Technical Note

An Investigation of the Effects of Laminated Glass on Bullet Deflection

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Abstract: This study finds that, because of the gun and ammunition used, bullet deflection varies when penetrating a laminated windshield, but not enough to significantly alter the calculated location of a shooter. All of the rounds, with the exception of two, fell within the generally accepted range of negative five degrees to positive five degrees used in shooting reconstruction.

Introduction

Although a considerable amount of previous research exists that focuses on bullet deflection when penetrating tempered glass, little research is available on bullet deflection when penetrating laminated glass, such as windshields. In their review, Burke and Rowe [1] found a mathematical model of bullet deflection to be impossible to produce because of a bullet's unpredictable trajectory after ricochet. Thornton and Cashman [2] found tempered glass to significantly affect deflection. The research of Haag and Haag [3] suggests a consistent bullet deflection of approximately 1 to 5 degrees downward and in extreme cases, 10 to 15 degrees. Their research suggests that if a downward deflection of approximately 5 degrees occurs, the back-extrapolation or calculated location of the shooter will be closer to the vehicle and laminated glass than the actual location of the shooter.

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This study will examine bullet deflection patterns to determine whether enough bullet deflection occurs after perforating the laminated glass to change the calculated location of the shooter versus the known location of the shooter.

Materials and Methods

Materials

- Smith and Wesson M&P .40 caliber (Smith & Wesson, Springfield, MA)
- Beretta 92F, 9 mm (Beretta USA Corp., Accokeek, MD)
- Llama IV .45 caliber(Llamo-Gabilondo y Cia SA, Eibar, Spain)
- Winchester Ranger "Law Enforcement", 180 grain, T-Series jacketed hollow point (JHP), .40 caliber ammunition (Winchester Ammunition Company, East Alton, IL)
- Winchester, 180 grain, full metal jacket (FMJ), .40 caliber ammunition (Winchester Ammunition Company)
- CORBON Luger+P, 115 grain, JHP, 9 mm ammunition (Corbon & Glaser, LLC, Sturgis, SD)
- Lawmen Luger, 147 grain, FMJ Clean-Fire, 9 mm ammunition (Speer Ammo, Lewiston, ID)
- Winchester 45 ACP, 230 grain, FMJ, .45 caliber ammunition (Winchester Ammunition Company)
- Winchester 45 ACP, 230 grain, JHP, .45 caliber ammunition (Winchester Ammunition Company)
- The Secure Firing Device (Ranger Model with optional cabinet) (Twin Tooling Inc., Gormley, Ontario, Canada)
- Laminated automobile windshields
- Wooden holding device to secure windshield
- Bore laser sight

Methods

All research for this study took place in an indoor range located at the Ohio Bureau of Criminal Investigation in London, Ohio, over the course of three days. A bureau employee constructed a wooden device to secure the laminated windshields and to allow the windshields to be angled differently. This wooden device was placed on top of a table facing the firing device and held one windshield that was tilted 30 degrees in the vertical plane and away from the gun. (After taking a sample of sedan windshield slopes in the employee parking lot, 30 degrees from horizontal was found to be closest to the average of several recorded slopes.) The gun, held securely by the firing device, sat 3.78 m (149 inches) from the windshield; the windshield sat 1.12 m (44 inches) from a cardboard target (Figure 1). [As in the case of the windshield slopes, 1.12 m (44 inches) was the average of distances from the windshield to the headrest or seatback (which is a typical secondary impact after perforation through the windshield) in the sample taken in the employee parking lot.] Each gun was fired from a distance of 1.41 m (55.5 inches) above the ground at an angle of -5 degrees downward angle. (Gun height and slope were selected to be representative of a standing shooter's position firing at a windshield of average height above the ground for a sedan.) Five rounds of hollow point and five rounds of full-metal jacketed bullets were used in conjunction with each of the three different guns. Before each round, the projected flight, predicted by a bore laser sight placed inside the gun's barrel, was marked on both the windshield and the target with a permanent marker. To be considered, the round had to make contact with the point on the windshield to verify the accuracy of the laser bore sight to the actual flight path of the bullet. After ensuring that the bullet came in contact with the point on the windshield previously identified by the bore sight, bullet deflection was measured by comparing the bullet's projected flight path to the bullet's actual flight path as compared to the mark identified on the target with the bore sight.

Results

In our analysis, left and downward bullet deflections were assigned negative values, and right and upward deflections were assigned positive values. The horizontal and vertical deviations from the projected impact point were recorded in millimeters (Tables 1–3).

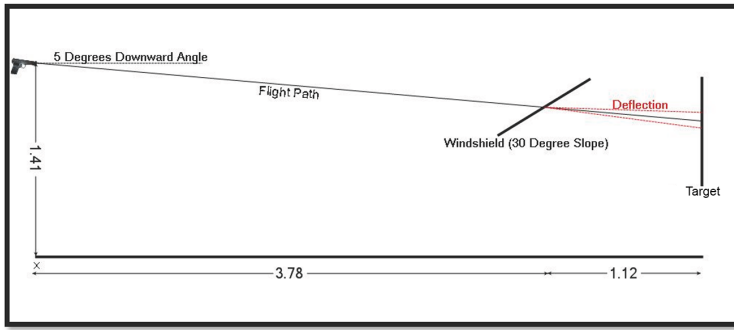

Figure 1

Set-up configuration.

Firearm and Bullet Type	1st	2nd	3rd	4th	5th	Average
9 mm – FMJ	+25 mm	-13 mm	-11 mm	+19 mm	+23 mm	+8.6 mm
9 mm – JHP	-2 mm	+23 mm	+10 mm	+40 mm	+23 mm	+18.8 mm
.40 Caliber – FMJ	-12 mm	-16 mm	+18 mm	+10 mm	+15 mm	+3.0 mm
.40 Caliber – JHP	+20 mm	+8 mm	+5 mm	+2 mm	-7 mm	+5.6 mm
.45 ACP – FMJ	+20 mm	-15 mm	+8 mm	-40 mm	-35 mm	-12.4 mm
.45 ACP – JHP	+30 mm	-35 mm	-32 mm	-15 mm	+12 mm	-8.0 mm

Table 1

Horizontal deviation data.

Firearm and Bullet Type	1st	2nd	3rd	4th	5th	Average
9 mm – FMJ	+23 mm	+11 mm	-14 mm	+14 mm	-38 mm	-0.8 mm
9 mm – JHP	-45 mm	-81 mm	-5 mm	-75 mm	+35 mm	-34.2 mm
.40 Caliber – FMJ	-65 mm	+8 mm	-70 mm	-50 mm	-55 mm	-46.4 mm
.40 Caliber – JHP	+55 mm	-25 mm	-65 mm	+38 mm	+20 mm	+4.6 mm
.45 ACP – FMJ	+175 mm	+43mm	+93 mm	-50 mm	-73 mm	+37.6 mm
.45 ACP – JHP	-63 mm	-125 mm	+31 mm	-14 mm	+23 mm	-29.6 mm

Table 2

Vertical deviation data.

Firearm and Bullet Type	Left (-) or Right (+) Deflection	Downward (-) or Upward (+) Deflection	Horizontal Deviation in %	Vertical Deviation in %
9 mm – FMJ	+8.6 mm	+0.8 mm	0.44°	0.04°
9 mm – JHP	+18.8 mm	-34.2 mm	0.96°	1.75°
.40 Caliber – FMJ	+3.0 mm	-46.4 mm	0.15°	2.37°
.40 Caliber – JHP	+5.6 mm	+4.6 mm	0.29°	0.24°
.45 ACP – FMJ	-12.4 mm	+37.6 mm	0.63°	1.92°
.45 ACP – JHP	-8.0 mm	-9.6 mm	0.41°	0.49°

Table 3

Mean bullet deflection.

All of the bullets perforated the windshield and were within the ±5 degrees threshold, with the exception of two. Those two bullets, both from the .45 Caliber ACP, had a greater vertical deviation than 98 mm (Table 2). The deflection angle was calculated from the projected flight path of the bullet versus the actual path of the bullet after perforating the windshield for both the horizontal and vertical angles (Figure 2).

Discussion

The mean deflection values for each gun and bullet type (Figure 3) do not support a consistent downward deflection pattern proposed by previous research [3]. Bullet deflection in this study occurred in every direction and did not exhibit a specific pattern. Deflection varied even among rounds using the same gun and ammunition. Despite the variance in deflection values, we do not find deflection to dramatically affect the projected location of a shooter. Haag and Haag [4] suggest that a range of -5 degrees to +5 degrees to be "a reasonable uncertainty level for any numerical value for most bullet paths derived from actual scene work". All rounds, with the exception of two, fell inside this accepted range for shooting reconstruction suggested by Haag and Haag.

Conclusion

Based on the evidence presented, bullet deflection through laminated glass does not appear to significantly affect the calculated location of the shooter. Although further research is suggested, this study provides a comparison to the results of similar studies on bullet deflection through tempered glass. Individuals performing a shooting reconstruction at a scene with laminated glass perforated by one or many bullets can continue to reliably calculate a shooter's location based on this study's findings.

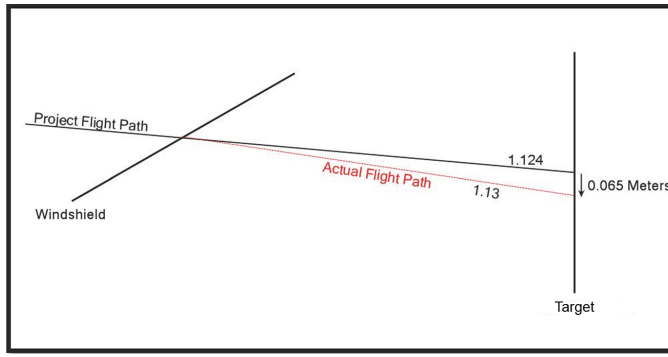

Figure 2
Deflection.

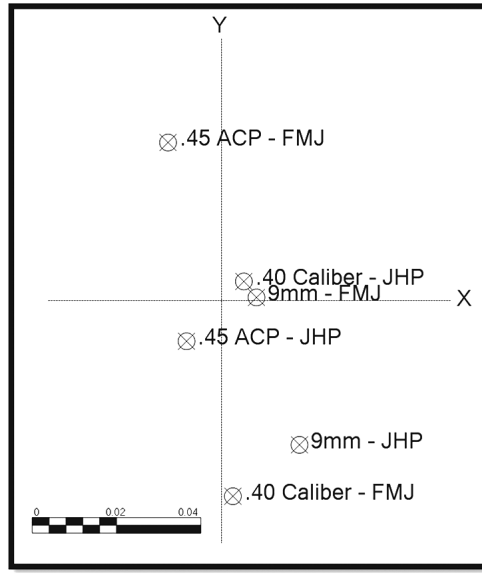

Figure 3
Point map illustration of mean bullet deflection.

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