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The Effect of Glass as an Intermediate Target on Bullets: Experimental Studies and Report of a Case

It is well known that intermediate targets may influence the distribution of pellets in fatal injuries by shotguns [*1-3*] and that a variety of objects, including glass, window screens, and articles of clothing, may serve as intermediary targets for bullets, may cause ricochet of bullets, or may become secondary missiles [*4,5*]. Although methods are available for examination and comparison of glass fragments, recent textbooks do not consider the potential effect of glass as an intermediate target on the characteristics of the wound of entrance. The results of experimental ballistic studies with glass, as well as a medicolegal case, are discussed in this report.

Report of a Case

The police were notified of a fatal shooting in a residential area of the city. Upon arrival at the scene of death, they found the body of a 41-year-old man at the bottom of six steps, cluttered with debris, leading from the grounds of the building into a vacant basement apartment. The face of the victim was covered with frozen blood and a large wound was seen on the right side of his face near the chin.

The on-the-scene investigation disclosed that the body of the victim had been dragged about 8 m (25 ft) from the back door of a ground-level apartment, along the foundation of the building, and into the stairwell.[4] The suspect, a 33-year-old-man and the occupant of the ground-level apartment, said that he thought the victim was a burglar who was attempting to enter the back door of his apartment. He shot the victim in the face, through the glass window of the storm door, with one round from a caliber-.357 Magnum Smith & Wesson revolver.

The investigators observed the broken window of the storm door, with fragments of glass outside the apartment. They estimated the range of fire at about 1 m (3 ft) and concurred with the possibility that the bullet passed through the glass before entering the victim. The suspect was arrested by police.

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[4]Original data were measured in English customary units.

The autopsy of the victim, performed on the day after death, revealed a single, stellate, penetrating bullet wound of entrance located at the right anterior side of the chin, 25 mm (1 in.) below and 6.4 mm (1/4 in.) anterior to the right corner of the mouth (Fig. 1). Four major stellate lacerations emanated from the wound. The greatest diameter of the wound was 57.2 mm (2 1/4 in.), with the bullet wound of entrance measuring 6.4 mm (1/4 in.) in diameter and surrounded by a 3.2-mm (1/8-in.) marginal abrasion. Grayish-black material with a metallic sheen was observed in the wound. There was no apparent evidence of thermal effect such as charring of tissues or singeing of hair. In the right anterior region of the neck, 12.7 mm (1/2 in.) below the wound of entrance, there was a 3.2- by 0.8-mm (1/8- by 1/32-in.) laceration. A 1.6- by 1.6-mm (1/16- by 1/16-in.) punctate abrasion of the skin was seen 19.1 mm (3/4 in.) anterior to the anteromedial aspect of the wound of entrance. No residues of gunpowder or glass were observed on the skin of the face.

The track of the penetrating bullet wound extended through the right internal carotid artery to the level of the second cervical vertebra in the right posteromedial aspect of the neck. A deformed lead bullet was recovered from the subcutaneous tissues of the neck. There was a fracture of the right anterior aspect of the mandible. A small metallic fragment, 4.8 mm (3/16 in.) in diameter, was found near the site of fracture. There was no other evidence of injury, and except for slight cardiac hypertrophy, there were no other significant pathologic findings. It was the opinion of the medical examiner that the wound of entrance had the characteristics of a contact bullet wound.

Evidence acquired by the investigators at the scene of death and at the autopsy included the clothing of the suspect and victim, fingernail clippings and blood from the victim, bloodstains and glass fragments, the revolver, and five caliber-.357 cartridges. The evidence was submitted to a forensic sciences laboratory for examination.

The fragments of tempered glass recovered at the scene had physical and optical properties identical to those found embedded in the bedroom slippers and bathrobe of the suspect and the shirt of the victim. Bloodstains from the rear door were Group O human blood, but comparative specimens from the victim were not suitable for conclusive grouping. The bullet recovered from the victim had been fired from the revolver of the suspect.

Because of the findings, the suspect was charged with homicide and held in custody for trial.

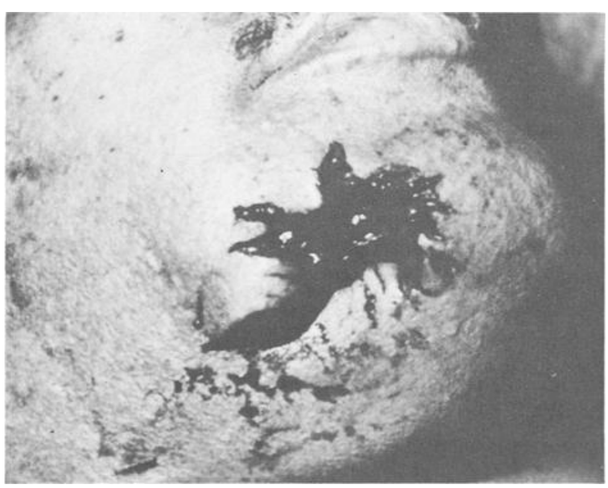

FIG. 1—*Stellate wound of entrance in chin of victim caused by bullet fired from caliber-.357 Magnum revolver (AFIP Neg. 74-1055-1).*

Special Pathologic and Criminalistic Studies

Histologic examination of tissue from the track of the wound by light microscopy revealed fragments of bone as well as brownish-black foreign material. The foreign material did not resemble the residue of gunpowder. Further inspection of the paraffin block containing tissue from the track disclosed a metallic fragment; this was removed, dissolved in concentrated nitric acid, and qualitatively identified as lead by the iodide method.

The portion of the block containing the fragment was removed, deparaffinized in chloroform, and digested in 1*N* sodium hydroxide in a plastic tube. The resulting sediment was washed with particle-free distilled water, mounted in particle-free polyvinyl alcohol, and covered with a plastic coverslip. Particles typical of glass fragments were detected by light-field microscopy with polarization.

The exemplar fragments of tempered glass obtained at the scene had the same refractive index and dispersion as the glass found in the track of the wound. The particle was too small for determination of density.

Experimental Ballistic Studies

To determine the potential effect of the glass on the in-flight characteristics of bullets and also the characteristics of the wound of entrance, experimental studies were conducted by firing the revolver obtained from the suspect through tempered glass similar to that of the glass in the storm door.

Several 660- by 711-mm (26- by 28-in.) panes of 3.2-mm (1/8-in.) tempered safety glass[5] were obtained for this study. The revolver, a caliber-.357 Magnum Model 28 Smith & Wesson Highway Patrolman with a 102-mm (4-in.) barrel, was loaded with caliber-.357 Magnum Western Super X, 158-grain Lubaloy, Index 357 1P ammunition containing ball powder. The muzzle of the weapon and the faces of 127- by 127- by 381-mm (5- by 5- by 15-in.) optically clear gelatin blocks (20% gelatin[6] at 10°C) were placed at specific distances from the intervening pane of glass for each test firing (Table 1). One cartridge was fired for each test. A sheet of 457- by 607-mm (18- by 24-in.) white blotter paper was placed behind the gelatin block to determine an estimate of the dispersion of glass and gunpowder residues. Each firing was photographed with a high-speed motion picture camera,[7] loaded with black-and-white reversal film, at a speed of 8000 frames/s. Fragments of the shattered panes of tempered glass were obtained for comparison (Fig. 2). After the completion of each test, photographs of the glass and the gelatin blocks were obtained, as well as roentgenograms of the gelatin blocks.

TABLE 1—*Distances used in experimental studies of caliber-.357 Magnum revolver firing 158-grain caliber-.357 Magnum bullets through tempered safety glass into 381-mm (15-in.) gelatin blocks.* [a]

Test Firing	Distance Between Muzzle and Glass, in.	Distance Between Glass and Target, in.
A	12.0	6.0
B	12.0	12.0
C	18.0	18.0
D	24.0	24.0

[a] 1 in. = 25.4 mm.

[5] Temper Tut, Type G, seamed edges, available from Hamilton of Indiana, Vincennes, Ind.
[6] Pharmagel A, Kind and Knox Gelatin Company, Sioux City, Iowa.
[7] HYCAM (high-speed camera), Redlake Corp., Santa Clara, Calif.

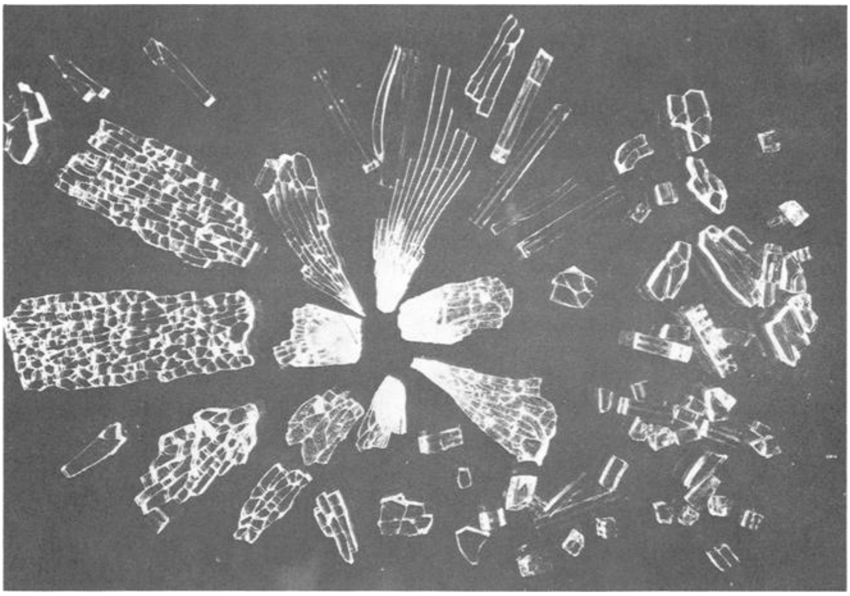

FIG. 2—*Fragments of tempered safety glass recovered after test firing during experimental studies (AFIP Neg. 73-12145).*

Results of Experimental Studies

Test A

The bullet perforated the gelatin block. A jagged, irregular hole in the pane of tempered glass measured 165 by 216 mm (6.5 by 8.5 in.) in greatest dimensions (Fig. 3). Numerous fragments of glass perforated the paper screen behind the gelatin block. Several fragments also struck a reflective screen 0.8 m (2.5 ft) from the left side of the block, as well as the wall 2.4 m (8 ft) in front of the location of the pane of glass. Particles of ball powder bounced from the screen, and numerous fragments of glass and particles of ball powder were found on the face of the gelatin block, with the greatest density up to 51 mm (2 in.) from the site of entrance of the bullet (Figs. 4 and 5).

Test B

After passing through the pane of glass, the bullet perforated the gelatin block and the paper behind the gelatin block. The upper quarter of the pane of glass was destroyed (Fig. 6). Fragments of glass perforated the paper backdrop in six places, and a few particles of ball powder were also found on the paper. The face of the gelatin block showed less gunpowder and glass than were observed in Test A, but there were numerous fragments of glass and ball powder distributed evenly on the face of the block (Fig. 7). Particles of lead were embedded in the face of the block (Fig. 8) and were also observed in the track of the bullet.

Test C

The bullet shattered the pane of glass and perforated the gelatin block. The central two thirds of the pane of glass was entirely shattered (Fig. 9). Focal areas of perforation

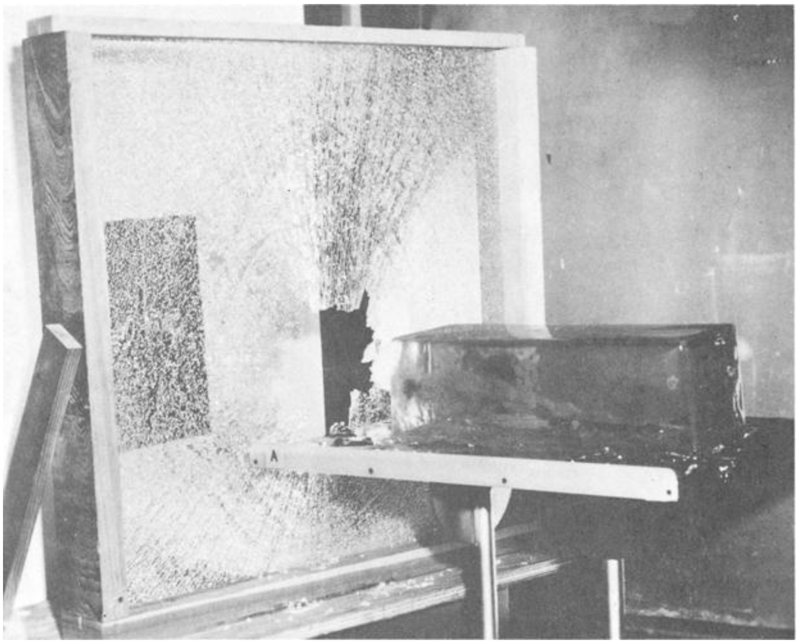

FIG. 3—*Hole in tempered safety glass that was shattered in Test A. The gelatin block is 152 mm (6 in.) from the glass. The distance between the muzzle of the revolver and the glass was 305 mm (12 in.) (AFIP Neg. 73-11799-5).*

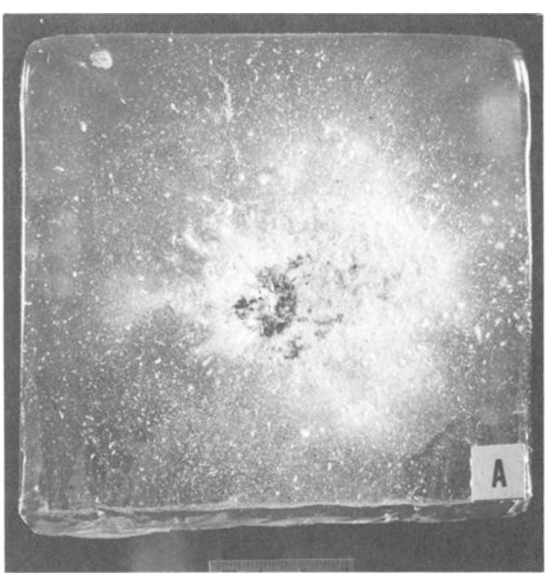

FIG. 4—*Distribution of glass, gunpowder, and metallic residues on face of gelatin block after Test A. Note the rounded appearance of the site of entrance of the bullet (AFIP Neg. 73-12140).*

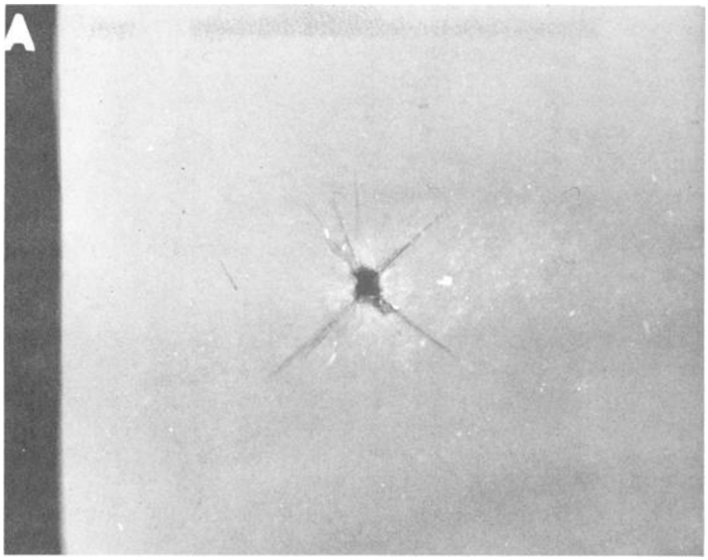

FIG. 5—*Roentgenogram of face of gelatin block after Test A. Note the distribution of opaque fragments and the stellate shape of the hole in the block (AFIP Neg. 73-12619-1).*

FIG. 6—*Hole in tempered safety glass shattered in Test B. The gelatin block is 305 mm (12 in.) from the glass. The distance between the muzzle of the revolver and the glass was 305 mm (12 in.) (AFIP Neg. 73-11799-6).*

of the cardboard backdrop were noted, and a few particles of ball powder were seen. Powdery fragments of glass were distributed evenly about the face of the gelatin block, and particles of lead penetrated the face of the block for a distance of 11.1 mm ($^7/_{16}$ in.) (Figs. 10 and 11). Particles of ball powder were also observed on the face of the block.

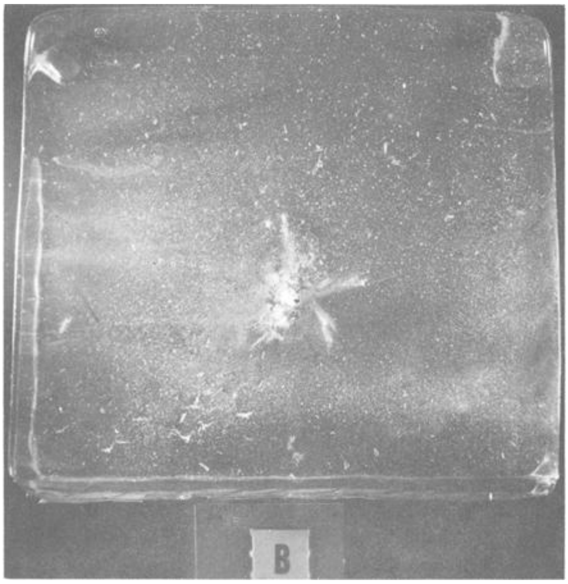

FIG. 7—*Distribution of glass, gunpowder, and metallic residues on face of gelatin block after Test B. Note the stellate shape of the site of entrance of the bullet (AFIP Neg. 73-12141).*

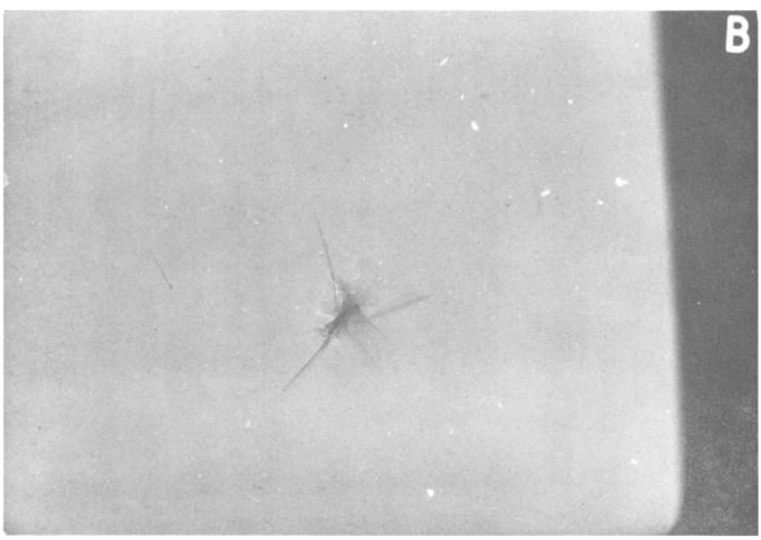

FIG. 8—*Roentgenogram of face of gelatin block after Test B (AFIP Neg. 73-12619-2).*

Test D

The bullet perforated the gelatin block and the cardboard backdrop behind the block. Fragments of glass also perforated the cardboard in six places, but ball powder was not observed on the cardboard. The central portion of the pane of glass was shattered, resulting in a hole measuring 215.9 by 406.4 mm (8.5 by 16 in.) in greatest dimensions. Small amounts of powdered glass, as well as particles of ball powder, were observed on the face

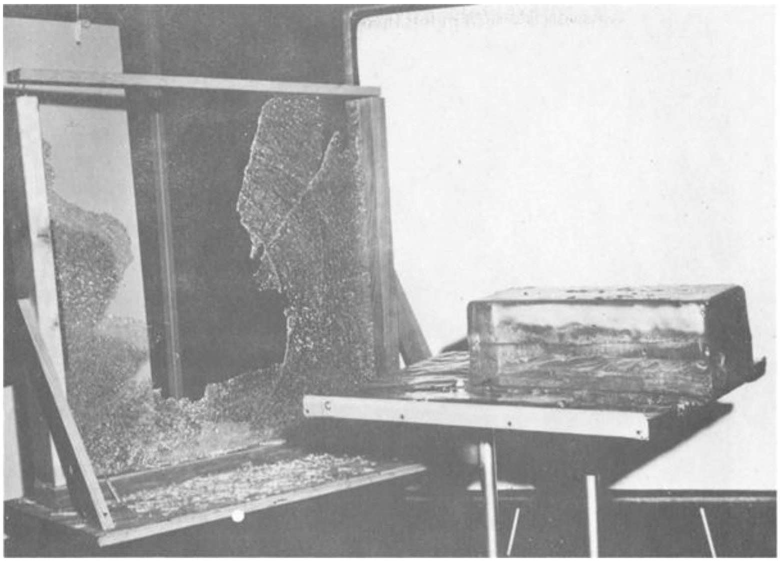

FIG. 9—*Hole in tempered safety glass shattered in Test C. The gelatin block is 457 mm (18 in.) from the glass. The distance between the muzzle of the revolver and the glass is 457 mm (18 in.) (AFIP Neg. 73-11799-2).*

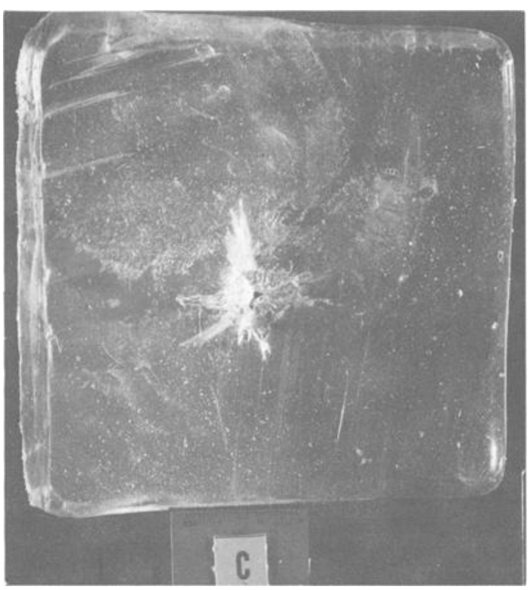

FIG. 10—*Distribution of glass, gunpowder, and metallic residues on face of gelatin block after Test C. Note the stellate shape of the site of entrance of the bullet (AFIP Neg. 73-12142).*

of the gelatin block (Fig. 12). Small fragments of lead were embedded in the face of the gelatin block for a distance of approximately 6 mm (1/4 in.) (Fig. 13).

The photographs of the faces of the gelatin blocks show differences in the appearance of the sites of entry by the bullets. There is a round hole at the site of entrance of the

FIG. 11—*Roentgenogram of face of gelatin block after Test C (AFIP Neg. 73-12619-3).*

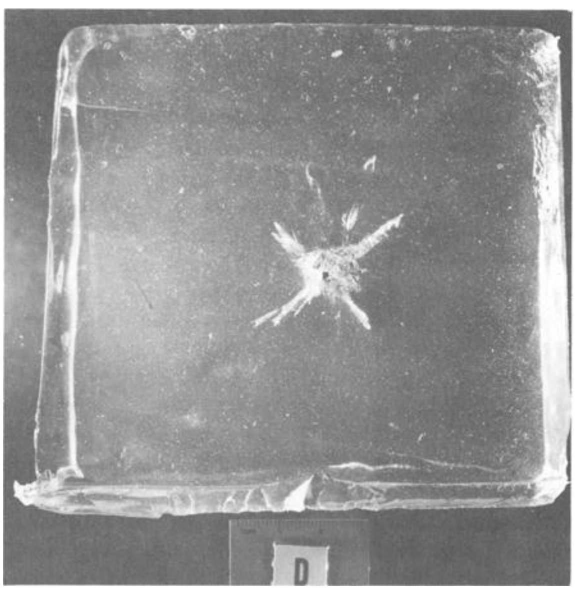

FIG. 12—*Distribution of glass, gunpowder, and metallic residues on face of gelatin block after Test D (AFIP Neg. 73-12143).*

bullet in Test A. In Tests B, C, and D, however, the sites of entrance of the bullet all have a stellate appearance. The decreasing density and the relative distribution of fragments of glass are also shown in these photographs. Roentgenographs of the faces of the gelatin blocks, which had been cut to a dimension of 127 by 127 by 127 mm (5 by 5 by 5 in.), show the relative distribution of the metallic particles of the lead from the bullets (Fig. 14).

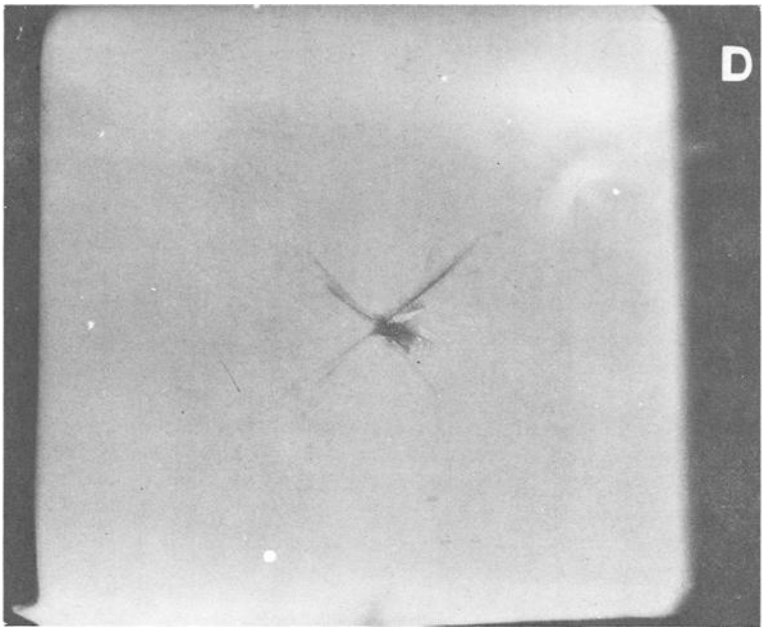

FIG. 13—*Roentgenogram of face of gelatin block after Test D (AFIP Neg. 73-12619-4).*

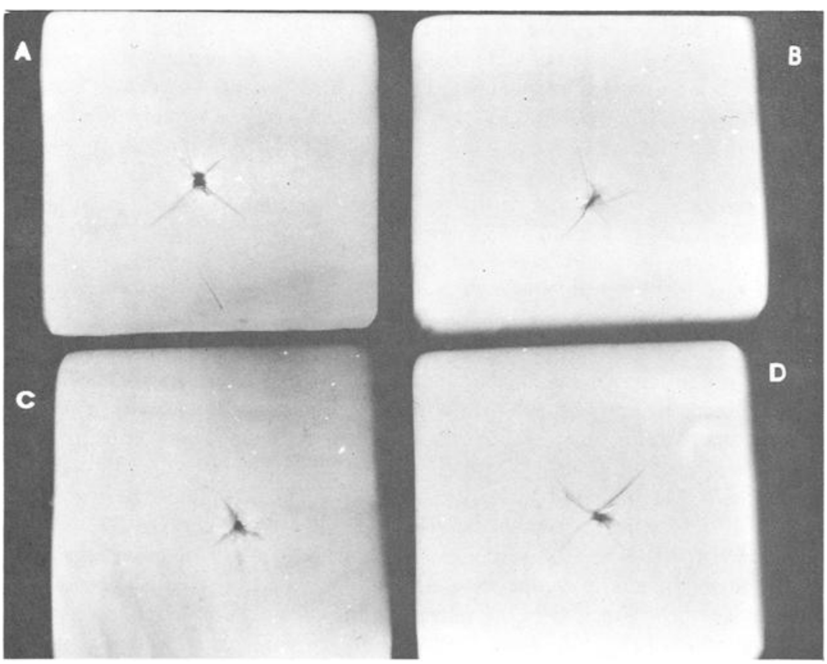

FIG. 14—*Composite roentgenogram of faces of gelatin blocks after Tests A, B, C, and D, showing comparison of shapes at site of entrance of bullets and distribution of opaque residues (AFIP Neg. 73-12620).*

Table 1 lists the distances between muzzle and glass and between glass and gelatin block in the four tests.

Discussion

Although the gross characteristics of the stellate wound of entrance in the chin of the victim resembled those of a contact gunshot wound, powder residue was not found in the track, and charring of tissues was not evident.

The experimental studies, as well as the subsequent pathologic findings, supported the allegation that the revolver was fired through the window of the storm door. The exact locations of the muzzle of the revolver and the victim, as related to the pane of glass, are not known. The presence of fragments of glass and lead in the wound without thermal effect and gunpowder residues in the wound, in contrast to the results of the experimental studies, are not indicative of a contact range of fire.

Experimental studies show that as the distance between the muzzle and the target is increased in relationship to the intervening pane of glass, there is decreased density in the distribution of the fragments of glass on the surface of the gelatin block. There is also less likelihood that particles of unburned ball gunpowder will be found. As the distance between the muzzle of the revolver and the target is increased from 457 to 1219 mm (18 to 48 in.), however, the hole at the site of entrance into the gelatin block is more likely to have a stellate appearance.

McLaughlin and Beardsley [*6*] have considered the issue of range of fire when a bullet passes through glass serving as an intermediary target. They compared results of studies for detection of the distribution of gunpowder residues on the glass with residues found on cloth targets after test firings. In their case, however, the glass was intact except for the hole caused by the bullet.

Tempered glass shatters into numerous small, irregular fragments; these may preclude detection of residues of gunpowder on the side of the glass from which a weapon is fired. Furthermore, if there is an issue as to whether the bullet passed through the glass or the glass was broken in some other manner, additional studies are indicated. The detection of fragments of glass in the track of the wound would support the contention that the bullet passed through glass before striking the victim. Depending upon the distance between the victim and the glass, injuries by glass or fragments of glass on the skin and clothing of the victim would offer further support to this contention.

The characteristics of wounds of entrance by bullets fired in contact with the skin are described in recent textbooks of forensic pathology [*4, 7-9*]. These features may include evidence of marginal abrasion about the wound, charring and thermal effect on skin and underlying tissues, and residues of gunpowder and metal about the site of entrance and in the track. Laceration of the wound, usually in a stellate shape, occurs as the result of the rapid expansion of gases in the temporary cavity between the skin and underlying bone, as between the scalp and the skull. High-velocity missiles fired at great distances, however, may also result in irregular wounds of entrance when they enter the skin over bony surfaces [*5*].

A caliber-.357 Magnum 158-grain lead bullet has a muzzle velocity between 423 and 465 m/s (1410 and 1550 ft/s), with the velocity decreasing to between 372 and 414 m/s (1240 and 1380 ft/s at 45 m (50 yards) [*10*]. The experimental studies with gelatin blocks and intermediate targets of tempered glass indicate that the stellate appearance of the site of entrance may be related to the velocity of the missile at close ranges, as well as the potential distortion of the soft lead bullet by the intervening target. Further studies of this type are indicated to determine the significance of intermediary targets to bullets fired at varying ranges under controlled conditions.

During the trial of the accused man, the results of the experimental studies were presented objectively. The prosecution contended that the victim had been shot at contact range and that the results of the experimental studies supported not only the gross pathologic findings but also the results of examination of other physical evidence. The man was acquitted by the jury.

Summary

When a lead bullet is fired at close range through a pane of glass serving as an intermediary target, the wound of entrance may have an atypical appearance. The victim of a penetrating caliber-.357 Magnum bullet wound of the chin had a stellate wound of entrance suggestive of a contact range of fire. Further pathologic studies, as well as experimental ballistic studies, supported the contention by the accused man that the revolver had been fired through a pane of tempered glass in a storm door.

There is a paucity of information in the literature of the forensic sciences concerning the effects of intermediate targets on bullets. The experimental procedures for resolution of these problems have been discussed and the need for further research has been indicated.

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