GUNSHOT WOUNDS

Practical Aspects of Firearms, Ballistics, and Forensic Techniques

SECOND EDITION

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Contact Wounds

A **contact wound** is one in which the muzzle of the weapon is held against the body at the time of discharge. Contact wounds can be hard, loose, angled, or incomplete. In contact wounds gas, soot, metallic particles avulsed from the bullet by the rifling, vaporized metal from the bullet and cartridge case, primer residue, and powder particles are all driven into the wound track along with the bullet.

In **hard contact** wounds, the muzzle of the weapon is held very tightly against the skin, indenting it so that the skin envelopes the muzzle at the time of discharge. All the materials emerging from the muzzle will be driven into the wound, often leaving very little external evidence that one is dealing with a contact wound. Inspection of the entrance, however, will usually disclose searing and powder blackening (soot) of the immediate edge of the wound (Figure 5.1). Subsequent autopsy will reveal soot and unburnt powder particles in the wound track.

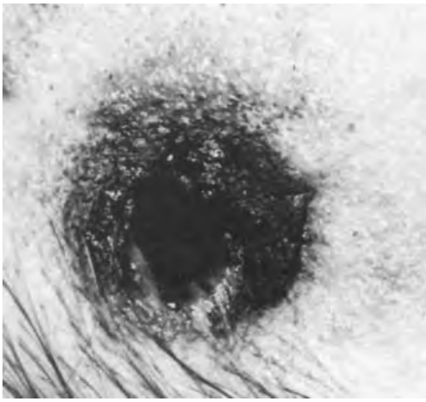

Figure 5.1 Close-up of hard-contact wound of head with a .38 revolver.

Hard contact wounds of the head from .22 Short or .32 Smith & Wesson Short cartridges are often difficult to interpret because of the small powder charge loaded into such cartridges. These wounds may appear to be distant because of an inability to detect the small amount of soot produced and to recover unburned powder grains in the wound track. Compounding this problem is the fact that in distant wounds from .22 Short and .32 S & W Short cartridges, drying of the edges can simulate the blackened and seared margins of hard contact wounds. In situations such as this, as well as in cases of decomposition of a body, examination of the wounds with the dissecting microscope for soot and powder grains is of value.

In the author's experience, with use of the dissecting microscope, soot is always present in contact handgun wounds, with powder particles identified in virtually all cases. Unfortunately, recognition of material as soot is to a certain degree subjective. Drying, hemolyzed blood, and decomposition can simulate or mask soot. Generally, blood can be removed by running or spraying hot water over the wound. Clots resistant to the hot water can be dissolved with hydrogen peroxide. Neither hot water nor hydrogen peroxide will remove the soot. In cases in which one is not sure whether a wound is contact and in which no powder particles can be identified by the dissecting microscope, the use of energy dispersive x-ray (EDX) or scanning electron microscope-energy dispersive x-ray (SEM–EDX) should be employed. Using these devices, one can analyze for the vaporized metals from the bullet, cartridge case, and primer.

In contact wounds, muscle surrounding the entrance may have a cherry-red hue, due to carboxyhemoglobin and carboxymyoglobin formed from the carbon monoxide in the muzzle gas. Even if this discoloration is not present, elevated levels of carbon monoxide may be detected on chemical analysis. Control samples of muscle should always be taken from another area of the body if such determinations are to be made. It should be realized that, whereas elevated carbon monoxide levels in the muscle are significant, the lack of carbon monoxide is not, as carboxyhemoglobin formation does not always occur. By using gas chromatography, carbon monoxide has been detected in wounds inflicted up to 30 cm from the muzzle.[2]

The presence of both powder particles and carbon monoxide in a gunshot wound would seem to leave no doubt that one is dealing with an entrance wound. In fact, on occasion both carbon monoxide and powder may be found at an exit. In the case illustrated in Figure 5.2, the deceased shot himself

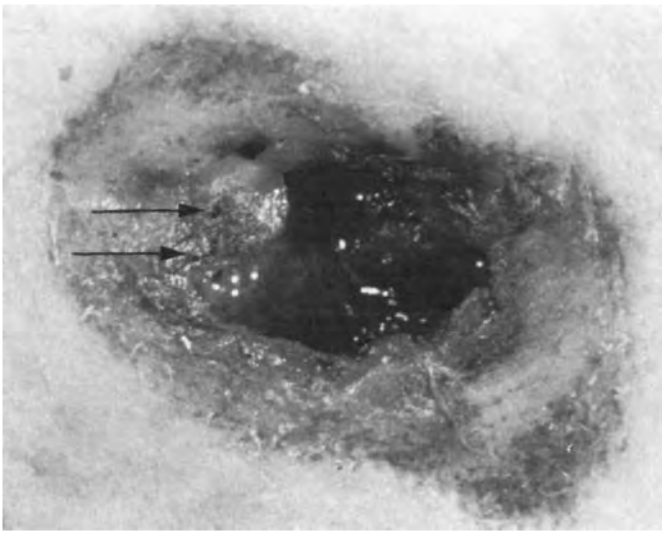

Figure 5.2 Shored exit wound of back with grains of ball powder in exit wound.

in the left chest with a .357 Magnum revolver. A perfect imprint of the muzzle was seen on the chest, thus indicating the contact nature of the wound. Examination of the exit in the back, however, revealed grains of ball powder in the exit wound and a cherry-red color in the adjacent muscle caused by carbon monoxide. The presence of carbon monoxide was confirmed analytically. To further confuse the interpretation of the wounds, the exit was shored. Thus, the exit in this case was characterized by an abraded margin, powder grains, and carbon monoxide.

The author has seen a number of cases in which ball powder traveled through the body and was found at the exit. All cases involved contact wounds, with the entrances in both head and trunk. The weapons involved were of .22 Magnum, .38 Special, 9-mm Luger, .357 Magnum and .44 Magnum caliber. In one case, an individual had his hand in front of his face and in hard contact with the muzzle of a .357 Magnum when it discharged. Ball powder traveled through the hand tattooing his face.

The author has never seen a case in which flake powder traveled completely through either the head or trunk and was in or adjacent to the exit. He has knowledge, however of one case involving cylindrical powder in which an individual shot himself in the head with a .44 Magnum handgun and cylindrical powder grains were present in the wound tract through the brain, and at the exit in the scalp.[3]

Though carbon monoxide and powder may travel through a body and be found at the exit, the author has never personally seen soot do so.

Contact Wounds Over Bone

Contact wounds in regions of the body where only a thin layer of skin and subcutaneous tissue overlies bone usually have a stellate or cruciform appearance that is totally unlike the round or oval perforating wounds seen in other areas (Figure 5.3A). The most common area in which stellate wounds occur is the head. The unusual appearance of contact wounds over bone is due to the effects of the gas of discharge. When a weapon is fired, the gases produced by the combustion of the propellant emerge from the barrel in a highly compressed state. In hard contact wounds, they follow the bullet through the skin into the subcutaneous tissue where they immediately begin to expand. Where a thin layer of skin overlies bone, as in the head, these gases expand between the skin and the outer table of the skull, lifting up and ballooning out the skin (Figure 5.4). If the stretching exceeds the elasticity of the skin, it will tear. These tears radiate from the entrance, producing a stellate or cruciform appearing wound of entrance. Re-approximation of the torn edges of the wound will reveal the seared, blackened margins of the original entrance site.

In some contact wounds over bone, instead of the classical stellate or cruciform wound, one finds a very large circular wound with ragged, blackened, and seared margins. This type of wound is more common with the less powerful calibers such as the .32 ACP or .380 ACP (see Figure 5.3B). On occasion, however, it is seen with even the larger more powerful cartridges such as the .38 Special and .45 ACP.

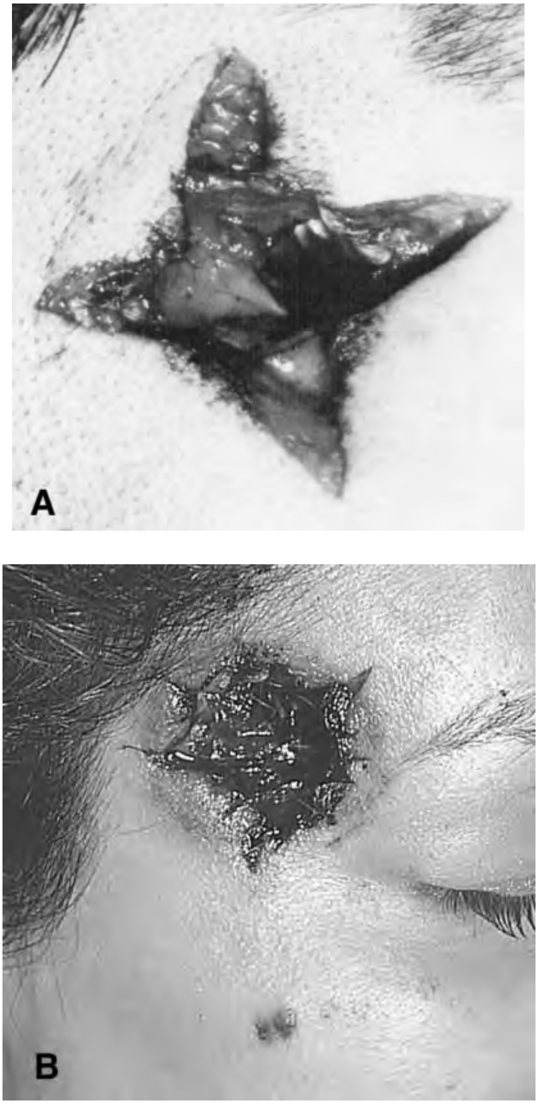

Figure 5.3 Contact wounds of head. **(A)** Stellate wound of temple from .38 Special revolver; **(B)** circular wound of entrance from .380 ACP.

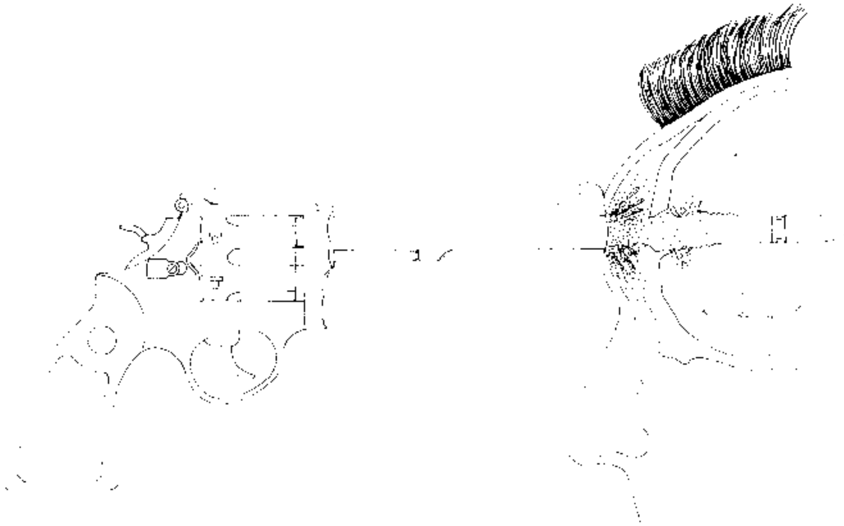

Figure 5.4 Contact wound of head showing dissection of gas between scalp and skull.

The presence of tearing of the skin as well as its extent depends on the caliber of the weapon, the amount of gas produced by the combustion of the propellant, the firmness with which the gun is held against the body, and the elasticity of the skin. Thus, contact wounds of the head with a .22 Short usually produce no tearing, whereas those due to a .357 Magnum usually do. It must be stressed, however, that exceptions occur.

Irregular, cruciform, or stellate entrance wounds can occur in individuals shot at intermediate or distant range, where gas plays no role in the production of a wound. These occur when the bullet perforates the skin over a bony prominence or curved area of bone covered by a thin layer of tightly stretched skin (Figure 5.5). The head is the most common site for such wounds. The forehead as it slopes back at the hairline; the top and back of the head; the supraorbital ridges and the cheek bone are common sites (Figures 4.22; 5.5A). An uncommon site is the elbow (Figure 5.5B). If the bullet is deformed or tumbles prior to striking the body, the tendency to produce cruciform or stellate wounds is further accentuated. A tangential gunshot wound of the face may simulate a stellate contact wound (Figure 5.6).

In contact wounds of the head, if the skin and soft tissue are retracted, soot will usually be found deposited on the outer table of the skull at the entrance hole (Figure 5.7). Soot may also be present on the inner table and even on the dura. Soot is usually not seen on bone when the wound is inflicted by either a .22 Short or a .32 Smith & Wesson Short cartridge.

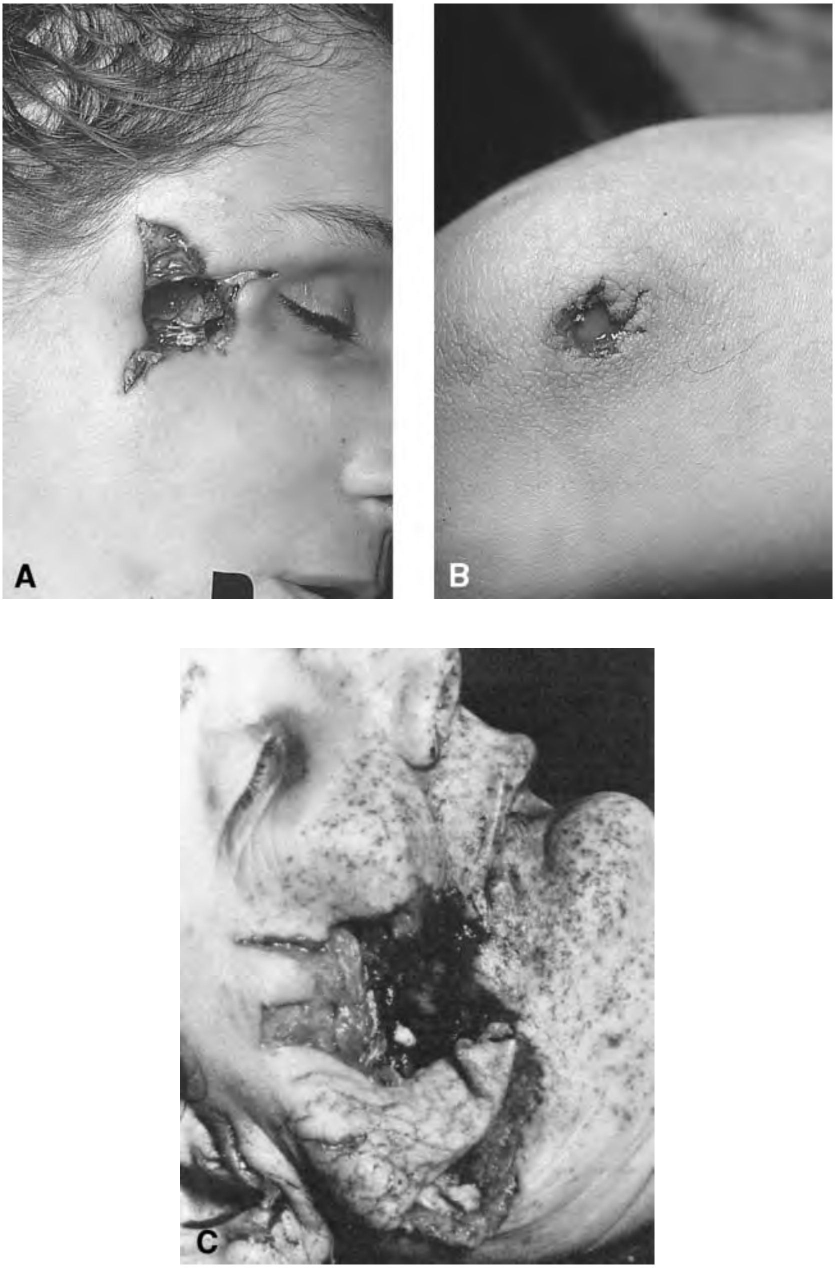

Figure 5.5 Distant range wounds of: **(A)** right side of face (from .357 Magnum revolver) and **(B)** elbow; **(C)** intermediate-range gunshot wound from .357 Magnum — range approximately 1 ft.

Figure 5.6 Tangential gunshot wound of left cheek from 9-mm bullet.

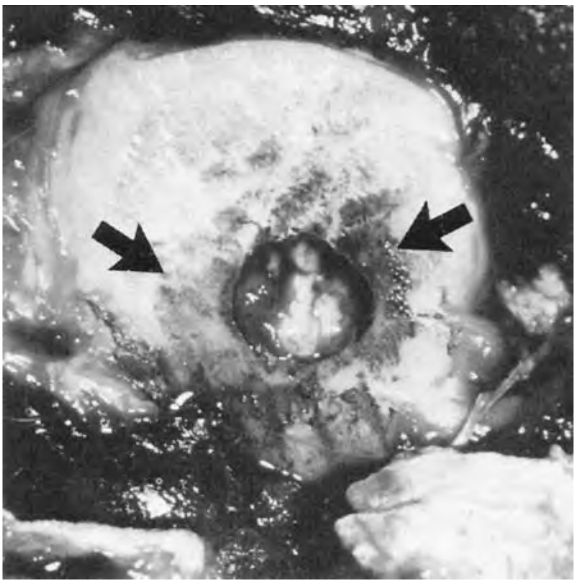

Figure 5.7 Powder soot deposited on outer table of skull around entrance site.

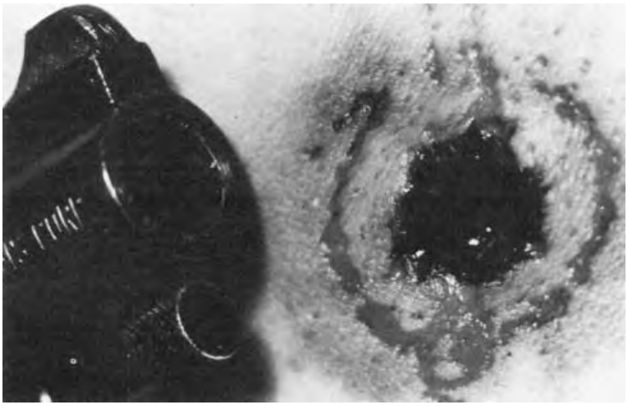

Figure 5.8 Contact wound with muzzle imprint.

Rarely, in contact wounds of the head from weapons of .38 Special caliber and greater that fire cartridges loaded with true (spherical) ball powder, the large irregular or stellate wounds produced may initially appear to show neither soot nor powder. Careful examination with a dissecting microscope will reveal small clusters of ball powder. It must be kept in mind, that the presence of only one or two grains of powder does not necessarily indicate a close range wound. The author has seen a number of distant entrance wounds in which one or two grains of powder have been carried to and deposited in the entrance wound by a bullet.

In contact wounds of the trunk, stellate or cruciform entrances in the skin usually do not occur, even when the weapon and ammunition used produce large volumes of gas, because the gas is able to expand into the abdominal cavity, chest cavity, or soft tissue. Rarely, contact wounds of the chest overlying the sternum, inflicted by handguns firing high-velocity pistol ammunition, may produce extremely large circular wounds of entrance with ragged margins.

In contact gunshot wounds in areas where only a thin layer of skin overlies bone (usually the head), the gas expanding in the subcutaneous tissue may produce effects other than tearing of the skin. The ballooned-out skin may slam against the muzzle of the weapon with enough force to imprint the outline of the muzzle on the skin (Figure 5.8). Such imprints may be extremely detailed. The more gas produced by the ammunition and weapon, the harder the skin will impact against the muzzle, and thus the greater the detail of the imprint.

Imprints of the muzzle of the weapon occur not only in regions where a thin layer of skin overlies bone but also in the chest and abdomen (Figure 5.9). Here, the gas expands in the visceral cavities and adjacent soft tissue. Thus, instead of just the skin flaring out against the muzzle, the whole chest or

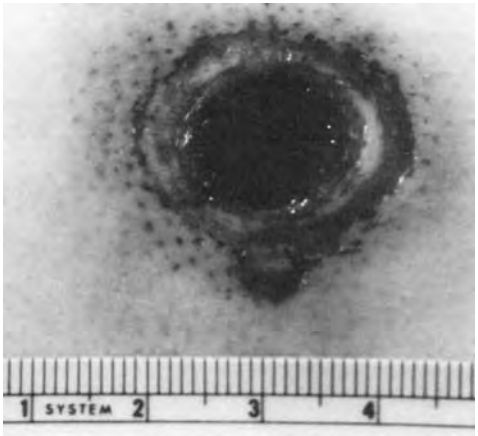

Figure 5.9 Muzzle imprint on chest from .38 Special Colt revolver. The diameter of the imprint is 24 mm, not quite double the actual diameter of the muzzle of the gun which was 13 mm.

abdominal wall will bulge out. These imprints are often larger, sometimes twice, the actual dimensions of the muzzle of the gun. Thus, in Figure 5.9, the muzzle imprint measures 24 mm in diameter while the muzzle diameter was actually 13 mm.

In contact wounds of the trunk in which there is a muzzle imprint, one may see a wide zone of abraded skin surrounding the bullet hole (Figure 5.10). This zone of abrasion is due to the skin rubbing against the muzzle of the weapon when, on firing, the skin flares back impacting and enveloping the muzzle. This zone is often interpreted incorrectly as a zone of searing from the hot gases of combustion. Differentiation is usually possible in that

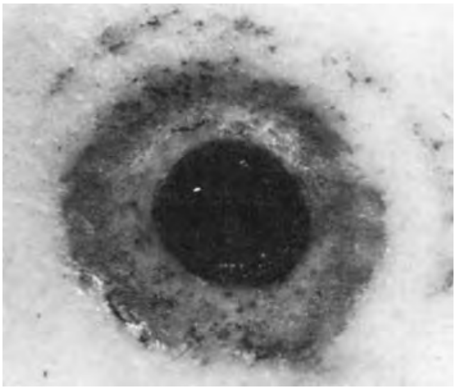

Figure 5.10 Hard-contact wound of chest from 9-mm automatic. Abraded skin around entrance.

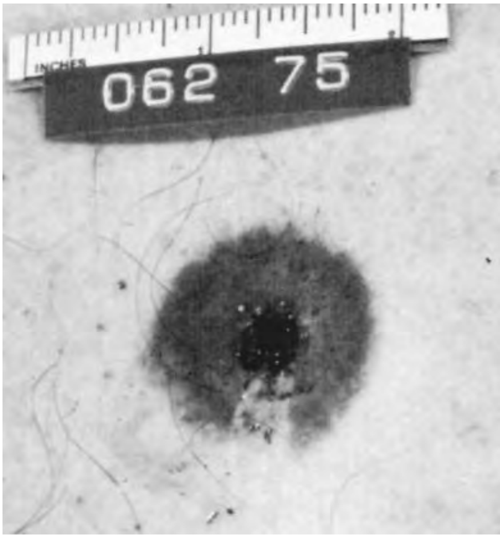

Figure 5.11 Loose-contact wound with circular zone of soot around entrance.

in seared zones, such as seen in near-contact wounds, the seared skin is heavily impregnated with soot, whereas in this impact zone it is not. This zone is often wider than the diameter of the barrel because the skin has been bent back around the end of the barrel, totally enclosing it.

A **loose-contact wound** is produced when the muzzle of the weapon is held in very light contact with the skin at the time of discharge. The skin is not indented by the muzzle. Gas preceding the bullet, as well as the bullet itself, indent the skin, creating a temporary gap between the skin and the muzzle through which gas can escape. Soot carried by the gas is deposited in a band around the entrance (Figure 5.11; see also Figure 4.2). This soot can be easily wiped away. A few unburnt grains of powder may also escape out this gap and be deposited on the skin in the band of soot. Particles of powder, vaporized metals, and soot will be deposited in the wound track along with carbon monoxide.

Angled and **incomplete-contact wounds** and their appearances have been discussed in detail in Chapter 4 (see Figures 4.3 and 4.4).

Near-Contact Wounds

These wounds and their characteristics have already been discussed in detail in Chapter 4. However, a number of additional points can be made. Small clumps of unburned powder may pile up on the edges of the entrance and in the seared zone of skin found in such wounds. These collections of powder are most prominent in wounds inflicted by .22 Magnum handguns whose cartridges contain ball powder. Near-contact wounds with handguns usually occur at ranges less than 10 mm. There is some variation depending on caliber, ammunition, and barrel length.

Hair

Many textbooks, in their descriptions of contact and near-contact wounds in hairy regions, put great stress on the presence of burned hair. In actual practice, charred or seared hair is rarely seen, most probably because the gas emerging from the barrel blows it away. Even in seared zones of skin, however, unburned hairs are numerous. Occasionally, seared hair is seen when a revolver is discharged close to the head while long hair overlays the cylinder gap.

Gas Injuries

The gas produced by combustion of the propellant can produce internal injuries as severe as or more severe than injuries produced by the bullet. Gas-produced injuries are most severe in the head because of the closed and unyielding nature of the skull. The skull, unlike the chest or abdominal cavity, cannot expand to relieve the pressure of the entering gases. In contact wounds of the head from high-velocity rifles or shotguns, large quantities of gas entering the skull produce massive blow-out fractures with extensive mutilating injuries. The top of the head is often literally blown off with partial or complete evisceration of the brain. Contact wounds of the head with handguns, while often producing secondary skull fractures, do not ordinarily produce the massive injuries seen in high-velocity rifles and shotguns.

Massive injuries from contact handgun wounds of the head, when they do occur, are associated with Magnum calibers, e.g., the .357 Magnum, the .44 Magnum or high velocity, high-energy cartridge loadings of medium caliber weapons, e.g., .38 Special **+P+** cartridges. These cartridges can inflict contact wounds that in their severity mimic wounds from rifles and shotguns. Such a wound is illustrated in Figure 5.12, where the deceased was an elderly white female who shot herself in the head with a .38 Special revolver. The ammunition used was Remington 125-gr., jacketed, hollow-point, loaded with ball powder. Because of the severe nature of the wound, on the initial viewing of this body it was suspected that the woman had been shot with a shotgun.

Contact wounds of the abdomen and chest from handguns ordinarily do not produce striking injuries of the internal viscera due to gas. Exceptions occur with the high-velocity **+P+** loadings and the .44 Magnum, especially if the wound is inflicted over the heart or the liver.

Figure 5.12 Contact wound of right temple from .38 Special revolver firing a high-pressure load.

Intermediate-Range Wounds

An intermediate-range gunshot wound is one in which the muzzle of the weapon is away from the body at the time of discharge yet is sufficiently close so that powder grains emerging from the muzzle strike the skin producing powder tattooing; this is the sine qua non of intermediate-range gunshot wounds.

In addition to the powder tattooing, there may be blackening of the skin or material around the entrance site from soot produced by combustion of the propellant. The size and density of the area of powder blackening vary with the caliber of the weapon, the barrel length, the type of propellant powder, and the distance from muzzle to target. As the range increases, the intensity of powder blackening decreases and the size of the soot pattern area increases. For virtually all handgun cartridges, soot is absent beyond 30 cm (12 in.). (For a more detailed discussion of powder soot, see Chapter 4.)

Although soot usually can be wiped away either by copious bleeding or intentional wiping, powder tattooing cannot. Tattooing consists of numerous reddish-brown to orange-red, punctate lesions surrounding the wound of entrance (Figure 5.13). Powder tattooing is due to the impact of unburned, partially burned, or burning powder grains onto and into the skin. Powder tattooing is an antemortem phenomenon and indicates that the individual was alive or at least that the heart was beating at the time the victim was

Figure 5.13 Powder tattooing from disk powder.

shot. If an individual is shot at intermediate range after the heart has stopped beating, mechanical markings will be produced on the skin. These markings, however, will not have the reddish color, i.e., the vital reaction of antemortem tattoo marks. Postmortem tattoo marks have a yellow, moist appearance. They are less numerous than markings produced in the living subject at the same range.

For handguns, forensic textbooks generally have stated that the powder tattooing extends out to a maximum distance of 18 to 24 in. (45 to 60 cm) from the muzzle. Such statements do not take into account the different physical forms of propellant powder. At present, in the United States, handgun cartridges are loaded with four forms of propellant: flake, spherical (true) ball powder, flattened ball powder, and cylindrical powder (Figure 5.14). Ball powder is favored in high-pressure loadings such as the .357 Magnum cartridge—because for consistent homogenous ignition of ball powder, high pressure, and thus high temperature conditions are necessary. In the past, however, ball powder was used for pistol loadings down to the .25 ACP. Some manufacturers use uncoated ball powder for better ignition. Grains of uncoated ball powder are a pale green color.

Flake powder usually is in the form of disks though some foreign manufacturers produce flake powder in the form of quadrangles. Circular disks of flake powder can vary greatly in diameter and thickness. If the graphite coating is lost the flakes have a pale green translucent appearance.

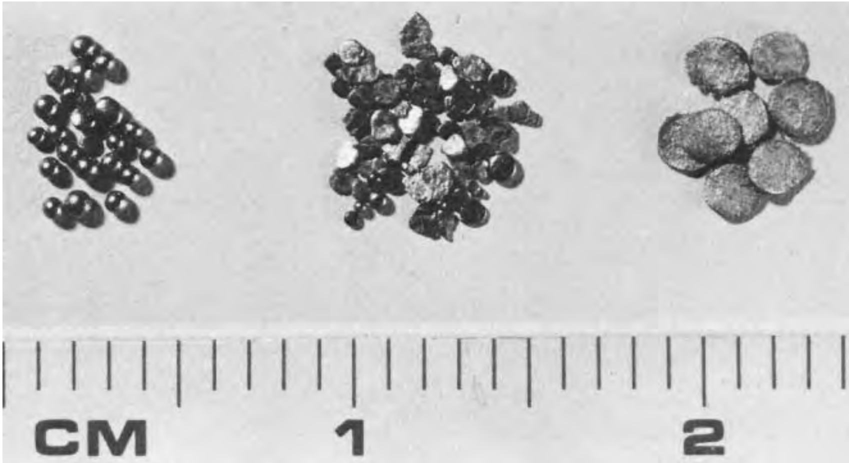

Figure 5.14 Ball, flattened ball, and flake (disk).

Handgun cartridges loaded with cylindrical powder are uncommon in the United States.

As a result of animal experiments, it appears that in a .38 Special revolver with a 4-in. barrel, cartridges with flake powder produce powder tattooing out to 18 to 24 in. (45 to 60 cm); cartridges loaded with flattened ball out to 30 to 36 in. (75 to 90 cm), and cartridges loaded with true or spherical powder out to 36 to 42 in. (90 to 105 cm) (Table 5.4).[4] In contrast, a .22 caliber rimfire revolver with a 2-in. barrel, firing .22 Long rifle cartridges produces powder tattooing out to 18 to 24 in. (45 to 60 cm) with flake powder and 12 to 18 in. (30 to 45 cm) with ball powder (Table 5.5).

In centerfire cartridges, powder tattooing extends out to greater ranges with ball powder (both spherical and flattened ball) than with flake powder, because of the shape of the powder grains. The sphere has a better

Table 5.4 Maximum Range of Powder Tattooing from .38 Special Revolver with 4-in. Barrel

Range (cm)	Flake[a]	Flattened Ball[a]	Ball[a]
30	+	+	+
45	+	+	+
60	+	+	+
75	0	+	+
90		+	+
105		0	+
120			0

[a] + = tattooing; 0 = no tattooing.

Table 5.5 Maximum Range of Powder Tattooing from .22 Revolver with 2-in. Barrel Firing Long Rifle Ammunition

	Type of Powder[a]	
Range (cm)	Flake	Ball
15	+	+
30	+	+
45	+	+
60	+	0
75	0	0

[a] + = tattooing; 0 = no tattooing.

aerodynamic form than a flake; thus, ball powder can travel farther retaining more velocity, enabling it to mark the skin at a greater range. In .22 rimfire ammunition, however, flake powder produces tattooing out to a greater distance than ball powder. The explanation is that the individual grains of ball powder used in the .22 ammunition are so fine that any aerodynamic benefit obtained from the shape is lost as a result of its lighter mass.

The maximum ranges for powder tattooing that have been given should only be used as a rough guide as this data is based on animal tests.[4]

The maximum range at which tattooing occurs, as well as the size and density of the powder tattoo pattern, depends not only on the form of the powder but on a number of other variables, including the barrel length, the caliber, the individual weapon, and the presence of intermediary objects such as hair or clothing that will absorb some or all of the powder grains.

The greater the range, the larger and less dense the powder tattoo pattern. The increase in size of the pattern is due to gradual dispersion of the powder grains, with decreased density of the pattern resulting not only from dispersion but also from rapid loss of velocity of the individual grains; fewer grains reach the target and those that do may not have enough velocity to mark the skin. At close range, a gun with a short barrel will produce a wider and denser tattoo pattern than a longer barrel weapon as more unburned particles of powder will emerge from the short barrel (Figure 5.15). Tattooing will, of course, disappear at a closer range with a short-barreled gun compared with a long-barreled gun. Silencers will filter out a great proportion of the soot and powder particles, thus making the range from muzzle to target appear greater than it actually was.

To a degree, hair and clothing prevent powder from reaching the skin. In centerfire cartridges, ball powder readily perforates hair and clothing at close and medium range. In contrast, except at close range, flake powder usually does not produce powder tattooing through clothing or dense hair, as the grains of flake powder have difficulty in perforating these materials.

Figure 5.15 Two intermediate-range gunshot wounds (range, 15 cm). Upper tattoo pattern produced by weapon with 6-in. barrel; lower pattern from weapon with 2-in. barrel.

The influence of the type of powder on the extent and degree of powder tattooing and blackening was exhibited in a case in which an individual was shot with a .45 automatic loaded with Norma ammunition. Testing revealed that the maximum range of powder tattooing and blackening in this particular weapon with this particular ammunition was only 6 in.

Although powder tattooing may extend out to almost four feet with a .38-caliber revolver, individual powder grains can travel much farther. In an experiment using a .38 Special 4-in. barrel revolver firing standard velocity Remington ammunition in which the bullet weighed 158-gr. and the powder was flake, individual flakes of powder were deposited on material out to a maximum of 6 ft. from muzzle to target (Table 5.6).[5] A high-velocity Remington cartridge loaded with a 125-gr. semi-jacketed hollow-point bullet and ball powder, discharged from the same weapon, deposited powder grains on a target 20 ft. from the muzzle. An identical cartridge loaded with flake powder deposited powder on clothing out to a maximum of 9 ft. from the muzzle (Table 5.6). Additional tests were carried out with a .357 Magnum revolver having a 4-in. barrel. Cartridges loaded with flattened ball powder deposited grains of powder out to a maximum of 15 ft. Cartridges loaded with flake powder deposited flake powder out to a maximum of 10 ft. (Table 5.6).

Table 5.6 Maximum Distances Traveled from Muzzle to Target by Different Forms of Powder from Different Caliber Weapon (both with 4-in. barrels)

Caliber	Type of Powder in Cartridge Case	Maximum Distance Traveled by Powder Grains (ft)
.38 Special	Ball	20
	Flake[a]	9
	Flake[b]	6
.357 Magnum	Ball	12
	Ball	15
	Flake	10

[a]High-velocity loading; [b]standard velocity loading.

In view of the fact that powder grains can travel such great distances, the presence of a few unburned grains of powder around an entrance in the skin or clothing does not necessarily indicate an intermediate-range wound but, depending on the individual form of powder, can be produced by a weapon being discharged as much as 15 to 20 ft. from the victim. At these ranges, however, the powder has insufficient velocity to mark the skin.

In addition to soot and powder grains, other materials are deposited on the body when a weapon is discharged in close proximity to the body. These materials include: antimony, barium and lead from the primer; copper and zinc (sometimes nickel) vaporized from the cartridge case by the intense heat; fragments of metal stripped from or vaporized from previously fired bullets and deposited in the barrel; copper, aluminum or lead stripped or vaporized from the bullet that was fired; and the grease and oil that had coated the barrel or bullet before discharge. The metallic particles can be detected on the body or on clothing by soft x-ray if they are large enough. Trace metal deposits of these metals can be detected by EDX and SEM–EDX.

The appearance of powder tattoo marks on the skin depends on the physical form of the powder. Powder tattoo marks produced by flake and cylindrical powder are irregular in shape, reddish brown in color, and show great variability in size (see Figure 5.13). Such markings are usually relatively sparse compared to tattooing from ball powder. Slit-like tattoo marks due to grains of flake powder striking on their side may be seen. Occasionally, fragments, intact flakes or both will be found lying on the skin. The number of such flakes is relatively small. Flakes can on occasion penetrate into the dermis, in which case they may produce bleeding from these sites. Small blood clots at the points of penetration may give the appearance of a spray of dried blood. The author has seen a few cases involving flake powder where large numbers of flakes were embedded in the epidermis with some penetrating into the dermis. The flakes of powder were found to be very small, very thick yellow-green disks. The tattooing produced by these thick disks very closely resembled the tattooing of ball powder. Differentiation was possible only by observation of the thick disks in the wound.

In contrast to flake powder, powder tattooing due to spherical (true) ball powder is considerably more dense with numerous fine, circular, bright red tattoo marks, many containing a ball of unburned powder lodging in the center of the lesion (Figure 5.16A). On seeing the powder tattoo marks from spherical ball powder, one is struck immediately by the resemblance to the petechiae of an intravascular coagulation disorder. Attempts at wiping away the ball powder grains are only partly successful, as many if not most of the little balls of powder are deeply embedded in the skin.

In powder tattoo patterns due to flattened ball, the number of markings produced is greater than in the case of flake powder but fewer than from ball powder. The individual markings tend to be finer, more uniform and more hemorrhagic than flake, approaching those of ball powder in their appearance (Figure 5.16B). Powder grains are recovered embedded in the skin, but they are not nearly as numerous as in cases of true ball powder tattooing.

The previous descriptions of powder tattooing concerned centerfire handguns. Powder tattooing from .22 rimfire cartridges is different. Those cartridges are loaded with either small, thick disks or very fine ball powder (Winchester ammunition). Ball powder produces extremely fine but faint tattooing, whereas flake powder produces a larger, more prominent tattoo pattern. These latter markings more closely resemble those of centerfire flattened ball powder than those of traditional flake powder. In some instances flake or parts of flakes have penetrated into the dermis.

Powder tattooing may be present in **angled contact wounds**. In such wounds, as the angle between the barrel and skin decreases, the gap between the skin and barrel increases. At some point the gap becomes sufficiently large that unburnt grains of powder escaping through the gap will skim over the zone of seared skin, fanning out from the entrance, impacting distal to the entrance wound (see Figure 4.3C). In contrast, if a weapon is discharged at intermediate range with the barrel at an angle to the skin (an **angled intermediate wound**), dense tattooing is predominantly on the same side of the wound as the gun with scattered tattooing on the opposite side (Figure 5.17).

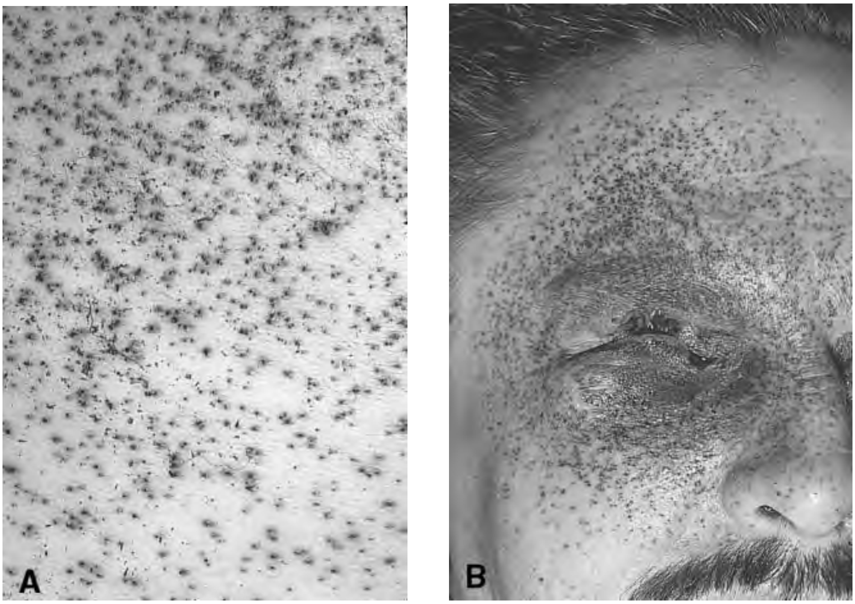

Figure 5.16 Powder tattooing from **(A)** true ball powder and **(B)** flattened ball powder.

The author has never seen *true* powder tattooing of the palms of the hands from powder exiting the muzzle of a gun. He has, however, seen numerous cases in which powder grains were embedded in the palm without the vital reaction that gives tattooing its appearance (Figure 4.9; 4.20A). Lack of tattooing in the palms is apparently due to the thicker stratum corneum protecting the dermis from any trauma. The author has seen rare cases where there were what appeared to be four to five powder tattoo marks on the palm. In these cases, the powder would have had to have come out the cylinder gap. Therefore, it is possible that the marks on the palm were not tattoo marks, but stippling due to fragments of lead accompanying the powder out the cylinder gap.

The size and density of the powder tattoo pattern on the body around the wound of entrance can be used to determine the range at which the weapon was discharged by replication of this pattern on test material. To do this however, the same weapon, and ammunition identical to that of the fired round, should be used in the testing. Selection of ammunition used for test firings is extremely important because different brands and lots of ammunition contain different powders and quantities of propellant. Therefore, ideally, unfired cartridges recovered from the gun or cartridges that came from the same box of ammunition that the fired ammunition came from should be used in the tests.

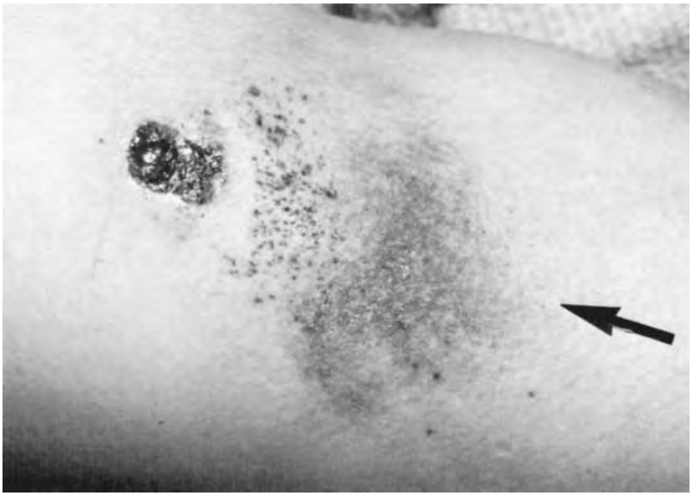

Figure 5.17 Angled intermediate gunshot wound with powder tattooing on side from which the bullet came. Arrow indicates direction of bullet.

Muzzle-to-victim range determinations from powder tattoo patterns on the skin are made by Firearms Examiners, using measurements of the tattoo pattern obtained by the pathologist or from photographs. The distance at which a test pattern identical in size and density to the powder tattoo pattern on the body is produced is assumed to be the range at which the gun was fired at the individual. Test patterns generally are produced on white blotting paper. Unfortunately, experiments have shown that powder tattoo patterns on paper are consistent with skin tattoo patterns only up to 18 in. of range.[4] At ranges greater than 18 in., there is no correlation between the size and density of the tattoo pattern produced on the body and the pattern produced on blotting paper.

Another potential problem with range determinations that are based on the size of powder tattoo patterns is a simple one of variation in measuring. Different individuals measuring the same powder tattoo pattern may produce different measurements.[4] This is due to the fact that some individuals measure the whole pattern, whereas others measure the main area of the pattern, excluding occasional "flier" tattoo marks.

Cylinder Gap

When a revolver is fired, gas, soot, and powder emerge not only from the end of the muzzle but also from the gap between the cylinder and the barrel (see Figure 2.11). This material emerges, fan-like, at an approximate right angle to the long axis of the weapon. If the revolver is in close proximity to the body at the time of discharge, there may be searing of the skin, deposition of soot or even powder tattooing from gas and powder escaping from the cylinder gap. The tattooing will be relatively scant. If there is intervening clothing, it may be seared, blackened or even torn by the gases. In rare cases, if a hand is around the cylinder gap at the time of discharge, the gases may lacerate the palm (Figure 14.5).

If the cylinder of the revolver is out of alignment with the barrel, as the bullet jumps from the cylinder to the barrel, fragments of lead may be sheared off the bullet. These fragments can produce marks on the skin that resemble powder tattoo marks. Such marks, however, are larger, more irregular, and more hemorrhagic than traditional powder tattoo marks. In addition, fragments of lead are often seen embedded in the skin. These fragment wounds are usually intermingled with powder tattooing produced by powder escaping from the cylinder gap (Figure 5.18).

Figure 5.18 Suicide contact wound of left temple with powder tattooing and lead fragment stippling of left side of neck. The larger areas of hemorrhage are due to the lead fragments.

Distant Wounds

In distant gunshot wounds, the muzzle of the weapon is sufficiently far from the body so that there is neither deposition of soot nor powder tattooing. For centerfire handguns, distant gunshot wounds begin beyond 24 in. (60 cm) from muzzle to target for cartridges loaded with flake powder and beyond 42 in. (105 cm) for cartridges loaded with ball powder. The exact range depends on the particular weapon and ammunition and can be determined exactly only by experimentation with the specific weapon and ammunition.

All these figures presuppose the lack of clothing. Clothing will absorb soot and powder, in some cases making close-range wounds appear to be distant by examination of the body alone. This points out the need for examination of the clothing in conjunction with the autopsy. The presence of isolated powder particles on either the clothing or the body does not necessarily signify that one is dealing with an intermediate range wound, as individual powder particles may travel considerable distances before deposition on the body.[5]

Whether powder perforates clothing to mark the skin depends on the nature of the material, the number of layers of cloth, and the physical form of the powder. With handguns, ball powder can readily perforate one and even two layers of cloth to produce tattooing of the underlying skin (Figure 5.19). Rarely, ball powder will perforate three layers. The author has never seen it perforate four layers and produce tattooing. While flake powder usually does not perforate even one layer of cloth, at very close range, it may do so.

Range determinations cannot be made for distant gunshot wounds. Bullets fired from 5, 50, or 500 ft will produce identical entrances. Gunshot wounds of entrance, whatever the range, are identified by the presence of a reddish zone of abraded skin (the abrasion ring) around the entrance hole. This zone becomes brown and then black as it dries. The abrasion ring is due to the bullet rubbing raw the edges of the hole as it indents and pierces the skin. Occasionally, entrance wounds will not have an abrasion ring (Figure 5.20). In handguns, this is most commonly associated with high velocity cartridges such as the .357 Magnum and 9-mm Parabellum, loaded with jacketed or semi-jacketed bullets. Rarely, the wounds will have small tears radiating outward from the margins ("micro-tears") (Figure 4.19A).

In some areas of the body, e.g., the palms, it is the rule not to have an abrasion ring. This is discussed in more detail in Chapter 4.

Addendum: Centerfire Handgun Cartridges

There are scores of centerfire handgun cartridges. A few of the more common ones will be described.

.25 ACP (6.35 × 16)

The .25 ACP, the smallest of the currently manufactured centerfire handgun cartridges, was introduced in the first decade of the twentieth century. The

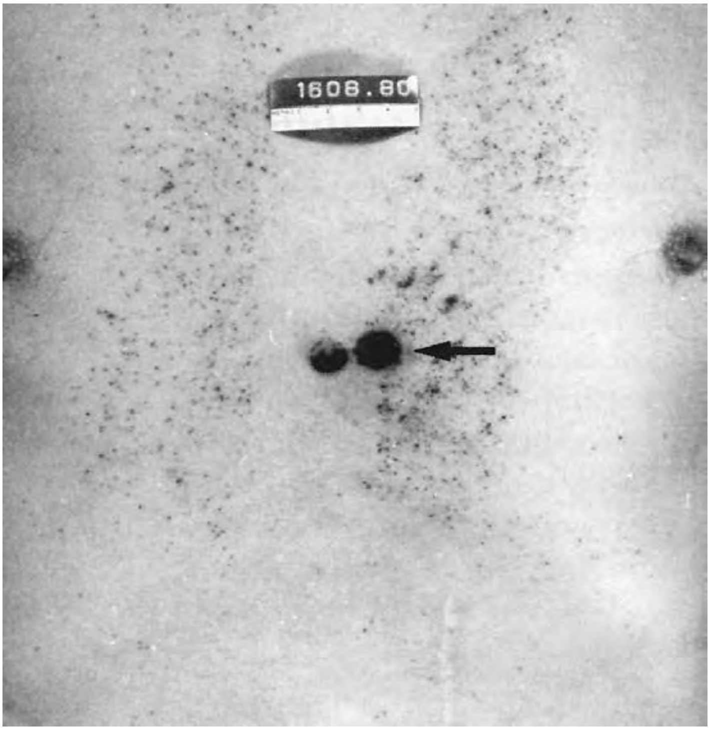

Figure 5.19 Unusual ball powder tattoo pattern resulting from shirt. The powder passed through the shirt, except for the center facing, where there were four layers of cloth rather than one. Arrow indicates entrance. Circular mark medial to entrance is imprint of button.

cartridge generally is loaded with a 50-gr. full metal-jacketed bullet. Muzzle velocity is around 760 ft/sec. A limited production of cartridges loaded with a hollow-point jacketed bullet was made by Winchester in the early 1970s. All these cartridges were loaded with ball powder. These bullets as a general rule do not expand in the body. In 1981, Winchester-Western introduced a cartridge loaded with a 45-gr. expanding-point projectile. The bullet is lead, unjacketed, but coated with a copper Lubaloy® finish. The bullet has a hollow point filled with one No. 4 steel birdshot pellet. The projectile without the shot weights approximately 42.6 gr. CCI cartridges are loaded with bullets having lead cores covered on all surfaces by a thick (0.004 inch) electroplated coating of copper.

.32 ACP (7.65 × 17SR)

The .32 ACP was introduced in 1899 by Fabriqué Nationale for the first successful semiautomatic pistol ever manufactured. It is used extensively in

Figure 5.20 Entrance wound of back showing absence of abrasion ring. The bullet was a semi-jacketed .357 Magnum.

Europe. Czechoslovakia manufactured a submachine gun for it, the Scorpion. The cartridge is semirimmed and will chamber and fire in a .32 revolver. It is generally loaded with a 71 gr. full metal-jacketed bullet, with a muzzle velocity of 905 ft/s. Winchester markets a cartridge loaded with a 60-gr aluminum-jacketed hollow-point bullet. Muzzle velocity is 970 ft/sec.

.32 Smith & Wesson and .32 Smith & Wesson Long

The .32 Smith & Wesson and .32 Smith & Wesson Long cartridges were introduced in 1878 and 1903, respectively. They are revolver cartridges. The .32 S & W is loaded with an 85-gr. lead roundnose bullet. Muzzle velocity is 680 ft/sec. The .32 S & W Long is loaded with a 98-gr. lead roundnose bullet. Muzzle velocity is 780 ft/sec. These cartridges were used extensively in cheap weapons of the Saturday Night Special design. They are essentially obsolete.

.38 Smith & Wesson (9 × 20R)

The .38 Smith & Wesson revolver cartridge was introduced in 1877 with a black powder loading. In Britain, it is called the .380/200. The cartridge is usually loaded with a 145-gr. lead bullet. Muzzle velocity is 685 ft/sec. A 200-gr. loading with a muzzle velocity of 630 ft/sec used to be available. The .38 S & W is essentially an obsolete cartridge. It is rarely seen in the United States.

.38 Special

Introduced in 1902, the .38 Special is the most popular centerfire handgun cartridge in the United States. The standard loading for more than 50 years was a 158 gr. round nose lead bullet having a muzzle velocity of 755 ft/sec. Since the mid-1960s, numerous high velocity semi-jacketed hollow-point and soft-point loadings have been introduced. Bullet weights are generally 95, 110, 125, and 158 gr. in these new loadings. Muzzle velocities range from 950 to 1200 ft/sec. Any weapon chambered for the .357 Magnum cartridge will chamber and fire the .38 Special cartridge.

.357 Magnum

Introduced in 1935 by Smith & Wesson, the .357 Magnum is the .38 Special cartridge case lengthened about 1/10 in. so that it will not chamber in the .38 Special revolver. Standard loading was a 158-gr. lead semiwadcutter bullet with a muzzle velocity of 1235 ft/sec. New semi-jacketed loadings are generally 110, 125, and 158 gr. with muzzle velocities ranging from 1235 to 1450 ft/sec.

.380 ACP (9 × 17 mm/9-mm Kurz/9-mm Corto/9-mm Browning Short)

The .380 cartridge was introduced in the United States in 1908 by Colt and in Europe in 1912 by Fabriqué Nationale. Standard loading is a full metal-jacketed, 95-gr. bullet with a velocity of 955 ft/sec. Semi-jacketed hollow-point loadings are commercially available. This cartridge is increasingly popular in the United States.

9 × 18-mm Makarov

This cartridge was developed by the former USSR as their standard pistol cartridge. In power, it is slightly superior to the .380 ACP. It was not seen in the United States until the early 1990s when large quantities of Makarov pistols began to be imported from China, Russia, and other former Warsaw Pact countries. The standard military loading is a full metal-jacketed 95-gr. bullet having a muzzle velocity of 1060 ft/s. This cartridge is not a true 9 mm as the bullet has a diameter of 0.364 inches compared to 0.355 for the 9 × 19mm.

.38 Colt Super Auto (9 × 23SR)

The .38 Colt Super Auto cartridge was introduced in 1929 as an improved version of the .38 Colt Auto cartridge introduced in 1900. It has never really gained much popularity in the United States. Standard loading is a 130-gr. full metal-jacketed bullet with a muzzle velocity of 1275 ft/sec.

9-mm Luger (9-mm Parabellum/9 × 19-mm)

Introduced in 1902, the 9-mm Luger is the most widely used military handgun cartridge in the world. All modern submachine guns are chambered for this cartridge. A typical military cartridge is loaded with a 115-gr. full metal-jacketed bullet and has a muzzle velocity of 1140 ft/sec. Standard loadings are with 115, 124 and 147 gr. bullets, full metal-jacketed or hollow-point bullets. The 147 gr. bullet as loaded is subsonic. The 9 mm was considered by many American shooters as inferior to the .45 ACP. Studies by the military, a number of civilian government agencies as well as by private individuals have shown that this is incorrect; there is no appreciable difference in the effectiveness of the 9 mm and the .45 ACP cartridges. This cartridge became the standard pistol caliber for the United States military in 1985 and is used by many if not most police agencies in the United States.

.40 Smith & Wesson

This cartridge was introduced in early 1990. It is ballistically similar to the .45 ACP but the cartridge is closer in size to the 9-mm Parabellum. Because of the smaller size than the .45 ACP cartridge, weapons designed originally for the .45 ACP can accommodate more rounds in the magazine. This cartridge is popular with many police organizations. Standard loadings are with 155 and 180 gr. bullets. Muzzle velocity is 1125 and 990 ft/s, respectively.

.45 ACP (11.43 × 23)

The .45 ACP cartridge was adopted as the official military caliber of the United States in 1911. It has never been popular outside the United States. Adoption was based on a series of wound ballistics tests by the U.S. Army prior to its adoption. It was considered a great "man stopper," but more recent testing has shown it no more effective than the 9-mm Luger cartridge which has replaced it in the U.S. military. Standard military loading is with a 230-gr. full metal-jacketed bullet that has a muzzle velocity of 855 ft/sec. Semi-jacketed hollow-point cartridges are available. This cartridge should not be confused with the .45 Colt cartridge introduced in 1873 by Colt for their Peacemaker single-action revolver.

.44 Smith & Wesson Magnum

The .44 Smith & Wesson Magnum is the most powerful commercially successful handgun cartridge produced. It was introduced in 1955. Not only are a number of revolvers chambered for this cartridge but also a pistol and a number of carbines. The cartridge is loaded with either a 240-gr. lead soft-point bullet or a semi-jacketed hollow-point bullet. Muzzle velocity is 1180 to 1350 ft/sec. This cartridge is unpleasant to shoot for most individuals.

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