J Forensic Sci, Apr. 1976, Vol. 21, No. 2

R. L. Rivers,[1] *M.D.; L. B. Miller,*[1] *B.S.;*
and G. S. Loquvam,[1] *M.D.*

Soft Tissue Radiography in Determining Contact and Near-Contact Gunshot Wounds

Determination of firing distance is an important consideration in the investigation of gunshot wounds. To define this distance as precisely as possible many studies have been proposed and conducted to correlate the deposits remaining on target surfaces with the muzzle-to-target distance. Among these have been microscopic tissue examination [*1*]; various chemical tests, including atomic absorption spectrophotometry, neutron activation analysis, and so forth [*2,3*]; and visual examination of powder patterns [*4*]. Some of these techniques allow correlation of the pattern with an approximate distance. Others only support conclusions of greater or less than a particular distance. Results of these methods become difficult or impossible to assess where surface deposits are destroyed or obliterated. This study describes the application of soft tissue radiography to the characterization of contact and near-contact gunshot wounds independent of surface integrity.

Materials and Method

Thirty-six excisions of postmortem skin were obtained by modifying the abdominal autopsy incision. Twelve actual contact or near-contact wounds were excised and X-rayed prior to sectioning for histological slides. Various revolvers, a semiautomatic pistol, and a rifle were used for tests. Jacketed, copper-gilded, and nonjacketed bullets were used in the tests.

A 2 by 8-in. (51 by 203-mm) rectangular excision of human scalp with thick hair and the skin of a guinea pig were used for the hair studies. Strips of material from a pair of Levi® pants and a cotton undershirt were used to represent heavy and light clothing, respectively.

The firearms used included these revolvers: .22 caliber Röhm RG-23, 1¾-in. (44.45-mm) barrel; .32 caliber Smith & Wesson 32/20, hand ejector model, 5-in. (127-mm) barrel; and .38 caliber Colt, double action Army 38, 6-in. (152-mm) barrel. Also used in the tests were a .25 caliber PIC Decatur semiautomatic pistol with a 2-in. (51-mm) barrel and a .22 caliber Remington rifle, Nylon 66, with an 19½-in. (495.3-mm) barrel.

The ammunition for the tests included .22 caliber long rifle (LR) Western T22 (standard velocity), 40-grain lead (index T22LR); .22 caliber LR Winchester Super X, 40-grain Kopperklad® (index WSX22LR); .25 caliber (6.35 mm) automatic pistol, Western 50-grain full metal case (index 25AP); .25 caliber Smith & Wesson long, Remington-Peters 98-grain lead (index 1232); and .38 caliber Special Remington 125-grain, semijacketed

Received for publication 18 April 1975; revised manuscript received 24 June 1975; accepted for publication 26 June 1975.

[1] Fellow in forensic pathology, criminalist, and Director, respectively, Institute of Forensic Sciences, Oakland, Calif.

hollow point (index 2038). All ammunition contained flake powder except the .38 caliber and .22 caliber Winchester, which contained ball powder.

A single 2 by 8-in. (51 by 203-mm) elliptical excision of skin was stapled to a $\frac{3}{32}$-in. (2.3812-mm) thick cardboard mount and positioned over a bullet trap. From one to five shots were fired into each sample. While contact wounds were easily placed, the long-distance shots required a single sample due to the small area involved.

All firearms were discharged at press contact, where the tissue was slightly indented by the muzzle; light contact, where the weapon muzzle was just in contact with the tissue surface; and near contact, where the muzzle was $\frac{1}{16}$-in. (1.588 mm) from contact with the tissue. They were also fired at measured distances of 1, 3, 6, 12, 24, 36, and 72 in. (25.4, 76.2, 152.4, 304.8, 609.6, 914.4, and 1828.8 mm). Test firings at press contact, light contact, near contact, and distances up to 6-in. (152.4 mm) were repeated at least six times. Shots at longer distances were discontinued after two firings.

The test samples and actual wounds were photographed with a Polaroid Model MP3 camera and 55 positive/negative PN film. Specimens were then placed in a Faxitron Model 805 X-ray cabinet on a sheet of 8 by 10-in. (203 by 254-mm) Kodak extra fine grain, high contrast, industrial X-ray film (Type M). Automatic exposure control was utilized but the average kV (peak) was 50 at 0.8 mA.

Some specimens were then cleansed with a surgical soap and scrub brush. They were again photographed and radiographed. An autopsy specimen with multiple contact gunshot wounds was charred with a blow torch to simulate a burned body.

Results

A radio-opaque pattern of fragments and residue from nonjacketed lead bullets can be seen in tissue circumscribing all contact and close gunshot wounds (Figs. 1–4). Jacketed

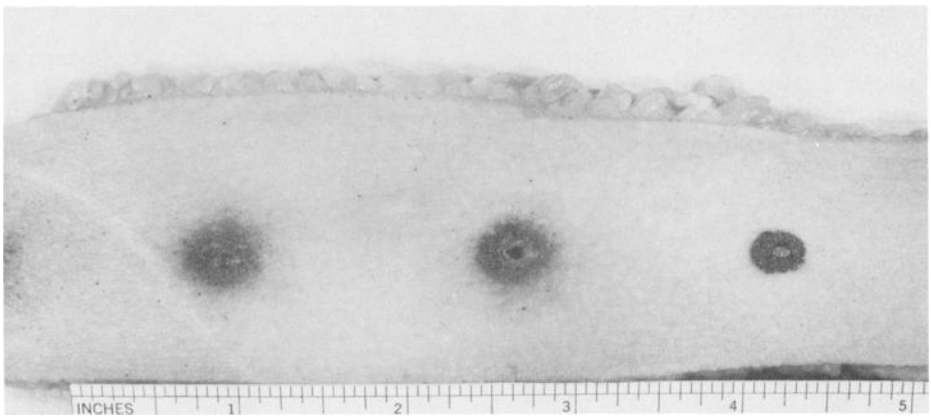

FIG. 1—*Powder patterns from .22 caliber rifle with .22 caliber LR Western T22 ammunition*; (left to right) *3-in. (76 mm), 1-in. (25 mm), and light contact.*

and semijacketed ammunition failed to show a deposit under the same conditions. Since nonjacketed bullets leave a radio-opaque ring while jacketed bullets do not, it would appear that the ring is predominately lead. Lead bullets coated with a gilding metal such as Kopperklad® show a ring pattern similar to uncoated lead bullets.

The three types of contact wounds through hair-covered scalp and animal fur failed to obliterate the characteristic ring found in the radiographs. Near-contact wounds

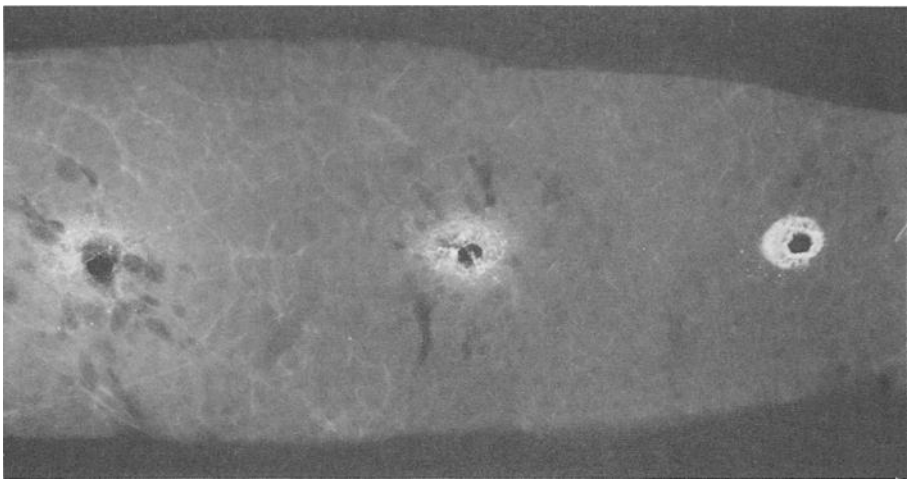

FIG. 2—*Radiograph of specimen in Fig. 1. The radio-opaque ring dissipates at 3 in. (76 mm) and beyond.*

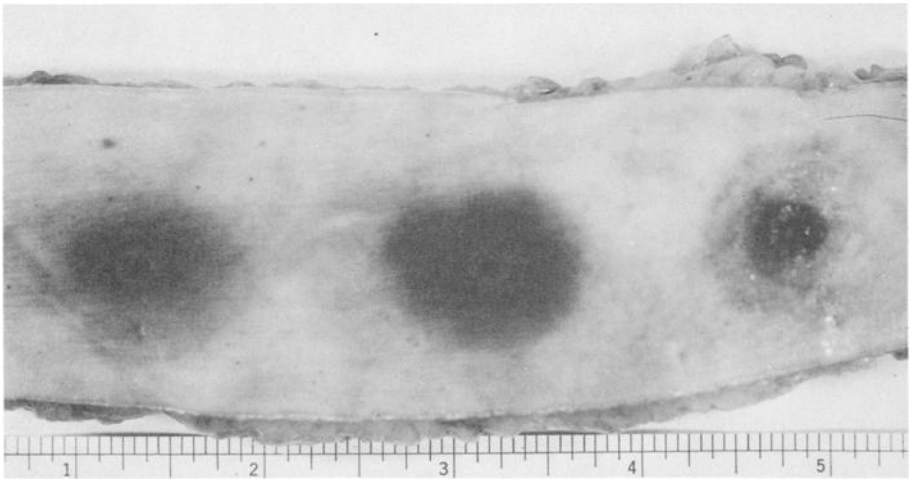

FIG. 3—*Powder patterns from .32 caliber revolver at light contact* (left) *and 3-in. (76 mm)* (middle) *and from a .38 caliber revolver at light contact* (right).

through light and heavy cloth obliterated the powder pattern on the skin, but radiographs demonstrated the persistence of the ring in the tissue.

Specimens subjected to surgical cleansing and burning retained the radio-opaque ring. After burning, the diameter of the ring decreased but the density increased due to shrinkage of the tissue.

Pursuant to a case investigation, an excised bullet wound from an exhumed, partially decomposed body showed a residue ring with soft tissue X-ray. When compared to test firings of the questioned weapon, an estimate of contact distance could be determined.

Press contact wounds caused the familar blow-back effect on tissues and demonstrated a large amount of residue not in a ring-like pattern. Firings with the weapons and ammunition employed in this study showed a dissipation of the ring beyond a distance of 3-in. (76 mm).

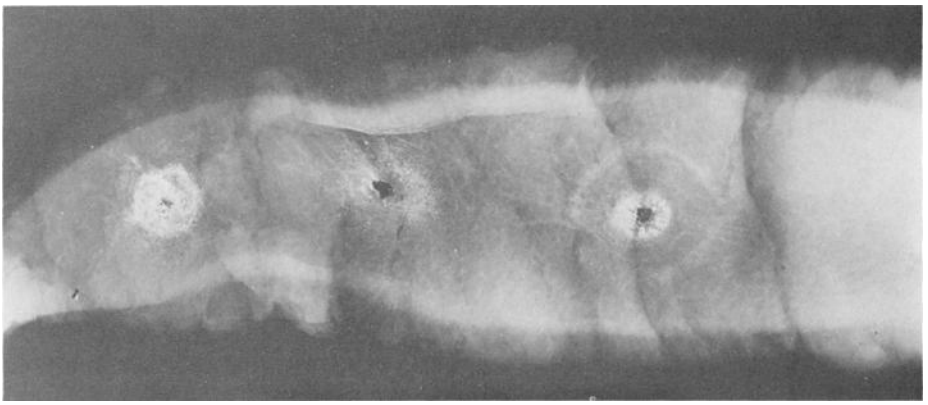

FIG. 4—*Radiograph of specimen in Fig. 3. Note the dissipation of ring at 3 in. (76 mm)* (middle).

Discussion

Ordinary characteristics of contact wounds may be altered, obscured, or obliterated as in the following circumstances:

1. Powder patterns may be lost with the clothing or obscured with blood.
2. Thick hair and pigmentation of the skin can increase the difficulty in the examination of a powder pattern.
3. Powder patterns are obliterated in burned and badly decomposed bodies.
4. In the hospital the wounds are cleansed, shaved, and sutured. Chest tubes may be placed in thoracic wounds with alteration of the surrounding tissue.

Microscopic examination of gunshot wounds is valuable in differentiating close and distant wounds. However, sections of tissue must be carefully chosen and determination of contact wounds by this method is not accurate. Chemical examination of residues to estimate firing distances requires the presence of an unaltered powder pattern.

Soft tissue radiographs can surmount these difficulties by demonstrating a characteristic residue ring in contact wounds caused by nonjacketed bullets. The radiograph is a permanent, clear representation of a contact wound. It can be compared with radiographs of wounds reproduced by firing the same gun and ammunition at various distances into skin samples. Soft tissue radiographs should be used to confirm all suspected contact wounds. Since many wounds are excised for histological sectioning, radiographs can be performed prior to sectioning.

Summary

Contact and near-contact gunshot wounds ordinarily show distinctive gunpowder patterns, muzzle imprints, or tearing of the skin. Microscopic and chemical examination have been used to estimate firing distances. A new method that utilizes soft tissue radiography is described.

Nonjacketed lead bullets deposit a pattern of fragments and residues in tissue circumscribing contact and close gunshot wounds. Various patterns are presented to contrast the appearance of contact from distant gunshot wounds using various firearms and different types of bullets. This procedure may be used as an adjunct in the determination of contact and close gunshot wounds.

Acknowledgments

We wish to thank the following persons for their technical assistance: Mr. Duane Dillon, Contra Costa Crime Laboratory and Mr. Charles V. Morton, Institute of Forensic Sciences.

References

[*1*] Adelson, Lester, "A Microscopic Study of Dermal Gunshot Wounds," *American Journal of Clinical Pathology*, Vol. 35, No. 5, 1961, pp. 393–402.

[*2*] Krishnan, S. S., "Firing Distance Determination by Atomic Absorption Spectrophotometry," *Journal of Forensic Sciences*, Vol. 19, No. 2, 1974, pp. 351–356.

[*3*] Krishnan, S. S., "Firing Distance Determination by Neutron Activation Analysis," *Journal of Forensic Sciences*, Vol. 12, No. 4, 1967, pp. 471–483.

[*4*] Barnes, F. C. and Helson, R. A., "An Empirical Study of Gunpowder Residue Patterns," *Journal of Forensic Sciences,* Vol. 19, No. 3, 1974, pp. 448–462.

1890 N. Waterman St.
San Bernardino, Calif. 92404