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"Foreshoring": Characteristics of Shored Entry Wounds and Corresponding Wounds with Shoring Material as an Intermediate Target

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ABSTRACT: Just as an exit wound can be shored by firm material pressed against the skin, so can an entry wound. The configuration of supported entrance wounds is examined in relation to type of shoring material and weapon caliber, by using anesthetized pigs. Corresponding wounds with the same shoring materials used as intermediate targets are also studied.

KEY WORDS: pathology and biology, wound ballistics, ballistics

Characteristics of shored exit wounds as influenced by the kinetic energy of the round, shoring material, and shoring pressure were studied in a previous report by the author.[2] It was determined that the degree of shoring abrasion increased directly with the kinetic energy of the round and the rigidity[3] of the shoring material, and probably inversely with the shoring pressure. In addition, the frequent findings of a round or oval defect with an abraded margin, contusion and particulate matter from the shoring substance mimicking powder stippling, and a stellate configuration may lead to misinterpretation of an exit wound as distant, close range, or contact entrance, respectively.

Just as firm material may support or shore the skin at the exit site, so may it be pressed firmly against the skin at the entrance site; such a situation would occur if someone were shot through a wooden, metal, or glass door while pressing his body against it to prevent

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The experiments reported herein were conducted according to the principles described in "Guide for the Care and Use of Laboratory Animals" of the Institute of Laboratory Animal Resources, National Research Council, DHEW Publication No. (NIH) 78-23, Revised 1978.

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[2]D. S. Dixon, "Characteristics of Shored Exit Wounds," unpublished report.

[3]For the purposes of these studies, a high degree of rigidity is indicated by the likelihood that a particular shoring material will shatter when perforated by a projectile.

the entry of the assailant. This "foreshoring" actually represents a specialized type of intermediate target, where the intervening distance between intermediate target and skin is zero. A similar situation arises when a projectile perforates a part of the body such as an extremity and reenters at another site; shoring by tissue at a reentry site was not examined in the following study.

The scientific literature contains few articles on intermediate targets. Breitenecker and Senior [*1*] investigated intermediate targets in shotgun injury. A recent article by Stahl et al [*2*] demonstrated that a bullet fired at close range through a pane of glass serving as an intermediate target may give the entry wound an atypical, stellate appearance suggestive of a wound produced at a contact range of fire; these authors also indicated the need for further research on the subject of intermediate targets.

An experimental model based on a modification of one used in a previous study was designed to evaluate foreshoring or shored entry wounds along with the corresponding wounds having the shoring material as an intermediate target. The effects of kinetic energy of the round and of the type of shoring material were examined.

Materials and Methods

The weapons selected for this study were an F.I.E. 0.22-caliber revolver; a Ruger 0.357 Magnum revolver, "Ruger Security Six"; a Colt 0.38-caliber Special revolver, "Police Positive Special"; and a Remington 0.45-caliber M1911 A1 U.S. Army semiautomatic pistol. The ammunition used in each weapon, respectively, was Remington High Velocity .22 Long Rifle 40-grain solid point; Remington .357 Magnum 158-grain lead; Western .38 Special 158-grain lead; and Western .45 automatic 230-grain full metal jacket.

The animals used to receive the shored entry wounds and the entry wounds with intermediate targets were male mixed-breed "mini-pigs," each weighing approximately 23 to 34 kg (50 to 75 lb). Surgical anesthesia was achieved by intravenous administration of sodium pentobarbital (approximately 30 mg/kg body weight) by means of an indwelling "butterfly" cannula in a lateral ear vein. The animals were washed and lightly clipped without damage to the skin.

On the ballistic firing range, the animals were placed in a wooden frame designed to hold the skin at the entry site pressed against sheets of various materials used for shoring and to hold the same shoring material as an intermediate target with 150 mm (6 in.) between barrel tip and intermediate target and 150 mm (6 in.) between intermediate target and the skin at the entry site (Fig. 1).

The shoring materials included 0.48-mm (0.019-in.) aluminum sheet metal, 6-mm (1/4-in.) plywood, 13-mm (1/2-in.) plasterboard, 6-mm (1/4-in.) clear Plexiglas®, and 6-mm (1/4-in.) plate glass. Control wounds were also produced without shoring material.

The wooden frame was connected to a stainless steel cart with four C-clamps. Weapons were individually attached to a remote control firing stand and were discharged with a push button located outside the range of fire.

During weapon firing, every attempt was made to insure the uniformity of the procedure in the following respects. Shots were fired as nearly perpendicular to the shoring material as possible. Pigs having similar elasticity of abdominal skin were chosen for the study. In addition, the distances were kept constant at 150 mm (6 in.), specifically the distance between the muzzle of each weapon and the shoring material and, in the cases of intermediate targets, the distance between intermediate target and skin surface. The pressure of the skin at the entry site against the shoring material was maintained by the placement of a concrete block on the side of the animal opposite the shored entry site.

The experimental shored entry wounds and wounds with intermediate targets were visually examined, photographed, completely excised with underlying subcutaneous tissue, and studied under a dissecting microscope.

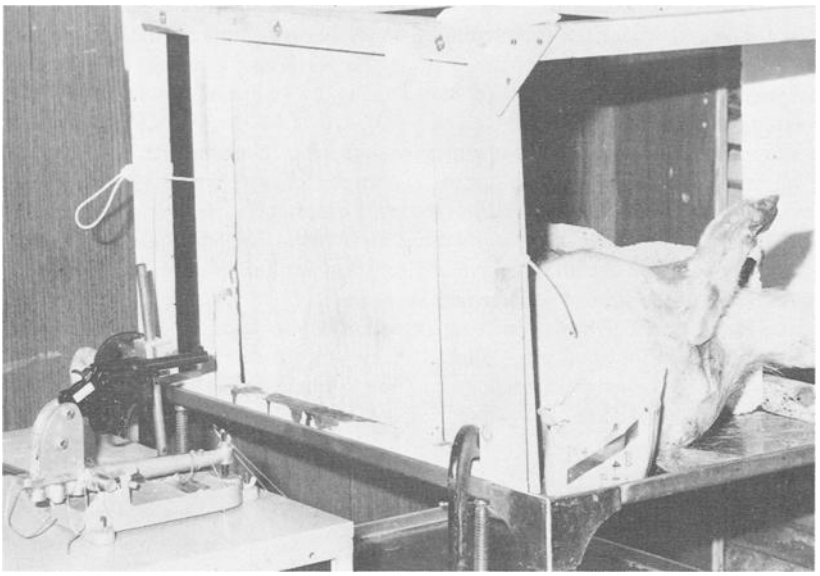

FIG. 1—*Wooden frame designed to hold skin at entry site against various shoring materials. Note plywood as a shoring material and intermediate target (AFIP Neg. 79-11318-2).*

Results with the Dissecting Microscope

Each experimentally produced wound was studied under an American Optical stereomicroscope for details of wound configuration. The wounds were analyzed with attention to the following: shape of skin defect, degree of abrasion and contusion, relative amount and type of particulate matter, maximum wound diameter including abraded margin, and maximum width of abrasion ring. These data are presented in Table 1.

The control entrance wounds had the appearance of typical entry wounds. They were characterized by a round skin defect and a slight abrasion of the margin as well as by deposition of smoke on the skin surface and powder stippling.

Of the 20 experimentally produced shored entrance wounds and the 20 wounds with intermediate targets, the number showing the various features and the percentage of the total number in each group demonstrating these features are given in Table 2.

Virtually all of the entry wounds in which the projectile penetrated the skin demonstrated a round defect with or without radiating lacerations and with margins having various degrees of abrasion. Some examples of foreshored entry wounds with prominent abrasion are shown in Figs. 2 and 3. Several of the intermediate target entrance wounds also had prominent margin abrasion as shown in Fig. 4. Even those wounds with no projectile penetration of skin showed a circular area of abrasion with superficial, radially arranged lacerations; one such wound is shown in Fig. 5.

Lacerations of various sizes radiating from the central defect were noted in many wounds (40% of shored entrances, 35% of entrances with intermediate targets at 150 mm [6 in.], and 38% of all wounds); the typical appearance is demonstrated in Figs. 6 through 8.

Contusion around the wound was much less common in shored entrance wounds (25%) and in entrance wounds with intermediate targets (20%) than in shored exit wounds (63%), as indicated in a previous study.

TABLE 1—*Features of shored entry wounds and of wounds with intermediate targets as affected by type of shoring material and weapon caliber.*

Relationship of Material to Skin Surface	Weapon Caliber	Shape of Defect	Degree of Abrasion	Degree of Contusion	Particulate Matter Present	Wound Diameter, cm	Maximum Abrasion Ring Width, cm
			Control				
...	.22	round	±[a]	+	++(S[b],P[c])	0.4	0.1
...	.45	round	±	+	+++(S,P)	1.0	0.2
...	.38	round	±	+	+++(S,P)	0.7	0.2
...	.357	round	+	0	+(S,P)	0.8	0.2
			Plywood Shoring				
Shored	.22	round	+	++	+(S,P,F[d])	0.5	0.1
Intermediate	.22	round	+	+	+(S)	0.7	0.2
Shored	.45	round	+	+	+(F)	0.9	0.2
Intermediate	.45	round	+	0	+(S,F)	0.9	0.3
Shored	.38	round, 3 lac[e]	++	0	++(S,P,F)	1.2	0.5
Intermediate	.38	round	++	+	++(S,P,F)	1.2	0.2
Shored	.357	round	+	0	+(S,P,F)	1.2	0.4
Intermediate	.357	round	±	0	+(S,P,F)	0.7	0.2
			Plasterboard Shoring				
Shored	.22	round	±	0	+(S,F)	0.6	0.2
Intermediate	.22	round	±	0	+(S)	0.5	0.2
Shored	.45	round, 3 lac	±	+	+(F)	1.0	0.2
Intermediate	.45	round, 5 lac	+	0	+(S,F)	0.9	0.2
Shored	.38	round, 3 lac	++	+	+(S,P,F)	1.0	0.3
Intermediate	.38	round	+	+	+(S,F)	0.7	0.2
Shored	.357	round	+	0	+(S,P,F)	1.2	0.4
Intermediate	.357	round	±	0	+(F)	0.6	0.1
			Metal Shoring				
Shored	.22	round	±	0	+(S,F)	0.5	0.2
Intermediate	.22	round	±	0	+(S,P)	0.5	0.1
Shored	.45	round	+	0	+(S,P)	0.9	0.1
Intermediate	.45	round	±	0	+(S,P)	0.9	0.3
Shored	.38	round	±	0	++(S,P,F)	1.0	0.2
Intermediate	.38	round	±	0	++(S,P)	0.9	0.2
Shored	.357	round	±	0	+(S,P)	0.9	0.1
Intermediate	.357	round	+	0	+(P)	1.2	0.4

TABLE 1—*Continued*

Relationship of Material to Skin Surface	Weapon Caliber	Shape of Defect	Degree of Abrasion	Degree of Contusion	Particulate Matter Present	Wound Diameter, cm	Maximum Abrasion Ring Width, cm
			Plexiglas Shoring				
Shored	.22	NP[f]	+[g]	0	+(P,F)	...	3.0
Intermediate	.22	round	+	++	+(P,F)	0.7	0.2[h]
Shored	.45	round, 4 lac	±	0	+(S,P,F)	2.0	0.2
Intermediate	.45	round, 3 lac	++	0	+(P,F)	2.1	0.7[i]
Shored	.38	round, 4 lac	±	0	+(S,P,F)	2.0	0.2
Intermediate	.38	round, 3 lac	++	0	++(S,P,F)	1.6	0.6
Shored	.357	round, multiple lac	+++	0	+++(S,P,F)	1.7	0.5
Intermediate	.357	round, 4 lac	++	0	+++(S,P,F)	1.5	0.5
			Glass Shoring				
Shored	.22	NP	+	0	+(F)	...	2.5
Intermediate	.22	NP	+	0	+(S,F)	...	1.4
Shored	.45	round, 4 lac	+	+	+(P,F)	1.8	0.3
Intermediate	.45	round, 3 lac	+	0	+(P,F)	1.2	0.2
Shored	.38	round, 4 lac	+++	0	+(S,P,F)	2.6	0.9
Intermediate	.38	round, 3 lac	+++	0	+(S,P,F)	2.0	1.0
Shored	.357	round	+	0	+(F)	2.9	0.6
Intermediate	.357	round, multiple lac	+	0	+++(S,P,F)	2.6	0.9

[a] ± signifies that abrasion partially encircles defect.
[b] S = smoke or soot.
[c] P = recognizable powder particles.
[d] F = foreign material from intervening targets.
[e] Overall character of wound is obviously round but wound has radiating lacerations; lac = laceration.
[f] NP = no penetration of missile.
[g] Abrasion is stellate in configuration.
[h] Satellite lacerations with overall diameter of 6.5 cm.
[i] Satellite lacerations with overall diameter of 5 cm (Fig. 5).

TABLE 2—*Number and percentage of shored wounds, of wounds with intermediate targets, and of all wounds demonstrating different features of wound configuration.*

Feature	Shored Wounds		Wounds with Intermediate Targets		All Wounds	
	n	%	*n*	%	*n*	%
Round defect	18[a]	90	19[a]	95	37[a]	93
Radiating lacerations	8	40	7	35	15	38
At least partial circumferential abrasion	20	100	20	100	40	100
Complete circumferential abrasion	13	65	14	70	27	68
Contusion	5	25	4	20	9	23
Particulate matter						
All types	20	100	20	100	40	100
Smoke, soot	14	70	15	75	29	73
Powder	14	70	13	65	27	68
Foreign material	18	90	14	70	32	80

[a] The three wounds that do not show a round defect are those with no projectile penetration.

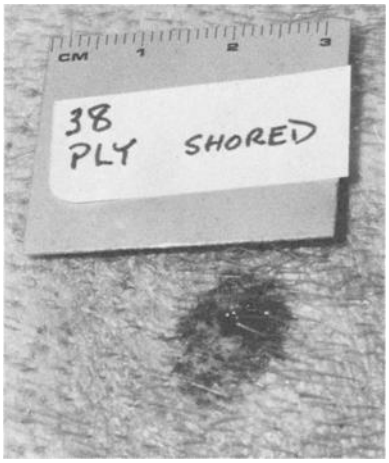

FIG. 2—*Shored entrance wound produced by .38-caliber weapon with plywood foreshoring (AFIP Neg. 79-11318-3).*

Particulate matter, including smoke and soot, unburned powder, and foreign material from the shoring substance or intermediate target, was very common in all wounds, with 68% showing powder, 73% showing smoke or soot, and 80% showing foreign matter.

One wound demonstrated a large circular hole reminiscent of the so-called cookie-cutter injury encountered in shotgun wounds (Fig. 9).

Discussion

Excluding those wounds without missile penetration, analysis of wound configuration showed that the typical shored entrance wound has a round central defect in virtually all cases, as do the entrance wounds with intermediate targets; all of the wounds had some

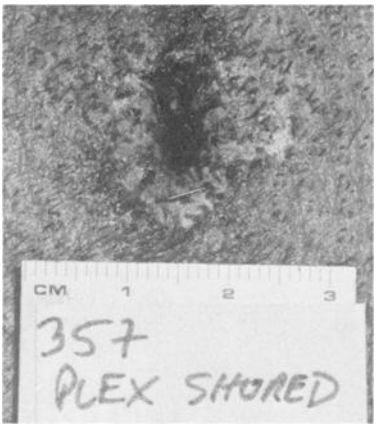

FIG. 3—*Shored entrance wound produced by .357-caliber weapon with Plexiglas foreshoring (AFIP Neg. 79-11318-4).*

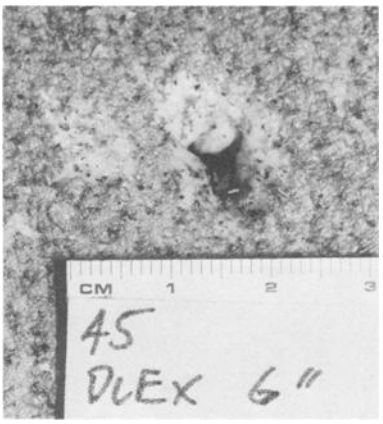

FIG. 4—*Entrance wound produced by .45-caliber weapon with Plexiglas used as intermediate target and placed 150 mm (6 in.) from the skin surface. Note satellite lacerations (AFIP Neg. 79-11318-5).*

part of the circumference abraded, and in 68% of them the entire circumference was abraded. Many of these wounds showed a greater degree of abrasion than the control wounds, but there was no reliable way of differentiating shored entrances and entrances with intermediate targets based on degree of marginal abrasion. The greatest degree of abrasion was produced by those weapons with high kinetic energy of the round and by those shoring materials that were most rigid, such as Plexiglas and plate glass; these findings parallel those of the previous study on shored exit wounds.

Most of the wounds produced in this study (75%) had a greater wound diameter than the control wounds from the same weapons, suggesting that overall wound size is increased by foreshoring and by more distant intermediate targets.

The presence of radiating lacerations in 38% of all wounds parallels Stahl's finding [*2*] of a stellate appearance in a distant entrance wound with glass as an intermediate target.

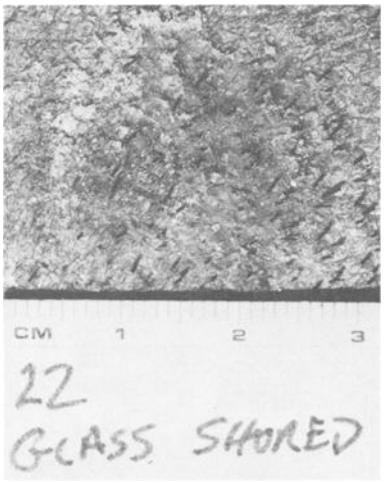

FIG. 5—*Nonpenetrating missile wound with circular area of abrasion; wound was produced by .22-caliber weapon with glass shoring at entry site (AFIP Neg. 79-11318-6).*

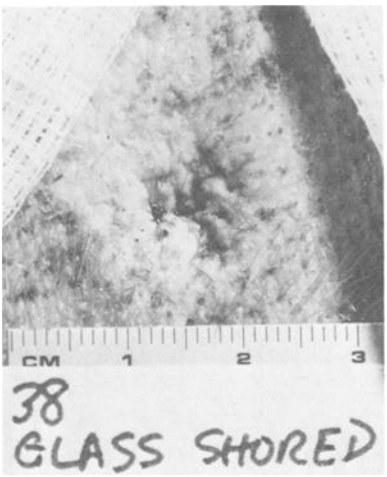

FIG. 6—*Shored entrance wound produced by .38-caliber weapon with glass shoring (AFIP Neg. 79-11318-7).*

Experimentally, these lacerations were seen most commonly in wounds shored by the most rigid materials and with the rounds having the greatest kinetic energy; these same factors influenced the presence of radiating lacerations in entrance wounds with intermediate targets.

Some combination of particulate matter, including soot or smoke, unburned powder, and foreign matter from the shoring material or intermediate target, was seen in 100% of wounds; even with a barrier, smoke and powder were commonly seen. Therefore, their presence cannot be relied on to exclude an intermediate target or foreshoring.

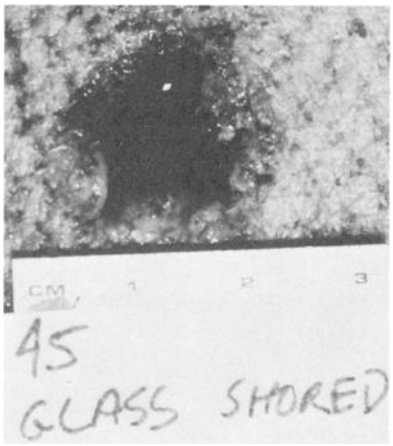

FIG. 7—*Shored entrance wound produced by .45-caliber weapon with glass shoring (AFIP Neg. 79-11318-8).*

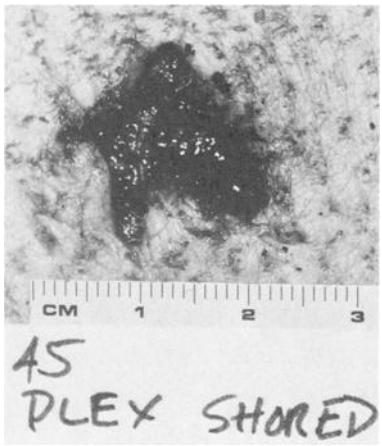

FIG. 8—*Shored entrance wound produced by .45-caliber weapon with Plexiglas shoring (AFIP Neg. 79-11318-9).*

Conclusions

Shored entrance wounds and entrance wounds with intermediate targets have a greater wound diameter and demonstrate greater marginal abrasion than control wounds produced by the same weapons. These features are directly proportional to the kinetic energy of the round and to the rigidity of the intervening material. The stellate appearance of some wounds is due to radiating lacerations, which depend on the same two factors and may lead to misinterpretation of the range of fire; a distant wound may thus be mistaken for a contact wound. The presence of smoke or powder on the skin surface may not be used to exclude foreshoring or an intermediate target. In addition, large wounds simulating a shotgun injury may be formed.

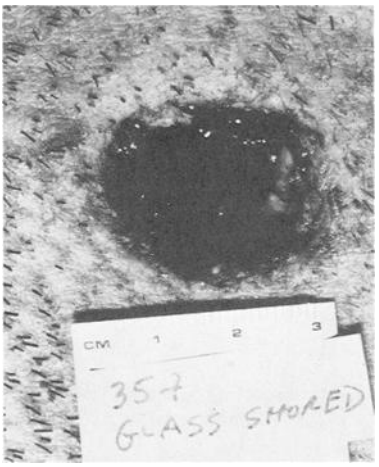

FIG. 9—*Shored entrance wound produced by .357-caliber weapon with glass shoring (AFIP Neg. 79-11318-10).*

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