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Winchester Silvertip® Ammunition—A Study in Ordnance Gelatin

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ABSTRACT: This study of Winchester Silvertip® hollow point ammunition measures bullet velocity from production handguns and evaluates performance in ordnance gelatin. Depth of penetration, size and shape of the temporary cavity, degree of radial fissuring along the missile track, and bullet expansion after impact are compared to nonhollow point ammunition of similar caliber. It is clear that hollow point bullets of this type create greater disturbance upon impact with tissue simulant than common commercial solid round nose ammunition as measured by temporary cavity size and radial fissuring. However, for all types of handgun ammunition there is a poor predictive correlation of radial fissuring with instantaneous temporary cavity size. Hollow point performance can be modified by various factors such as angle of incidence relative to target surface and prior deformation of the bullet tip. The elemental composition of bullet jackets and cores is not uniform throughout this product line.

KEYWORDS: forensic science, ballistics, wound ballistics

The Winchester Silvertip® (ST) hollow point bullet for center fire pistols and revolvers consists of a soft lead hollow point core covered by a thin jacket of either aluminum or, in some calibers, a nickel-plated copper jacket. The cartridge calibers currently available, with jacket type and year introduced, are in Table 1.[3]

To test Silvertip performance, the bullets were fired into 20% ordnance gelatin blocks and the impacts recorded on high-speed motion picture film. The parameters studied were bullet velocity, bullet expansion after impact, penetration, temporary cavitation, and radial fissuring produced by the bullets in the gelatin. The results were compared to those achieved by solid bullets of the same calibers.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Air Force or the Department of Defense. Received for publication 10 Oct. 1985; accepted for publication 30 Oct. 1985.

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TABLE 1—*Silvertips*.

Caliber	Introduced	Jacket
9 mm (115 gr.)	1979	Al
.45 Auto (185 gr.)	1979	Al
.32 Auto (60 gr.)	1980	Al
.380 Auto (85 gr.)	1980	Al
.38 Special +P (95 gr.)	1980	Al
9 mm (115 gr.)	1980	Cu/Ni
.38 Super (125 gr.)	1982	Cu/Ni
.357 Magnum (145 gr.)	1982	Cu/Ni
.45 Long Colt (225 gr.)	1982	Al
.44 Special (200 gr.)	1983	Al
.38 Special +P (125 gr.)	1984	Al
.41 Magnum (175 gr.)	1984	Cu/Ni
.38 Special (110 gr.)	1984	Al

Material and Methods

The Silvertip and solid bullets test-fired are listed in Table 2.

The bullets were fired from the following weapons:

.32 Auto Automatic Colt pistol, Model 1903-08, 2½-in. (6.35-cm) barrel;
.38 Special Smith and Wesson revolver, Model 60, 2-in. (5-cm) barrel;
9-mm Automatic Beretta pistol, Model 92S, 5-in. (13-cm) barrel;
.44 Special Colt revolver, Single Action Army Model, 5½-in. (14-cm) barrel;
.45 Long Colt revolver, SAA Model, 5½-in. (14-cm) barrel; and
.45 Automatic Colt pistol, Model 1911-A1, 5-in. (13-cm) barrel.

At least five of each bullet type were fired through photoelectric screens connected to a computing chronograph (Model 4001, Electronic Counters Inc.); an average velocity was calculated. From two to five of each bullet type were fired under chronographic surveillance into 5°C 5- by 5- by 14-in. (13- by 13- by 35.5-cm) rectangular 20% gelatin blocks (Pharmagel A, Ordnance Type 250 A, Kind and Knox Gelatin Co.). At least one impact of each bullet type was recorded on film (Kodak 4-X Reversal Film 7277) using a Hycam high-speed motion picture camera with a film transport rate of 8000 frames per second and an effective shutter speed of 1/20 000 s. Features of the "wound track" in each block were measured, photographed, and also X-rayed with a Hewlett-Packard 43805 N Faxitron specimen X-ray machine at 80 KV on Kodak Industrial Grade X-ray film.

The blocks were cut transversely with a thin stainless steel wire across the permanent cavity in the zone of maximal internal disruption, permitting measurement of lateral fissures that radiated from the permanent cavity. The resultant 1-cm-thick slabs were photographed. The location of the depth of the crosscut was measured from the impact surface.

TABLE 2—*The Silvertip and solid bullets that were test-fired.*

Silvertip	Solid
.32 Auto ST HP (60 gr.)	.32 Auto FMJ (71 gr.)
.38 Sp ST HP (95 gr.)	.38 Sp LRN (158 gr.)
9-mm ST HP (115 gr.)	9-mm FMJ (115 gr.)
.44 Sp ST HP (200 gr.)	.44 Sp LRN (246 gr.)
.45 LC ST HP (225 gr.)	.45 LC LRN (255 gr.)
.45 Auto ST HP (185 gr.)	.45 Auto FMJ (230 gr.)

Total penetration and chronographic velocity of each missile were recorded. Bullets were retrieved from the blocks or, if they exited, from a sawdust bullet trap immediately behind the block. Bullet expansion was quantitated by direct measurement. The true diameter of the temporary cavity at 2, 4, and 6 in. (5, 10, and 15 cm) of block penetration was measured for each bullet type from enlargements of single motion picture frames depicting the maximum temporary cavity. Radial fissures along the permanent cavity were measured from transverse slices of the blocks at the point of maximal fissuring and their value in predicting true temporary cavity maxima was tested.

Our "atraumatic bullet trap" was constructed from discarded 17- by 13- by 9-in. (43- by 33- by 23-cm) cardboard reagent boxes that are internally partitioned into 9- by 4- by 4-in. (23- by 10- by 10-cm) compartments by interlocking corrugated cardboard panels. When filled with dry sawdust and placed end to end, two boxes stopped all handgun Silvertip and full metal jacketed ammunition tested in the second box when fired directly into the boxes. Those bullets exiting interposed gelatin all stopped in the first box. The "atraumatic" quality of this simple, economical, disposable bullet trap was established by its ability to stop the Glaser Safety Slug® in .380 auto, 9 mm, and .45 auto with no jacket deformation and no spillage of shot content. Bullet recovery and identification was facilitated by marking the box ends according to entrance holes after each shot.

During the course of testing, it was noted that dropping an aluminum jacketed Silvertip can deform its hollow point. To determine if this would affect performance, four .45 ACP Silvertip bullets were tapped on a hard surface until an approximate 40% reduction of the hollow point orifice was achieved, converting it nearly into half moon outline. These bullets were fired into gelatin at a 90° incident angle.

To determine if angle of incidence would affect performance, five .45 ACP Silvertip rounds were fired at 14-in. (35-cm) long gelatin blocks such that they struck the long side at a low incident angle (15°).

In the final phase of test-firing, Silvertip ammunition and 123-grain full metal jacket rounds in 9 mm were fired through fresh marrow-filled proximal tibias embedded in gelatin by a method previously described [*1*].

Selected rounds were studied in a Phillips 501 scanning electron microscope equipped with a model 711 energy dispersive X-ray analyzer at 30 KV to determine elemental composition of the jackets and core material.

Results

The velocity of the Silvertip bullets (Fig. 1) in all calibers tested was higher than that of the solid (nonhollow point) ammunition. This correlates with the lesser weights of the Silvertip bullets. Penetration of the gelatin blocks was greater for solid rounds than for Silvertip ammunition. Most solid bullets exited the blocks; none of the Silvertip bullets exited except for three of eight .44 Sp Silvertips. These three exiting .44 Specials had the lowest velocity of the eight .44 caliber rounds from the 5½-in. (14-cm) barrel and failed to expand to the degree of those that lodged in the blocks. The maximum temporary cavities formed by the Silvertip bullets were substantially larger than those caused by the solid ammunition (Figs. 2 and 3). The results are summarized in Table 3.

Alone among the various Silvertip calibers tested, occasional 9-mm rounds fragmented along the wound track in plain gelatin when fired from a 5-in. (13-cm) barreled Beretta 92 S (Fig. 2). These were the only instances where macroscopic gelatin fragments were isolated in the wound track, in accord with findings of Fackler et al. [*2*].

The four .45 Auto Silvertip bullets that had their tips deformed before firing minimally expanded to an average of .55 caliber (20% increase) (Fig. 4). Two of them exited the 14-in. (35.5-cm) blocks and the remaining two penetrated the blocks to 12½ and 13½ in. (32 and 34 cm), exceeding all undeformed rounds.

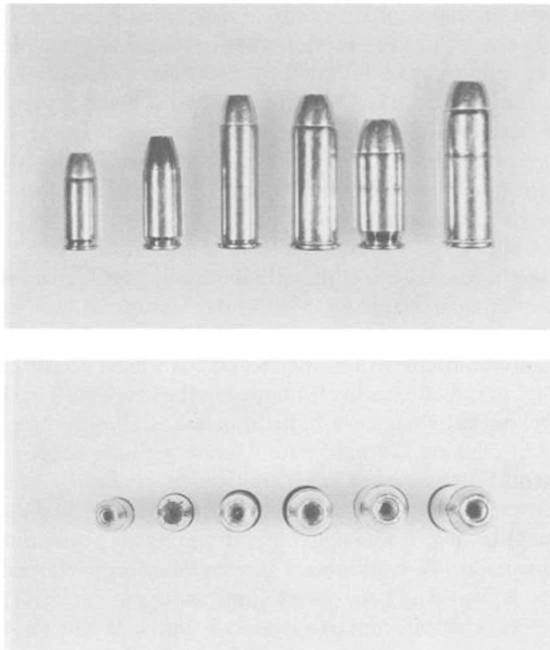

FIG. 1—*Side* (top) *and top* (bottom) *views of sample Silvertip cartridges in* (left to right) *.32 Auto, 9 mm, .38 Special, .44 Special, .45 Auto (incised tip), and .45 Colt.*

The entrance defects of the .45 Auto Silvertip bullets fired into the blocks at a low angle had a progressively deepening trough-like shape. All these shots exited the blocks into the sawdust bullet trap after traversing the blocks for greater distances than the .45 Auto Silvertip bullets that had 90° frontal impacts. The zone of maximal disruption and point of maximal fissuring were delayed about 1 in. (2.5 cm) deeper into the target substance. Study of the recovered bullets showed reduced and asymetrical expansion, accounting for greater penetration (Fig. 4).

Silvertip bullets expanded in gelatin significantly in all calibers tested (Fig. 4). The average expansion for each caliber is listed in Table 4.

None of the solid bullets deformed significantly after passing through the target blocks. The full metal jacketed bullets in particular could not be distinguished from unfired bullets except for their rifling grooves.

Radial fissuring along the permanent cavity in gelatin was more extensive with Silvertip ammunition than with solid and lead hollow point ammunition of the same caliber (Figs. 5 and 6). However, radial fissures and simple formulas do not permit accurate predictions of true temporary cavity size (Table 5).

The fresh bone encased in gelatin struck by a 9-mm Silvertip bullet suffered a severe comminuted fracture (Figs. 7, 8, and 9), in contrast to the perforating channel as a result of a full metal jacket bullet (Figs. 10 and 11).

Metallic Composition of Jackets

On energy dispersive X-ray analysis, the aluminum jackets of .45 Auto ST, .44 Special ST, and .32 Auto ST present a pure K-shell peak for aluminum with no trace of other metals.

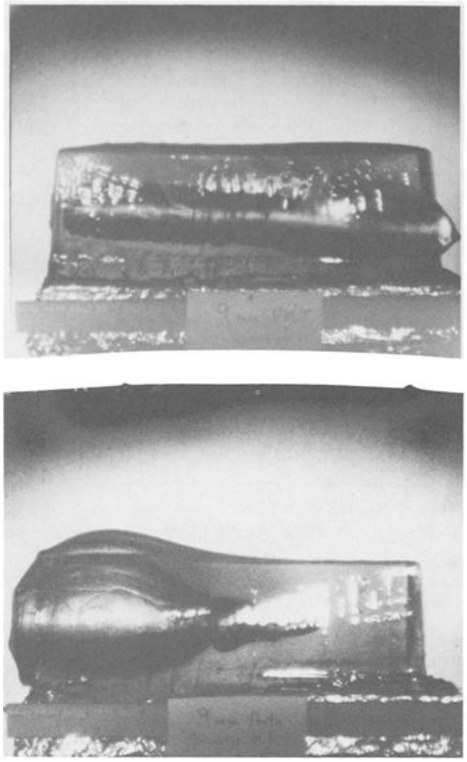

FIG. 2—*Single high-speed motion picture frames depicting the maximum temporary cavities for* (top) *9-mm full metal jacket ammunition and* (bottom) *copper-nickel jacketed 9-mm Silvertip, indicate the larger cavity for the Silvertip. The Silvertip but not the full metal jacketed bullet remained in the 14-in. (35.5-cm) long gelatin blocks after firing from the 5-in. (13-cm) barrel of a Beretta 92 S.*

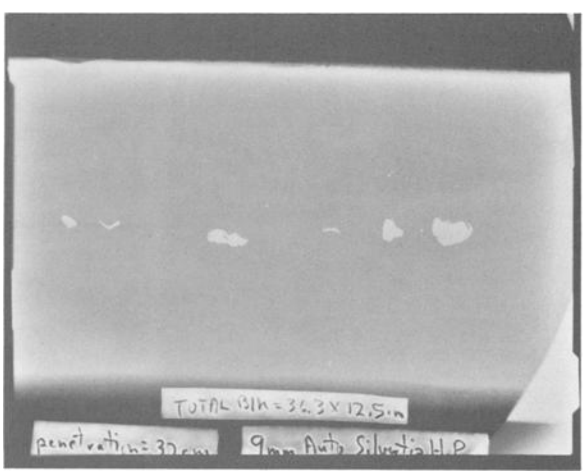

FIG. 3—*Specimen radiograph of the block in Fig. 2b indicating 9-mm Auto Silvertip fragmentation.*

TABLE 3—*Performance.*[a]

Average Bullet Type	Average Velocity, ft/s	Total Penetration	T.C. Diam. at Penetration of			Radial Fissuring, in.	
			2 in.	4 in.	6 in.	Max. at Pentr. of, in.	Combined Fissure Length, in. (and #)
.32 Auto FMJ	811	exit	1.0	0.9	1.4	6.5	1.0 (2)
.32 Auto ST	919	5.0 in.	2.0	0.8	0	2.0	2.2 (3)
.38 Sp. LRN	663	exit	1.1	1.3	1.4	3.5	1.2 (4)
.38 Sp. ST	865	9.3 in.	2.8	1.9	1.3	2.0	3.5 (5)
9-mm FMJ	1065	exit	2.2	2.3	2.3	9.8	3.5 (3)
9-mm ST	1218	8.4 in.	3.8	4.5	4.1	2.5	6.7 (8)
.44 Sp LRN	691	exit	0.9	1.4	1.8	10.0	1.9 (2)
.44 Sp ST	802	12.0 in.[b]	3.5	3.1	2.4	2.0	4.2 (4)
.45 LC LRN	799	exit	1.0	1.7	2.4	6.0	2.7 (4)
.45 LC ST	845	8.4 in.	3.7	3.3	2.6	2.8	11.0 (7)
.45 Auto FMJ	838	exit	2.2	2.2	2.2	2.0	3.4 (9)
.45 Auto ST	937	8.4 in.	5.2	5.5	4.7	4.0	5.8 (5)

[a]1 in. = 2.54 cm and 1 ft/s = 0.3048 m/s.
[b]Three of eight .44 Sp. Silvertips exited the gelatin blocks, this average being based on the five that did not exit.

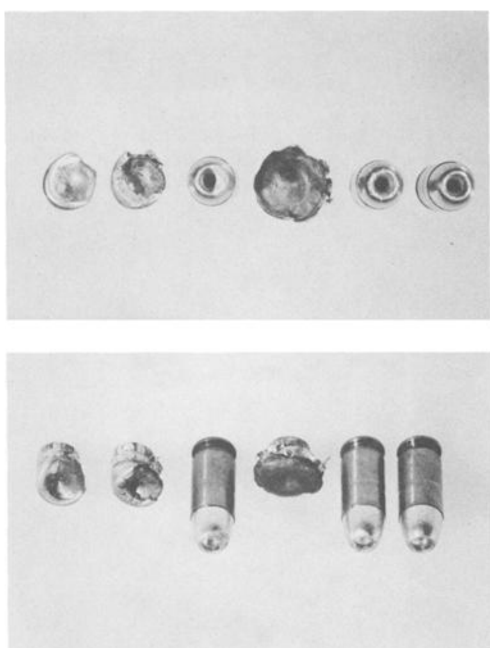

FIG. 4—*Oblique* (top) *and top* (bottom) *views of .45 Auto Silvertip bullets to show* (left to right): *without and with tip incisions; full symmetrical expansion after perpendicular impact and 8 in. (20 cm) of penetration of 20% ordnance gelatin; hollow point tip purposely deformed before test firing; incomplete asymmetrical expansion of predeformed bullet after impact and excessive penetration of gelatin; minimal asymmetrical deformation of Silvertip that entered the side of a block at a 15° incident angle and exited into sawdust after traversing 11 in. (28 cm) of gelatin.*

TABLE 4—*Expansion*.

Bullet	Caliber after Impact	% Expansion
.32 Auto	.46	44
.38 Special	.51	34
9 mm	.74	95
.44 Special[a]	.69	57
.45 Long Colt	.75	65
.45 Auto	.80	78

[a]The five .44 Special bullets lodging in the gelatin targets. (Three additional .44 Special bullets that exited expanded to an average of 0.50 in. [1.27 cm]).

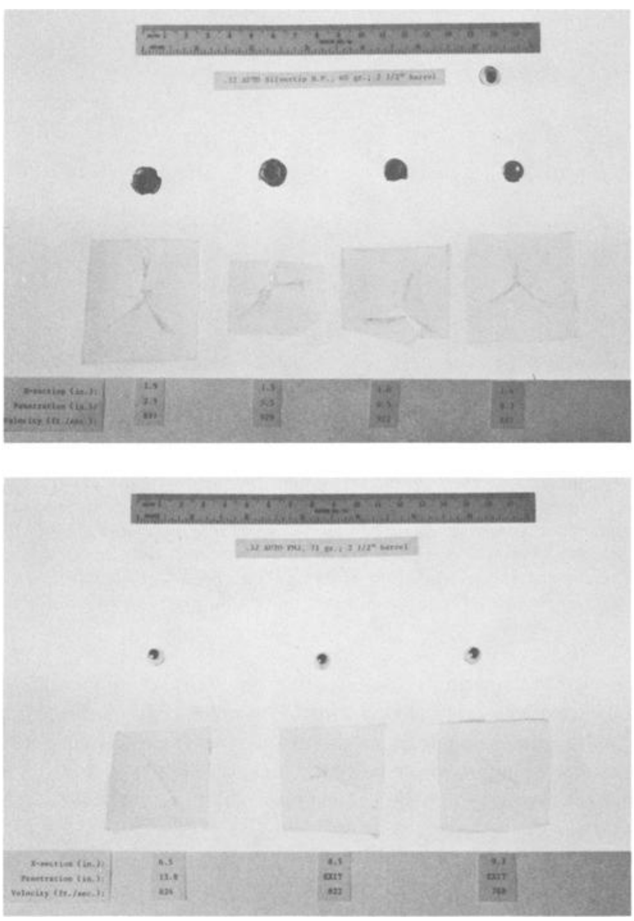

FIG. 5—*Slabs of gelatin 1 cm thick obtained by crosscuts through the maximal zone of disruption show radially directed fissures. Fissuring is greater for the .32 Auto Silvertip ammunition* (top) *than full metal jacket bullets* (bottom), *correlates with expansion, and is inversely proportional to penetration.*

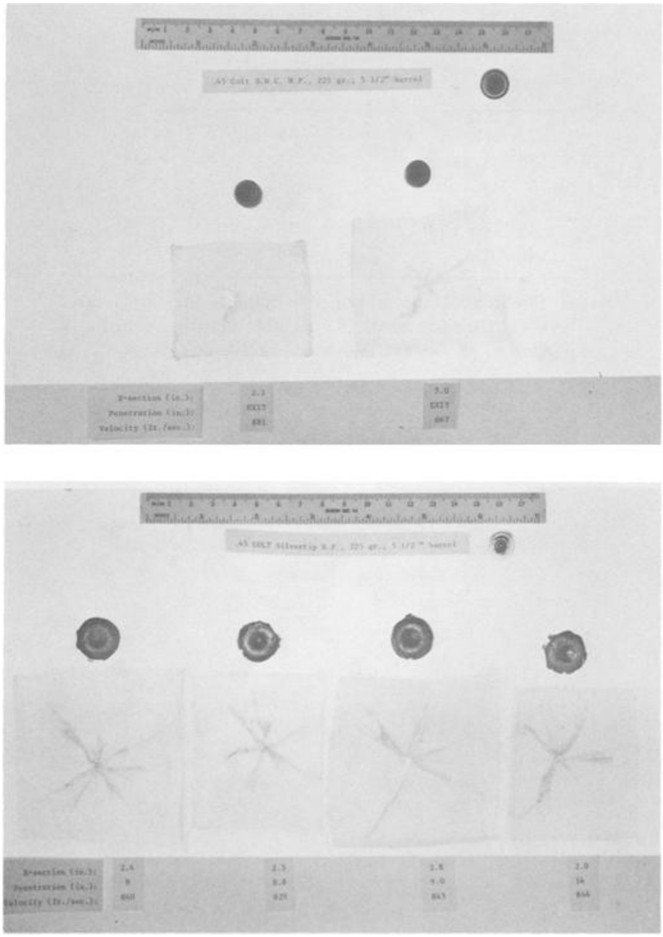

FIG. 6—*Transverse sections through the permanent cavities created in gelatin by* (top) *two .45 Colt lead hollow point bullets and* (bottom) *four .45 Colt Silvertip bullets indicate the more extensive radial fissuring as a result of the Silvertips. In each, an unfired bullet is at the upper right; the missiles responsible for each track are above the permanent cavity cross sections. Note the lack of expansion in* (top), *even though the velocity of each exceeded the Silvertips. This result contradicts the criticism, "Winchester has gone to a lot of trouble to create a jacketed bullet that performs like a lead hollow point."*

The rise of the peak during analysis is expedited by light scraping, which presumably removes the transparent wax lubricant coating.[3] The jacket of the 9-mm Auto ST, when analyzed directly, features a strong peak for nickel and a lesser one for copper. When scratched deeply with a steel or diamond implement, the nickel peak disappears and the peaks of zinc accompany that for copper; the nickel is a surface coating, not alloyed with copper.

Metallic Composition of Cores

The cores of 9-mm ST, .32 Auto ST, .44 Special ST, and .45 Auto ST present the peaks of lead without antimony. The core of two .45 Auto ST bullets, in addition, gave a strong peak characteristic of aluminum and small peaks indicative of traces of iron. The explanation for these additional core metals in only the two .45 rounds was not apparent but was verified by reanalysis of deeper core material exposed by scratching with a diamond stylus.

TABLE 5—*Fissure predictions of maximum temporary cavity size (all measurements in inches).*[a]

Caliber	*a* Depth	*b* Predicted T.C. Diam.	*c* True T.C. Diam.	*d* % error of *b*	*e* Predicted T.C. Circ.	*f* True T.C. Circ.	*g* % error of *e*
.32 Auto FMJ	7.2	1.9	1.8	+5	2.3	5.7	−60
.38 Sp. LRN	3.5	1.5	1.6	−6	2.5	5.0	−50
.38 Sp. ST	2.0	2.1	3.1	−32	5.2	9.8	−47
9-mm ST	3.5	2.0	4.2	−52	3.6	14.1	−74
.44 SP LRN	10.0	2.8	1.7	+65	4.1	5.3	−23
.45 LC LRN	5.8	2.5	2.3	+9	5.3	7.3	−27
.45 LC ST	1.8	2.2	3.5	−37	9.4	11.1	−15

[a]Explanation of Table 5:
(*a*) Depth of the plane of transverse section relative to the block face.
(*b*) Sum of the two longest fissures plus 2 cm (0.79 in.).[4]
(*c*) T.C. diameter measured from the single cine frame showing maximal expansion.
(*d*) 100 − (*b*/*c* × 100).
(*e*) Sum of all radial fissures multiplied by two [*12*].
(*f*) πc (π × true diameter).
(*g*) 100 − (*e*/*f* × 100).

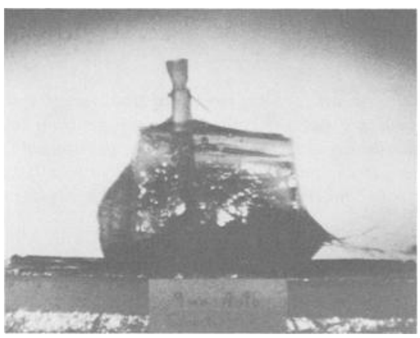

FIG. 7—*9-mm Silvertip hollow point; gelatin/inverted proximal tibia target system. The temporary cavity at maximal expansion is large and oval (compare to Fig. 10); exiting missile fragments are to the right.*

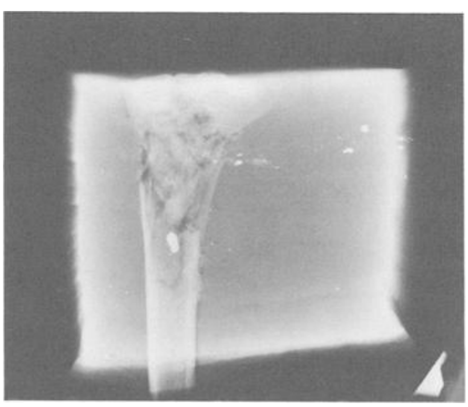

FIG. 8—*9-mm Silvertip hollow point; gelatin proximal tibia target system. A specimen radiograph of the target indicates comminution of the bone over a wide zone and also fragmentation of the bullet with retention of metallic debris. The macerated bone was reconstituted from 23 fragments.*

FIG. 9—*9-mm Silvertip hollow point; gelatin proximal tibia target system. The 30- by 22-mm entrance defect on the anterior surface* (left) *is considerably larger than the 20- by 10-mm exit defect* (right)*; this is attributed to partial expansion of the bullet in gelatin before contacting the bone, and then fragmentation of the missile in the marrow space such that only half escaped through the posterior cortex. The bone material (mostly cancellous) that could not be repositioned is to the right in* (right).

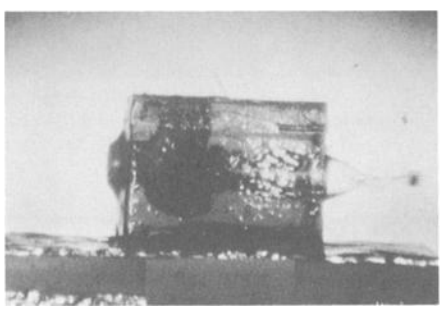

FIG. 10—*9-mm Auto, full metal jacket bullet; gelatin/inverted proximal tibia target system. The temporary cavity at maximal expansion has a tubular configuration; the missile has exited to the right. A radiograph of the target showed no retained metallic fragments. The recovered missile could not be distinguished from an unfired bullet except for its rifling grooves.*

Discussion

Following numerous exhaustive studies [*3-5*], the controlled expansion hollow point bullet has been widely accepted by law enforcement agencies including the FBI [*6*]. Compared to solid lead round nose bullets or full metal jacket rounds of similar caliber, hollow point bullets are less likely to overpenetrate, and thereby pose less hazard to bystanders. Their tendency to flatten on impact with a hard surface reduces ricochet potential [*6*].

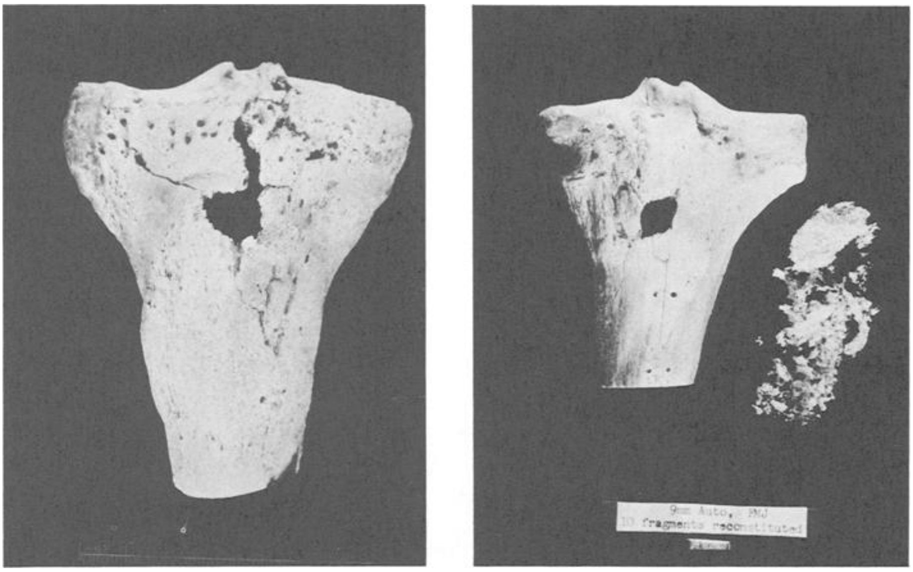

FIG. 11—*9-mm Auto, full metal jacket bullet; gelatin proximal tibia target system.* (Left and right) *after maceration, the bone segment was reconstructed from ten fragments. Anterior entrance* (left) *and posterior exit* (right) *defects resemble an irregular 12-mm diameter drill hole. All fragments that could not be repositioned (mainly cancellous bone) are to the right in* (right).

For several years there has been increasing industrial competition among ammunition manufacturers to meet the law enforcement requirement for handgun ammunition that avoids overpenetration, minimizes ricochet hazard, and maximizes "stopping power." Modern expanding handgun bullet technology began with James Harvey's experiment in the 1950s and came to fruition with Lee Juras' Super Vel® in the mid-1960s [*7*]. Enhanced velocity semi-jacketed hollow point bullets are designed to expand in the target.

A revolver can accept these loads, with their higher chamber pressures and recoil energies, and still function smoothly since return to battery is independent of ignition. An autoloading pistol, however, imposes limitations of lower pressure and recoil tolerances to function reliably. In the autoloader, the cartridge must be transferred from the magazine up the feed ramp to the chamber. This is accomplished by forward force from the spring-driven slide to the rear of the cartridge which strips the next round from the magazine and pushes it against the upward-canted feed ramp. Friction against the ramp favors a round nose bullet with a full metal jacket over other bullet designs for feeding reliability. However, hard jacket bullets tend to overpenetrate and, in the smaller calibers, transfer minimal energy to the target. The special requirement of the autoloader, then, has been for a bullet that will reliably expand at velocities that can be attained within acceptable chamber pressure limits, yet still feed reliably.

The Winchester Silvertip was designed to meet the twin law enforcement objectives of bullet expansion and reliable feeding in autoloader pistols. Invented by Henry Halverson, the product was awarded U.S. Patent 4,193,348 dated 10 March 1980 [*8*]. The bullet has a soft lead hollow point core covered by a thin aluminum (or copper-nickel) jacket. Soft lead is not exposed at the bullet tip nor is there a sharp edge since an attenuated continuance of the jacket extends over the tip and down into the hollow point. This is because the lead core is inserted into the gilding metal cup from the rear and subsequently the nose is formed through several steps that force jacket material into the cavity. The open end of the cup becomes the bullet base for aluminum jacketed types, but the nose for copper-nickel types. Therefore, all aluminum jacket bullets have lead exposed at the base, whereas the base is covered with the copper-nickel jackets. The smooth jacket is hard enough to glide up the feed ramp from the magazine but sufficiently malleable to allow bullet expansion in the target. Jacket reflection on impact is facilitated by small radial incisions cut in the jacket at its tip. These are found in all calibers except those produced before early 1980 where they are absent[3] (Fig. 4). The copper-nickel jacket of 9-mm, .38 Super, .357 Magnum and 41 Magnum Silvertip rounds is harder than the aluminum jacket to delay expansion and minimize the tendency for fragmentation at their higher velocities. Nevertheless, 9-mm Silvertips with copper-nickel jackets fragmented more than half the time when fired from a 5-in. (13-cm) barrel into gelatin. Impact fragmentation of an initially intact bullet may indicate more extensive internal damage to the target than if there is no fragmentation [*1,2,5*].

There is little in the forensic science literature written about this ammunition. In a case

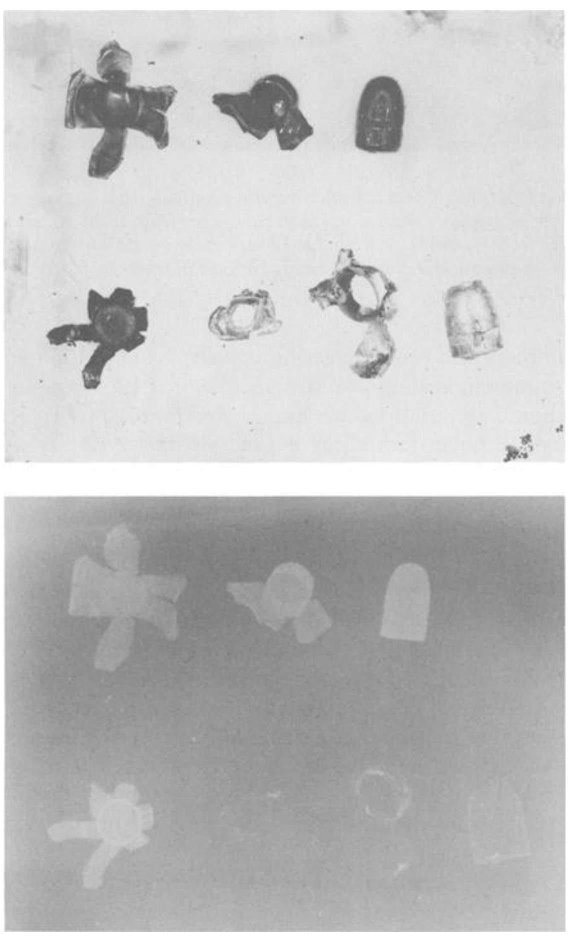

FIG. 12—*A direct photograph* (top) *and a specimen radiograph* (bottom) *of bullet jackets, the lead having been removed by high temperature melting, confirms the relative radiolucency of the aluminum-type Silvertip jacket* (three at lower right) *compared to the copper-nickel Silvertip jacket* (lower left) *and conventional copper jackets* (upper row). *To simulate jacket fragments in tissue, the X-ray exposure was made of jackets embedded in a 5¾-in. (14.6-cm) thick block of 20% ordnance gelatin, situated 1 in. (2.5 cm) above the film plane.*

report [9], it was stated that the aluminum jacket of the Silvertip bullet was difficult to see in radiographs. We confirmed this clinically significant fact by specimen X-ray (Fig. 12). However, the comparison X-ray clearly shows the cupro-nickel-type Silvertip jacket is clearly visualized.

Reports in firearms magazines specify the Silvertip bullet is "the most reliable expanding cartridge ... yet found," [10] "with excellent expansion characteristics when impacting in soft material" [11]. In the present study, Silvertips expanded impressively, the increase in diameter being from 34 to 95%. Penetration of Silvertips was less than that of all round nose control ammunition except for three .44 Special Silvertips that exited the gelatin blocks. These three bullets had the lowest velocity of the eight .44 Special Silvertips tested, and this is why they did not expand significantly (13%) and therefore passed through the blocks.

It has previously been noted that a hollow point bullet that fully expands during passage through gelatin makes no larger entrance or exit holes than round nose bullets [5].[3] Our results agree with this, but indicate that the degree of internal disruption along the wound track does vary. Radial fissuring is a crude indication of energy delivery (Fig. 5), but using popular formulas [12],[4] does not seem to correlate well with the actual dimensions of the instantaneous maximum temporary cavity (Table 5). Radial fissuring has been used previously to rank projectiles in terms of relative effect when high-speed motion picture techniques were not available, but this may not be valid.

Our tests indicate deformation of the hollow point mouth before firing as can occur simply by dropping a round during loading will impede expansion (Fig. 4). So does plugging the hollow point, as can occur during passage through certain intermediary targets such as a 1/4-in. (0.6-cm) thick pine board. When the nose cavity is filled, the missile behaves like a solid slug [13]. These findings may have importance to bullet performance in live targets. It is possible that oblique entry and deformation or plugging of a hollow point projectile by early bone contact may impede expansion and produce less tissue disturbance than expected with a potent hollow point.

Temporary cavities produced by Silvertip bullets were all greater than those produced by the control bullets. This can be attributed to the fact that the Silvertips expanded to mushroom shape, resulting in a greater rate of kinetic energy transfer per unit length of wound track. The solid bullets did not mushroom, created narrow tubular tracks, and exited the blocks, thus transferring only part of their energy to the targets, even those containing bone.

Acknowledgments

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References

[1] Ragsdale, B. D., "Gunshot Wounds: A Historical Perspective," *Military Medicine*, Vol. 149, June 1984, pp. 301-315.
[2] Fackler, M. L., Surinchak, J. S., Malinowski, J. A., and Bowen, R. E., "Bullet Fragmentation: A Major Cause of Tissue Disruption," *Journal of Trauma*, Vol. 24, No. 1, Jan. 1984, pp. 35-39.
[3] Bruchey, W. J., Jr. and Frank, D. E., "Handgun Ammunition: Incapacitation Effects," National Institute of Justice Report 100-83, Law Enforcement Standards Laboratory, National Engineering Laboratory, National Bureau of Standards, Washington, DC, Nov. 1983.
[4] Higgins, E. J., "The Hollow Point Bullet," A Report from the Research and Development Unit for the Commonwealth of Massachusetts, Department of Public Safety, Boston, Dec. 1974.

[4]M. L. Fackler, M. D., Col. M.C., U.S. Army, Division of Combat Casualty Care, Letterman Army Institute of Research, The Presidio of San Francisco, CA, 1985-1987.

[5] Nicolletti, R., "Ammunition Testing and Evaluation for the Denver Police Department," A Report, Denver, CO, 1983.
[6] FBI Policy Statement, "U.S. Department of Justice: Reasons for FBI Adoption of the Controlled Expansion, Hollow Point Bullet as A Service Round," Federal Bureau of Investigation, Washington, DC, Feb. 1983.
[7] Ayoob, M., "Handgun Stopping Power. Part II," *American Handgunner*, Nov./Dec. 1982, pp. 36, 37, 54, 56, and 57.
[8] Wallack, B., "Henry Halverson and His Silver Bullet," *Guns*, Oct. 1983, pp. 38, 39, 77, and 78.
[9] Conradi, S. E., "New Aluminum-Jacketed Ammunition," *The American Journal of Forensic Medicine and Pathology*, Vol. 3, No. 2, June 1982, pp. 153-155.
[10] Metcalf, D., "New Handgun Factory Ammunition," *Shooting Times*, Dec. 1981, p. 48.
[11] Arnold, D., "More Punch for Pocket Autos," *Guns and Ammo*, Feb. 1982, p. 76.
[12] Krauss, M. and Miller, J. F., "Studies in Wound Ballistics. Temporary Cavities and Permanent Tracts Produced by High Velocity Projectiles in Gelatin," U.S. Army Chemical Warefare Laboratories Technical Report WIR 2340, Army Chemical Center, MD, Feb. 1960.
[13] Spangenberger, P., "Winchester Silvertip .45 Colt," *Guns and Ammo*, Vol. 28, Aug. 1984, pp. 67 and 69.

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