CASE REPORT

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Determination of Shooting Distance from Deformation of the Recovered Bullet

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ABSTRACT: A method is reported for estimating shooting distance by comparing the amount of bullet deformation of a recovered bullet with that produced in a series of test bullets fired into 10% ordnance gelatin at 4°C. Bullet deformation and fragmentation pattern in this gelatin was previously found to be comparable to that seen in living animal muscle. Striking velocities of the test bullets were lowered stepwise until a test bullet was produced with less deformity than the evidence bullet. Two shots were then made through the abdomen of a fresh swine cadaver at velocities approximating those of the last two test shots in gelatin. This served as verification of the gelatin's calibration against animal tissue and gave an additional set of bullets whose degrees of deformation bracketed that of the evidence bullet. Separate interpolations were done for bullet length, average bullet tip diameter, and bullet weight using both sets of bracketing test bullets. The resulting velocities were then converted to distances using the manufacturer's velocity tables. The average of the interpolations was 256 yds (234 m); all six fell within a range of 33 yds (30 m) (from 238 to 271 yds [218 to 248 m]).

KEYWORDS: criminalistics, ballistics, wound ballistics

A man was killed while deer hunting in California in autumn 1985. The fatal wound was inflicted by a single bullet which entered the upper area of the abdomen anteriorly, exited posteriorly after injuring bowel, liver, and kidney, and was captured in a packsack which the man was wearing.

The county investigating officials sought the aid of the California Department of Justice Criminalistic Laboratory in evaluating the recovered bullet. From rifling marks and bullet morphology, it was determined to be a Federal 150 grain soft-point bullet fired from a 30-30 Marlin lever action rifle. The investigators had reason to suspect homicide in this particular

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case and were especially interested in knowing the distance from which the shot had been made. Homicide was considered less likely if the shooting distance was over 100 yds (90 m).

Personnel at the State Criminalistics Laboratory were aware of work done at the Wound Ballistics Laboratory of the Letterman Army Institute of Research on calibrating ordnance gelatin against animal tissue to reproduce quantitatively both bullet deformation and tissue disruption. They asked if this technology might be of use in estimating the distance traveled by the bullet before entering the body.

Unlike other tissue simulants, that used at the Letterman Army Institute of Research (10% ordnance gelatin shot at 4°C) has been shown to reproduce the bullet deformation and fragmentation pattern seen in living animal muscle [*1-3*]. Although the gelatin calibration was done using muscle, it has recently been found to show similar results in soft tissue shots of the abdomen as well.[4]

Since bullet deformation in tissue is a function of the velocity with which it enters the tissue, a series of bullets of progressively lower striking velocities was shot into gelatin to estimate the shooting distance. Sufficient gelatin thickness was used to capture the entire bullet path and recover the bullets. The evidence bullet was then compared with the captured bullets and found most closely to resemble the bullets with striking velocities corresponding to a shooting distance between 200 and 300 yds (183 and 274 m). Two more shots were then done through the abdomen of a fresh swine cadaver at velocities corresponding to this distance and similar degrees of bullet deformation were produced.

Method

All shots were made with the target surface 10 ft (3 m) from the rifle muzzle, and velocities were measured with a Model 464 T chronograph made by Electronic Counters, Inc., Syosset, NY. Impulses to activate the counter were generated as the bullet broke a circuit of metal foil on thin paper screens that were spaced 50 cm apart and placed between the muzzle and target surface. All shots were fired with Federal 150 grain soft-point bullets in 30-30 Winchester caliber (to match the evidence bullet) from a Winchester Model 94 lever-action rifle.

Two 25- by 25- by 50-cm blocks of 10% ordnance gelatin were placed end to end for each of the four shots into gelatin to insure capturing the entire bullet path. Gelatin temperature for each shot was 4°C. Based on the penetration depths observed in these shots (maximum of 64 cm), a single gelatin block was placed against the predicted exit site on the 25-cm-thick abdomen of the swine cadaver. The swine had been dead for 15 min at the time of the first shot and 20 min at the time of the second shot. The shots through the swine abdomen were made transversely, the bullet path at 90° to the long axis of the body. All shots were captured in the gelatin.

Results

Figure 1 shows the evidence bullet (No. 4) compared to the series of bullets caught in gelatin. Table 1 shows a compilation of striking velocities and measurements of bullet lengths, diameters of the expanded bullet tips, and weights of the recovered bullets. The dimensions and weight of the evidence bullet are included in Table 1 under the vertical column headed E.B.

As expected, as striking velocity decreased, bullet length increased, tip diameter decreased, and bullet weight increased (as a result of less bullet fragmentation).

As shown in Table 1, length of the evidence bullet was 54% of the distance between the bullet shot at 1602 ft/s (488 m/s) and the one shot at 1493 ft/s (455 m/s). Using this percentage figure the evidence bullet would have an interpolated velocity of 1543 ft/s (470 m/s).

[4]M. L. Fackler, unpublished data, 1984.

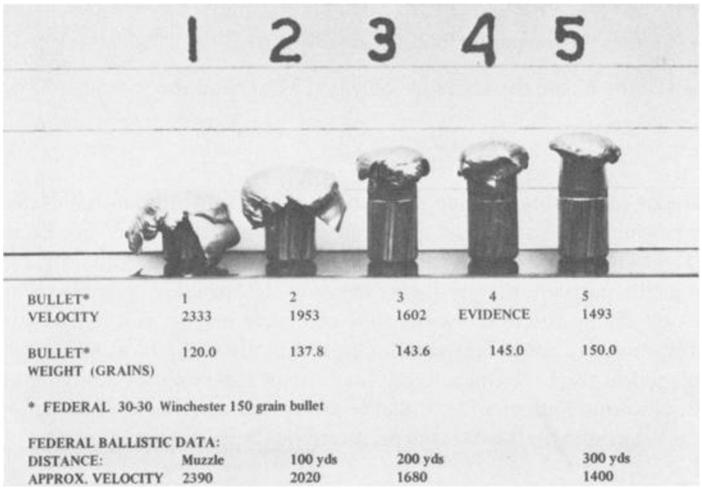

FIG. 1—*Photograph comparing gross appearance of the evidence bullet* (4) *with the four test bullets fired into gelatin.*

TABLE 1—*Measurements of physical characteristics of recovered bullets fired into ordnance gelatin and swine abdomen.*[a]

Bullet velocity, ft/s	2333	1953	1659[b]	1602	E.B.[c]	1493	1458[b]
Bullet length, in.	0.433	0.574	0.667	0.686	0.726	0.760	0.761
Bullet tip diameter, in.	max 0.713	0.714	0.505	0.481	0.470	0.439	0.400
	min 0.651	0.579	0.440	0.449	0.400	0.436	0.448
	ave 0.682	0.647	0.473	0.465	0.435	0.438	0.424
Bullet weight, grains	120.0	137.8	139.5	143.3	145.0	150.0	147.0

[a]1 ft/s = 0.3048 m/s and 1 in. = 2.54 cm.
[b]Indicates shots done through abdomens of fresh pig cadaver.
[c]E.B. refers to evidence bullet.

Using the same interpolation method with the average bullet tip diameter as the experimental variable, the evidence bullet would have a velocity of 1481 ft/s (451 m/s), and based on bullet weight the evidence bullet velocity would be 1575 ft/s (480 m/s).

An additional set of calculations using the two bullets shot through the fresh swine abdomen yielded an interpolated velocity of 1534 ft/s (468 m/s) based on bullet length, 1502 ft/s (458 m/s) based on average tip diameter, and 1512 ft/s (461 m/s) based on bullet weight.

Another set of interpolations using the FEDERAL Cartridge Co. Ballistic Data tables (pertinent parts of these tables are shown in Fig. 1) was assembled to determine the distances from the gun muzzle that would correspond to the velocities derived above. These distances are:

1543 ft/s (470 m/s) corresponds to 249 yds (228 m),
1481 ft/s (451 m/s) corresponds to 271 yds (248 m),
1575 ft/s (480 m/s) corresponds to 238 yds (218 m),
1534 ft/s (468 m/s) corresponds to 252 yds (230 m),

1502 ft/s (458 m/s) corresponds to 264 yds (241 m), and
1512 ft/s (461 m/s) corresponds to 260 yds (238 m).

The average of the above distances is 256 yds (234 m) and the spread is 33 yds (30 m).

Discussion

The purpose of calibrating a tissue simulant against living animal tissue was to obtain a data base from which soft tissue disruption caused by a penetrating projectile could be estimated with a reasonable degree of accuracy. The disruption type, quantity, and location along the projectile path are the pertinent, measurable variables; they are determined reliably from 25- by 25- by 50-cm blocks of 10% ordnance gelatin at a temperature 4°C into which the projectiles are shot. This simulation technique is the basis of the wound profile method developed at the Letterman Army Institute of Research for studying and teaching the principles of wound ballistics [*1*]. Bullet recovery and correlation of its deformation and fragmentation behavior with the damage produced has been an important part of these studies [*3*].

The query by the California Department of Justice Criminalistic Laboratory concerning the determination of shooting distance from a recovered soft-tip bullet led to what appears to be a useful extension of the wound profile technique. It is well known that "mushrooming" or tip-flattening expansion of the soft-tip or hollow-point bullet increases with increasing striking velocity. It seems logical, therefore, to use this fact to estimate the striking velocity from the degree of bullet deformation. This is, in fact, what was done.

The close agreement of the data presented here, that is, from the gelatin and the swine abdomen for all three physical parameters of bullet deformation (length, tip diameter, weight loss), supports the conclusion that the evidence bullet was most likely fired from a distance of 200 to 300 yds (183 to 274 m).

Certain cautions need to be mentioned in the application of the method presented. First, valid results can be expected only if the tissue simulant used has been shown to deform the bullet to the same degree as animal tissue. We found it necessary to change the concentration of the ordnance gelatin from the commonly used 20% to the 10% we now use to achieve this end in 1982, concomitant with the development of our wound ballistics research program [*1*]. Second, the evidence bullet must not have struck bone during its path through the body; this would cause more deformation than soft tissue and the resultant physical evidence would be misleading. Third, the evidence bullet must be matched to the test bullets in terms of weight, construction, and manufacturer. Variations in thickness and hardness of bullet jacket and hardness of the lead core can be expected to vary between manufacturers and might well cause variations in bullet deformation and fragmentation patterns. The best circumstance would be to have test bullets from the same box as the evidence bullet. Shooting test bullets from the same rifle as the evidence bullet would also be ideal, but in this case that was not possible. The Model 94 Winchester used for this study had a 20-in. (51-cm) barrel. The evidence bullet was shot from a Marlin lever action rifle but there is no way to determine whether the weapon used was a Model 336C which has the same barrel length, or a Model 336A which has a 24-in. (61-cm) barrel. If the evidence bullet was shot from a 24-in. (61-cm) barrel, the effect would be to increase the estimated distance by approximately 30 yds (27 m) (equivalent to an increase in muzzle velocity of about 100 ft/s [30 m/s]). This increase would not materially alter the conclusion obtained in the present investigation, but could be a factor to consider in other possible applications of the method presented.

Conclusion

The purpose of this report is to present the basic method of a technique that should prove useful in cases where information on shooting distance is critical and the bullet has been recovered.

The close and consistent relationship of bullet deformation to striking velocity seen in the results of this case report are in agreement with published work from the Letterman Army Institute of Research [*1,3*], a large body of unpublished data, and data in preparation for publication at the same institution. Had a more exact determination of shooting distance been required or had this evidence been prepared for use in court, more shots would have been made in the fresh animal cadaver.

It is felt that the use of bullet deformation to determine shooting distance is a fruitful area for further research.

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