangible projectiles will break up entirely or nearly entirely after entry into the body, with only those tiny fragments available for collection (Figures 11.10A-B and 11.10C-D). R.I.P. ammunition (Radically Invasive Projectile), termed a trocar round, manufactured by G2 Research and a Liberty Ammunition Civil Defense round each have a nose that breaks apart into several small fragments (Figure 11.11A and B), with each fragment becoming an independent projectile, and a base, which also continues to penetrate into the body.⁴



Figure 11.1. Radiograph of a decedent with a gunshot wound. The right pleural cavity is filled with blood (ie, a hemothorax) and the left pleural cavity is filled with air (ie, a pneumothorax), with both findings being caused by the gunshot wound. The trachea is deviated to the left side.

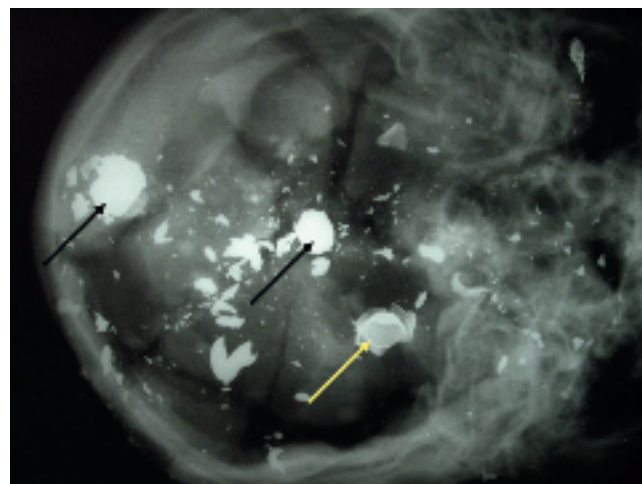


Figure 11.2. Radiograph of decedent with multiple gunshots. The lead core fragments (black arrows) are distinguishable from the copper jacket fragments (yellow arrow), with the copper jacket fragments being less radio-dense. Although all fragments of significant size should be recovered, it is most important to recover the copper jacket fragments as they will bear the rifling marks that will allow the firearm examiner to match the projectile(s) recovered from the body to the suspected weapon used. The fragment of most importance is the base of the projectile, as that is the fragment which will bear the rifling marks.

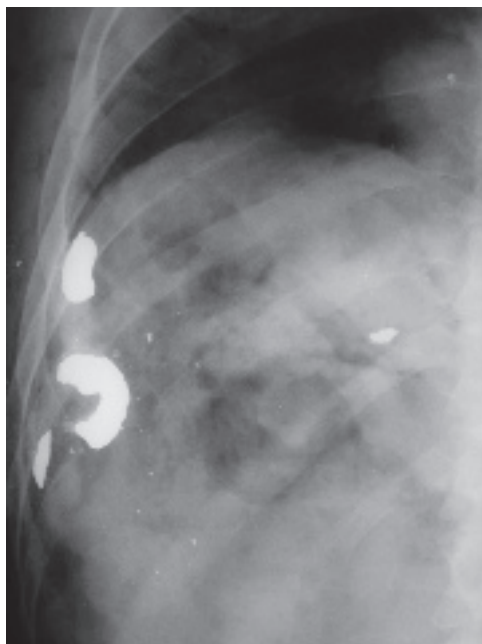


Figure 11.3. Radiograph of decedent shot with shotgun slug. A shotgun slug is fired as one large projectile, which can break into fragments while passing through the body. The most characteristic radiographic finding of a shotgun slug injury is a C-shaped fragment.



Figure 11.4. Radiograph of decedent shot with buckshot. Buckshot is similar to birdshot in that there are numerous pellets instead of a single projectile; however, the pellets are much larger and are often found in multiples of three, assuming that all fired pellets strike the decedent and can therefore all be identified at autopsy (ie, if any pellets in the group do not hit the decedent it would not be known exactly how many buckshot pellets were fired from the shell). Buckshot pellets vary from size 12, which is 0.24 inches each, to size 000, which is 0.36 inches each.

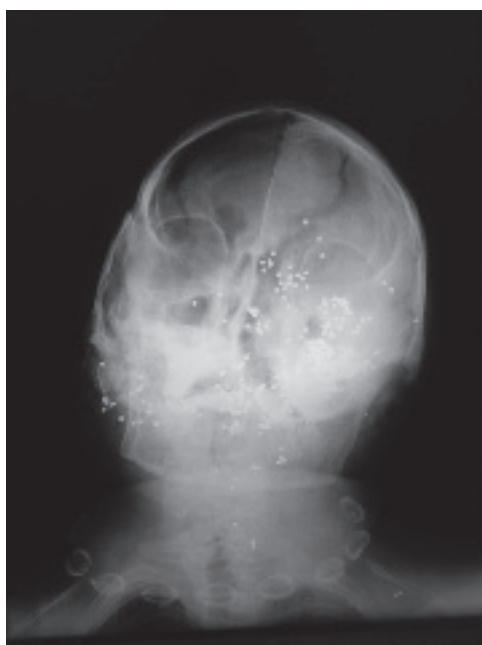


Figure 11.5. Radiograph of decedent shot with birdshot. The charge from the shotgun shell is composed of numerous tiny pellets, which range in size based upon the shotgun shell type. For birdshot, the pellets range from shot size 12, which is 0.05 inches each, to shot size BB, which is 0.180 inches each. Around 10 to 20 pellets should be recovered so that the ammunition type can be determined by the firearm examiner.



Figure 11.6. Radiograph of decedent shot with a high-powered rifle. With most high-powered rifle ammunition, a large fragment of the projectile with the base that has the rifling marks can be identified (although one is not visible in this radiograph); however, a lead snowstorm pattern is the characteristic feature of this weapon. The lead snowstorm pattern is created by a portion of the projectile breaking up into innumerable small fragments.

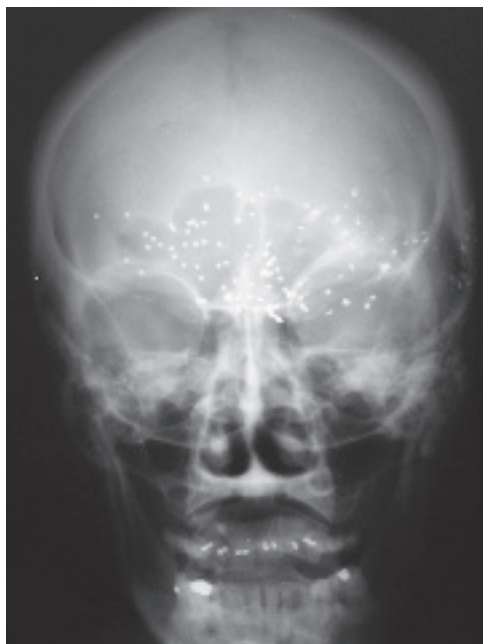


Figure 11.7. Radiograph of a decedent shot with snakeshot. Snakeshot or ratshot is a handgun or rifle type projectile filled with numerous tiny pellets, like a small shotgun shell. The appearance of the radiograph is similar to the radiograph of a decedent shot with birdshot from a shotgun; however, fewer pellets are present.



Figure 11.8. Radiograph of decedent shot with 0.25 ACP, Winchester Expanding Point ammunition. The projectile includes a lead core and a single large pellet. ACP, Automatic Colt Pistol.



Figure 11.9. Radiograph of a decedent shot with Glaser round. The projectile consists of a hollow copper jacket filled with numerous tiny pellets and capped with a blue plastic cap. While the copper jacket portion and the pellets are visible on radiograph, the blue plastic cap will not be visible. Its presence must be suspected by the general appearance of the radiograph and then searched for and hopefully identified during the autopsy.

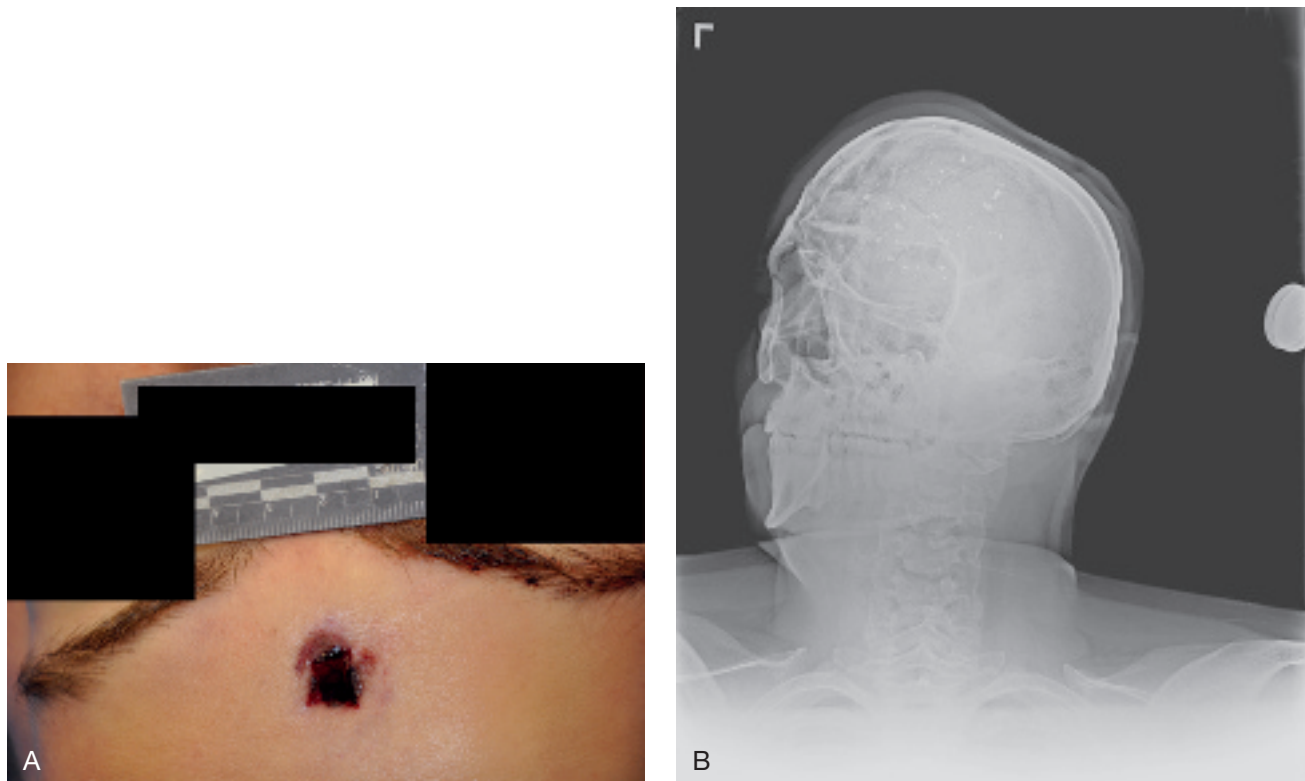


Figure 11.10A-B. Image and radiograph of a decedent shot with frangible ammunition. The decedent had a gunshot wound of the forehead (A). However, the frangible projectile fired from the 0.223 rifle completely broke up, leaving no fragment of significant size to recover (B). Encountering this form of ammunition can be disconcerting for the forensic pathologist, as the body will have an entrance wound and no exit wound, yet no large projectile fragment to recover. The numerous tiny fragments can be recovered as best as possible, but, with no base with rifling present to match to the suspected weapon, the evidentiary value is minimal.

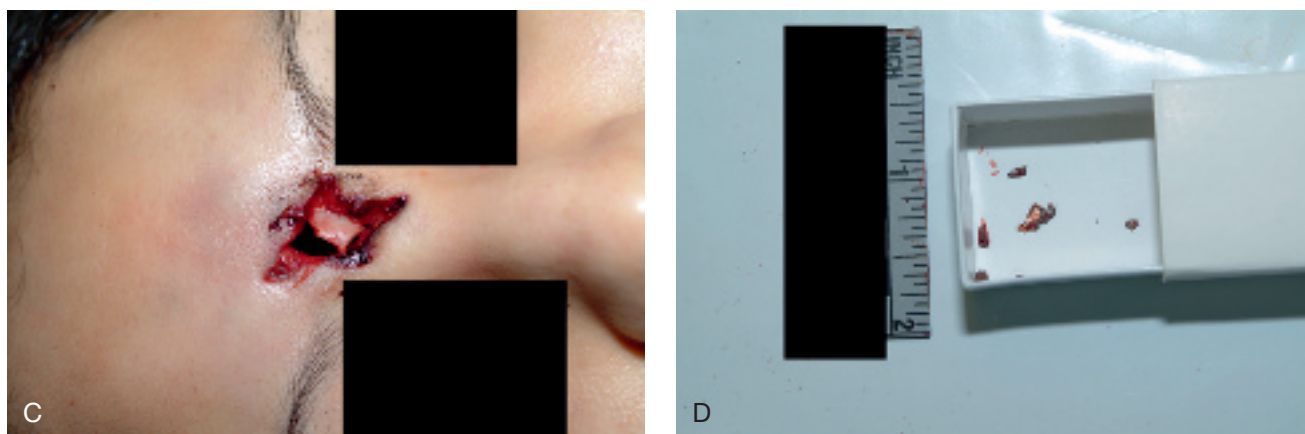


Figure 11.10C-D. Images of a decedent shot with frangible ammunition. The decedent had a gunshot wound of the forehead (C). (D) shows the fragments that were recovered during the autopsy, with no large fragment with rifling marks present.

FAQ: Should all decedents with a firearm injury have radiographs obtained?

Answer: Yes, radiographs can help identify the cause of the wound (ie, weapon type) and can help the pathologist locate the evidentiary material (ie, the projectile or projectile fragments). Even when an entrance wound and exit wound are both present, radiography should be performed, as important fragments of the projectile (eg, the copper jacket, if it has separated from the lead core, or a fragment of the copper jacket) may still remain in the body (Figure 11.12A and B). In addition to anterior-posterior radiographs, lateral radiographs can also be very useful in helping to pinpoint the location of the projectile in the body (Figure 11.13A and B). Also, in offices without access to a full-body radiography instrument, numerous radiographs can be printed and combined to produce an overall radiographic map of the body to help locate projectiles (Figure 11.14).

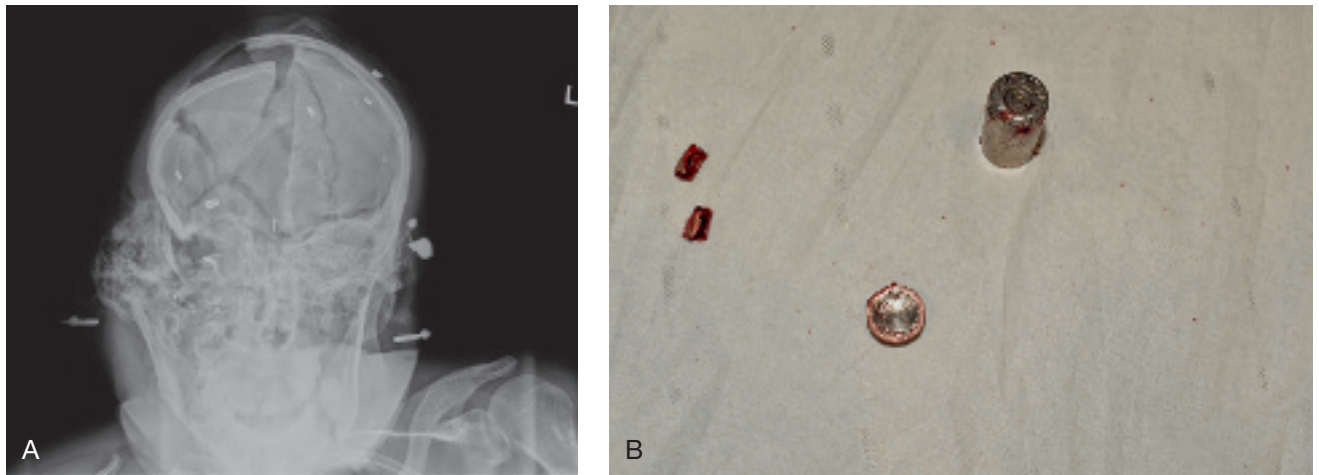


Figure 11.11. Radiograph of decedent shot with Liberty Ammunition Civil Defense round and image of cartridge and projectile recovery. The nose of the projectile is composed of numerous leaflets of copper jacket that break loose from the remainder of the projectile after penetration into the body, accounting for the numerous fragments on radiograph (A). The base of the projectile is a round disk. As best as possible, each fragment should be recovered; however, the base of the projectile has the rifling marks. In (B) are the fired cartridge case, the disklike base of the projectile, and two of the fragments of the copper jacket nose.

PEARLS & PITFALLS

It is best to x-ray a body with a known or suspected firearm(s) injury prior to removal of the clothing and even prior to removal of the body from the body bag. The projectile may have passed completely through the body but be caught up in the clothing (Figure 11.15A and B) or be loose in the body bag. If its presence is not identified prior to removal of the clothing, the projectile may be lost during removal of the clothing.

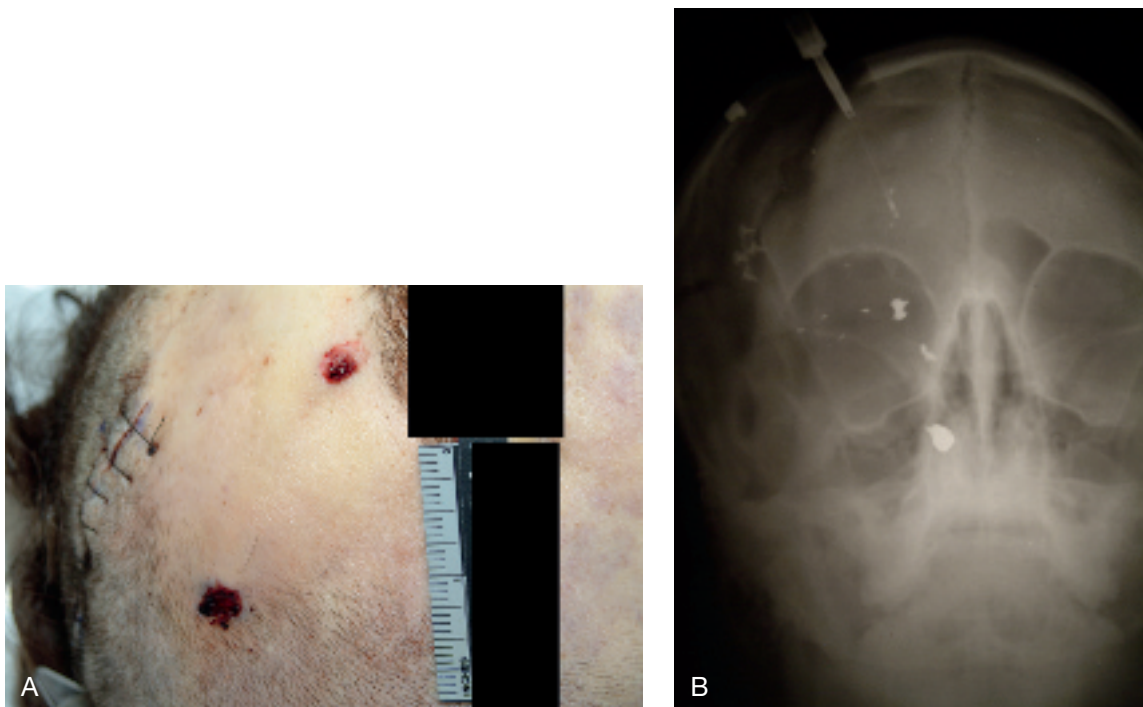


Figure 11.12. Image and radiograph of a decedent shot in the head. In (A), the scalp has both an entrance (the anteriorly located wound in the image) and an exit wound. When the projectile struck the cranium, it separated into a copper jacket and a lead core, with the lead core penetrating into the brain and the copper jacket exiting the scalp. (B) is a radiograph of the head revealing the fragments of the lead core of the projectile.

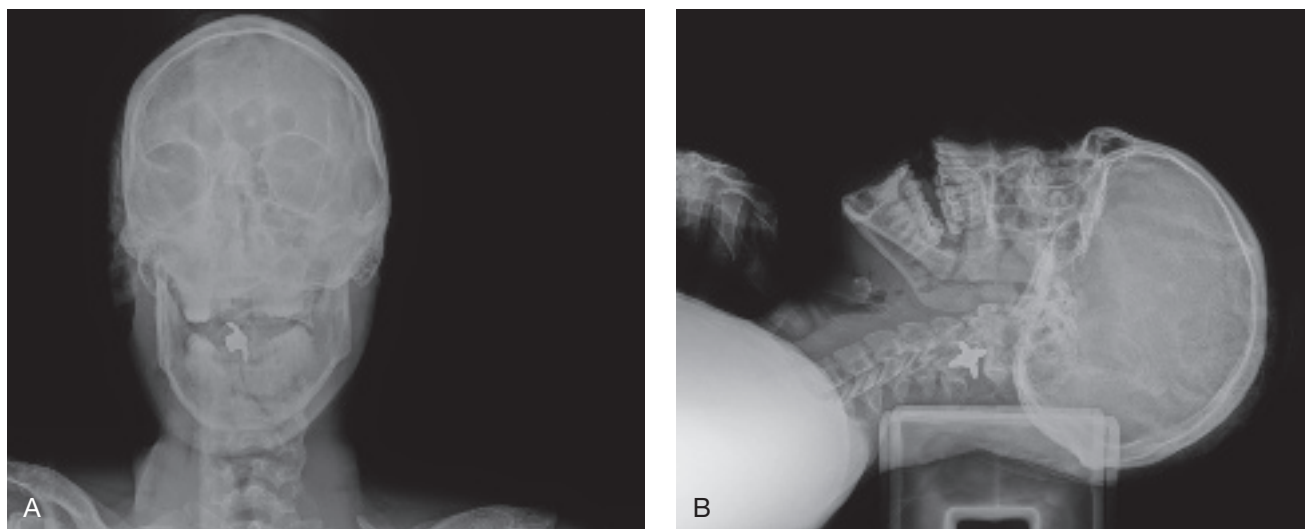


Figure 11.13. Radiographs of decedent with intra-oral gunshot wound, with projectile in neck. With an anterior-posterior oriented radiograph only, it is not possible to pinpoint the exact location of the projectile in the body (A); however, with a lateral image in combination with the anterior-posterior image, it is possible to pinpoint the location (B). Using a laterally oriented radiograph can save the forensic pathologist time and frustration by preventing searching for a projectile in the wrong location.

PEARLS & PITFALLS

While the copper and lead components of the projectile are easily identified on radiographs, other components of a projectile may not be apparent. The shot sleeve (or, shot cup) of a shotgun shell is made of plastic and the wadding can be made of a cardboard (Figure 11.16). The blue tip of a Glaser round and the plastic red tip found in a Hornaby Personal Defense Round will not show up on radiograph (Figure 11.17). In addition, some forms of projectiles (eg, aluminum) will not show up on a radiograph. Only a heightened level of suspicion, knowledge of the ammunition type, or some degree of thoroughness and/or luck during the dissection, all used in correlation with the autopsy findings, will allow for the identification and collection of these projectiles and projectile fragments. Another important and related consideration is that the jacket and core may separate and, if this situation is not recognized, one portion may not be recovered at autopsy. One clue that this has happened is that if only a lead core is recovered and that lead core does not have rifling marks then a jacket is most likely also present and should be searched for and recovered.

PEARLS & PITFALLS

General radiographs of the body, in addition to those in the vicinity of the wounds and the apparent pathway of the projectile, may be useful as they could help to identify a bullet embolus (Figure 11.18A and B), or another finding of interest (eg, an air embolus in the case of a gunshot wound of the neck (Figure 11.19A and B)). Bullet emboli can occur in a variety of circumstances, for example, entry into the heart or the aorta or another artery, with embolization to a distal location,⁵⁻¹¹ or entry into a vein, with subsequent embolization to heart or lung^{12,13} or the arterial system through a patent foramen ovale.¹⁴ In addition to embolization, aspiration of the projectile can also occur and projectiles can pass into the bladder.^{15,16} Tandem projectiles can also occur (ie, two projectiles fired from one shot); thus, the decedent may have one entrance wound but two projectiles within the body. A similar situation could arise with overlapping gunshot wounds, in which the entrance of two separate gunshot wounds overlap, creating the appearance of a single entrance wound.



Figure 11.14. Radiographs of the decedent. Numerous radiographs of the decedent covering the majority or entirety of the body can be obtained, printed, and combined into one overall radiographic map of the body, which can help ensure all projectiles are recovered.

EXTERNAL EXAMINATION

OVERALL PATTERNS OF INJURY TO THE BODY

During the external examination, the pathologist will determine (1) whether wounds from a firearm injury are an entrance wound or an exit wound, and (2) a relative range of fire for the wound (ie, relative distance of the weapon from the body when it was fired [contact, close, etc.]). The actual distance of the weapon from the body is determined by the firearm examiner who test fires the weapon at sequential ranges and compares the distribution of gunpowder residue to that found on the body (if any). Cleaning the entrance and exit

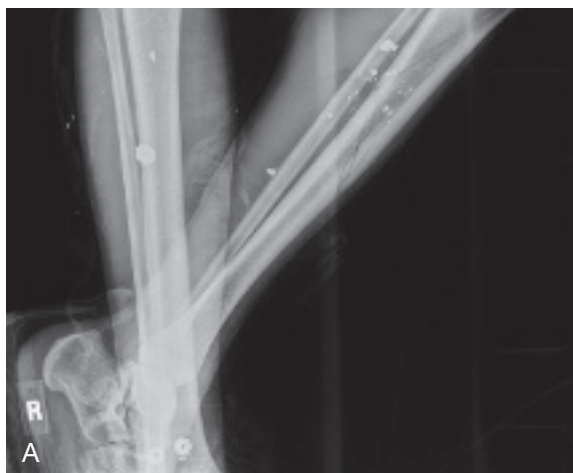


Figure 11.15. Radiograph of a decedent shot in the lower extremity and gross photograph of the clothing. When radiographs of the body were obtained, a projectile was identified that appeared to be in the right lower extremity (A). When the clothing was removed, the projectile was found within the clothing (B). If the presence of the projectile had not been known prior to removal of the clothing, the projectile may have been lost during the autopsy.



Figure 11.16. Decedent shot with a shotgun at a close range. Within the tissue is the plastic shot sleeve. The shot sleeve will not appear on radiograph so its presence must be suspected based upon the overall injury pattern to allow it to be identified during the autopsy. The shot sleeve can fragment and one or more of the plastic leaves may be separated from the main portion.

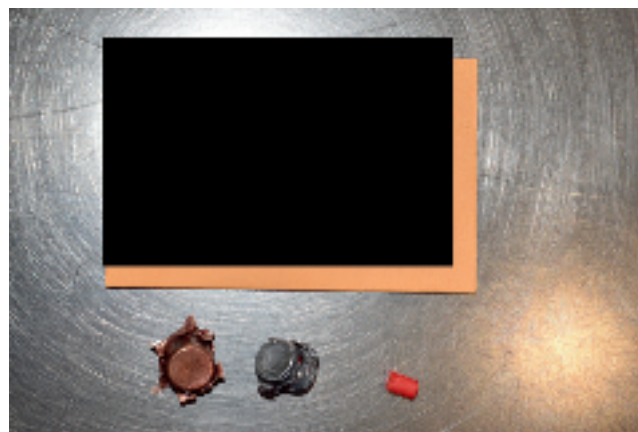


Figure 11.17. Decedent shot with type of ammunition with a plastic nose. In addition to the main projectile, with a copper jacket and a lead core, which separated in the body, at the tip of the projectile is a small rod of red plastic. This small rod of red plastic will not appear on a radiograph, but can be found at autopsy and would assist with identification of the ammunition type.

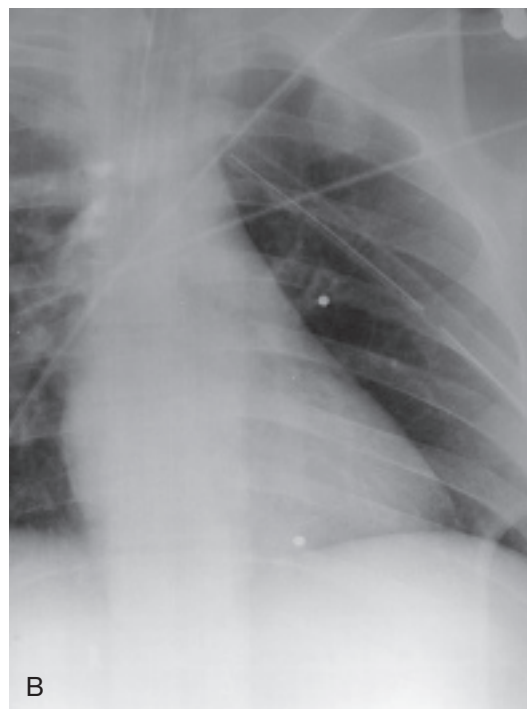


Figure 11.18. Radiographs of a decedent shot with birdshot. The main concentration of the pellets is centered on the abdomen (A); however, two pellets were found near the heart (B). They arrived at this location by penetrating into the vasculature and being carried by the flow of blood to their resting location (ie, a bullet embolus). Emboli can turn a non-lethal wound into a lethal wound. With a patent foramen ovale, a single pellet could enter the venous system, be carried to the right side of the heart, cross over into the left atrium, and embolize to a coronary artery or cerebral artery, causing death.

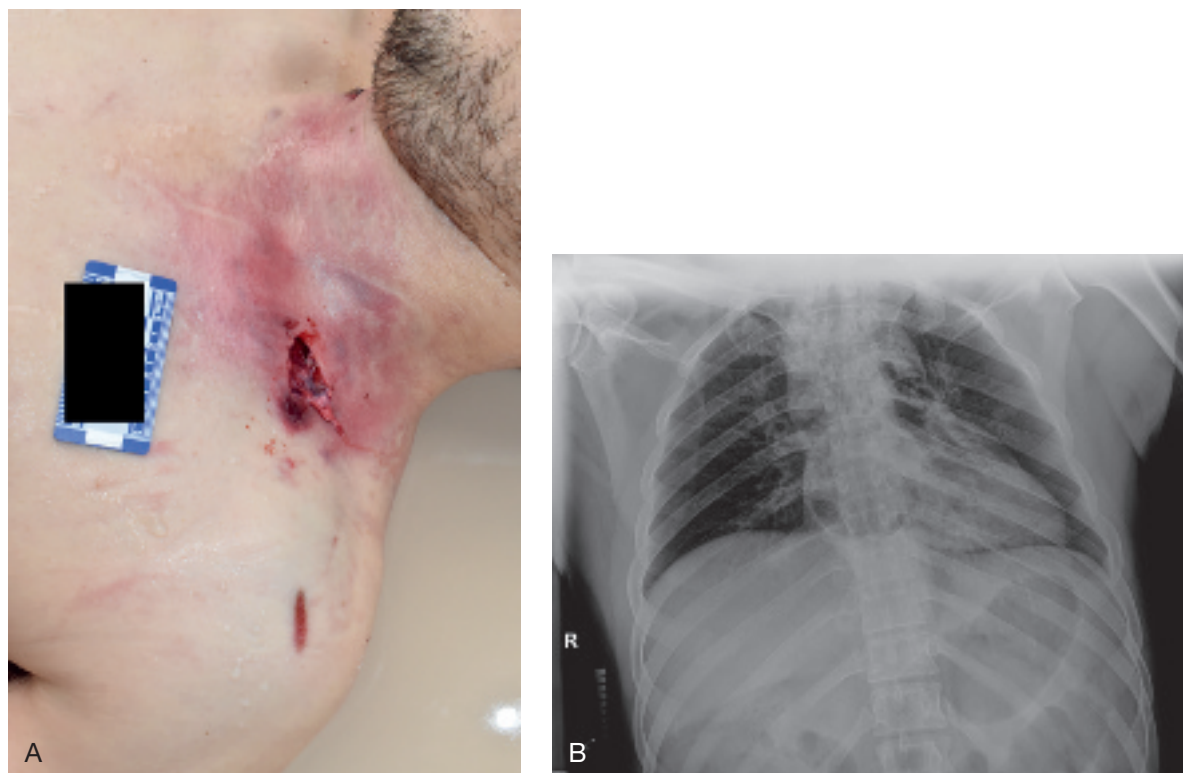


Figure 11.19. Image and radiograph of a decedent with a gunshot wound of the neck. (A) shows the gunshot wound of the neck. (B) is a radiograph of the chest, which reveals an air embolus. With a gunshot wound or stab/incised wound of the neck, obtaining a radiograph of the chest is useful as it may identify an air embolus.

wounds of extraneous blood is necessary prior to final examination of the defects, and will markedly improve one's ability to correctly examine the wound (Figure 11.20A and B). Given the tenacious nature of dried blood, care must be taken when removing that blood so as to prevent loss of important features (eg, soot on the skin). As such, certain techniques may help to preserve changes on the skin.¹⁷

The external examination can include evaluation of the clothing, which can potentially assist in determination of entrance vs exit and relative range for the wound. Sometimes soot

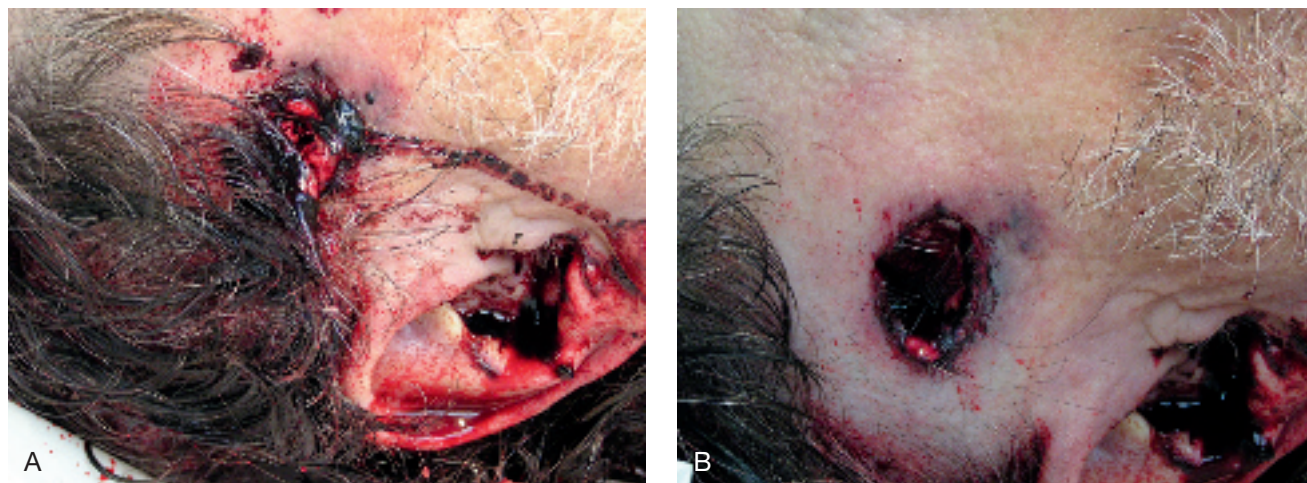


Figure 11.20. Entrance wound prior to and after cleaning. Being able to search for the patterns at the skin surface that allow for interpretation of entrance vs exit and relative range of fire depends upon sufficient preparation of the wound. (A and B) illustrate how features become much more apparent after the wound is cleaned. To best examine and subsequently photograph the wound for documentation purposes, blood (liquid, clotted, and dried) and scalp hair (or other body hair present) should be removed to provide for the best visualization of the gunshot wound. If determination of range is challenging, the hair that is shaved from around the wound can be retained for examination for gunshot residue by the firearm examiner.



Figure 11.21A. Decedent who sustained a close range gunshot wound of the left upper extremity. Near the end of the shirt sleeve is an irregular circular defect in the clothing surrounded by a fine gray-black powder, which is soot.

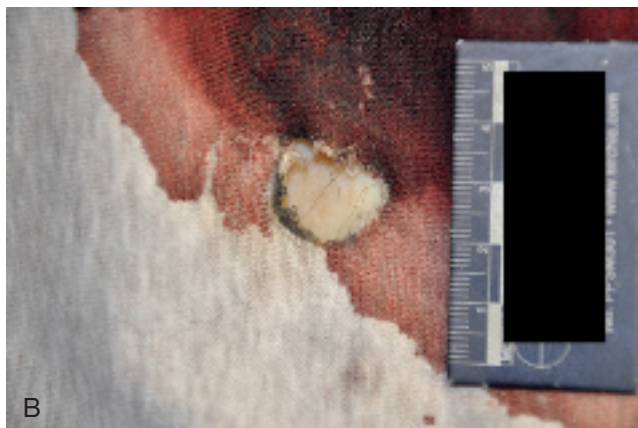


Figure 11.21B. Decedent who sustained a contact self-inflicted shotgun wound. The circular defect in the shirt has a rim of black, which is soot from the discharge of the shotgun. However, bullet wipe could appear very similar, rubbing off on the clothing at the very edge of the entrance defect.

or gunpowder will not be present on the skin surface around the wound, but will be present on the clothing; however, bullet wipe, from the material on the surface of the projectile rubbing off onto the clothing, can be present and must not be confused with soot, as bullet wipe would not be specific to a certain range of fire (Figure 11.21A and B).

By external examination, one common overall pattern is that of an extensively damaged head, with gaping lacerations of the scalp, complex and widespread fractures of the cranium, and avulsion of the brain from the cranial cavity (ie, the head is blown open). This pattern is produced most frequently by contact or intra-oral shotgun wounds or contact or intra-oral high-powered rifle wounds and is due to the expulsion of gas and smoke upon discharge of the weapon and the higher damaging capacity of these two weapons at a contact or intra-oral range (Figure 11.22). Even given the destruction of the head, the tissue can be re-approximated and the entrance defect identified (Figure 11.23A-D). Handguns and 0.22 caliber rifles would not normally produce such a wound (Figure 11.24). Thus, even the overall pattern of a firearm injury, without examining the specific details of the skin surface at the wounds, can guide a forensic pathologist toward the weapon type used in the death.

External examination of the body where the decedent has sustained a firearm injury also includes collection of evidence. Specific to a firearm injury is collection of the clothing, especially the clothing item(s) where the projectile passed through, and sampling the skin of the hands for gunshot residue.



Figure 11.22. Decedent who sustained a contact shotgun wound of the head. The head is extensively damaged, with multiple lacerations of the scalp, extensive and comminuted fractures of the cranium, and avulsion of the brain.



Figure 11.23. Decedent who shot themselves with a high-powered rifle. Like a contact shotgun wound, the head is extensively damaged with multiple lacerations of the scalp and comminuted fractures of the cranium resulting in a near complete loss of the anterior portion of the head (A). As with a contact shotgun wound of the head, the tissue can be re-approximated (B) to help identify the entrance site (C). In this case, the entrance wound was at the chin. The marginal abrasion and some soot deposition are visible. While the entrance wound in such situations can essentially always be found, the exit wound may not be identified. Given the usual lack of abrasion ring or gunshot residue at the exit wound, the slitlike or stellate nature of an exit wound can easily be obscured by the other damage to the scalp. The scene photograph confirms the autopsy findings (D).

PEARLS & PITFALLS

While contact or intra-oral high-powered rifle wounds and contact or intra-oral shotgun wounds most often cause extensive damage to the head, with the scalp extensively lacerated, the cranium extensively fractured, and the brain often avulsed, and contact range or intra-oral handgun wounds most frequently do not cause nearly as extensive of damage, the head can be intact with a contact or intra-oral shotgun wound and can be extensively damaged (ie, with the cranial cavity open) with a contact or intra-oral handgun wound (Figure 11.25A and B).



Figure 11.24. Decedent who sustained a contact gunshot wound of the head. In comparison to Figure 11.23A, this individual shot themselves with a handgun. Low-caliber weapons (eg, 0.22) will often only have an entrance wound, whereas high-caliber weapons (eg, a 9 mm) will often have an entrance and exit wound, but while they can have numerous fractures of the cranium, the overall general structure of the head itself is most often intact.

FAQ: Will gunshot residue testing help to distinguish a suicide from a homicide?

Answer: Gunshot residue testing will determine if an individual was in a gunshot environment and, given the firearm injury of the body, that fact is already known. Testing for gunshot residue is accomplished by using a small plastic device (a stub) with a sticky pad on one surface to sample the skin, touching the sticky pad against the skin repeatedly at various points on the dorsal and ventral surface of the hands to collect potential residue. This stub is then analyzed by a forensic science laboratory using a scanning electron microscope to look for primer particles (including barium, antimony, and lead). It is possible for an individual who is shot by another person to have gunshot residue on their hands, depending upon how close they were to the shooter, and it is possible for an individual who shot themselves to not have gunshot residue on their hands. Technically, gunshot residue testing could complicate an investigation. If gunshot residue testing is performed on an individual who by autopsy correlated with investigative findings is certainly a suicide, and that gunshot residue testing result is negative (ie, no gunshot residue is identified), family members, especially if they already suspect a homicide, may dispute the results of the investigation, and refuse to accept



Figure 11.25. Decedents who sustained an intra-oral shotgun wound and a contact range 0.40 caliber handgun wound. In (A), although the weapon used was a shotgun, the head is relatively intact and the scalp is not widely lacerated; however, the cranium is extensively fractured. In (B), although the weapon used was a handgun, the head is extensively lacerated, the cranium markedly fractured, and the brain partially avulsed from the cranial cavity.

the determination of a suicide. Gunshot residue testing does have application in investigations however. If an individual reports that they were not at the location of the gunshot wound or were some distance from the weapon when it went off, they should not have gunshot residue on their hands. If that person is suspected to have caused the injury, collection of a gunshot residue kit from them may assist with the investigation. Gunshot residue kits most often contain three stubs: one for each hand and one for the forehead. While just using the hands after firing a weapon can remove gunshot residue from the skin, the forehead is less frequently touched, and gunshot residue deposited here can linger for a longer time period.

FAQ: In a body with an entrance wound but no exit wound, is a complete autopsy required to recover the projectile?

Answer: Whether a complete autopsy is performed to evaluate a firearm injury is dependent upon office policies, the forensic pathologist's experience, and the circumstances of the death. In some cases of suicide, a forensic pathologist may be comfortable with an external examination only with a perforating gunshot wound or with a partial autopsy for recovery of the projectile only for evidentiary purposes (ie, to potentially match to a weapon if ever needed). The two most difficult substances for the projectile to perforate are bone and skin, so often a projectile will become lodged just underneath the skin on the opposite side of the body from the entrance wound and can be recovered with an incision in the skin (Figure 11.26A-C).



Figure 11.26. Recovery of projectile from underneath the skin. The individual sustained a contact range gunshot wound of the chin (A). The pathway of the projectile was from right to left, upward, and backward, with the projectile coming to rest just underneath the scalp in the left parietal region, noticeable as a bulge in the skin in (B) and revealed with an incision in the adjacent skin (C). Care should be taken to cut adjacent to the projectile and not over the projectile as, if the scalpel contacts the projectile, extraneous markings on the metal can be produced.

INTERPRETATION OF GUNSHOT WOUND PATTERNS IN THE SKIN

Introduction: While the radiography and overall appearance of the body may guide a forensic pathologist in their identification of a firearm injury as a cause of death, examination of the wound characteristics on the skin surface is vital to evaluation of the autopsy findings. With firearm injuries, once the location of the wound on the body has been determined, interpretation of the pattern of changes on the adjacent skin surface allows for determination of entrance wound vs exit wound and identification of features that will allow for a general determination of range of fire. The wounds are examined for the general shape of defect (eg, circular, stellate, slitlike), location on the body (with measurements from the top of the head or the sole of the foot to the wound, distance of the wound from the midline, and distance of the wound from the nearest fixed point (eg, a nipple) used to document the location of the wound), presence or absence of a marginal abrasion, the presence or absence of a muzzle abrasion, and presence or absence of soot or stippling (ie, soot, which is burned gunpowder, or stippling/powder tattooing, which is produced by unburned gunpowder striking the skin). In addition, carbon monoxide-induced discoloration of underlying musculature can assist in determination of a contact range firearm injury.

ENTRANCE WOUNDS FOR HANDGUNS/RIFLES

Pattern at autopsy: Classically, entrance wounds are a circular defect in the skin, which is usually completely surrounded by a rim of abrasion (ie, the marginal abrasion) (Figure 11.27). The circular defect is a permanent loss of tissue, with the tissue carried forward into the wound track and ejected backwards in the direction that the shot came from.¹⁸ Soot will appear as a fine powder-like substance associated with the wound. Using soot to help determine range of fire will be discussed below, but the presence of soot at the skin defect assists in determination of entrance vs exit as well. Unburned gunpowder will strike the skin, sometimes embedding in the skin, producing a punctate, or dotlike, abrasion. This change is referred to as stippling or, with embedded gunpowder, powder tattooing. Like soot, using stippling to help determine range of fire will be discussed below, but the presence of stippling at the skin defect assists in determination of entrance vs exit as well. Of note, gunpowder residue can rarely be found at the exit¹⁹ (Figure 11.28A and B). A muzzle abrasion will be a circular or semi-circular abrasion often slightly distant from the entrance defect and which surrounds or partially surrounds the wound (Figure 11.29A-D). A muzzle abrasion is characteristic of a contact entrance wound. Sometimes, specific details such as the sight at the end of the weapon or the recoil spring guide may create a more specific abrasion pattern (Figure 11.30A and B).

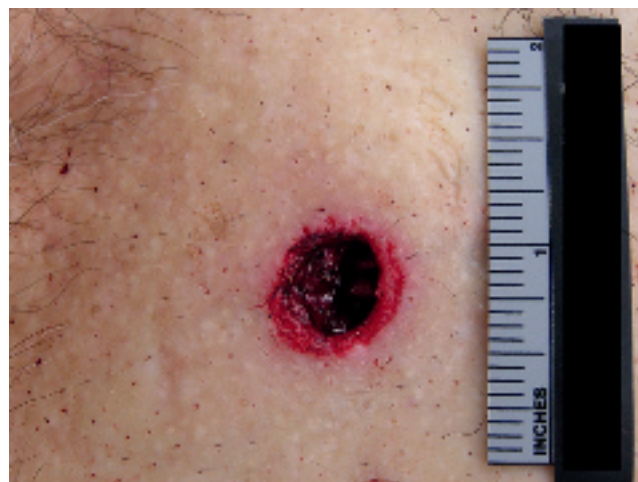


Figure 11.27. Entrance gunshot wound of the body. With a classic entrance-type gunshot wound, there is a central circular defect in the skin, which has a variably wide rim of marginal abrasion.

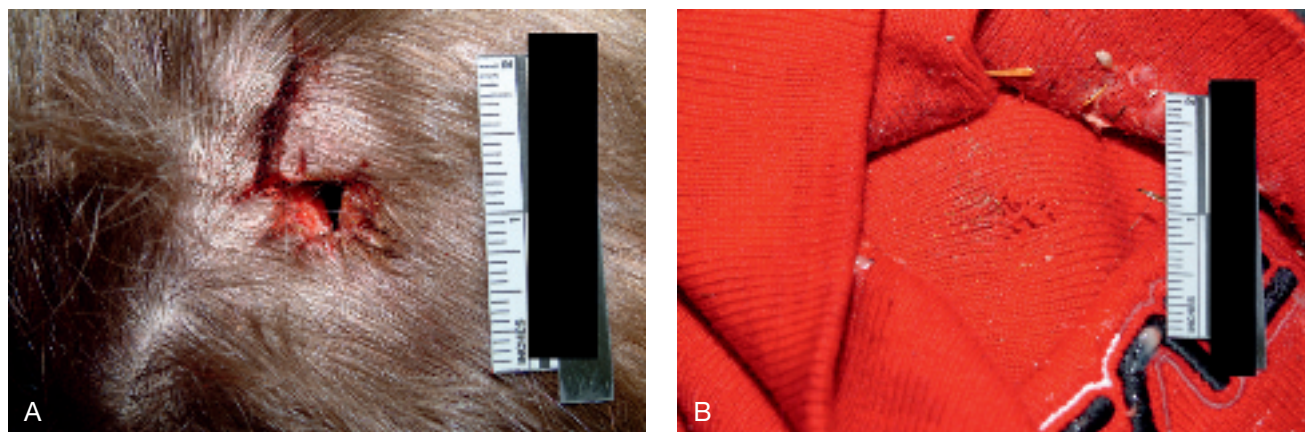


Figure 11.28. Exit gunshot wound with gunpowder. The decedent sustained a contact gunshot wound of the head, with the entrance a large gaping defect on the right side of the head, which was initially interpreted by the coroner as the exit. (A) shows the exit defect (with the hair unshaven in this image to preserve the gunpowder particles for photography). No marginal abrasion is present. (B) shows the inner surface of the snow-type cap the decedent was wearing with gunpowder being present.

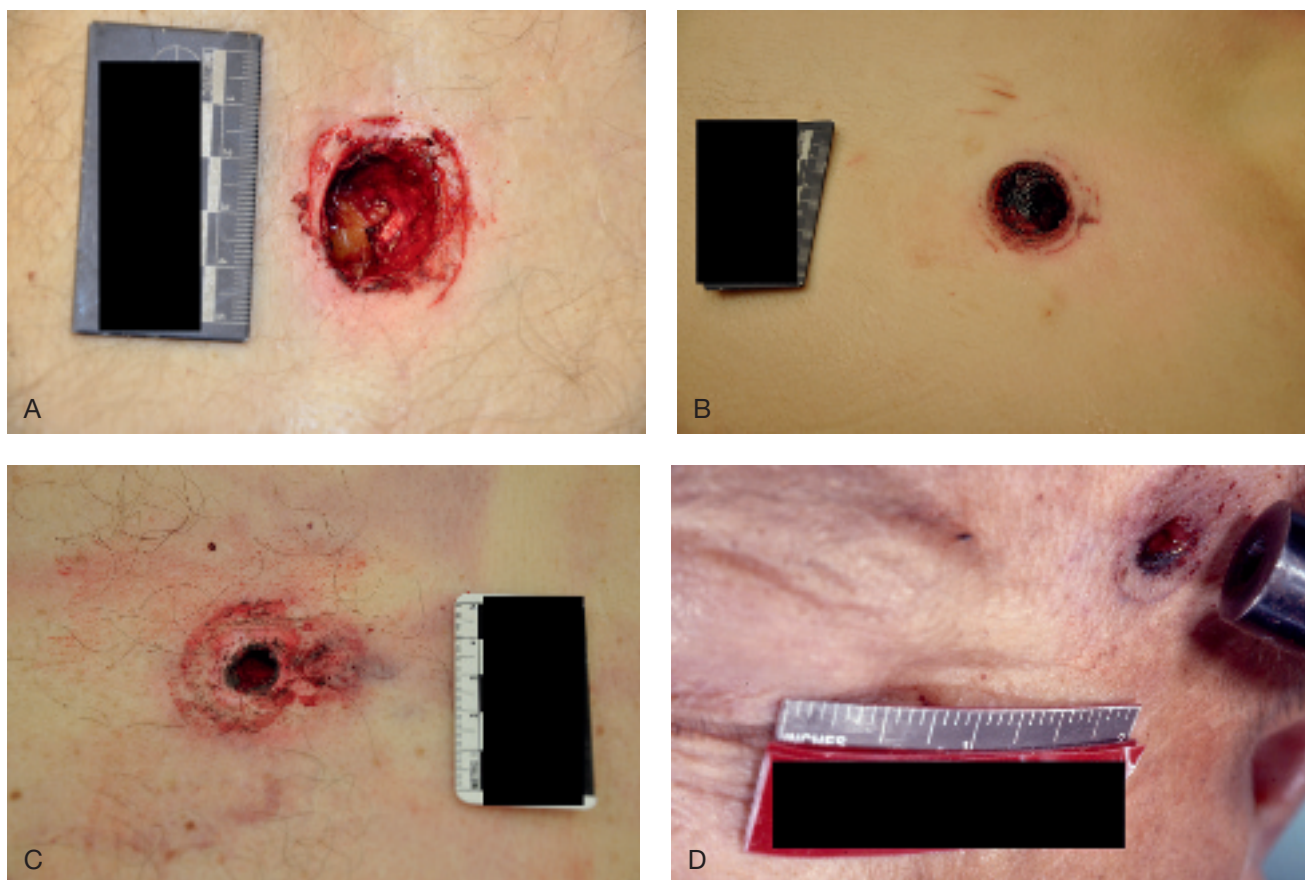


Figure 11.29. Entrance wound with muzzle abrasion. (A) is a contact shotgun wound of the chest with a muzzle abrasion, which is the nearly circumferential thin linear red discoloration on the skin just lateral to the wound. Other components of the end of the barrel such as the recoil spring guide or the gunsight can also leave an impression on the skin. (B) is a contact shotgun wound of the chest with a muzzle abrasion, but in which the sight impression is also present. (C) is a contact gunshot wound of the chest. The impression of the end of the firearm is present on the skin. (D) is an entrance gunshot wound with a muzzle abrasion. In this case, the impression of the end of the barrel is seen on the skin with soot on the skin as well. While images such as this with the causative weapon near the skin are good for demonstrative purposes, one must be careful that the weapon does not actually touch the skin, as that could allow for an argument of contamination of evidence.

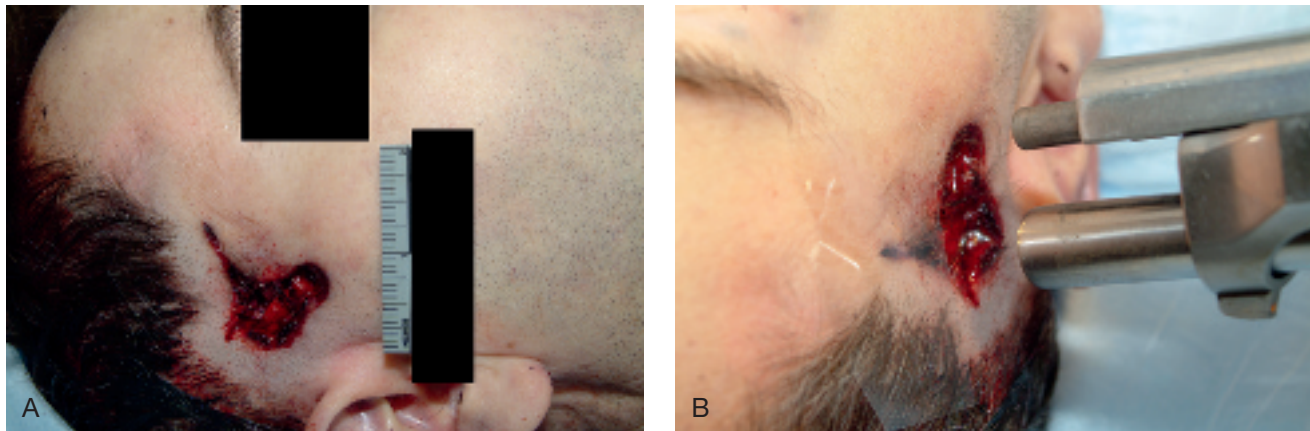


Figure 11.30. Entrance gunshot wound of the body with recoil spring guide injury. Although the recoil spring guide can cause a round abrasion on the skin adjacent to the entrance wound, in (A), it actually created a circular laceration adjacent to the gunshot wound, which, in combination with the marginal tear, caused the wound to appear larger. In (B), the weapon is compared to the entrance wound.

PEARLS & PITFALLS

When the projectile from a handgun or rifle enters the body perpendicular to the skin, the marginal abrasion will be a circumferential rim of uniform width; however, if the projectile enters the body at an angle, the marginal abrasion will be eccentric, wider in the direction from which the projectile entered the body (Figure 11.31). However, as the body at autopsy is usually not in the same position as the body when it was shot, caution must be used in interpreting an eccentric marginal abrasion. For example, a person who is moving when the projectile struck them may have skin folds that are different than when the body is being examined on a table at autopsy (Figure 11.32A and B).

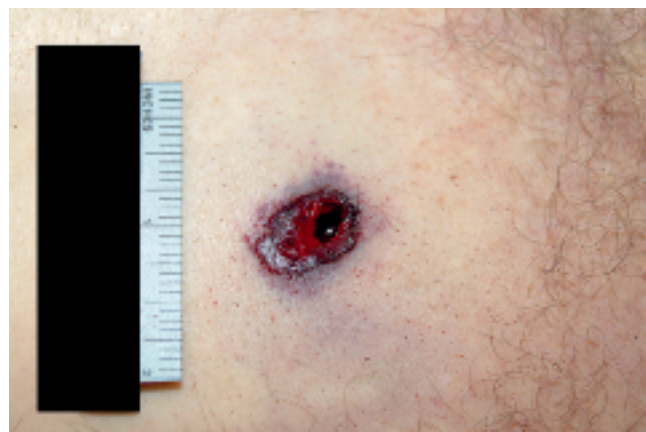


Figure 11.31. Entrance gunshot wound of the body with eccentric marginal abrasion. At 7 to 9 o'clock in the image, the marginal abrasion is much wider than elsewhere along the circumference of the wound. The projectile entered at an oblique angle to the skin, instead of perpendicular to the skin, entering from the side of the wider marginal abrasion.

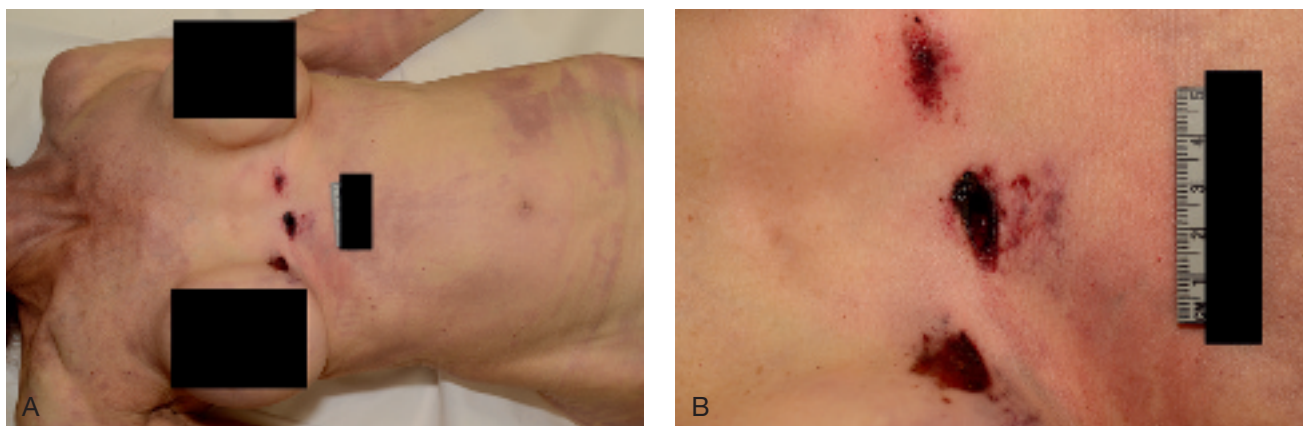


Figure 11.32. (A and B) Close range gunshot wound of the chest. This woman shot herself in the chest and the appearance of the wound illustrates the idea that the body at autopsy is not in the same position as when shot. There is a gunshot wound in the center of the chest and to each side, lateral and displaced from the entrance wound, are lesions of the skin and the medial surface of the right breast. Apparently, when the woman held the gun up to her chest, it compressed her skin and breasts together and more toward the center, allowing for the released hot gases to sear the skin.

FAQ: Can the caliber of the projectile be accurately estimated by the size of the entrance wound?

Answer: No, due to the elastic nature of the skin and variable anatomic properties of the target tissue the size of the entrance wound does not necessarily correspond to the caliber of the projectile¹⁸; however, the width of the abrasion ring can vary predictably with certain features of the weapon including projectile velocity.²⁰ In fact, even for gunshot wound defects in the bone, the size of the defect cannot reliably be used to predict the caliber of the projectile, although in any given case, certain calibers may be included or excluded.^{21,22}

FAQ: Does surgical intervention block the ability to determine entrance wound and exit wound and relative range of fire?

Answer: While surgical intervention can obviously obscure features that allow for determination of entrance and exit wounds and relative range of fire, most often distinguishing features remain. For example, often when surgical intervention occurs, the fragment of cranium removed may be retained by the hospital and can be recovered from the hospital for examination. Also, even with surgical intervention, bony changes or presence of soot may remain, allowing for, in at least some cases, a proper evaluation of the gunshot wound as to entrance and exit, and relative range of fire.²³

PEARLS & PITFALLS

Inexperienced observers often mistake entrance wounds for exit wounds based upon the size of the wound. A common misconception is that the exit wound is always larger than the entrance wound. While it is most often true for anything but contact range gunshot wounds of the head,²⁴ with contact gunshot wounds of the head, this is most often not true (Figure 11.33A-D). With a contact gunshot wound of the head, when the gases from the discharge of the weapon leave the barrel they enter the body and encounter the cranium, which forces the gases to extend laterally from the wound under the skin, which bulges the skin outward, causing it to tear. These tears can be quite extensive and make the entrance larger than the exit. Close re-approximation of the tips of the resultant skin tags allows for the identification of the entrance site, with the associated soot and marginal abrasion also being present. Also, examination of the underlying soft tissue and the dura and bone at the entrance defect will allow for the identification of soot as well as identification of a bevel.



Figure 11.33. Two sets of entrance and exit gunshot wounds of the head. Images (A and C) are the entrances. One common misconception is that the exit wound is always larger than the entrance wound; however, with contact range gunshot wounds of the head, the entrance, due to marginal tears, is usually the larger of the two. In Image (A), the muzzle abrasion and recoil spring guide are faintly apparent as is soot. The tears are secondary to the contact nature of the wound in a portion of the body with underlying bone. With a contact gunshot wound, the hot air released along with the projectile enters the head, but, cannot penetrate deeper due to the presence of the cranium, and instead causes the skin to tent outward and tear, leading to a large wound. Re-approximation of the wound can identify a marginal abrasion and soot. In contrast, (B and D), which are the corresponding exits, have no marginal abrasions.

PEARLS & PITFALLS

Entrance wounds of certain portions of the body have a different appearance than the classic entrance wound described above. Entrance wounds on the palms of the hands or soles of the feet, given the presence of thick skin vs the normal thin skin, which covers the remainder of the body, have a different appearance (Figure 11.34); entrance wounds of the eye (Figure 11.35) and entrance wounds of the scrotum (Figure 11.36A and B) can be challenging to interpret.²⁵

PEARLS & PITFALLS

Injuries other than gunshot wounds can potentially mimic a gunshot wound (Figures 11.37 and 11.38). A stab from an ice pick could mimic a 0.22 caliber wound. Open fractures can potentially also mimic a gunshot wound.²⁶

EXIT WOUNDS FOR HANDGUNS/RIFLES

Pattern at autopsy: Classically, exit wounds are stellate or slitlike and have no rim of marginal abrasion (Figure 11.39A-C). There usually should be no soot or stippling on the skin surrounding an exit wound, although it is possible for soot and/or gunpowder to traverse the body from the entrance wound to the exit site. While exit wounds are most frequently slitlike or stellate, circular wounds are also possible (Figure 11.40A and B).

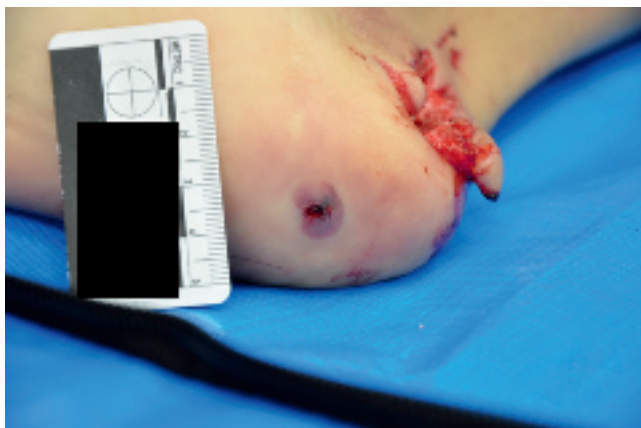


Figure 11.34. Decedent with a gunshot wound of the foot into the leg. The decedent was shot by her significant other. She apparently raised her right lower extremity between herself and him, and was shot in the sole of the foot. Unlike a typical entrance wound, there is no marginal abrasion. The thick skin of the sole of the foot (or palm of the hand) behaves differently than the thin skin covering the majority of the rest of the body.



Figure 11.35. Decedent with close range gunshot wound of the right eye. While the presence of stippling/powder tattooing easily identifies the gunshot wound as an entrance, the typical features of an entrance gunshot wound (eg, the marginal abrasion) are not as apparent in the thin skin of the eyelid.



Figure 11.36. Gunshot wound of the scrotum. The decedent sustained a perforating gunshot wound of the scrotum. The entrance (A) and exit (B) can be difficult to distinguish. Often, to perforate the scrotum, the projectile will pass through one or both thighs, which can help to interpret the pathway through the scrotum.

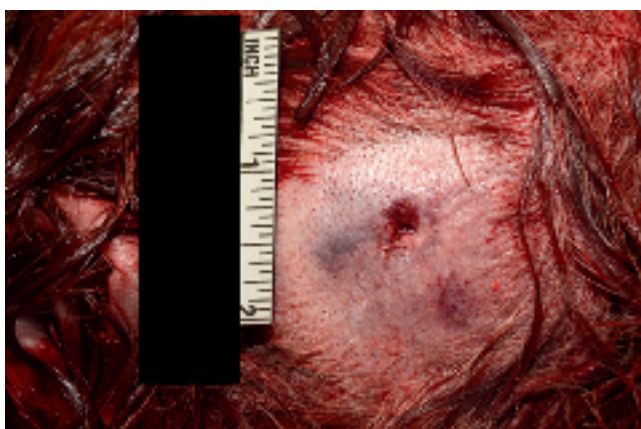


Figure 11.37. Decedent with gunshot wound mimic on back of head. On the posterior surface of head is a circular defect with a marginal abrasion, which mimics a small-caliber firearm injury such as a 0.22. However, there was no injury to the underlying cranium and a radiograph of the head revealed no projectile. The exact source of the injury is unknown, but is believed to have occurred during transport of the body to the morgue.

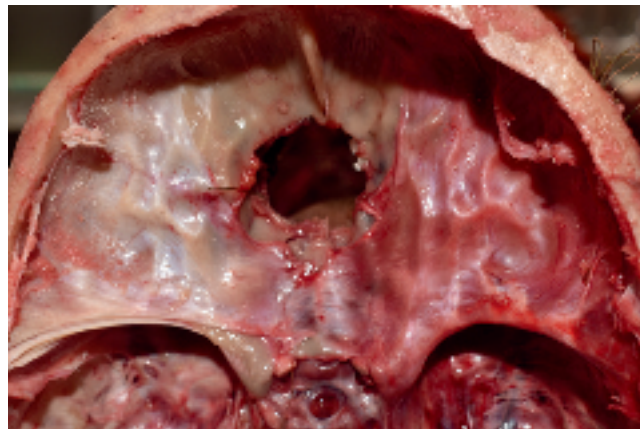


Figure 11.38. Cranial injury from farming accident. Although not on the external surface of the body, the round defect centered on the region of the cribriform fossa could mimic a firearm injury. The injury was caused during a farming accident, with an unspecified object on the vehicle driven into the cranium but not present at autopsy. If only skeletal remains had been recovered, the distinction from a gunshot wound could be more difficult.



Figure 11.39. Exit wounds of the body. With a classic exit-type wound, there is usually no central defect in the skin and no marginal abrasion. Instead the wound has a slitlike (A) or stellate (B and C) appearance.

FAQ: What do you do if the entrance and exit wounds are not distinguishable (ie, whether a wound is an entrance or an exit cannot be determined)?

Answer: Features that may assist with the determination of entrance wound vs exit wound other than just the appearance of the wound in the skin are beveling of underlying bone, color of the underlying musculature, examination of the clothing, the appearance on radiography, and, when available, viewing a video of the incident. When the projectile strikes flat bone, such as the neurocranium, the sternum, a clavicle, a rib, or the pelvis, the defect in the bony surface on the side struck first is smaller than the defect in the surface where the projectile exits the bone. The overall defect in the bone is similar to the shape of a cone, with the narrow end being the point of entry into the bone and the wide end being the point of exit from the bone. At an entrance wound, the defect in the bone bevels inward (ie, internal beveling, which widens out toward the interior surface of the bone) and at the exit wound, the defect in the bone bevels outward (ie, external beveling, which widens out toward the exterior surface of the bone) (Figure 11.41A-H). The finding of even one fragment from the rim of the entrance wound with internal beveling when used in combination with the skin features can potentially help distinguish entrance from exit. Occasionally, external beveling can occur at an entrance wound and internal beveling can occur at the exit wound²⁷⁻³⁰ and beveling can occur in the setting of injuries other than those that are firearm related as well.³¹ For example, absent Wormian bones can potentially mimic a gunshot wound of the cranium.³²

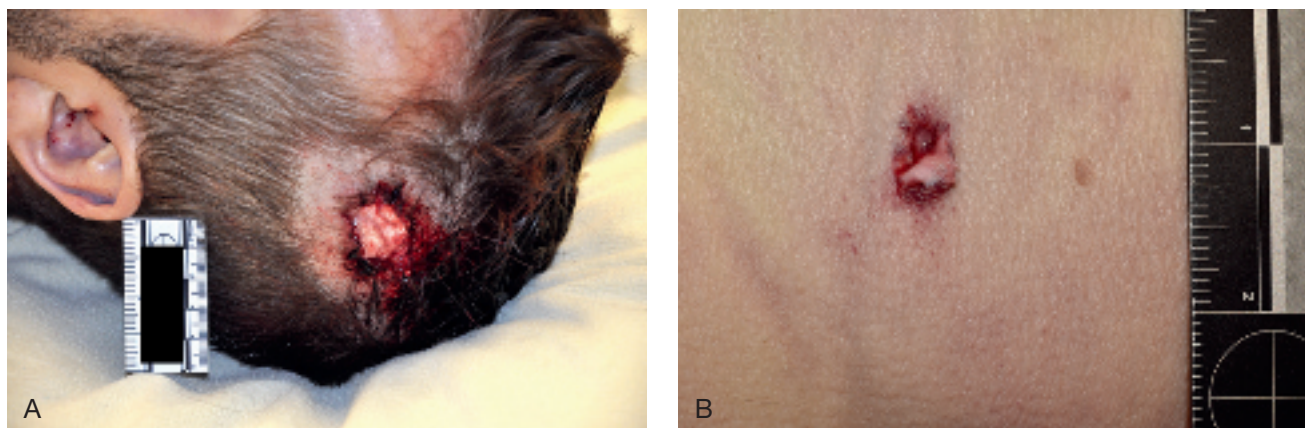


Figure 11.40. Exit wounds of the head and trunk. Exit wounds, while often slitlike or stellate, can have a variety of appearances, including more circular, with a permanent central region of tissue loss, similar to an entrance wound. These gunshot exit wounds of the head (**A**) and trunk (**B**) illustrate such a finding. Both gunshot wounds were found during separate autopsies.

With a contact gunshot wound, carbon monoxide staining (ie, a bright red discoloration) of the underlying musculature may be present due to binding of carbon monoxide from the gunshot wound with myoglobin or hemoglobin in the muscle (Figure 11.42). However, carbon monoxide-induced cherry red discoloration of the skeletal muscle has been identified at the exit wound in a reported case.³³

Examination of the clothing for soot or gunpowder (informally by the forensic pathologist, or formally by the firearm examiner) may provide the answer as to whether a particular wound in the skin represents an entrance or an exit. And, while inversion of fibers at the point of entrance or eversion of fibers at the point of exit in the clothing is mentioned by some,³⁴ caution in the interpretation is advised. Projectile distribution on the radiograph or computed tomography (CT)/magnetic resonance imaging may help,³⁴⁻³⁷ in that the fragments should spread outward from the entrance (Figures 11.43A and 11.43B). Review of the medical records may also assist in interpretation of firearm injuries after medical intervention has occurred, so as not to misinterpret medical intervention for an inflicted injury; however, clinical physicians are not accurate in determination of entrance and exit wounds of the body.³⁸ Videos of the incidence may also assist in distinguishing entrance from exit (Figure 11.44A-C).

PEARLS & PITFALLS

In the case of a shored (or supported) exit, a marginal abrasion will be present. A shored exit occurs when the skin at the exit site is against an object (eg, tight clothing) so that when the projectile impacts the undersurface of the skin and pushes it outward to create the exit, the skin impacts against the object against it, leading to abrasion of the margins of the exit wound. In a marginal abrasion created at the entrance of a projectile into the body, usually no residual epidermis is within the rim of abrasion; however, in a shored exit, islands of residual epidermis are often present. In addition, the marginal abrasion at an entrance wound often has a regular appearance, albeit which can be eccentric, whereas shored exit wounds tend to have a more irregular exit and the marginal abrasion tends to be lighter red in color. Distinguishing an entrance from a shored exit can be difficult for even an experienced forensic pathologist³⁹ (Figure 11.45A-K).

PEARLS & PITFALLS

When a projectile tangentially strikes the bone, a keyhole-type defect can be produced (Figure 11.46A-C). A keyhole defect will have both inward and outward bevel, inward bevel in the bone at the point the projectile was first in contact with and outward bevel in the bone at the point the projectile was last in contact with. While a keyhole defect is most commonly found at the entrance wound, keyhole defects have been reported at the exit wound.⁴⁰

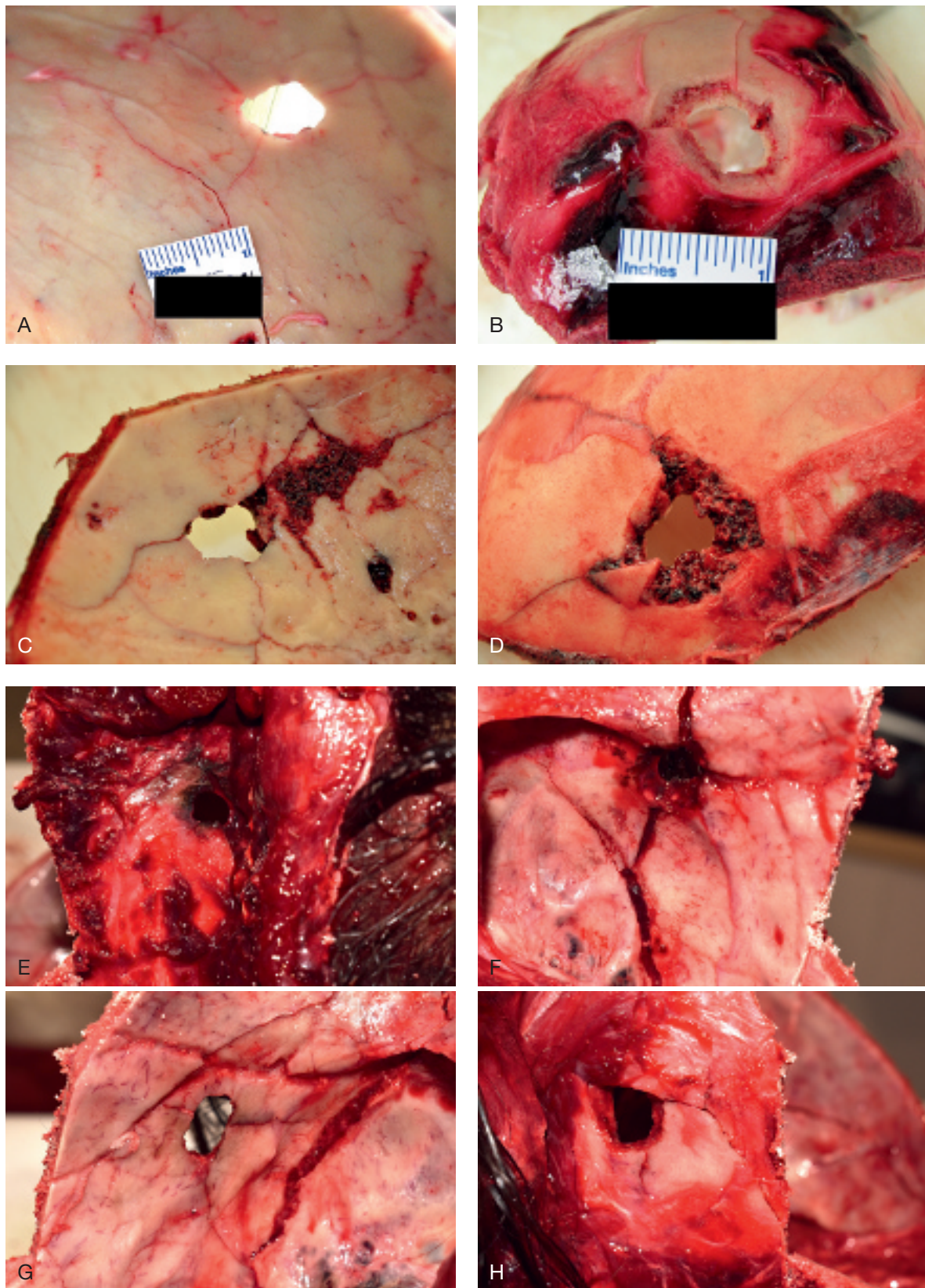


Figure 11.41. Examples of bevel in the cranium. (A) is the endocranial surface of an exit gunshot wound in the cranium. Note that the bone on the inner table extends all the way to the circular defect (ie, the defect has a punched out appearance). (B) is the ectocranial surface of the exit gunshot wound in (A). Note that the bone on the outer table of the cranium ends prior to the full thickness circular defect. This is outward bevel and is consistent with an exit wound. (C) is again the endocranial surface of an exit gunshot wound in the cranium, with (D) the corresponding ectocranial surface. Like (A and B), the bevel is outward, consistent with an exit wound. (E-H) are from a single gunshot wound. (E and F) show the defect in the bone at the entrance site, with inward bevel, and (G and H) show the defect in the bone at the exit site, with outward bevel.

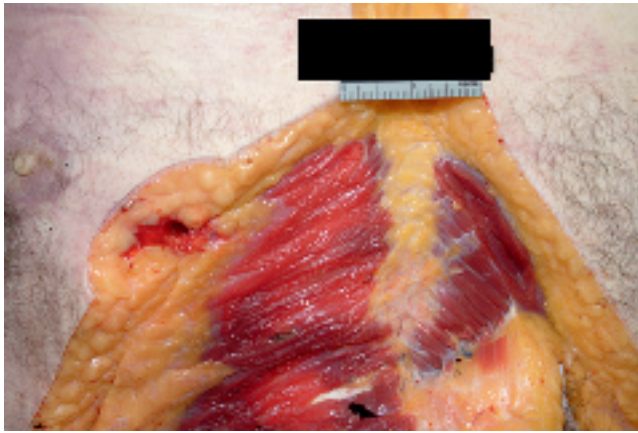


Figure 11.42. Contact gunshot wound of the body, with carbon monoxide staining of the underlying musculature. Carbon monoxide, which is released when a weapon fires, will, in a contact range wound, enter the body and bind to myoglobin and hemoglobin, which will give the musculature a more red or pink coloration. Some weapons, such as a 0.22 rifle, produce minimal soot, and identifying contact range gunshot wounds can be challenging; however, the carbon monoxide staining of the musculature can help.



Figure 11.43A. Gunshot wound that struck the femur. At the point where the projectile first struck the femur are radio-dense fragments. Fragments are also present in the soft tissue on the lateral surface of the bone. In addition, the bone fractured and the bone fragments traveled in the same direction as the projectile and are seen in the soft tissue lateral to the femur on the left side of the radiograph (arrow).



Figure 11.43B. Gunshot wound with pathway of projectile shown by fragments of the projectile. The projectile struck the vertebral column, which left a trail of tiny fragments that mark the pathway of the projectile. Since the projectile itself is present, the trail of projectile fragments can be used to determine the pathway.

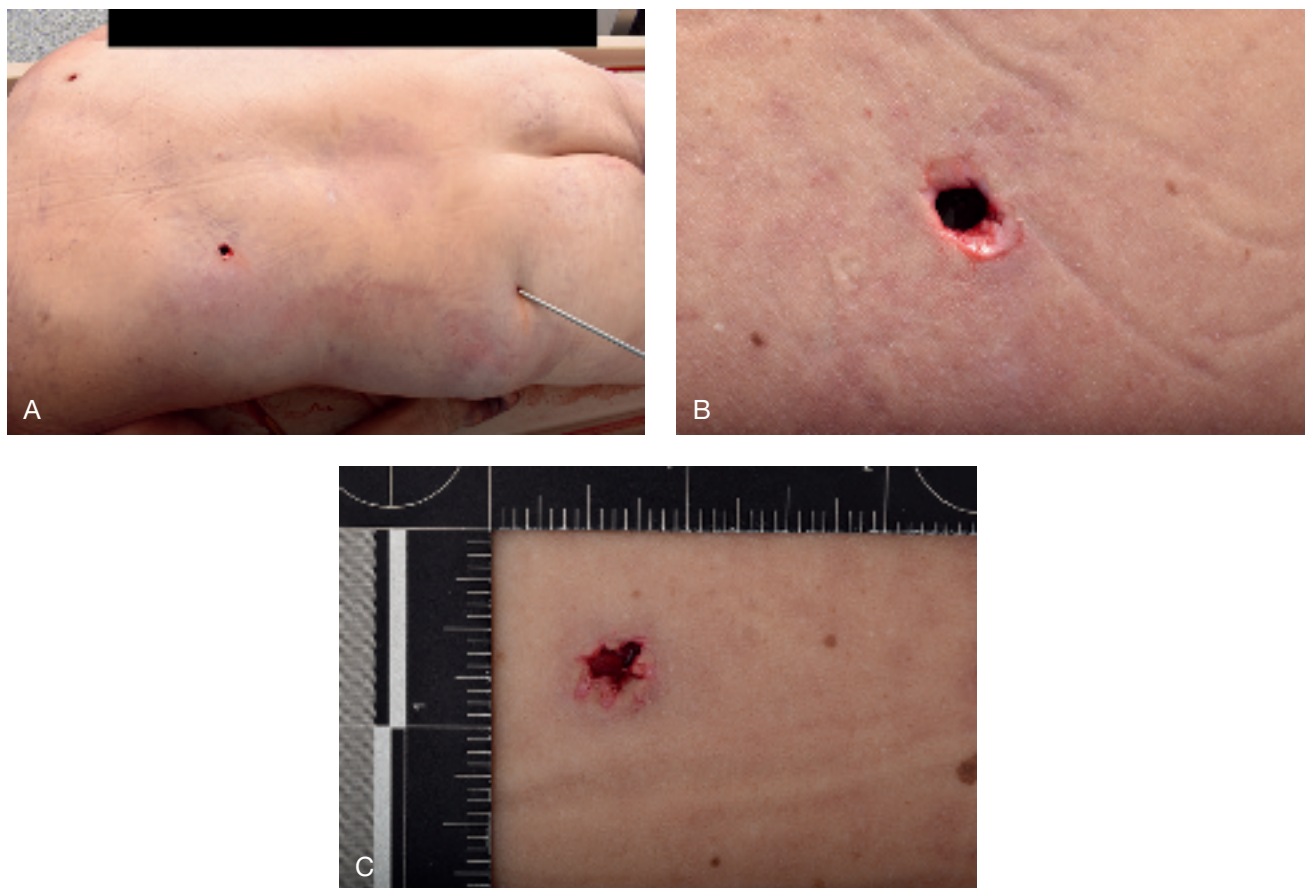


Figure 11.44. Gunshot wound of the body. This individual sustained multiple gunshot wounds. Two gunshot wounds, one representing entrance and one representing exit were present on the right side of the upper back and the left side of the middle of the back (A). The projectile pathway was between these two wounds, traveling roughly parallel to the vertebral column and just underneath the skin; however, both wounds are somewhat atypical. Viewing of a video of the incident showed the individual shot several times, and showed his body turning so his back was toward the shooters and falling forward bent at the hip, in which case his back would have been briefly parallel to the ground. From this video, (B) was determined to be the entrance wound and (C) was determined to be the exit.

KEY FEATURES to Evaluate to Distinguish an Entrance Wound From an Exit Wound

- Overall appearance of wound (circular vs slitlike or stellate)
- Presence or absence of soot
- Presence or absence of stippling/powder tattooing
- Presence or absence of marginal abrasion
- Presence or absence of muzzle abrasion
- Presence or absence of carbon monoxide staining of underlying musculature
- Inward or outward bevel in underlying bone

FEATURES OF WOUND THAT ALLOW FOR GENERAL DETERMINATION OF RANGE OF FIRE

Features of the wound that allow for general determination of range of fire are presence of soot either on the skin or within the depths of the wound and whether the soot on the skin easily wipes away or is associated with searing and is more adherent (Figure 11.47A-G), the presence of stippling/powder tattooing (Figure 11.48A-D), presence of a muzzle abrasion (Figure 11.49A and B), and carbon monoxide-related discoloration of the underlying musculature. DiMaio and Molina distinguish between a loose contact wound, which has a rim of soot that is easily wiped away and that occurs when the muzzle is loosely against the skin and a near-contact wound, which has a rim of soot that is associated with searing and is more tightly adherent to the skin and that occurs when the weapon is a short distance from the skin, but they indicate that there is overlap between loose contact and near contact wounds and that the distinction is not always possible.⁴¹ DiMaio and Molina

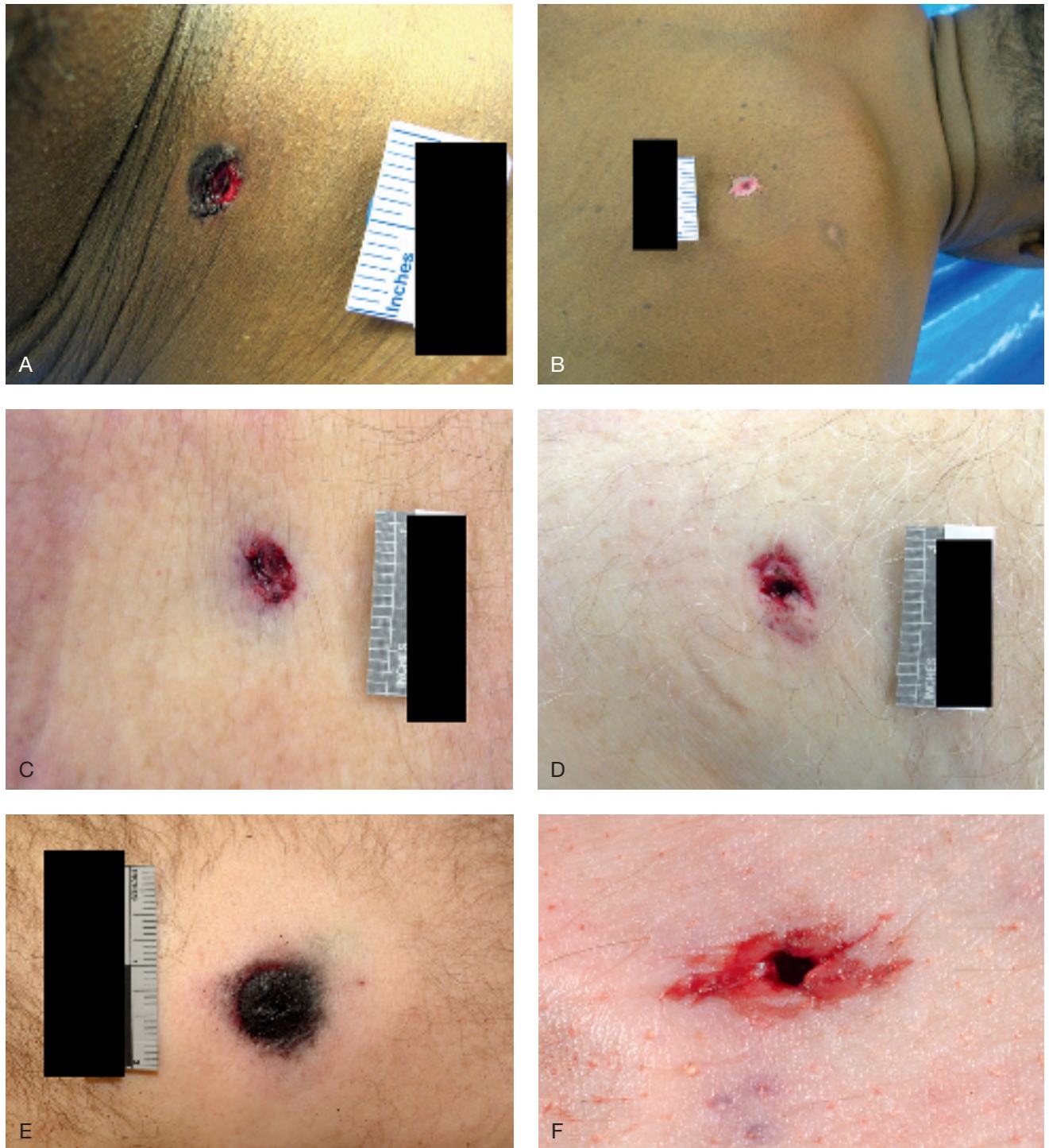
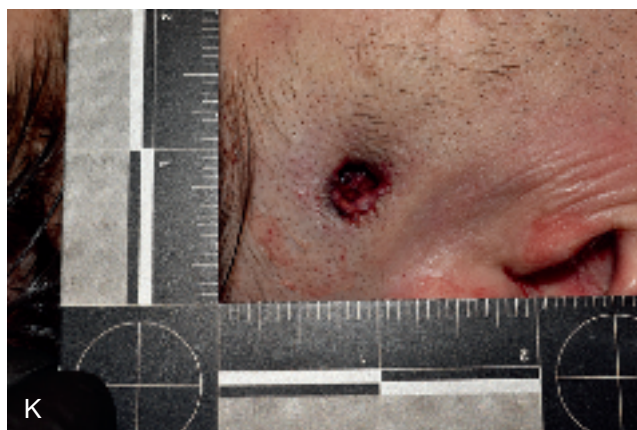
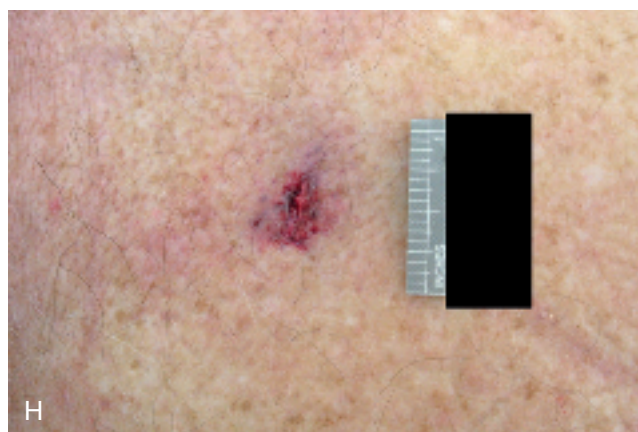


Figure 11.45. Examples of shored exit wounds. In a shored exit wound, there is an abrasion at the edge of the wound which can mimic the marginal abrasion normally found with an entrance wound. This occurs due to some object being against the skin at the exit site, thus, when the skin is pushed outward by the exiting projectile, the epidermis impacts that object, leading to an abrasion. Paired images (A and B), (C and D), and (E and F) are gunshot wounds illustrating both the entrance and exit wounds. (A, C, and E) are the entrance wounds with (B, D, and F) the corresponding shored exits. (G-K) are other examples of shored exit wounds, each with some amount of marginal abrasion.

Figure 11.45g-k (continued)



also prefer the term “powder tattooing” to describe the effect of unburned gunpowder on the skin, with the term “stippling” used as a more generic term for punctate red abrasions around the wound, which could describe the effect of unburned gunpowder or secondary objects such as glass fragments, whereas other authors, including Dolinak et al, prefer the term “stippling” to describe the effects of unburned gunpowder and the term “pseudo-stippling” to describe the effects of an intermediary object.^{34,41} The determination of actual range of fire is done by the firearm examiner, who will test fire the suspected weapon and ammunition type and match the autopsy findings to those of the test firing results to determine a range of fire (ie, shooting the weapon at various ranges to determine how widespread the soot and stippling is at various ranges, and then comparing that distribution to the distribution found at autopsy on the skin around the wound); however, in

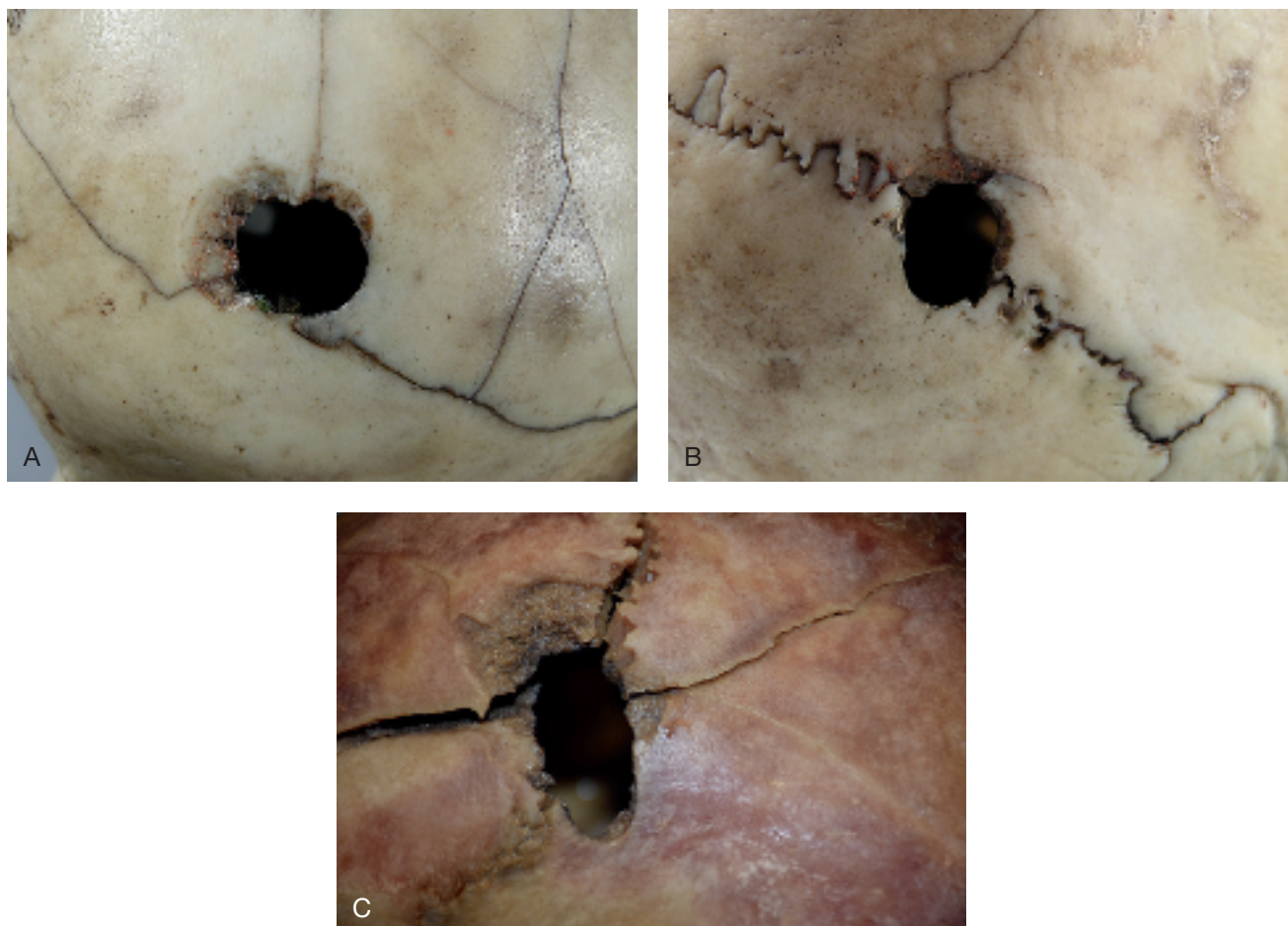


Figure 11.46. Examples of keyhole defects. In a keyhole defect, both inward (giving the surface a punched out appearance) and outward beveling of the bone occur at the same site. A keyhole defect is due to a projectile striking the bone in a tangential (ie, angled) manner. In (A), from 1 to 6 o'clock, the bony surface is punched out, whereas from 6 to 1 o'clock, there is an outward bevel. In (B), from 2 to 10 o'clock, the bony surface is punched out, whereas from 10 to 2 o'clock, there is outward bevel. In (C), from 3 to 9 o'clock, the bony surface is punched out, whereas from 9 to 3 o'clock, there is an outward bevel.

general, soot will mark the skin to around 6 to 8 inches from the weapon and stippling to 1 to 3 feet from the weapon.

Unfortunately, terminology used for the classification of gunshot wound ranges varies by author. Terms used include contact, tight contact or hard contact, loose contact, near contact, partial contact, close range, intermediate range, medium range, indeterminant range, and distant range (Table 11.1).^{34,39,41-45} For the figure legends in this book, the terms contact and close (for wounds with soot and/or stippling) will be used.

KEY FEATURES to Help Determine a Relative Range of Fire

- Presence or absence of muzzle abrasion
- Presence or absence of carbon monoxide staining of underlying skeletal muscle
- Presence or absence of soot on the skin and/or within the depths of the wound
- Presence or absence of seared skin
- Presence or absence of stippling/gunpowder tattooing

SAMPLE NOTE

When documenting the distribution of soot and/or stippling around the periphery of an entrance gunshot wound, use a clock face. For example, “Surrounding the entrance wound is a rim of stippling which is 3/4 inch wide at 12 and 3 o'clock, and 1/8 inch wide at 6 and 9 o'clock.”

SAMPLE NOTE

For classification of a gunshot wound in the summary section of the autopsy report, close range vs no evidence of close range may be best, as the terminology for various sub-categories of close range varies from author to author; however, if features of a contact wound are present such as soot only at the rim and within the depths of the wound or the presence of a muzzle abrasion, the term “contact” could be applied. In the autopsy summary section, or at least in the description of the wound in the body of the autopsy report, a listing of the features of the gunshot wound that allows for the determination of a relative range of fire would be both useful and important (such as describing the presence or absence of soot and/or stippling and the presence or absence of muzzle abrasion and a description of whether the soot is easily removable). The determination of a distant range gunshot wound (ie, a wound with no evidence of closer range fire) should only be made if no intermediary object was present, which could have collected or blocked the soot or unburned gunpowder so it did not strike the skin. If no gunshot residue is present on the skin and no other features for determination of range are available, the range can be labeled as indeterminant, which does not preclude the possibility of an intermediary object.

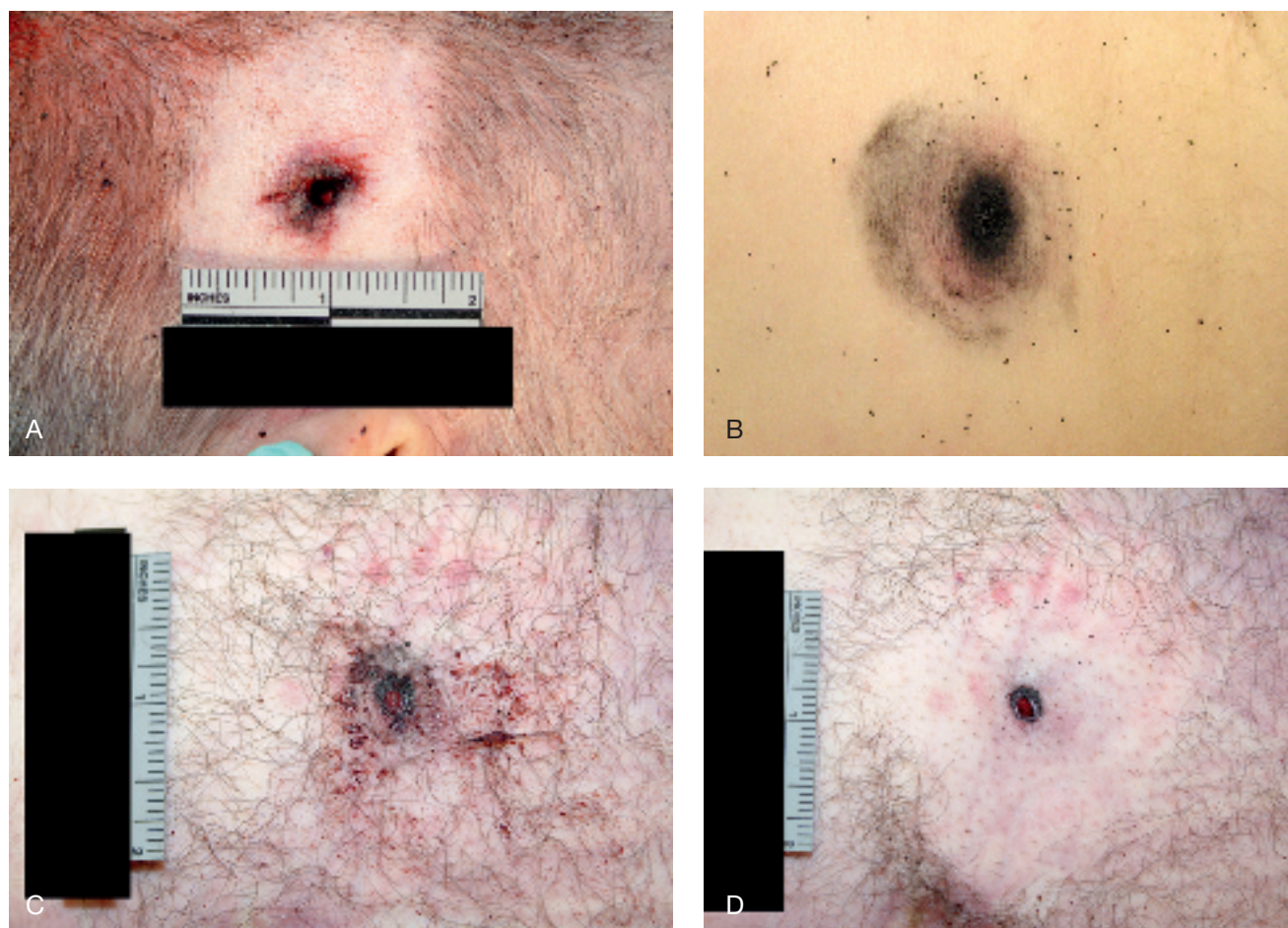


Figure 11.47. Soot deposition on the skin at the entrance wound. In (A), the body has a contact range gunshot wound of the head with soot at the rim of the entrance wound, but not on the surrounding skin. In (B), the body has a close range gunshot wound of the trunk, with a rim of soot on the surrounding skin. In addition, there are unburned gunpowder particles on the skin. In (C and D), the body has a close range gunshot wound of the trunk. In (C), prior to cleaning and shaving of the hair, a small rim of soot is present on the skin. In (D), after cleaning and shaving, the soot is no longer present (ie, easily wiped away). These images illustrate the importance of taking photographs of the entrance wound, especially when soot is identified, prior to cleaning as well as after, and the importance of a pathologist examining wounds prior to their being cleaned by an autopsy assistant.

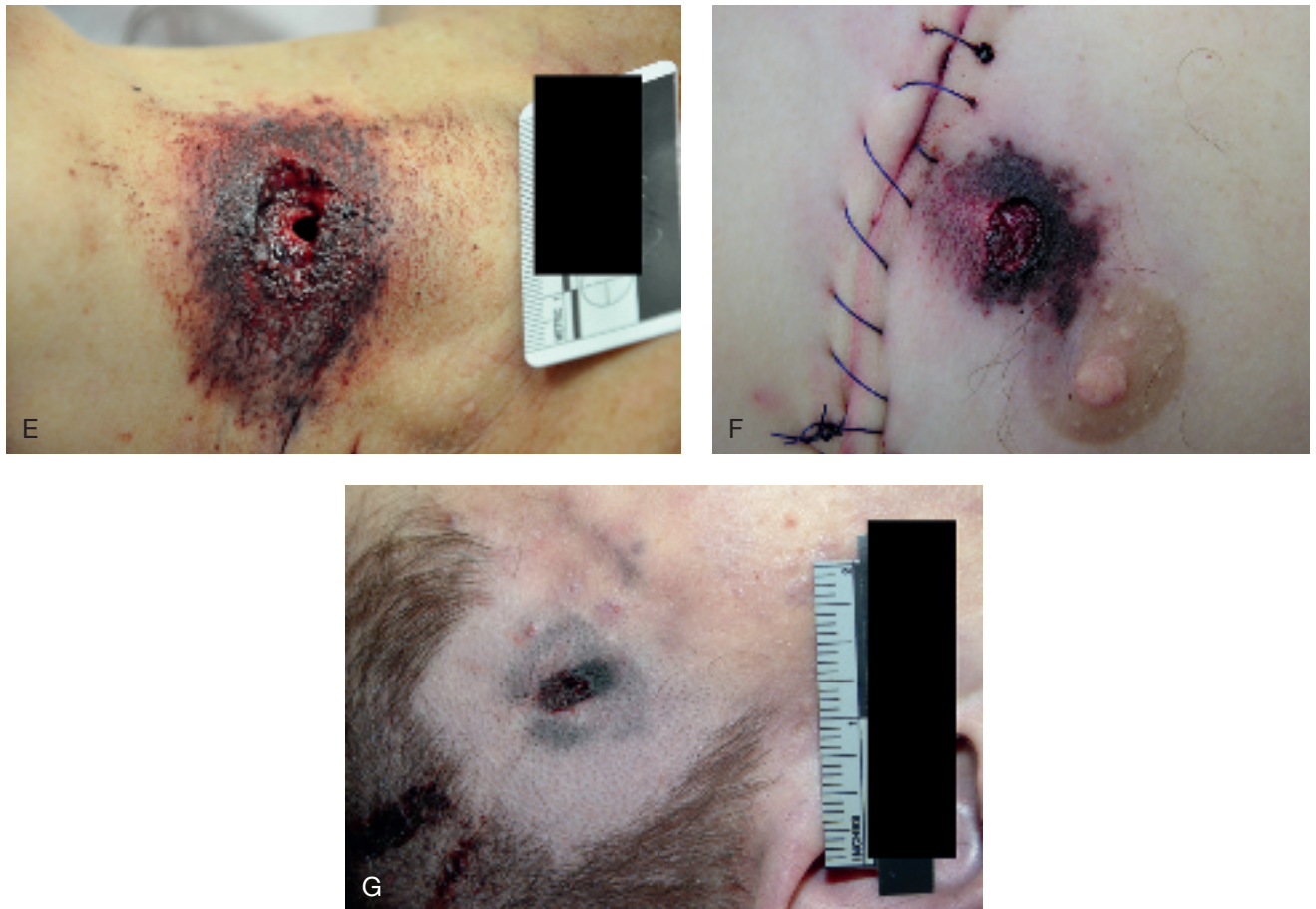


Figure 11.47 E-G. In (E), the body has a close range gunshot wound of the neck. The skin adjacent to the wound is seared, given its rough texture, and the soot is more tightly adherent. In (F), the body has a close range gunshot wound of the chest, adjacent to the nipple, and has undergone medical intervention, presumably with cleaning of the wound. The rough irregular rim around the entrance wound illustrates the effects of searing on the skin. In (G), the body has a close range gunshot wound of the head. This gunshot wound illustrates the overlap between the loose contact and near contact described by DiMaio and Molina,⁴¹ as there is a rim of soot immediately around the entrance, which is tightly adherent and a more peripheral rim of soot that is loosely adherent.

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Drying of the marginal abrasion can result in a black coloration, which can mimic soot and a contact gunshot wound (Figure 11.50A and B). In addition, there can be overlap between the marginal abrasion and a muzzle abrasion, and the muzzle abrasion can dry, mimicking a wider rim of soot than might actually have been present, confounding the determination by the firearm examiner (Figure 11.51A-D).

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Stippling/powder tattooing is produced by unburned gunpowder particles striking the skin, leaving punctate abrasions, with gunpowder sometimes embedded in the skin surface. Stippling/powder tattooing, as it is produced by gunpowder impacting the skin, tends to be regular in size, especially when ball gunpowder was used, with some slight variation in size occurring with flake gunpowder. Pseudo-stippling occurs when the projectile strikes an intermediary target (eg, a glass window) before hitting the victim, creating secondary projectiles (eg, fragments of glass). These secondary projectiles are often small and can produce punctate abrasions of the skin, similar to stippling (Figure 11.52A-D); however, in pseudo-stippling, there is more variation in size and shape of the punctate abrasions. Stippling due to unburned gunpowder striking the skin and pseudo-stippling due to secondary projectiles are not mutually exclusive, and it would be possible for a wound to have both.

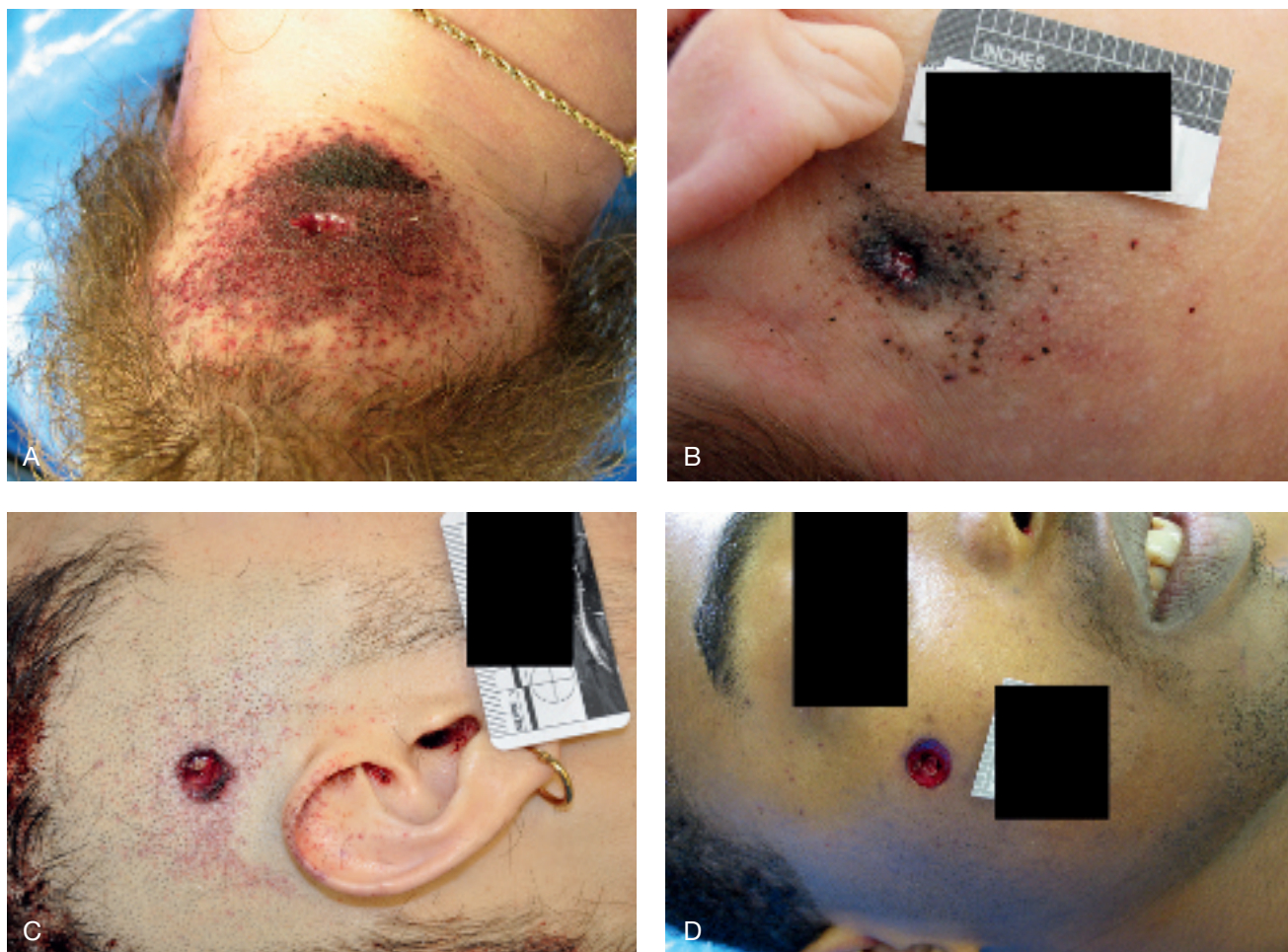


Figure 11.48. Stippling/powder-tattooing. In (A), the body has an entrance gunshot wound of the undersurface of the chin, which is surrounded by a dense rim of stippling. In (B), the body has a close range gunshot wound of the head just behind the ear. While there is a rim of soot, there is also stippling/powder-tattooing, with gunpowder loosely embedded in the skin. In (C), the body has a close range gunshot wound of the head. Compared to (A), the stippling around this wound is much finer in texture and as such more difficult to identify. In (D), the body has a close range gunshot wound of the cheek. Superior to the gunshot wound, adjacent to the right eye, is rare stippling. As stippling can indicate a distance of 1 to 3 feet, the identification of even rare stippling is important.

FAQ: Does decomposition preclude identification of entrance and exit wounds?

Answer: As long as the skin is intact, the entrance and exit wounds as well as their features for determination of range can often be identified^{46,47} (Figure 11.53A-C). However, if the skin is not intact, the task becomes more difficult but not impossible if soot is present in the underlying soft tissue, or if the projectile passed through bone, which allows for a bevel pattern to develop.⁴⁸ However, in some cases of advanced decomposition, even with bone involvement, the entrance and exit wounds cannot be distinguished.^{49,50}

SAMPLE NOTE: EXAMPLE OF GUNSHOT WOUND DESCRIPTION IN REPORT

“On the left side of the chest is a ½ inch circular entrance-type gunshot wound that is centered 13 inches below the top of the head, 3 inches to the left of midline, 1 inch superior to the left nipple and 2 inches medial to the left nipple. The wound has a circumferential ¼ inch wide marginal abrasion. Circumferentially on the skin surface in a 1/2 inch wide rim from the edge of wound is soot. The width of the rim of soot is consistent circumferentially.”



Figure 11.49. Muzzle abrasion at entrance wound. (A and B) both illustrate entrance gunshot wounds with a muzzle abrasion.

SAMPLE NOTE: EXAMPLE OF GUNSHOT WOUND DESCRIPTION IN REPORT

“In the left temporal region of the scalp is a 1/2 inch circular entrance-type gunshot wound that is centered 3 inches below the top of the head, 1 inch superior to the tragus of the left ear, and 1 inch anterior to the tragus of the left ear. At the edge of the gunshot wound is blackened discolored skin associated with a 1/8 inch wide circumferential marginal abrasion. At 1, 5, 6, and 9 o'clock are radiating tears, measuring 1/4, 1/2, 1/2, and 2 inches respectively.”

FAQ: Should gunshot wound pathways be described with scientific terminology?

Answer: With forensic autopsies, especially those involving gunshot wounds, most commonly, non-physicians are the persons most likely to read the report. Front/back and up/down can be more familiar to these readers than anterior/posterior and superior/inferior.

SAMPLE NOTE: WORDING OF GUNSHOT WOUND FOR DEATH CERTIFICATE

“Gunshot wound of the head” vs “Perforating contact gunshot wound of the head.” While both wordings are acceptable, it is good to remember that individuals who have a copy of the death certificate often will not have a copy of the autopsy report itself. Listing perforating (or penetrating, if the projectile only entered the head but did not exit) contact gunshot wound of the head as the cause of death provides more information.

TABLE 11.1: Terminology Used for the Classification of Gunshot Wound Ranges

	Fisher	DiMaio	Dolinak	Knight	Spitz	Wetli	Mason
Contact							
Tight contact/ hard contact	Muzzle abrasion, powder residue deep in wound	Powder residue deep in wound; searing and pow- der blackening at edge	On head, radiat- ing lacerations			Muzzle abrasion, ejector rod abra- sion; gunshot residue	Muzzle abrasion
Loose contact	Powder residue on skin and in depths	Soot in band around edge that can be wiped away		Soot in imme- diate vicinity of wound			
Near contact		Rim of soot and seared blackened skin; soot cannot be wiped away				Circular band of charred skin and gunshot residue; residue on skin	Muzzle abrasion
Near (loose) contact			Searing of skin, giving black discoloration; soot on skin				
Close	Cutaneous tattoo- ing or stippling from particulate powder	Contact, near contact, and intermediate range wounds are considered together as close range		Soot and pow- der tattooing	Gunsmoke deposited on skin	Soot on skin around wound that is eas- ily wiped away	Soot on skin
Intermediate		Powder tattooing (not stippling); can have soot	Stippling from un-burned gunpowder			Stippling; soot can be present	
Medium							Powder tattooing (grains embed- ded); stippling (impact marks)
Distant	None of above	Not possible to accurately determine			No gunsmoke deposited on skin		

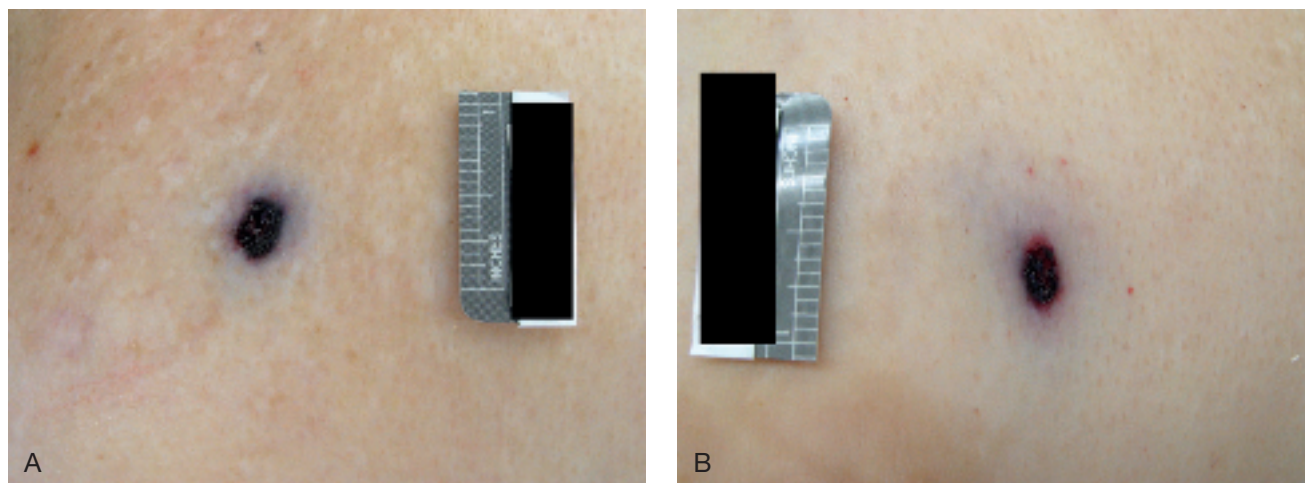


Figure 11.50. Entrance gunshot wounds with dried marginal abrasions. In both (A and B), the individuals were shot from a distance (which was determined based upon the scene investigation). Both entrance wounds have marginal abrasions, which have dried, giving them a dark coloration, which can mimic soot. Close inspection of the wound including with a dissecting-type microscope detailed examination of the underlying soft tissue (as, with a contact wound, should have soot if it is not present on the skin, or carbon monoxide discoloration), and examination of the clothing can help determine the true nature of the wound.

SPECIAL TYPES OF GUNSHOT WOUNDS

Introduction: To describe some gunshot wounds, specific terms are used, including shored exit, graze wound, tangential wound, superficial perforating wound, and re-entrance. Each has some features different from the classic entrance or exit wound described above. While

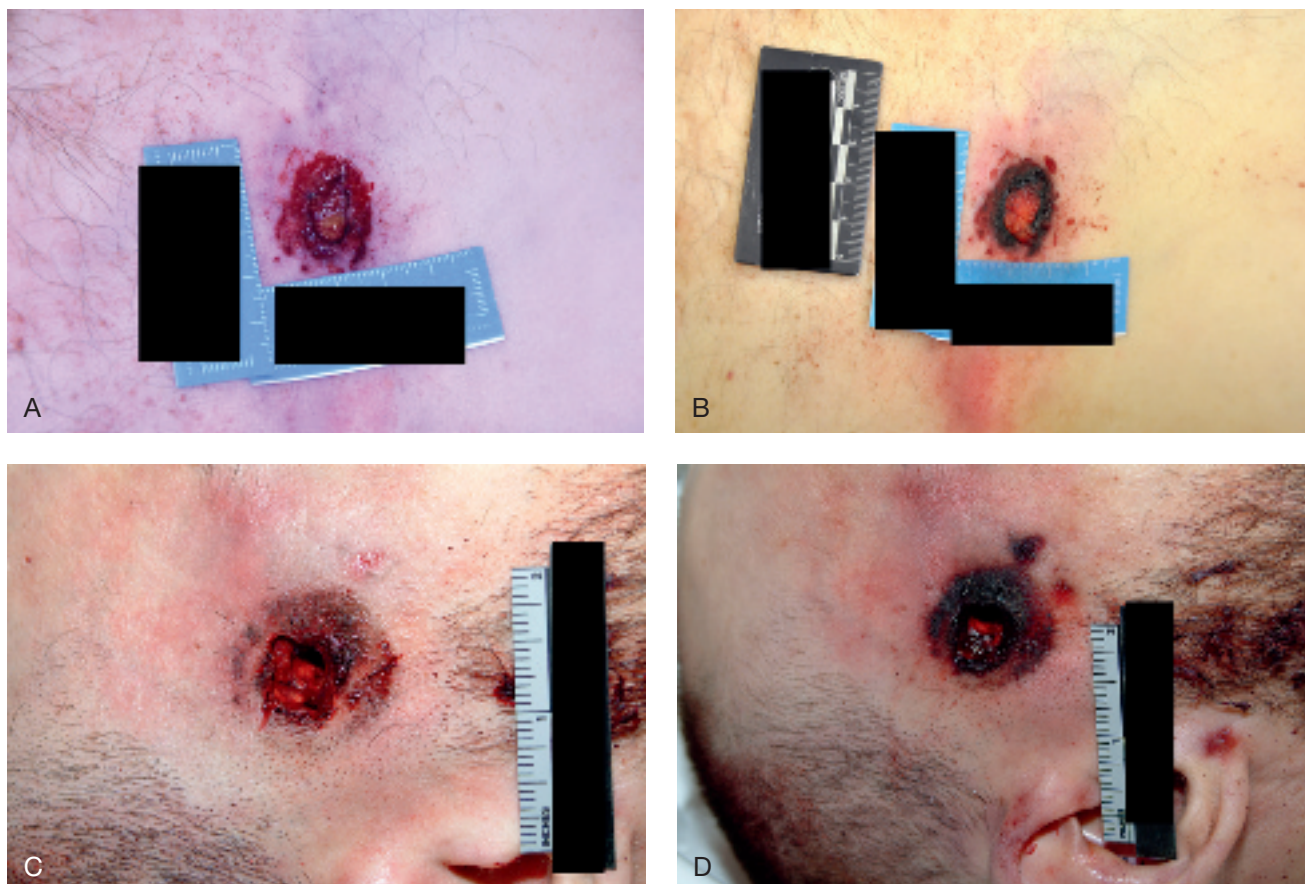


Figure 11.51. Decedents with firearm injury illustrating drying of the marginal abrasion/muzzle abrasion. In (A and B), the body has both a pre-autopsy photograph of the wound taken by investigators (A) and an autopsy photograph of the same wound (B) illustrating the effect of drying on the marginal abrasion/muzzle abrasion, producing a discoloration which can mimic soot. In (C and D), both autopsy photographs, but with time between the two photographs, (C) illustrates a muzzle abrasion, with some embedded soot, but (D) illustrates the same wound at a later time, with drying of the muzzle abrasion, mimicking a more dense rim of soot around the wound.



Figure 11.52. Pseudo-stippling on the skin. In (A), the decedent was shot through a door. The projectile mushroomed causing an atypical entrance wound at the lateral corner of the left eye. While the skin of the face surrounding the entrance has numerous abrasions, these abrasions are all quite variable in size and shape and were produced from secondary projectiles caused by the bullet striking the door first. In (B), the decedent was shot through a glass window. When the window broke, secondary projectiles (ie, fragments of glass) were propelled forward and struck the decedent. The punctate abrasions are similar to stippling/powder tattooing; however, there is significant variation in size and shape, and no embedded powder grains. In (C), the decedent has an entrance gunshot wound with a circumferential marginal abrasion but surrounding the skin are several punctate abrasions. The abrasions vary in size and shape and were created by secondary projectiles, from an object interposed between the shooter and the victim. In (D), the decedent has an entrance and exit gunshot wound of the knee. The numerous abrasions of the legs are pseudo-stippling due to an interposed target.

DiMaio and Molina separate between graze wound, tangential wound, and superficial perforating wound, other authors overlap the terminology.⁴¹ The descriptions below are made using DiMaio and Molina's terminology.

Description: A shored exit occurs when there is a marginal abrasion at the exit wound (Figure 11.54A-C). The cause is often tight clothing or some other object abutting against the skin at the site of the exit wound, such that when the skin bulges outward at the exit it strikes the adjacent object, leaving a marginal abrasion.⁵¹ The marginal abrasion of a shored exit wound is usually less regular and lighter red in color than a marginal abrasion on a typical entrance wound, and may have residual islands of epidermis within its confines but can still present a challenge to the observer.

Graze Wound

Description: A graze gunshot wound is essentially a wide linear abrasion of the skin, as the projectile does not or just barely perforates through the epidermis into the underlying subcutaneous tissue (Figure 11.55A and B).

Tangential Wound

Description: A tangential wound is essentially a laceration of the skin, where the projectile creates one continuous linear defect from the point it first contacts the skin, which will often

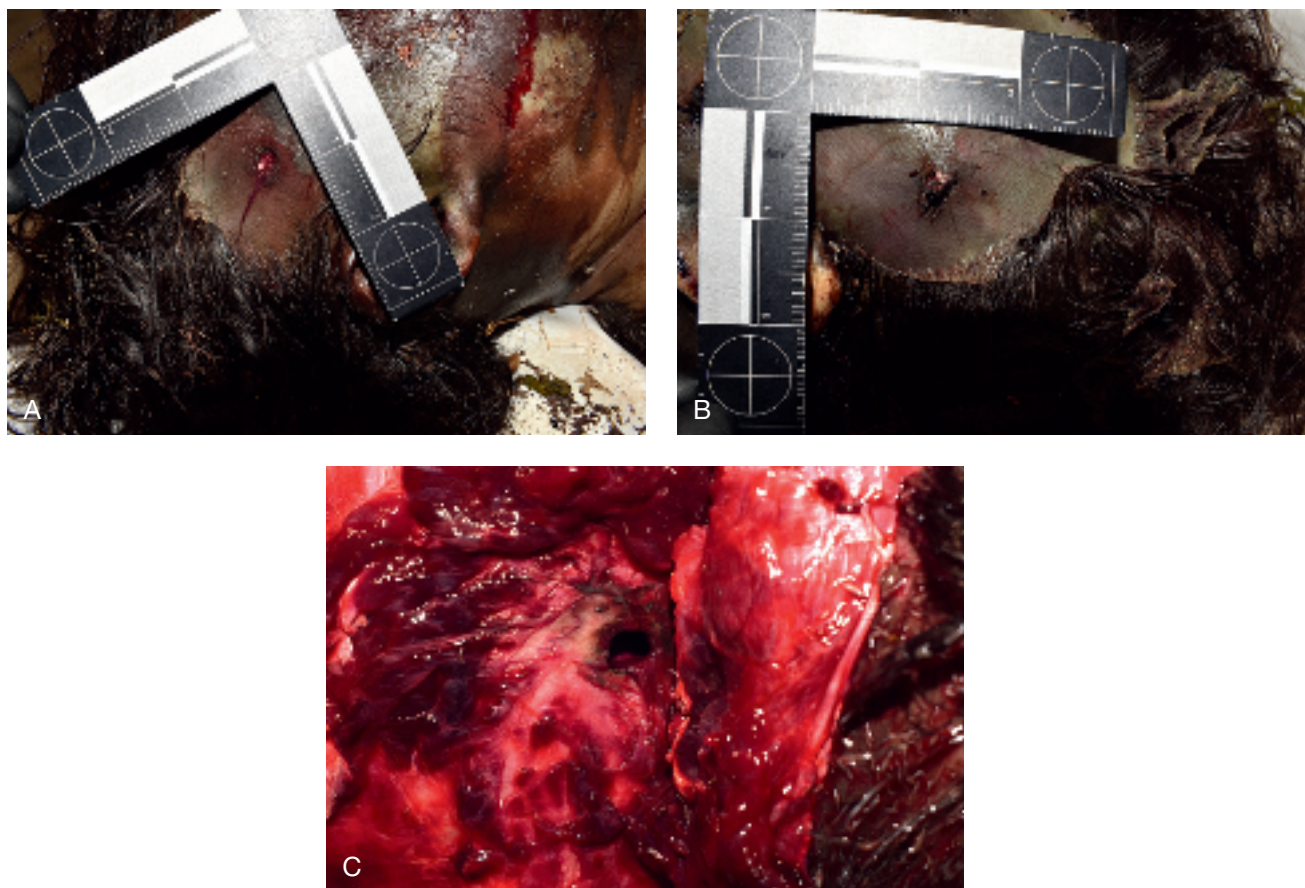


Figure 11.53. Entrance and exit gunshot wound in a decomposed body. Although the entrance (A) and exit (B) are difficult to distinguish, the presence of soot (C) on the bone underlying the entrance (as well as inward bevel at the entrance and outward bevel at the exit) confirmed the pathway of the projectile.

have a marginal abrasion, to the point where it loses contact with the skin (Figure 11.56). While some authors separate graze and tangential wounds,⁴¹ other authors use the terms more interchangeably, with a graze wound describing both.^{34,39}

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The skin tags in a tangential wound will point in the direction that the projectile was fired from (i.e., “points toward the weapon”) (Figure 11.57A-C). Close examination of one end of the defect will also often reveal a marginal abrasion, which was the point of first contact of the projectile. If there is an underlying fracture of the cranium, it may have a keyhole-type defect.

Superficial Perforating Wound

Description: A superficial perforating wound is a wound that has a distinct entrance wound and exit wound but which only perforates the skin and underlying soft tissue (Figure 11.58).

Re-Entrance Wound/Atypical Wound

Description: A re-entrance wound occurs when the projectile passes through one part of the body (eg, the upper extremity) and re-enters another part of the body (eg, the chest), or when the projectile passes through another object prior to striking the decedent (eg, a window). The re-entrance wound produced is often atypical. The atypical features can be a wider and more irregular marginal abrasion or non-circular shape of the entrance wound or

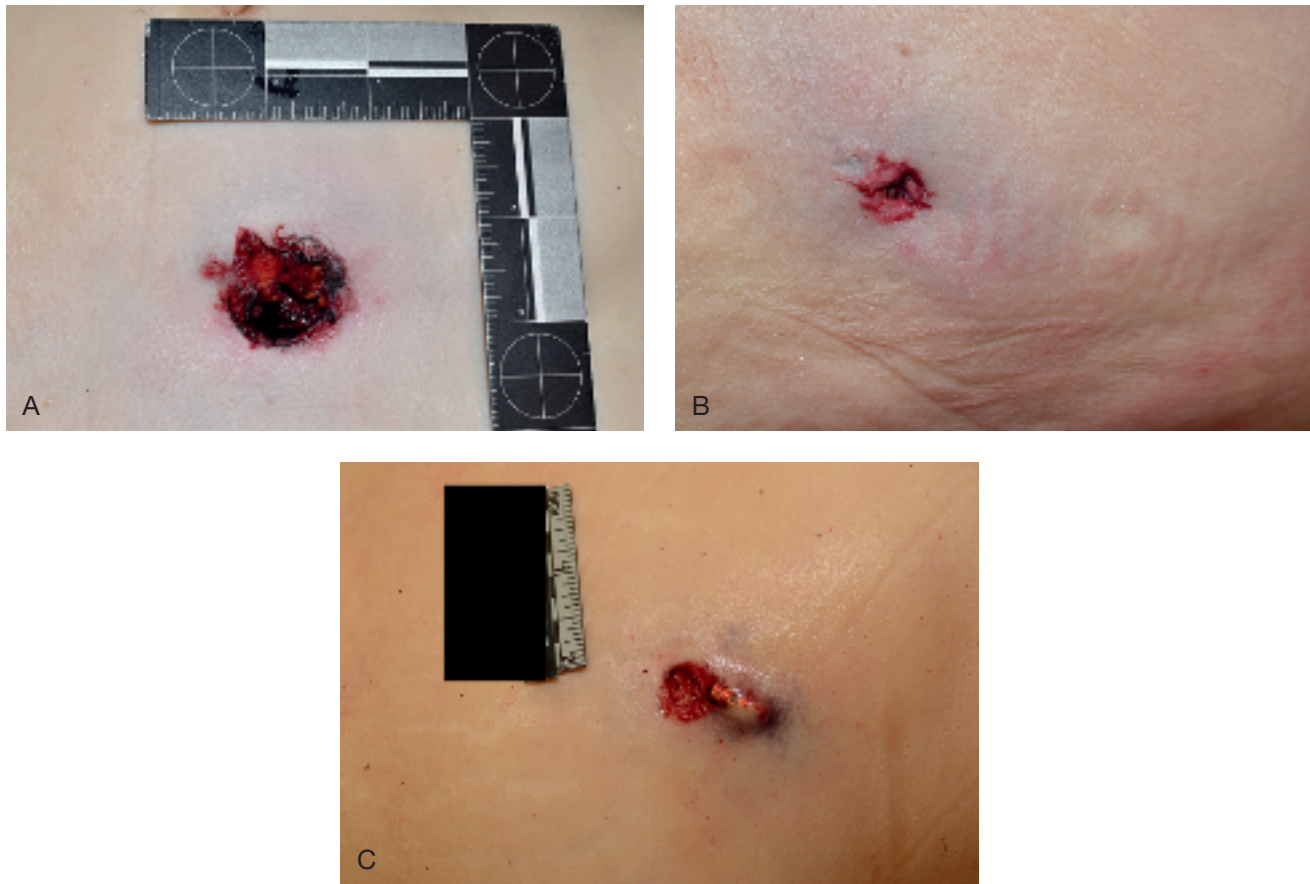


Figure 11.54. Shored exit wounds. The decedent in (A and B) died from the result of a single self-inflicted gunshot wound of the trunk. (A) is the entrance wound on the anterior surface of the trunk, with soot visible at edge. (B) is the exit wound on the posterior surface of the trunk. Note the abrasion at the margin of the exit wound, which mimics the marginal abrasion seen with entrance wounds. In (C), there is an exit wound with the projectile adjacent and just underneath the skin. From 2 to 6 o'clock is an eccentric abrasion ring. Based upon the angle at which the projectile exited the body, it created a marginal abrasion, which would, if the projectile were not in place, mimic an entrance wound with an eccentric marginal abrasion.

both (Figure 11.59A-G). The underlying reason for the atypical appearance of the wound is that the projectile, having struck another object prior to entering the body, will have become deformed or will have had its stable rotation disrupted, causing it to strike the body not in the usual fashion (eg, the projectile might strike the body sideways instead of tip first). An atypical entrance wound may be misinterpreted as a form of injury other than a gunshot wound.⁵²

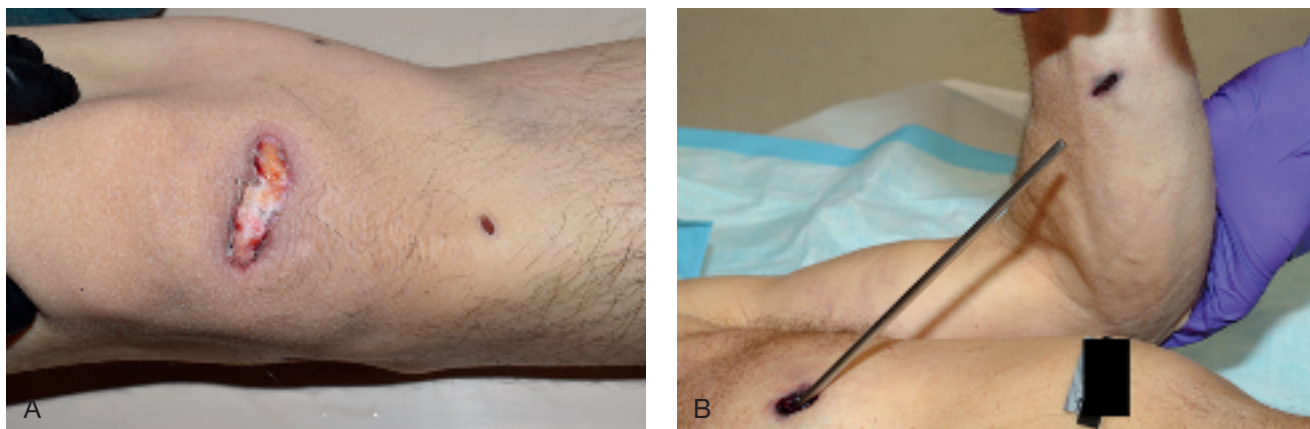


Figure 11.55. Graze entrance wounds. (A) is a graze wound of the right knee, with the projectile essentially just scraping away the epidermis and superficial dermis. While skin tags on a tangential wound can assist in determining the direction of fire, given the superficial nature of the wounds such as the one in the image, the edges can easily not develop sufficient skin tags to determine the pathway of the projectile, or the edges can dry, which also hinders interpretation. (B) is a graze wound of the left forearm, with subsequent entry of the projectile into the chest.



Figure 11.56. Tangential wound. This individual was shot multiple times. One of the gunshot wounds produced a tangential wound of the top of the head. Compared to a graze wound, the wound is deeper into the dermis, in this case, extending to the cranium. The pathway of the projectile was, in the image, left to right, which can be determined by examining the skin tags (see text and Figure 11.57A-C). At the arrow is a marginal abrasion.

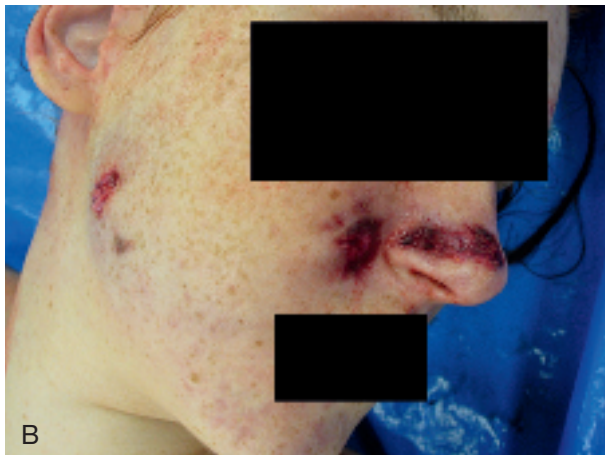


Figure 11.57. Tangential wound with skin tags for orientation. In (A), this individual was shot multiple times. One of the gunshot wounds produced a tangential wound of the top of the head. At the left side of the wound in the image is a marginal abrasion. The skin tags point to the left, which is the direction the projectile came from. The pathway of the projectile is left to right in the image. In (B and C), the individual sustained multiple gunshot wounds. The wound in the images was not lethal but illustrates several features of gunshot wounds. In (B) is a graze wound/tangential gunshot wound of the nose, with the entrance at the medial portion of the right cheek having a wide marginal abrasion from 12 to 6 o'clock and with the exit wound on the lateral surface of the right cheek having no marginal abrasion. (C) is a close-up of the wounds of the nose and cheek, with the wound of the nose having skin tags that point in the direction the projectile came from.



Figure 11.58. Superficial perforating wound. This individual was shot multiple times. One of the wounds of the extremities was a superficial perforating wound. On the left side of the image is the entrance wound, with a marginal abrasion. On the right side of the image is the exit wound, with no marginal abrasion. Unlike graze wounds or tangential wounds, the projectile perforated the skin and soft tissue of the body, with no communication on the skin surface between the two points; however, the projectile only perforates skin and subcutaneous tissue, not penetrating deeper into the body.



Figure 11.59A. Re-entrance wounds of the breast. This woman was shot at a close range through the breast. The round defect on the right side of the image is the entrance wound, with soot on the skin to the right. The projectile perforated the skin and soft tissue at the inferior aspect of the breast (ie, the two elongated defects in the middle of the image), and re-entered the trunk at the left side of the image, which is a more irregular defect, with an abrasion to the left, which likely resulted from the skin above being forced against the skin below, and stippling to the left of the abrasion. The wound also again illustrates how at the time of autopsy the orientation of the skin is not the same as when the decedent was shot. In this case, on the autopsy table, the breast does not rest against the body in the same fashion as it would when the decedent was standing or sitting, at the time they were shot.



Figure 11.59B1-B2. Re-entrance wound of the chest. The decedent was shot through the left upper extremity and that projectile then re-entered the chest at the upper border of the left breast. In (B1) can be seen the exit on the medial surface of the left arm and the re-entrance in the chest. (B2) is a close-up of the re-entrance in the chest. Instead of a round circular defect, the wound is more oval and irregular, and the marginal abrasion is also more irregular than if the projectile had not passed through the left arm first. Most ammunition types encountered by forensic pathologists will expand/mushroom after making contact with the body, which serves to dissipate all of the kinetic energy of the projectile into the body, causing more injury.



Figure 11.59C1-C3. Atypical entrance wound. Although re-entrance of the projectile can and often does produce an atypical entrance wound, sometimes entrance wounds may just appear atypical. In (C1) is an elongated entrance wound of the undersurface of the chin, with soot at the margin. (C2) is the corresponding exit wound, which has a typical stellate appearance. (C3) is the outward bevel present at the exit wound. Given that the individual's neck was most likely flexed at the time of the gunshot wound, the folding of the skin could alter the wound created by entrance of the projectile.



Figure 11.59D-G. Re-entrance wound. (D-G) are of a decedent with a gunshot wound of the right arm into the chest. (D) is the entrance wound in the lateral surface of the right arm. The wound is circular with a uniform marginal abrasion. (E) is the exit wound from the medial surface of the right arm. The wound is irregular in shape, with an irregular in width marginal abrasion. This is a shored exit, caused by the arm being against the chest. (F) is the re-entrance wound, with the defect non-uniformly surrounded by an irregular wide and large marginal abrasion, which resulted most likely from the projectile having mushroomed upon impact with the arm, and due to impact of the skin of the medial surface of the arm against the chest. (G) is an overall photo of the three defects.

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The presence of an atypical entrance wound often indicates that an intermediary target was present (ie, an object between the shooter and the decedent, which can include the decedent themselves, in the case of a re-entrance wound). When there is an intermediary target, it is possible for a fragment of that object to be carried forward with the projectile and into the body.⁵³ This fragment of the object may assist in re-constructing the events of the shooting.⁵⁴

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If the projectile is more superficially located in the body in comparison to its degree of deformation (eg, if the projectile is flattened but only perforated the skin of the abdomen and penetrated into the liver), consider a ricochet or intermediary target (Figure 11.60A-C).³⁴

ENTRANCE AND EXIT WOUNDS FOR SHOTGUNS AND RELATIVE RANGE OF FIRE

Entrance wounds for shotguns: While shotgun entrance wounds can have the same features described above for handguns/rifles (eg, marginal abrasion and soot/stippling), the nature of most shotgun projectiles, specifically buckshot and birdshot, allows for other patterns to be present at the entrance wound, which are discussed below under determination of relative range.

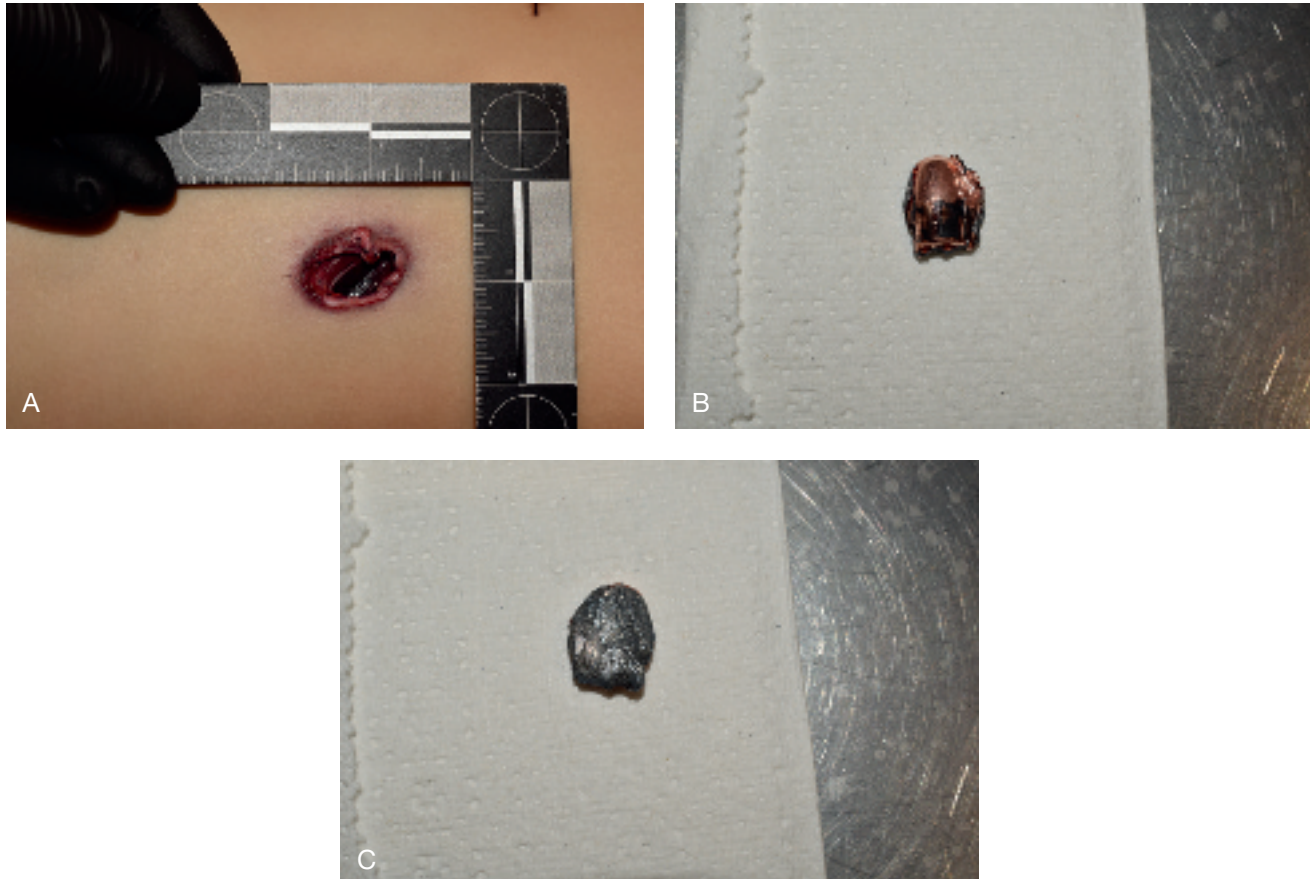


Figure 11.60. Decedent with gunshot wound following ricochet. (A) is the gunshot entrance wound on the trunk, which, for the caliber of projectile used, appeared larger than expected. The projectile did not strike any bone, but only penetrated into the abdominal cavity a short distance. The projectile, when recovered, was a flattened copper-jacketed lead core projectile (B and C), which is consistent with a ricochet.

Exit wounds for shotguns: The pellets, whether buckshot or birdshot, most often do not exit, although buckshot, given the large mass of each projectile, may be more likely to exit (Figure 11.61), and birdshot, when shot through a thin portion of the body (eg, the hand), could also exit.

FEATURES OF THE SHOTGUN WOUND THAT ALLOW FOR DETERMINATION OF RELATIVE RANGE OF FIRE

While a shotgun wound can be associated with both soot and stippling similar to a handgun or rifle wound, the nature of shotgun shells loaded with birdshot or buckshot allows for additional findings that allow for determination of range of fire beyond that for which stippling is normally present. When a shotgun shell with birdshot or buckshot is discharged, a mass of pellets and the shot sleeve (or shot cup)/wadding exit the barrel. At first, the mass of pellets will be tightly packed together and create a single round defect in the skin (Figure 11.62). As the pellets at the edge of the mass start to separate, the edge of the wound will be scalloped (Figure 11.63). Then, at a farther distance, individual pellets will separate from the central mass, creating satellite perforations near the edge of the main defect in the skin (Figure 11.64), and ultimately, no mass of pellets is present and only individual perforations will be present (Figure 11.65). In addition, the wadding/shot sleeve can strike the body and/or lodge within the entrance wound (Figure 11.66), or strike the skin at another point, leading to an abrasion (Figure 11.67A-D). Some shotgun shells contain tiny white particles which act as a filler among the shot pellets. This filler material can strike the skin or deposit within the wound (Figure 11.68). When individuals are shot multiple times with a shotgun, multiple appearances are, of course, possible (Figure 11.69). Given the variable nature of shotgun barrels, in that there are those with full choke or modified choke, or those that are sawed off or not sawed off, each of which could affect the spread of the pellets after leaving the barrel, the range of fire is best determined by a firearm examiner; however, the general knowledge of the pattern produced by the pellets as described above would allow a forensic pathologists to give investigators a general idea of how close the shot was fired at.

SAMPLE NOTE: SHOTGUN WOUND RANGE

Determination of range of fire of a shotgun wound is very difficult at the time of autopsy due to a variety of factors including tangential wounds and incomplete patterns of spread represented on the body (eg, not all birdshot or buckshot pellets struck the skin, so the true distribution of the pellets is unknown). Determination of range of fire of a shotgun wound is best left to the firearm examiner; however, the pathologist can assist in the most accurate determination by extensively photographing the wound and obtaining complete measurements of the injuries in the skin.



Figure 11.61. Decedent shot with buckshot. The entrance of the buckshot was in the back. On the right side of the chest were exit defects and also projectiles just underneath the skin. Some of the buckshot only penetrated into the body; whereas some of the buckshot perforated the body, with one pellet identified in the clothing.

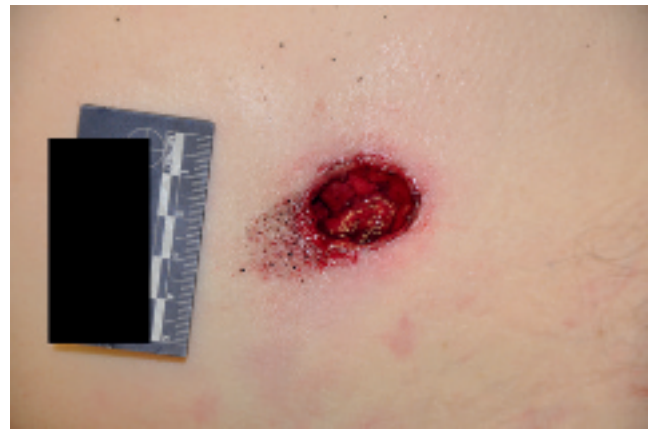


Figure 11.62. Circular shotgun wound entrance. When the charge of pellets that exits the barrel immediately or nearly immediately comes into contact with the skin, the resulting defect will be round, as the pellets all struck the skin in one cohesive mass, mimicking a large projectile. The soot present at 7 to 8 o'clock in the image resulted from a slight gap in the seal between the barrel and the skin which allowed some soot to escape and deposit on the skin.



Figure 11.63. Scalloped shotgun wound entrance. When the charge of pellets that exits the barrel travels a short distance prior to striking the skin or travels through clothing, the mass of pellets is allowed to separate slightly, which will give the edge of the wound a scalloped appearance.



Figure 11.64. Shotgun wound created by central mass of pellets with satellite perforations. As the charge of pellets continues to distance from the end of the barrel, some pellets break away from the central mass and will produce satellite perforations at the periphery of a large defect created by the bulk of the pellets still within a central mass. Examination of the wound in the image reveals soot. This wound was essentially a contact range gunshot through clothing. Passing through the clothing allowed for the slight dispersion of pellets.

FAQ: With the extensive destruction of the head that occurs with high-velocity rifle wounds or contact range shotgun wounds, can an entrance and exit always be identified?

Answer: Yes and no; while close inspection of the edges of the wound and re-approximation of skin edges should allow for the identification of the entrance site (Figure 11.70A-C), the exit site may not be identified.



Figure 11.65. Shotgun wound created by individual pellet perforations only. Once the central mass of pellets has entirely dispersed, only single individual defects from each pellet will be identified.



Figure 11.66. Wadding lodged in body. This individual was shot multiple times with both birdshot and buckshot. When the body was first viewed, one shot sleeve was partially entangled in the disrupted tissue at the left side of the jaw.



Figure 11.67A. Representative fired shot sleeve. This shot sleeve, fired from a 12 gauge shotgun, has opened up, with the four wings forming a plus sign. A 0.410 shell has a shot sleeve with only three wings.



Figure 11.67B. Wadding strike against the skin. When the shot sleeve passes through the air, the wings of the shot sleeve will open. The rectangular abrasion at 12 o'clock in the image is from a wing of the shot sleeve striking the skin.



Figure 11.67C. Wadding strike against the skin. At 12 o'clock, 6 o'clock, and 9 o'clock, and faintly at 3 o'clock are rectangular abrasions, consistent with the wings of the shot sleeve. At 3 and 6 o'clock are satellite perforations.



Figure 11.67D. Wadding strike against the skin. On the right cheek is a round abrasion, which is from the base of the shot sleeve impacting the skin (arrow). There are pellet perforations of the right eyelids, the right cheek, and the peri-oral region. The decedent has abrasions of the nose and chin that occurred after they collapsed from the shotgun wounds.



Figure 11.68. Scalloped shotgun wound with filler material. Contained within some shotgun shells are tiny white plastic pellets, which are filler material. These pellets can be found in closer range shotgun wounds.



Figure 11.69. Individual shot multiple times with a shotgun. The defect on the left side of the image has a central defect with numerous satellite perforations. Inferior to the wound is a round abrasion. This resulted from the base of the shot sleeve impacting the skin. The defect on the right side of the image has a shot sleeve embedded within the wound. Based solely upon this image, the shot that caused the wound on the left side of the image was fired at a greater distance than the shot that caused the wound on the right side of the image.



Figure 11.70. Extensively damaged head with identification of entrance wound. When a pathologist is confronted with a gaping defect of the head (**A**), finding the entrance wound can appear daunting; however, re-approximation of the wound edges (**B**) will usually always reveal the entrance wound (**C**). There is a marginal abrasion, with soot at the edge of the wound.

SAMPLE NOTE: WORDING CAUSE OF DEATH FOR HANDGUN/RIFLE WOUND VS SHOTGUN WOUNDS

In general, gunshot wounds are considering those caused by a handgun or rifle, and shotgun wounds are those caused by shotguns. If an individual dies from a self-inflicted wound of the head caused by a handgun or rifle, the death certificate is usually certified as “Contact gunshot wound of the head” or “Gunshot wound of the head.” If the individual dies from a self-inflicted wound of the head by a shotgun, the death certificate is usually certified as “Contact shotgun wound of the head” or “Shotgun wound of the head.”

SAMPLE NOTE: WORDING CAUSE OF DEATH FOR MULTIPLE GUNSHOT WOUNDS

If an individual dies from multiple gunshot wounds, the certifier can attempt to distinguish the most immediately lethal gunshot wound as the cause of death and list other gunshot wounds as contributory. For example, the cause of death is certified as “Gunshot wound of the head” in part I, and “Gunshot wounds of the extremities” are listed as contributory causes of death in part II. However, lumping everything together as “Multiple gunshot wounds” is often preferred, with a distinction of which gunshot wound(s) was/were most likely the lethal injury discussed with the family or in court as the question arises.

INTERNAL EXAMINATION

One important concept in understanding the pattern of injuries in the internal organs is the concept of a temporary cavity and a permanent cavity.⁵⁵ The permanent cavity is created by the actual passage of the projectile, and is the damage created when the projectile impacts tissue. Projectiles that deform (eg, hollow-point projectiles) and projectiles that are yawing (ie, rotating off their axis of flight) create a wider permanent cavity.³ Also, fragmentation of the projectile will contribute to a larger permanent cavity, with the secondary projectiles expanding the size of the permanent cavity.³

The temporary cavity is a wider zone of potential injury created by the transfer of kinetic energy to the tissue and can cause injury distal to the pathway of the projectile.^{56,57} The temporary cavity is created by tissue at the edge of the permanent cavity being pushed away from the projectile.³ Non-elastic tissues such as liver or bone are at greater risk for damage from the temporary cavity than elastic tissues such as muscle, bowel, and lung.³ This temporary cavity can also briefly expand the brain, leading to temporary herniation and resultant contusions (eg, of the uncus or cerebellar tonsils) (Figure 11.71A and B). Figure 11.72 illustrates the effects of a temporary cavity. The temporary cavity can stretch and tear tissue.

For handguns and rifles, the amount of damage done by the projectile is determined by its kinetic energy ($KE = 1/2 mv^2$), the type of projectile (eg, full metal-jacketed projectile vs hollow point), the bullet caliber and mass, the organ system struck, and the tendency for the bullet to lose speed and to tumble.²⁴ A high-velocity rifle will have more kinetic energy and can potentially cause more damage than a handgun, which have lower velocities; however, if a full metal-jacketed projectile is used, the bullet may pass entirely through the body, without imparting all of its kinetic energy to the tissue, whereas with an expanding projectile, such as a hollow point, the entirety of the projectile's kinetic energy will be imparted to the body, causing more damage. Also, an expanded bullet will create a larger permanent cavity. Both rifle wounds and contact shotgun wounds can cause extensive damage, whereas, contact range handgun wounds, even if a large caliber (eg, 0.38), can cause less extensive damage. Powder gases from contact wounds can contribute to injury and, with wounds of the head, can contribute to fracturing of the cranium, with fractures of the cranium due to the temporary cavity being rare³ (Figure 11.73).

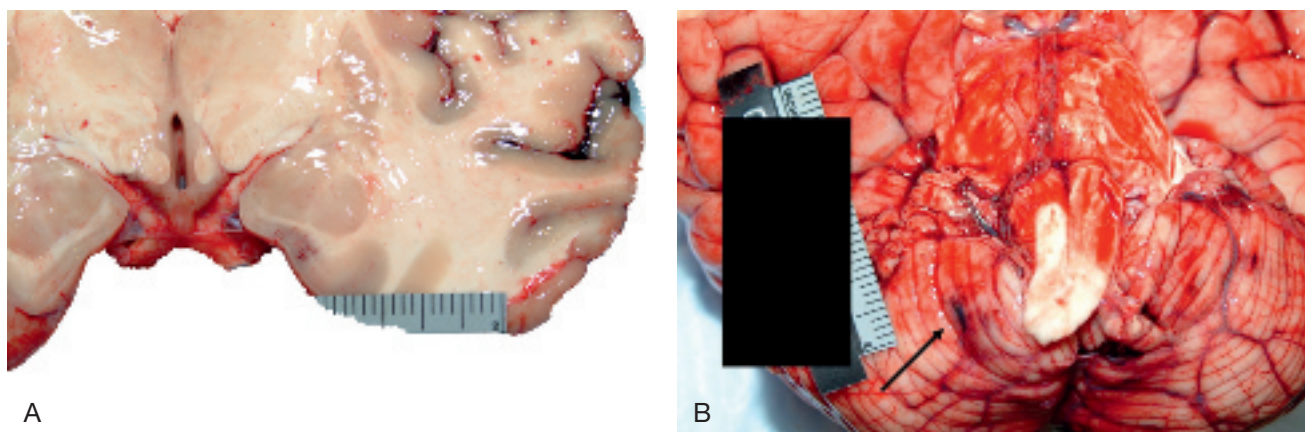


Figure 11.71. Contusions in gunshot wound of the head. This individual sustained a contact gunshot wound of the head, with the projectile passing through the cerebral hemisphere, and not affecting the hippocampus or cerebellum. When the brain expanded with the wound, the uncus and cerebellar tonsils briefly herniated, producing herniation contusions (A and B respectively, with arrow for tonsillar herniations).



Figure 11.72. Gunshot wound of the wrist and hand. The probe passes from the entrance wound at the wrist to the exit wound on the hand. In between, there is hemorrhage underlying an intact epidermis. When the temporary cavity expanded this region, it tore tissue leading to hemorrhage. The area of the hemorrhage between the entrance and exit wounds is not directly in the pathway of the projectile. (Courtesy of Hamo Muergerditchian.)

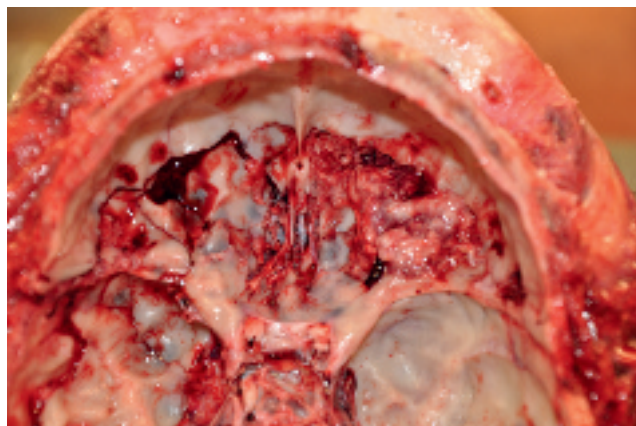


Figure 11.73. Fracture of orbital plates, not in pathway of projectile. This individual sustained a contact gunshot wound of the right side of the head, with the projectile passing upward and backward, but not through the orbital plates. The fracture of the orbital plates most likely resulted from powder gases, unless within a few centimeters of the wound track, in which case the temporary cavity could contribute.

FAQ: In a decedent with multiple gunshot wounds, can the pathway of each projectile be accurately determined prior to internal examination and, if not, can the pathway always be determined after internal examination?

Answer: While the possible pathway of the projectile(s) should at least be considered during the external examination following radiography, opening the body and documenting the injuries to the internal organs is necessary for determination of the actual pathway of the projectile, and often, the perceived pathways of the projectiles based upon the external examination are modified greatly by the internal examination. With multiple gunshot wounds that have intersecting pathways, accurate determination of the pathway for each projectile may not be possible in any given autopsy.

SAMPLE NOTE: DOCUMENTING INTERMINGLED PATHWAYS OF PROJECTILES

In the body of the report, when there is an overlap between projectile pathways, the report can be written such as to account for that. The report can separate out two (or more) gunshot wounds as to their entrances but can list shared injuries in a single paragraph and assign exits to the shared list of injuries and not to the entrance wounds themselves.

PEARLS & PITFALLS

Photographs displaying a probe to demonstrate the pathway of the projectile can be useful to the pathologist when they write their autopsy report, law enforcement when conducting their investigation, and attorneys when trying the case in court (Figure 11.74).

PEARLS & PITFALLS

Documenting an intra-oral gunshot wound can be difficult, especially since rigor mortis is most often present and renders opening the mouth a physical challenge, with the potential for damaging the teeth if done incorrectly. Removal of the neck organs, including the tongue, allows for better access to the area for photography; however, it is still often necessary to take more than one photograph until a good image is obtained.

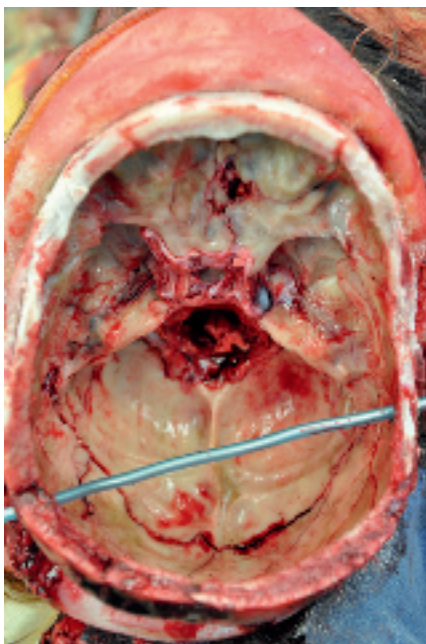


Figure 11.74. Documentation of pathway of projectile with probe. A probe can most often easily be placed between the entrance and exit wounds. This provides a nice visual representation of the pathway of the projectile, for use by the pathologist in writing their report or in explaining the injuries to other parties.

PEARLS & PITFALLS

Microscopic examination of the skin or soft tissue at the entrance wound or from the soft tissue underlying an entrance wound can, in the case of a contact gunshot wound, be used to help identify soot (Figure 11.75A and B), although separation of soot from bullet wipe on microscopic examination is problematic. Bullet wipe should only be present at the rim of the defect (ie, where the projectile contacted the soft tissue) and not on the soft tissue adjacent to the wound margin. In addition, it is possible to collect a cytologic specimen from the projectile and, using microscopic examination, potentially help determine what organs the projectile passed through.

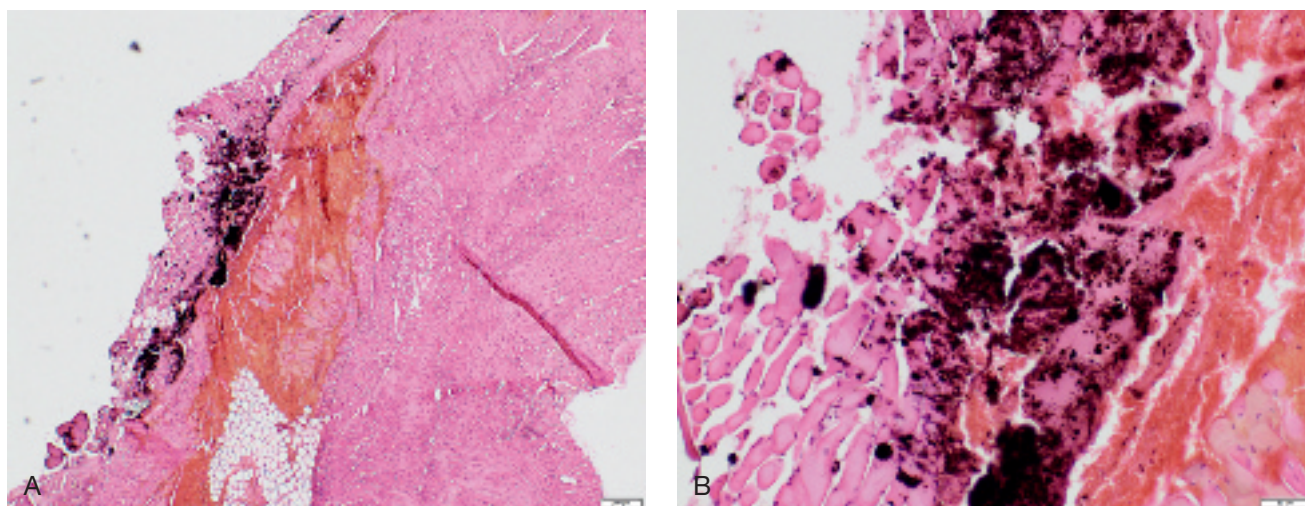


Figure 11.75. Microscopic examination for soot. Microscopic examination of the edge of the wound can assist in the identification and documentation of soot (A and B). This can be particularly useful in decomposed individuals or when drying to the edge of the wound has created artifact appearing as soot (hematoxylin and eosin, low power and high power).

PEARLS & PITFALLS

When an individual with a firearm injury is autopsied and blood is removed from a body cavity, that blood should be retained until all projectiles are accounted for; either that or strained or otherwise examined in a fashion to ensure no projectile is present before the blood is discarded. The same is true for any disaster pouch or other body bag in which the body is received. Accounting for all projectiles can involve additional radiographs of removed organs, removed clothing, and other items.

PEARLS & PITFALLS

While in almost all circumstances, for each entrance, there should be an exit wound, or, if no corresponding exit is present, the projectile should be found within the body, in the case of frangible bullets, after entrance of the projectile into the body, it can fragment to such a degree that no large projectile fragment is identifiable, and, on rare occasions, the pathways for two entrances can merge, leading to a single exit.⁵⁸

PEARLS & PITFALLS

Close inspection of the inner surface of the cranium can help identify an impact site. When projectiles impact the cranium, they often do not have enough energy to fracture through the bone and will instead tumble along the surface and come to final rest at a point some distance from where they impacted the cranium. Using the final resting point of the projectile in the determination of pathway may lead to a marked misrepresentation of the pathway of the projectile, whereas using the impact site, if one is present, should allow for the best determination of the pathway of the projectile (Figure 11.76A and B).

MECHANISM OF DEATH IN GUNSHOT WOUNDS

Lethal firearm injuries produce a variety of physiologic changes, which can lead to a relatively immediate death or a more delayed death. A delayed death can occur minutes to hours following the gunshot wound or days to months to years following the injury (Figure 11.77A-G). During a death investigation, a delayed death due to a gunshot wound is always important to consider in certain individuals as, if missed, the manner of death may be miscertified as natural, instead of as homicide, suicide, or accident. For example, if

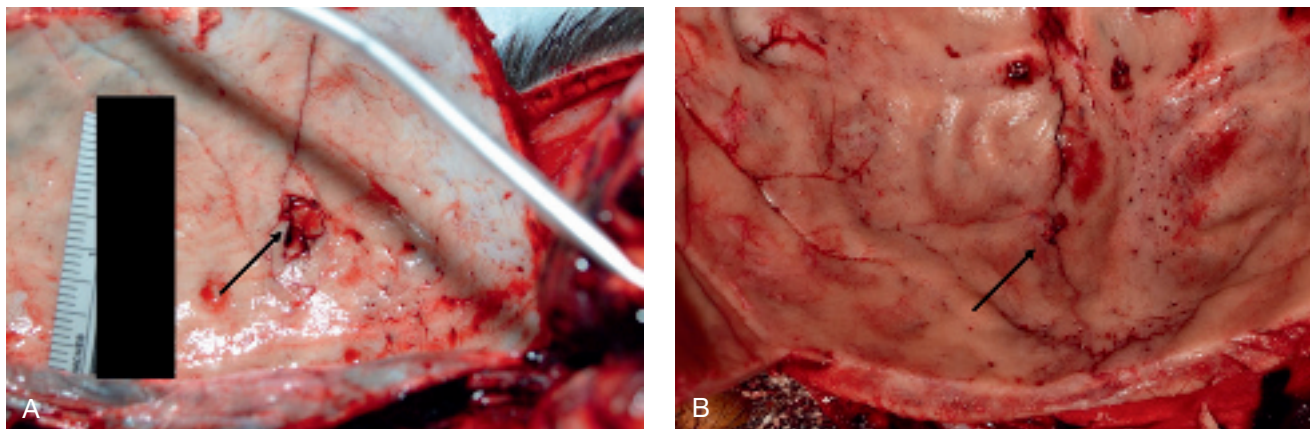


Figure 11.76. Impact site on endocranial surface of cranium from gunshot wound. Both (A and B) illustrate an impact site on the endocranial surface from a gunshot wound (arrow in each image), with both images coming from separate autopsies. The identification of an impact site can assist in a more accurate determination of the pathway of the projectile in gunshot wounds in which the projectile does not perforate the cranium.



Figure 11.77. Delayed deaths from gunshot wounds of the head. In (A-E), this individual survived for a short period of time after a self-inflicted gunshot wound of the head. (A) is the exit wound, with the pathway of the projectile being mostly upward through the anterior portion of the head. The projectile entered the cranial cavity through the floor of the left anterior cranial fossa (B) and perforated the left frontal lobe of the brain (C). The decedent shot himself while lying in bed (D), following which he got up and walked out into the hallway, where he collapsed and was subsequently found (E). In (F and G), this individual was shot by another person 10+ years prior to his date of death. The previous gunshot wound created a fistula between a cranial sinus and his cranial cavity (F).

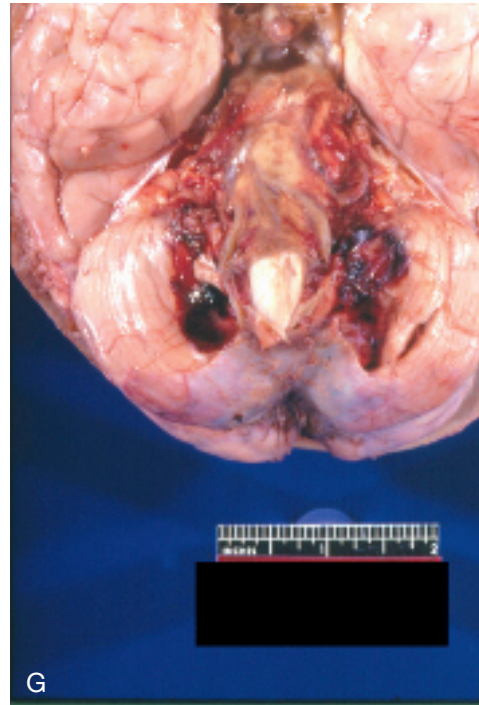


Figure 11.77. He developed sinusitis many years later, leading to meningitis and a cerebral abscess (**G**), and his death. The death certificate was initially signed by the clinical physician with meningitis as the cause of death, with gunshot wound of the head as a contributory condition, and the manner of death was natural. This certification was flagged by the Bureau of Vital Statistics, and referred to the medical examiner's office, with an autopsy subsequently performed.

a 40-year-old man dies due to pneumonia secondary to quadriplegia, it is possible that his quadriplegia is due to a gunshot wound.

While common mechanisms for immediate or relatively immediate death following a gunshot wound could include damage to the brainstem and exsanguination, other less common mechanisms can include tension pneumothorax, tension pneumocephalus,⁵⁹ air embolus,⁶⁰⁻⁶³ indirect damage to the spinal cord, development of a subdural hemorrhage,^{64,65} aortic dissection,⁶⁶ or fat embolus.⁶⁷ Meningitis can also occur relatively acutely following the gunshot wound.⁶⁸ In addition, gunshot wounds can cause acute ischemia due to inducing arterial vasospasm, which could produce downstream effects in an individual who survives for some period of time after the wound was incurred.⁶⁹

Common mechanisms for a significantly delayed death following a gunshot wound could include sepsis, pneumonia, seizure disorder, and pulmonary thromboembolism. Sepsis can develop due to perforation of the gastrointestinal tract or just the gunshot wound itself as all gunshot wounds are contaminated with bacteria.³ Other less common mechanisms that could result in a significantly delayed death include atrio-esophageal or arteriovenous fistula and intracranial aneurysm.⁷⁰⁻⁷²

PEARLS & PITFALLS

Gunshot wounds of the heart, aorta, and even the head may not be immediately incapacitating, and individuals are capable of purposeful movement for some period of time after the injury occurred⁷³⁻⁷⁸ and can even survive the event.^{77,79,80}

COMPOSITION OF PROJECTILES

As forensic pathologists will be collecting projectiles as evidence, it is important to understand the basic composition of a projectile. In general, most handgun and rifle projectiles are a lead core with a copper jacket, although other types of jacket are possible. The jacket

will have rifling marks from the barrel of the weapon, and examination of these rifling marks will potentially allow the firearm examiner to match the projectile found in the body to a weapon recovered and suspected to have been used in the death. The jacket will have both lands and grooves, from the rifling in the barrel, that can allow for an estimation of firearm type. However, the rifle barrel also produces microscopic scratches on the jacket, and this pattern can potentially be matched to the specific weapon that fired it (Figure 11.78). When the jacket is recovered from the body, care must be taken to not introduce additional damage to the surface; therefore, a metal instrument should not be used, and instead plastic forceps or fingers are best to handle the jacket so as to prevent damage and potentially obscuring of rifling marks. On radiographs, a copper jacket can be distinguished from a lead core based upon its radiodensity. The copper jacket is less radio-dense. Smaller-caliber projectiles, especially 0.22 caliber, often do not have a distinct copper jacket but may instead have a copper gild or simply be lead (Figure 11.79). Some forms of larger-caliber projectiles, such as wadcutter and semi-wadcutter, do not have a copper jacket (Figure 11.80). With shotgun wounds, the projectile will be either a slug, buckshot, or birdshot. In addition, if the range is close enough, the shot sleeve (ie, a plastic shot cup with three [0.410] or four [12, 20 gauge] petals) will be present (Figure 11.81). Some plastic shot cups produced by some manufacturers will have more than three or four petals. The wadding can be a component of the shot sleeve or separate.

FAQ: If an individual is shot with a shotgun, do all the pellets need to be recovered?

Answer: If the shotgun shell contained birdshot, only 10 to 20 representative pellets must be recovered, along with the wadding/shot sleeve (or shot cup) if present. In recovering birdshot pellets, recovery of intact pellets to enable accurate weight and diameter determination is most important (ie, five undamaged pellets are more useful to determine the ammunition type than 20 flattened pellets). If the individual was shot with buckshot, all pellets need to be recovered. The entry defect for a buckshot pellet and the entry defect for a handgun or rifle projectile can appear similar, and, on radiograph, a mushroomed smaller-caliber projectile and a deformed buckshot pellet could easily be confused. Therefore, recovery of all buckshot pellets is necessary to ensure that the individual was not shot with a shotgun with buckshot as well as a handgun or rifle.



Figure 11.78. Copper-jacketed projectile recovered from body. The jacket has large striations at the left side, which are lands and grooves. The pattern of lands and grooves can assist in identification of ammunition type (eg, Winchester vs Remington); however, microscopic examination reveals tiny grooves secondary to imperfections in the barrel, which will allow the firearm examiner to match the projectile recovered from the body to the weapon suspected of having fired it. Care must be taken at autopsy not to damage the projectile, so use gloved fingers or plastic forceps to retrieve the projectile and not metal forceps so as not to damage the rifling marks.

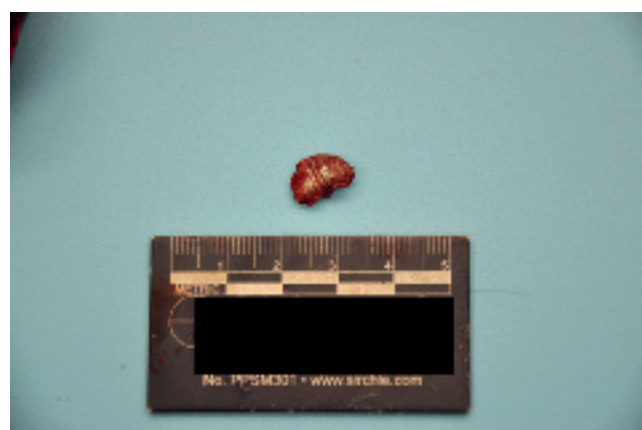


Figure 11.79. Lead projectile. Low caliber projectiles, such as a .22, are often only a lead projectile with no copper jacket, although some will be copper gilded. The lead projectile in these cases will bear the rifling marks.



Figure 11.80. Lead projectile. Not a 0.22 caliber projectile, but a larger-caliber projectile. Wadcutter and semi-wadcutter projectiles do not have a copper jacket.



Figure 11.81. Shotgun pellets, wadding, and shot sleeve. From left to right in the image are birdshot pellets, wadding, and the plastic shot sleeve.

MANNER OF DEATH DETERMINATION WITH GUNSHOT WOUNDS

With a firearm injury, depending upon the circumstances, four manners of death are possible: homicide, suicide, accident, and undetermined. Accidental firearm injuries are rare, and often represent a concealed suicide. Copeland and Dobi-Babic and Katalinic discuss features of accidental gunshot wounds.^{81,82} With the vast majority of firearm injuries, the manner of death is homicide or suicide; however, distinguishing between the two can be difficult. Other than a confirmed distant range gunshot wound (ie, with no soot on the clothing or skin, no intermediary object, and no other evidence of a closer range fire) and without a mechanism for doing so at the scene (ie, it is possible for an individual to set up a mechanism for causing a self-inflicted distant gunshot wound,⁸³ any other range can be encountered both as a homicide and as a suicide. Also, the location of a gunshot wound cannot, by itself, distinguish between a homicide and a suicide. A gunshot wound of the back of the trunk or back of the head can be the result of a suicide.^{84,85} While contact range gunshot wounds are the most common range encountered with gunshot wound suicides, close range gunshot wounds (with soot and stippling, or just stippling) of the face or scalp can still occur from suicidal actions⁸⁶ (Figure 11.82A and B). To assist in the determination



Figure 11.82. Homicide (contact of forehead) vs Suicide (with stippling). In (A), the decedent sustained a contact gunshot wound of the glabella region, which produced radiating tears characteristic of a contact wound. The wound was inflicted by another person. In (B), the decedent sustained a self-inflicted gunshot wound of the face, similar in region to (A) for comparison. This individual shot himself while holding the weapon at arm's length to look down the barrel of the weapon as it fired. Because the weapon was a distance from the body, only stippling is present. These two images illustrate how range of fire alone is an inadequate predictor of manner of death.

of homicide vs suicide, Cave et al. introduced a method for obtaining a likelihood ratio using various features of a gunshot wound to predict homicide vs suicide.⁸⁷

Determination of manner of death is based upon the scene investigation in combination with the autopsy findings. Additional findings, other than just the gunshot wound, may be identified at autopsy that would help support either homicide or suicide as a manner of death and should be searched for. For example, if an individual has a gunshot wound of the hand in addition to a lethal gunshot wound of another region of the body, that the individual held their hand between them and their attacker is most likely, and would support the manner as homicide (Figure 11.83). When individuals shoot themselves, they may hold the weapon with one hand or with two. When holding a handgun or rifle with a second hand, soot can deposit on the non-firing hand, from the muzzle or from the gap in revolvers (Figure 11.84A and B). Another deposit that can be found on the hands is a rust-colored discoloration, which indicates that the barrel of the weapon was against the skin for a prolonged period of time (Figure 11.85). When an individual uses an intra-oral site for the gunshot wound, they will often seal their lips around the barrel. When the weapon discharges, the gases released by the weapon will expand the mouth with no release, which can cause tears at the corners of the mouth and in a peri-oral distribution on the face (Figure 11.86). While grouped parallel scars on the extremities, both upper and lower, do not necessarily indicate the current gunshot wound was suicidal in origin, the scars do indicate past episodes of self-harm, which can add support to a determination of suicide (Figure 11.87A and B).

PEARLS & PITFALLS

Manner of death determinations of suicide can be the most controversial cases that a forensic pathologist will have, with families adamantly opposed to the death being a suicide. Having as much information as possible from the investigation and autopsy to support the manner of death as suicide is the best method to diffuse this disbelief.

FAQ: Is the finding of a weapon at a distance from the body necessarily indicative of a homicide?

Answer: No, individuals can easily throw a weapon after they have fired it.⁸⁸ Also, the individual can stagger and fall backward from a weapon, or after the shot has been fired, the weapon can tumble and end up some distance from the body.



Figure 11.83. Defensive type injuries of the hands. As with sharp force and blunt force injuries, a person being shot by another person can interpose their extremities, often upper extremities, but lower extremities are also possible, between themselves and their attacker. This type of injury is consistent with the decedent defending themselves, and would help establish homicide as the manner of death.



Figure 11.84A. Soot on the hand. If an individual holds a weapon with their second hand, such as for stabilization against their body while they fire the weapon, soot can be deposited on the hand being used to stabilize the weapon. Finding such soot on the hand helps support suicide as a manner of death, unless the individual was grabbing that weapon that was held by their attacker as that weapon was fired.



Figure 11.84B. Soot on hand. Soot deposited on the hands from holding the weapon can sometimes have a specific pattern. The evenly dispersed dots of soot on the hands are consistent with a muzzle flash suppressor on a rifle.

SAMPLE NOTES: DOCUMENTING A GUNSHOT WOUND

- I. Contact gunshot wound of the head:
 - A. Entrance: near the center of the forehead is a 1/2 inch entrance-type gunshot wound that is centered 2 inches below the top of the head and 1 inch to the left of midline. There is a circumferential marginal abrasion, which is up to 1/8 inch wide from 12 to 6 o'clock and up to 3/16 inch wide from 6 to 12 o'clock. On the skin around the wound is a rim of stippling, which is overall 3 × 2 inches in size.
 - B. Injuries: the projectile perforated the skin of the forehead, the left side of the frontal bone, with inward beveling, 1/2 inch in width on the inner surface of the bone, the left frontal lobe of the brain, the left temporal lobe of the brain, the left temporal bone, and exited.
 - C. Projectile recovery: within the left temporal lobe is recovered a fragment of copper jacket.
 - D. Exit: on the left side of the head, posterior to the left ear, is a 3/4 inch exit-type stellate gunshot wound that is centered 3 inches below the top of the head, 1 inch posterior to the tragus of the left ear, and 2 inches superior to the tragus of the left ear.
 - E. Associated findings: the left upper eyelid is hemorrhagic. There is patchy subgaleal hemorrhage, most prominent at the entrance and exit defects. The brain has patchy subarachnoid hemorrhage and a patchy thin subdural hemorrhage. Along the wound track are punctate hemorrhages of the cerebral parenchyma.
 - F. Pathway of the projectile: right to left, front to back, and slightly downward.

These injuries, having been once described, will not be repeated.

NEAR MISSES

Near miss #1: Interpreting the skin changes at the entrance wound alone as to the presence of soot or stippling/powder tattooing without considering clothing that might not have been received with the body but was worn by the decedent at the time of the firearm



Figure 11.85. Rust colored deposit on hand. When the hand has been in contact with the barrel of a weapon for a prolonged period, a rust-colored discoloration of the skin can occur.



Figure 11.86. Oral stretch marks. When a decedent shoots themselves in the mouth, they will most often have their lips sealed around the barrel. When the hot air and gases from the gunshot enter the mouth, they cannot exit, leading to over-expansion of the mouth which can produce stretch-type tears of the peri-orbital region, and even full-thickness tears of the lips.

injury can lead to misinterpretation of range. Figure 11.88A-C illustrates how clothing can block the deposition of soot on the skin and the ability of unburned gunpowder to create stippling. If the individual in Figure 11.88A-C had been wearing a solid shirt instead of a jersey, and if the gunshot wound to the neck had been lower, and if the clothing had been removed prior to the autopsy examination, no soot or stippling would have been identified, and the two wounds could have been misinterpreted as distant range gunshot wounds.

Near miss #2: Firearms injury and other injury types (eg, blunt and/or sharp force injuries) can be admixed and potentially misinterpreted. The individual in Figure 11.89A and B was both beaten and shot.

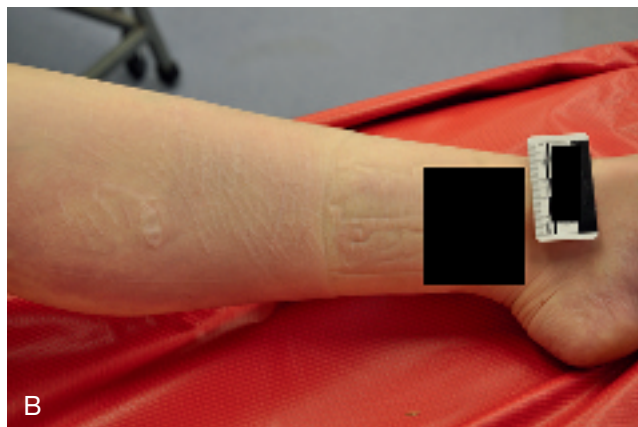


Figure 11.87. (A and B) Scars on extremities. In cases of suicide, examination of the body may provide other evidence of self-harm. Parallel linear scars on the extremities are indicative of past incidents of self-harm and can help support a current determination of a manner of suicide.

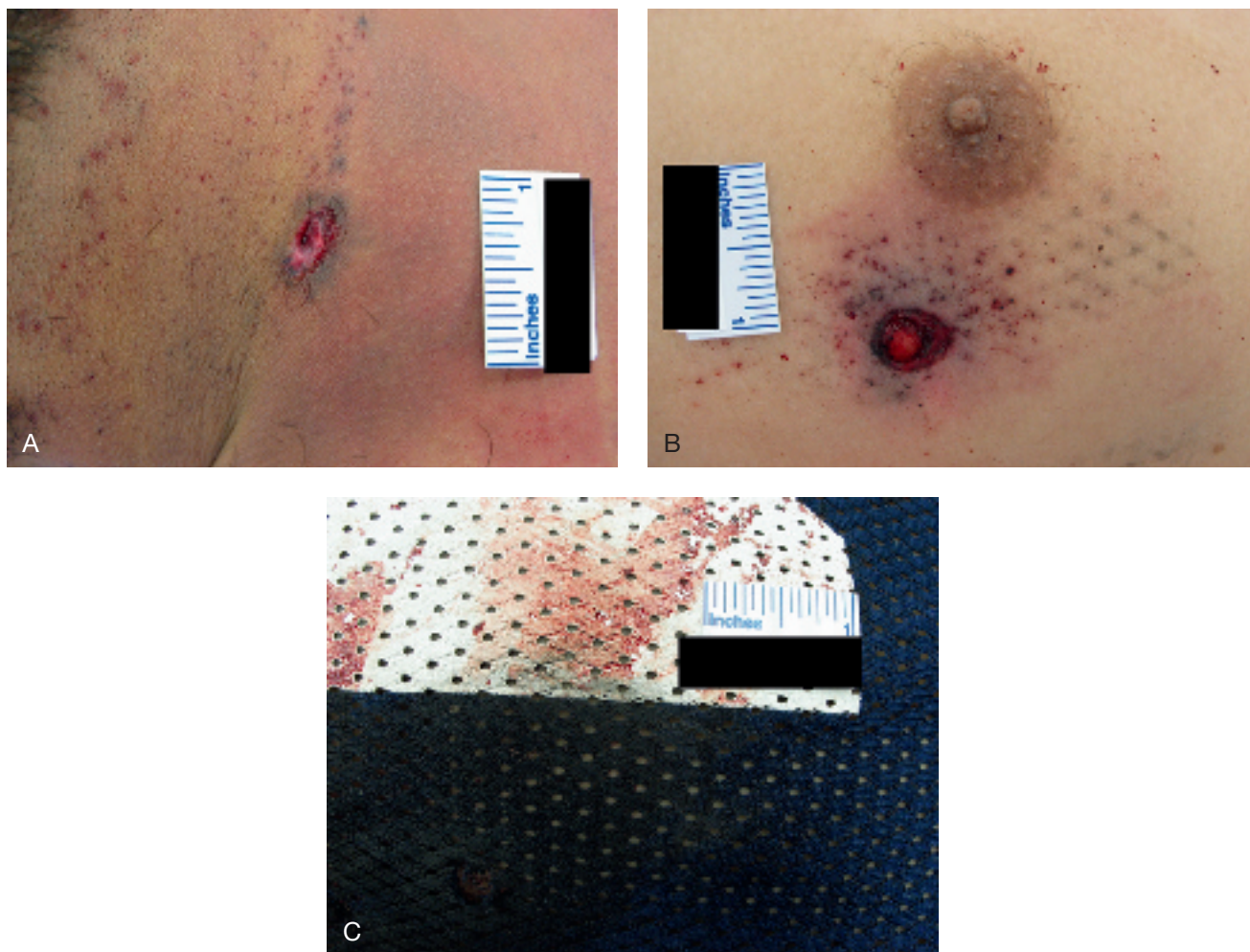


Figure 11.88. Clothing obstructing gunshot residue from striking the skin. This individual was shot twice. (A) is an entrance wound just at the junction between the neck and the back. Notice that to the left of the wound (which would be toward the head) there is stippling on the skin, but to the right of wound, there is no stippling on the skin. (B) is an entrance wound of the chest near the nipple. Around the wound are numerous same size and spaced circular collections of soot. (C) is the clothing the decedent was wearing—a jersey. On the anterior surface in the image can be seen soot. While the jersey blocked some soot, other soot entered through the holes and marked the skin as in (B). On the back, above the collar line, unburned gunpowder reached the skin, causing stippling, but below the collar line, the shirt blocked gunpowder from reaching the skin. If the shirt had been solid, instead of a jersey, and if the gunshot wound of the neck and back junction had been lower, neither soot nor stippling would have been found. This case illustrates the importance of not using the lack of soot or stippling as a sole criterion for a distant range gunshot wound.



Figure 11.89. Blunt force injuries and gunshot wound of the forehead and bridge of nose. Examination of the bridge of the nose and forehead revealed what were initially interpreted as a patch of lacerations (A); however, a radiograph of the head revealed a projectile fragment at this site. Re-examination of the wounds revealed that one of the lacerations was actually an entrance gunshot wound with a marginal abrasion, with the exit wound located at the medial corner of the right eye. A probe illustrates the pathway of the projectile (B).

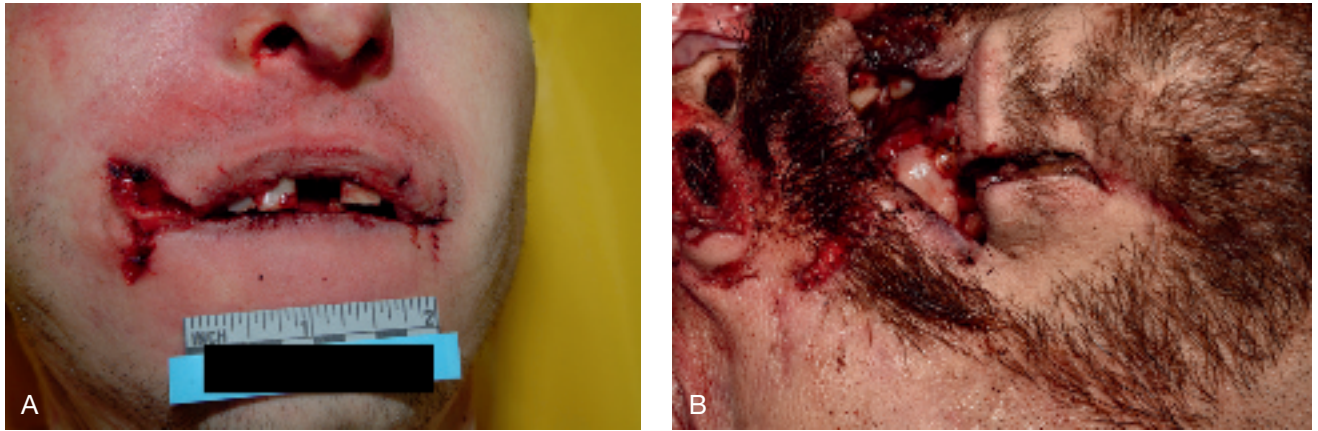


Figure 11.90. Oral and peri-oral tears. In (A), the injuries were associated with an intra-oral gunshot wound; whereas in (B), the injuries were associated with a train accident, with no evidence of a firearm injury from scene investigation or autopsy examination.

Near miss #3: While self-inflicted intra-oral rifle and shotgun wounds of the head frequently have oral and peri-oral tears in the skin, including up to full thickness tears of the lips (Figure 11.90A), a similar pattern of injury can be found in other circumstances. The decedent in Figure 11.90B was found on train tracks. Initial observation at autopsy identified oral and peri-oral tears. Despite extensive dissection, no definitive evidence of a gunshot wound or shotgun wound was identified, and radiography revealed no metallic fragments. Scene investigation did not identify a firearm. Review of the train videos, because of the incident occurring at night, were not informative, as it could not be determined whether the decedent was alive or dead at the time the train hit them.

Near miss #4: The individual in Figure 11.91A and B was shot multiple times with shotguns, both with buckshot and birdshot. The face had numerous punctate red lesions, which could be misinterpreted as birdshot, since birdshot loaded shells were used during the shooting incident; however, the lesions were actually stippling related to a close range shotgun wound.

Near miss #5: Incomplete radiography of the body can allow for projectiles to be missed. While many offices have access to a full-body scanner, which can produce a 3D radiograph of the entire body, and/or a CT scanner, many offices do not. If a radiograph does not include all areas of interest, a projectile may be missed. For example, if the projectile is just underneath the skin of the chest, but the radiograph does not include that

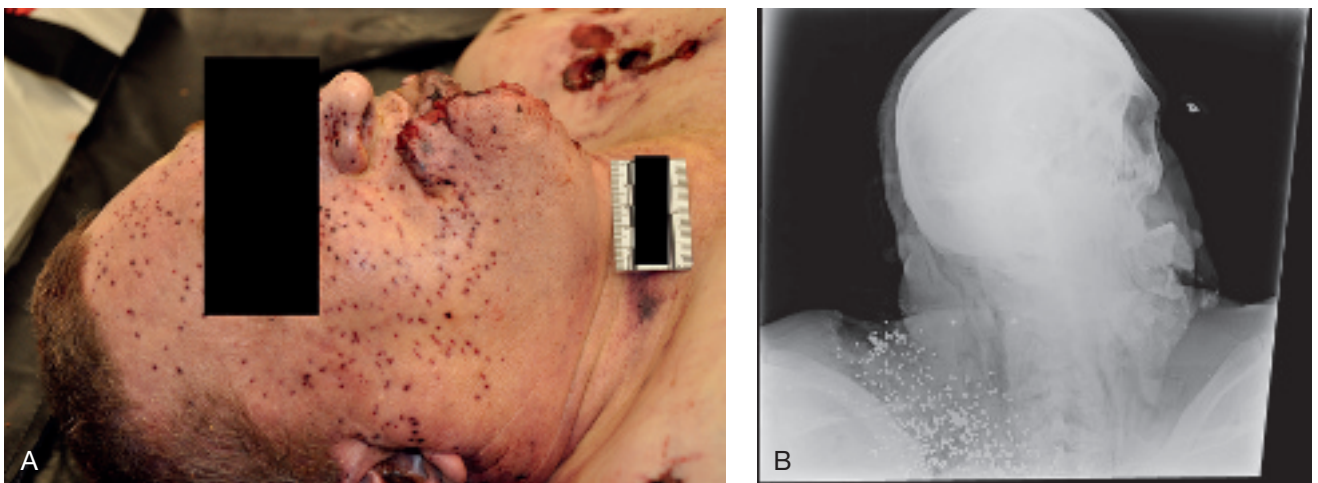


Figure 11.91. Photo and radiograph of individual shot with shotguns. (A) shows the face with numerous punctate red discolorations of the face, which could, in the context of the other injuries be interpreted as birdshot pellet entrances from a more distant range shotgun wound, in which the pellets had time to disperse completely from the central mass. (B) shows a radiograph of the head and upper chest. While there is a mass of birdshot pellets on the right side of the chest from another wound, there are no corresponding pellets in the head. The punctate red lesions on the face are stippling associated with a close range shotgun wound.

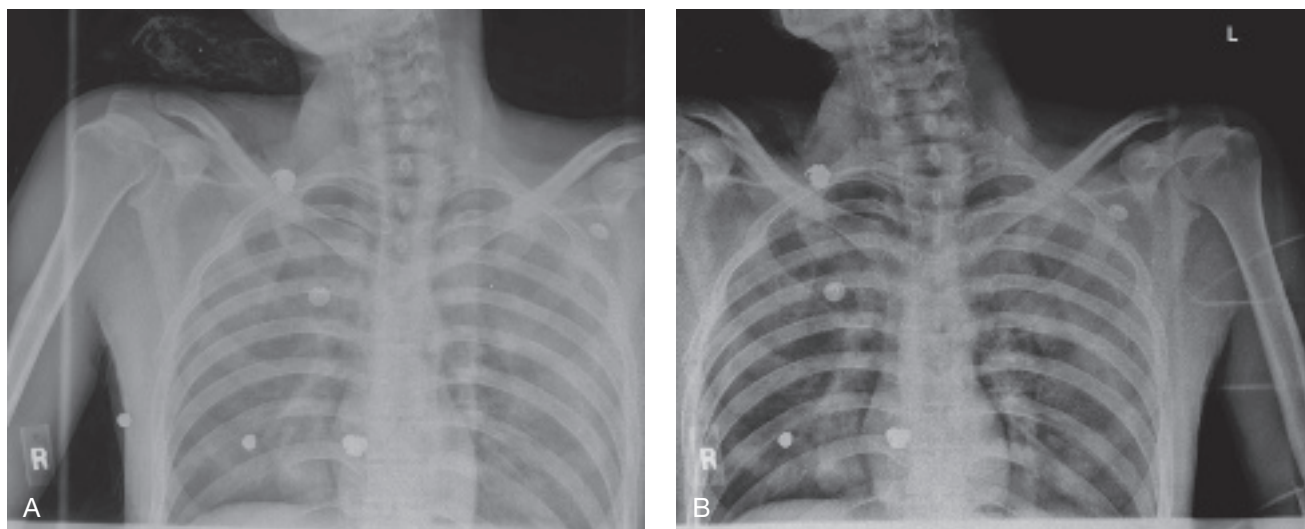


Figure 11.92. Radiographs of a decedent who was shot multiple times, both with buckshot and handgun projectiles. One radiograph (A) reveals a buckshot pellet that was immediately underneath the skin on the right side of the chest inferior to the axilla; however, radiograph (B), which during the course of the autopsy was actually taken first, does not include the very edge of the body and thus does not reveal the projectile. These two images illustrate the importance of complete coverage of the body by radiography when searching for projectiles.

area, the projectile may be missed (Figure 11.92A and B). Also, on a 2D radiograph, it is possible for projectiles and projectile fragments to overlap, and although one is recovered, the second one may be missed (Figure 11.93). Also, metallic objects in and on the clothing or associated with medical intervention can overlap a projectile, obscuring it on the radiograph.

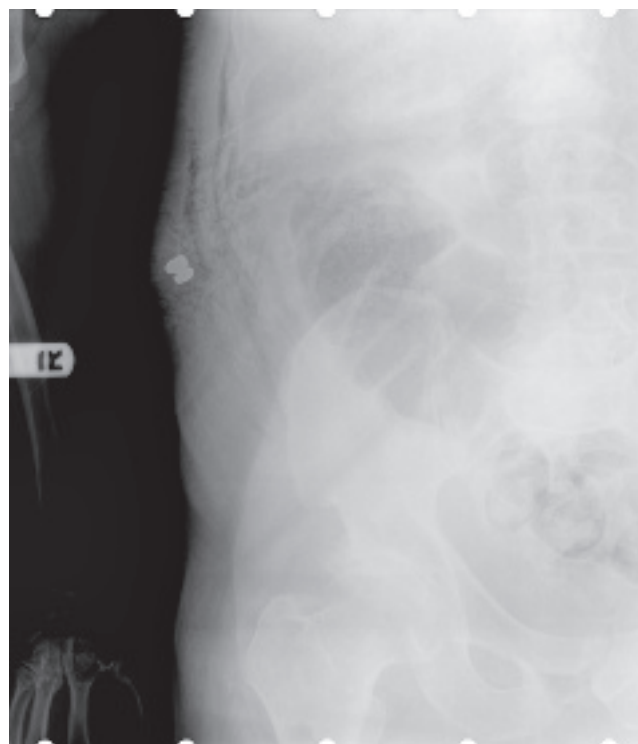


Figure 11.93. Radiograph of a decedent with overlapping projectiles. In the radiograph, two projectiles overlap but do not completely obscure each other; however, the image should represent how it is possible for one projectile to completely overlap another projectile, appearing as only one projectile on the radiograph. Use of two views (eg, anterior-posterior and lateral) or use of a device capable of producing a 3D radiograph would, obviously, automatically correct for this possible problem.

Near miss #6: It is not uncommon to encounter a retained projectile (ie, from a gunshot or shotgun wound that occurred previous to the decedent's terminal event) (Figure 11.94). This retained projectile should be recovered to confirm its identification. Retained projectiles can be difficult to find via dissection, as they are often contained within a fibrous coat and there is no associated hemorrhage. A retained birdshot pellet or BB from a previous gunshot wound, when present in the radiograph with a typical handgun projectile, could mimic a 0.25 ACP (Figure 11.95A-C).

Near miss #7: In suicidal gunshot wounds, while the temple, mouth, chin, and chest are common locations for the entrance,⁸⁹ the external ear canal (almost completely invisible to external examination), vagina, and anus are rare but potential locations for an entrance wound⁹⁰ (Figure 11.96A-D). In the same context, while projectiles most commonly exit the body through the skin, it is possible for the projectile to exit through the mouth, anus, or another naturally occurring orifice (Figure 11.97).

Near miss #8: To correctly interpret bevel in the bone, the entire circumference of the defect is required. If only half of the defect in the bone were available for interpretation, a keyhole defect in the bone could be misinterpreted as an exit defect (Figure 11.98).

Near miss #9: While it could appear that an individual with a firearm injury would not be missed at autopsy, such is not the case. With later stages of decomposition or with other significant injuries (eg, a person shot and then run over by a vehicle), gunshot wounds can be missed at autopsy. An index of suspicion based upon the scene investigation or additional imaging can help ensure that these cases are not missed.^{91,92}

Near miss #10: Cast projectiles are sometimes encountered. Because of their elongated form and cannellures for lubricants, they are easily identified on radiographs.⁹³



Figure 11.94. Radiograph of a decedent who was shot with a high-powered rifle. The radiograph reveals the characteristic lead snow storm pattern of a high-powered rifle, with the projectile at least partially breaking up into innumerable tiny fragments, but at the arrows are two round radio-dense objects. The round appearance of the radio-dense objects would not be compatible with a fragmenting high-powered rifle projectile, as the fragments so produced are irregular in size and shape and would not be essentially perfectly round. The individual had been previously shot with birdshot and had retained pellets. Any retained pellets/projectiles will be identified on radiographs and should be removed at autopsy to confirm their origin and retained.

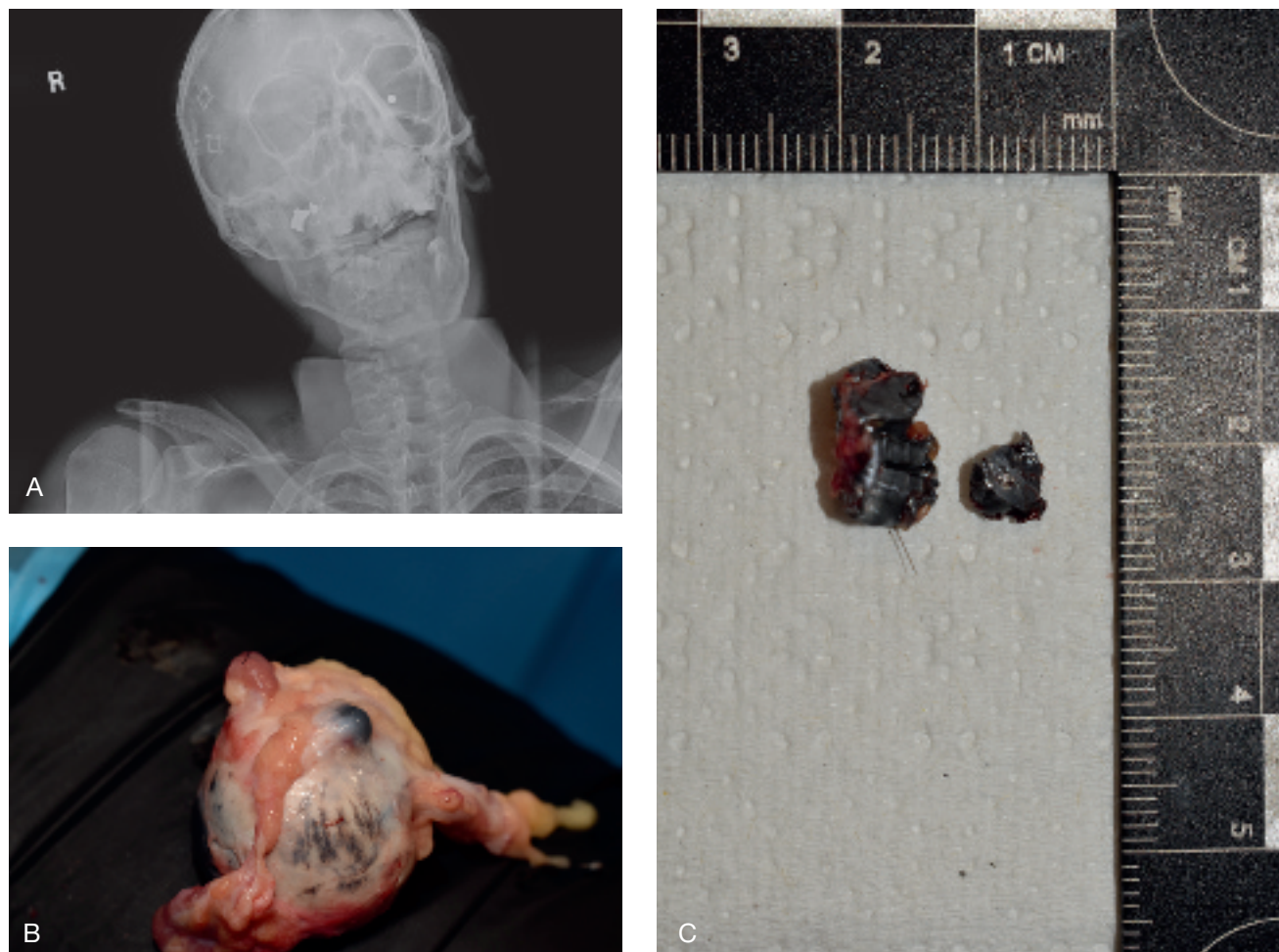


Figure 11.95. Radiograph and images of decedent shot with handgun, with retained projectile. (A) is radiograph, which revealed a single pellet near the left eye and projectile fragments and appeared as 0.25 ACP ammunition. The pellet actually was a retained BB (B) in a fibrous capsule at the edge of the left eye. (C) is of the projectile fragments recovered.

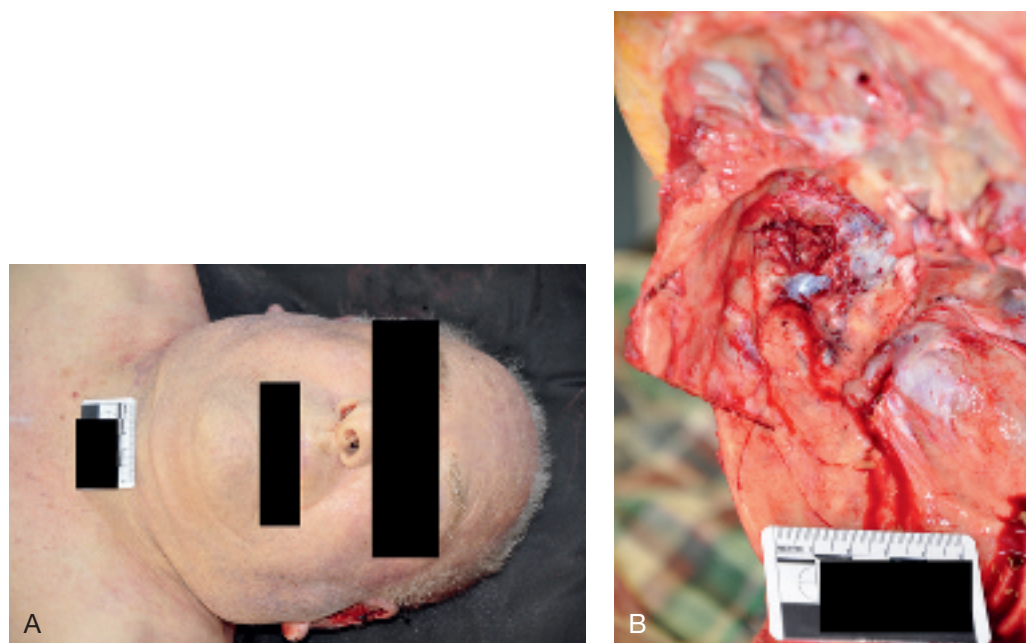


Figure 11.96. Decedent with gunshot wound of the ear. An autopsy was conducted on an individual who sustained a suicidal gunshot wound. Initially, blood was found in the left ear, but no entrance was identified upon external examination of the body including the head (A). The entrance was presumed to be intra-oral, with blood in the left ear being from basilar skull fractures, a common injury sequence pattern seen with gunshot wounds of the head. Upon removal of the brain, a defect was found in the left petrous ridge, which was the entry point of the projectile into the cranial cavity (B). Externally, no gunshot wound of the left ear was easily apparent (C) as the barrel of the weapon had been placed deep into the external ear canal. The pathway of the projectile is illustrated in (D).

Figure 11.96c-d (continued)

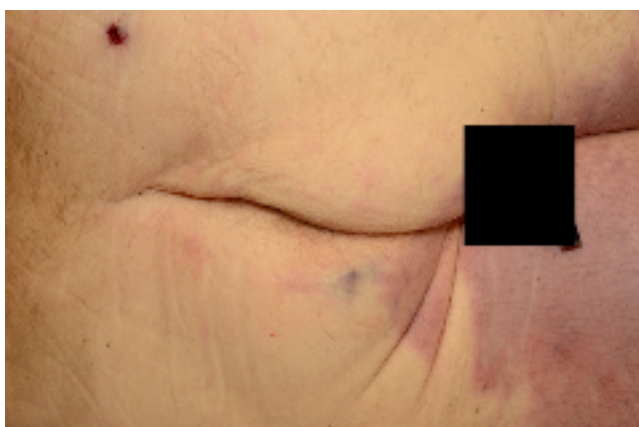
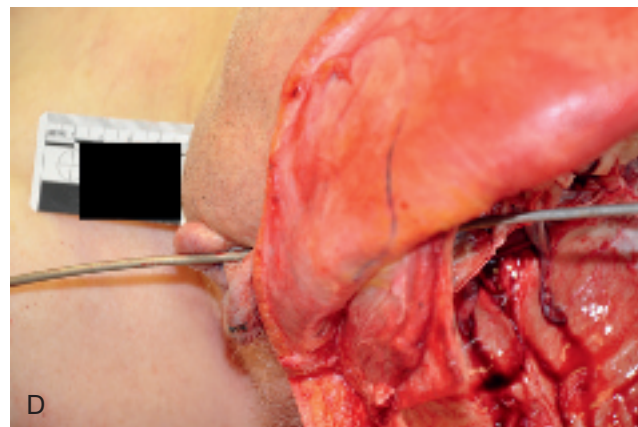


Figure 11.97. Near anal exit of projectile. Just lateral to the gluteal cleft at the left buttock is an ill-defined blue-purple contusion, underlying which was the projectile in the soft tissue. While the projectile did not actually exit through the anus, its proximity to the anus illustrates how such an event could occur.

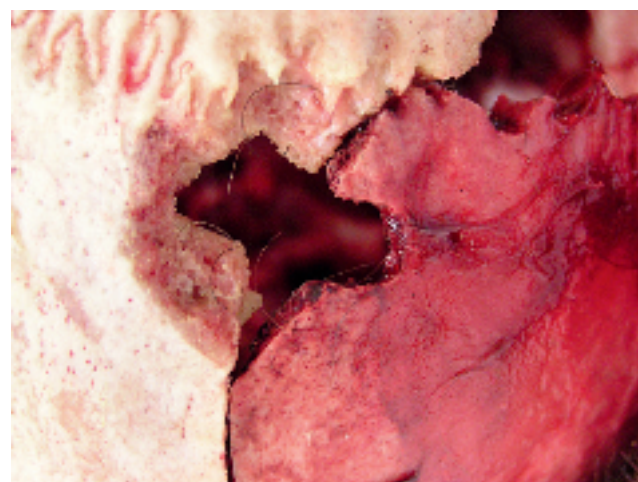


Figure 11.98. Example of a keyhole defect in the bone to illustrate that both sides of the defect are needed for proper interpretation. The image represents the re-approximation of two fragments of bone that encompassed the entrance wound. The fragment to the right side has a punched out appearance and the fragment to the left has a beveled appearance. When viewed together, the keyhole nature of the wound is apparent, and keyhole defects essentially always represent an entrance wound; however, if only the bone fragment on the left side of the image were examined (ie, the fragment with the outward bevel), the wound could easily be misinterpreted as an exit wound.

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