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An Experimental Study of Powder Tattooing of the Skin

Determination of the distance from muzzle to victim from the appearance of a gunshot wound in the skin is often of great importance. Such information may be necessary to confirm or disprove an account of the circumstances surrounding a death due to firearms. Contact wounds generally can be recognized by the presence of soot and powder in and around the wound as well as searing of the skin from the flame. When the contact wound overlays bone, tearing of the skin or muzzle imprints may be present. Intermediate range gunshot wounds are characterized by powder tattooing (stippling) of the skin around the wound of entrance. Soot may or may not be present. While soot can usually be wiped away, powder tattooing cannot. When the muzzle-to-target distance increases so that powder tattooing no longer occurs, the gunshot wound is called a distant wound and range determinations can no longer be made.

In deaths caused by gunshot wounds, pathologists are asked almost invariably if the wound is contact, intermediate, or distant. In intermediate range cases, both medical examiners and firearms examiners are often requested to estimate the muzzle-to-target distance based on the size and appearance of the powder tattooing on the skin.

The size of the area of powder tattooing depends on a number of factors. The most important are distance from muzzle to target, barrel length, caliber, the type of propellant, the individual weapon, and the type of weapon used [1].

Muzzle-to-victim range determinations from powder tattoo patterns on the skin are made by firearms examiners from measurements of the tattoo pattern obtained by the pathologist. Using the same weapon and ammunition, the firearms examiner attempts to reproduce on paper a pattern of the same size. The distance at which a pattern identical to that which is on the body is produced is assumed to be the range at which the gun was fired into the individual.

In constructing this experimental study, the authors wished to investigate three areas concerning powder tattooing. As most weapons involved in gunshot wound deaths are handguns, our study was limited to powder tattooing produced by handguns. The first purpose was to test the accuracy of forensic textbooks as to the maximum range at which powder tattooing occurs. This maximum ranges from 12 to 24 in. (0.3 to 0.6 m), depending on the source [2,3].

The second purpose was to determine if different forms of powder affect the maximum range at which powder tattooing occurs. Until recently, virtually all pistol cartridges

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were loaded with flake powder. Now, however, many cartridges are being loaded with ball and flattened ball powder (Fig. 1). The third area was the correlation of powder pattern determinations on white blotter paper with tattoo patterns on bodies.

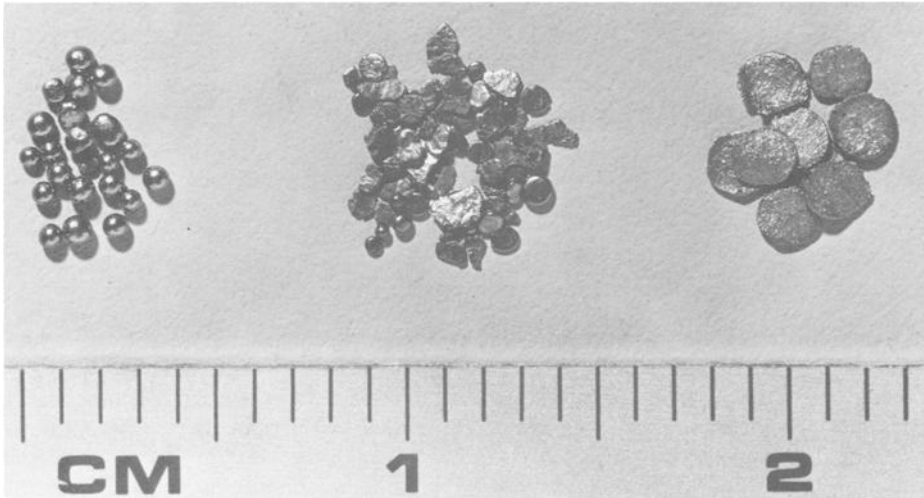


FIG. 1—Ball, flattened ball, and flake powders.

Experimental Procedure

Test firings were conducted on live white rabbits. Rabbits were used because they are easy to handle and inexpensive to purchase and house. The animals had to be alive, as powder tattooing is a vital reaction and does not occur after death. This was demonstrated by firing powder tattoo patterns on dead rabbits. In such tests, the marks produced on the skin by the grains of powder did not have the reddish brown, hemorrhagic coloration of antemortem marks. In addition, the postmortem markings were significantly fewer than antemortem powder tattoo marks.

The abdomens and chests of the rabbits were shaved. Any remaining hair was removed by depilatory cream. After being anesthetized, the animals were suspended by their front paws. They were then shot in the abdomen at varying distances. In virtually all cases, the animals died immediately. If death did not occur immediately, the animals were sacrificed with overdoses of barbiturates. Tests were limited to only two calibers, the .38 Special and the .22 long rifle. A Smith & Wesson Model 15-2 revolver with a 4-in. (101.6-mm) barrel was used for all .38 Special tests. The .22 caliber revolver used in all tests was a General Precision Corp. Model 20 with a 2-in. (50.8-mm) barrel, the barrel length typical of the "Saturday Night Special" revolvers.

Three forms of .38 Special ammunition were used in our tests: Winchester-Western 158 grain (gr), lead, hollow-point, loaded with flake powder; the same ammunition loaded with flattened ball; and Smith & Wesson 125 gr semijacketed, hollow-point, loaded with ball powder. The .22 long rifle ammunition used was 40 gr lead, Remington high velocity and Winchester high velocity cartridges. The former cartridges were loaded with flake powder, the latter with flattened ball. A Lee Engineering Co. handgun machine rest was used for the .38 Special weapon.

Results

Table 1 summarizes the results of our tests with the .38 Special ammunition. Figures 2-4 illustrate typical powder tattoo patterns on rabbits. These tests indicate that for

TABLE 1—Patterns of .38 Special powder tattoo in rabbits. Cartridges were loaded with three different forms of propellant.

Muzzle-to-Target Distance, in.	Size of Tattoo Pattern, in.		
	Flake	Flattened Ball	Ball
6	2.5 × 3.25	4.0 × 3.0	5.0 × 2.25
12	3.0 × 2.25	4.25 × 3.25	...
18	3.25 × 2.25	...	5.5 × 6.0
24	absent	4.0 × 4.5	...
30	...	3.5 × 4.0	6.0 × 7.25
36	...	scattered ^a	9.0 × 7.0
42	...	absent	6.5 × 6.5
48	rare ^b

1 in. = 2.54 mm

^a 15 to 20 tattoo marks.

^b 2 to 3 tattoo marks.

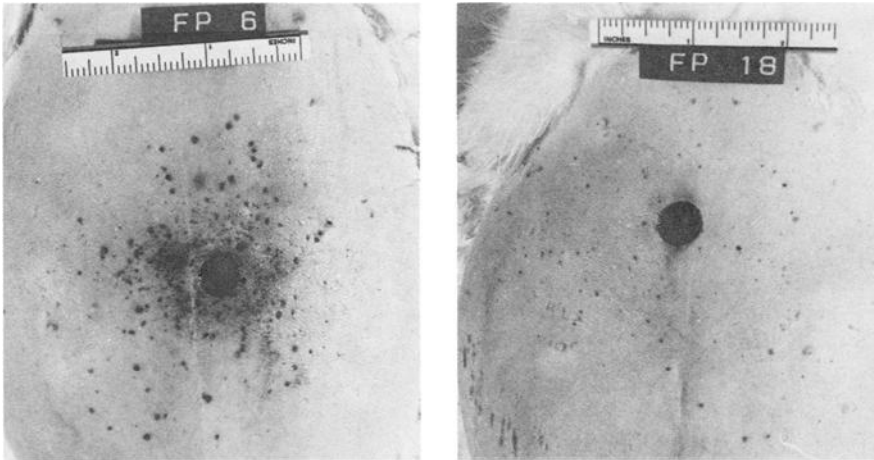


FIG. 2—Tattooing of skin from .38 Special cartridge loaded with flake powder; (left) range, 6 in. (152 mm); (right) range, 18 in. (0.4 m).

flake powder, powder tattooing disappears at a muzzle-to-target range of 18 to 24 in. (0.4 to 0.6 m). This distance is approximately the same as given in most forensic text books [2,3]. Thus, these statements are accurate for cartridges loaded with flake powder. Powder tattooing with flattened ball powder, however, extends out to 36 in. (0.9 m), twice that of flake powder. At a range of 42 in. (1 m), flattened ball no longer produced any powder tattooing. Ball powder causes heavy powder tattooing at 36 in. (0.9 m) of range, moderate tattooing at 42 in. (1 m) of range and rare tattooing at 48 in. (1.2 m).

Table 2 depicts the results with .22 long rifle ammunition loaded with flake and flattened ball powder. In contrast to .38 Special ammunition, flake powder causes powder tattooing to a greater distance than flattened ball. The tattooing from flake powder disappears at about 24 in. (0.6 m), while that due to flattened ball disappears at about 18 in. (0.4 m).

After completing the animal tests, the authors repeated these test firings on white blotter paper to determine the validity of paper patterns in determining range. Attempts to reproduce the animal powder tattoo patterns on paper with ball and flake powder revealed that the paper patterns are consistent with skin tattoo patterns only up to 18 in.

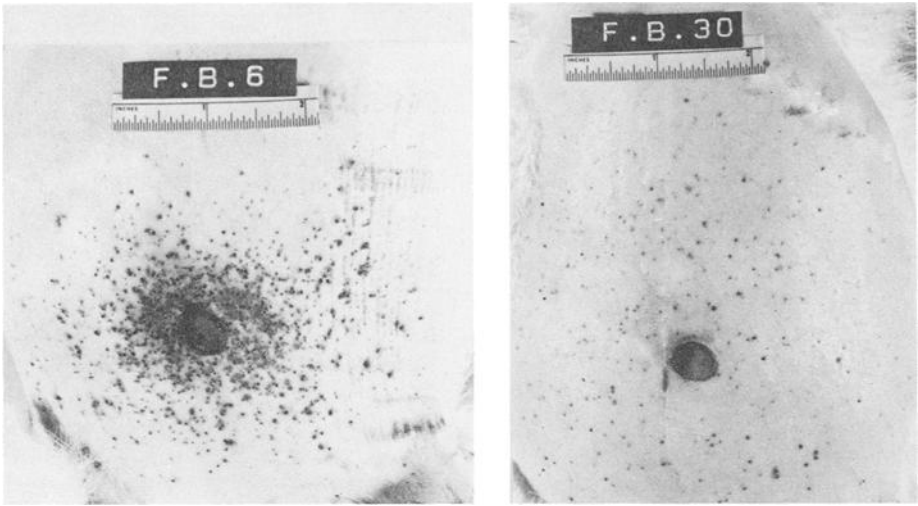


FIG. 3—Skin tattooing from .38 Special cartridge loaded with flattened ball powder; (left) range, 6 in. (152 mm); (right) range, 30 in. (0.8 m).

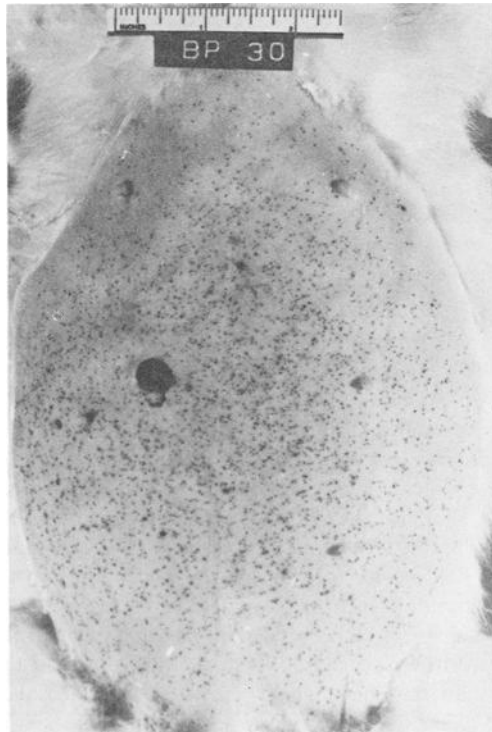


FIG. 4—Skin tattooing from .38 Special cartridge loaded with ball powder; range, 30 in. (0.8 m).

TABLE 2—Patterns of .22 long rifle powder tattoo in rabbits. Cartridges were loaded with two different forms of propellant.

Muzzle-to-Target Distance, in.	Size of Tattoo Patterns, in.	
	Flake	Flattened Ball
12	4.0 × 3.0	2.5 × 2.0
18	3.5 × 3.0	Rare ^a
24	Rare ^b	...

1 in. = 2.54 mm

^a1 to 2 tattoo marks.

^bLess than 5 tattoo marks.

(0.4 m) of range. Beyond this point, paper patterning was unreliable for both .38 Special and .22 cartridges.

For .38 Special flattened ball, the paper pattern at 24 and 30 in. (0.6 and 0.8 m), while approximately the same size as on the animals, was considerably less dense and did not resemble the tattoo pattern on skin. For ball powder at 30 in. (0.8 m) of range, the paper pattern was half the size of that of the skin pattern. In addition, it was considerably less dense. At 36 in. (0.9 m) of range, the paper pattern of ball powder was approximately one third that of the skin pattern with only negligible numbers of particles. On the skin, however, the tattoo pattern was extremely dense.

Discussion

The skin of rabbits is significantly thinner than that of humans. Therefore, powder tattooing should occur out to greater maximum distances for rabbits as compared to humans. Thus, the maximum distances obtained in our experiments are only a *guide* to the outer limits for tattooing in humans. It is, in fact, impossible to give *exact* figures for maximum distances of powder tattooing. This is because, as was pointed out in the beginning of the paper, powder tattooing depends on numerous variables: the range, the individual weapon, the type of propellant, barrel length, caliber and so forth.

These experiments have proven conclusively that the shape of the individual powder grain has a significant influence on the maximum range at which powder tattooing occurs. Powder tattooing at greater ranges for ball powder (both spherical and flattened ball) than flake powder in .38 Special is probably due to the shape of the powder grains. The sphere has a better aerodynamic form than the flake; thus, ball powder can travel further with greater velocity, enabling it to mark the skin at a greater range. The opposite finding in the .22 caliber ammunition is probably due to the flattened ball powder in .22 long rifle ammunition; the powder has such small particle size that any aerodynamic benefits obtained from its shape are lost due to its lighter mass.

The tests reveal that paper patterns are consistent with skin tattoo patterns only up to 18 in. (0.4 m) of range. Beyond this point, paper patterning was unreliable, for both the .38 Special and the .22 cartridges. While preparing to do this testing, we encountered a major source of error not anticipated, involving the measurement of the powder tattoo pattern on the animal bodies as well as on the paper. Measurements of the same wound pattern by the authors were virtually identical. However, two criminalists not associated with the study were asked to make the same measurements; their results were radically different from each other as well as the authors. In some cases, these variations were as great as 100%. Analysis of the difference between the two groups of measurements revealed that the authors were measuring the main powder pattern and ignoring "flyers," while the criminalists were measuring the entire pattern, including flyers. Even this,

however, was not consistent for the criminalists. These results indicate that reported tattooing dimensions are subject to significant error unless uniform measuring techniques are used. We strongly advocate that the person who duplicates the pattern on paper should either consult with the individual who initially measured it or personally observe the pattern on the body. Obtaining photographs with rulers included may be of some help in documenting the actual size of the pattern.

Summary

Test firings were conducted on specially prepared live rabbits to determine the approximate maximum ranges at which powder tattooing occurs for different forms of gunpowder. For .38 caliber, powder tattooing from cartridges loaded with flake powder disappears at a range of 18 to 24 in. (0.4 to 0.6 m). Powder tattooing with flattened ball powder extends to 36 in. (0.9 m), while that due to ball powder extends to 48 in. (1.2 m) of range. In .22 caliber, powder tattooing was observed out to 24 in. (0.6 m) with flake powder and 18 in. (0.4 m) with flattened ball. Attempts to reproduce the animal powder tattoo patterns on paper revealed that the paper patterns are consistent with skin tattoo patterns only up to 18 in. (0.4 m) of range.

Acknowledgments

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