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Experimental Model and Simulant for Studying Tissue Injury in the Near Human Porcine Equivalent by the 380-ACP Projectile

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Abstract

Hypothesis: The 380 ACP projectile will not have sufficient penetration to reach vital organs under all circumstances, especially to reach lethal penetration in the complex extended tissue model.

Methods: Five different projectiles were evaluated; Federal 380 ACP Full Metal Jacket, Federal Jacketed Hollow point, G9 Defensive external hollow point, Underwood Xtreme Defender and Buffalo Bore +P. These were fired through a Smith and Wesson Bodyguard model 2 into 3 porcine specimens, a chest model bone model and a combination of the 2 models. Velocity, depth of penetration and residual projectile construction were measured.

Results: The G9 external hollow point caused the largest cavitation and tissue damage. The G9 and Federal Jacketed hollow point did not penetrate the chest model in the combined construction. The Federal Full Metal Jacket, Underwood Extreme Defender and Buffalo Bore all penetrated through bone in the combined model. Buffalo Bore penetrated the deepest.

Conclusion: With the projectiles tested, caution should be used by relying on the jacketed hollow point and G9 external hollow point to penetrate under all circumstances, since both failed to reach the vitals after bone contact.

Keywords: 380 ACP Caliber; Tissue Injury; Ballistic Model; Projectile Testing; Self Defense; Near Humane Porcine Model

Introduction

Terminal ballistics implies the performance of a projectile entering the object of aim. This may be clay, wood, ballistic gelatin or tissue. Due to the ease of experimentation, a variant of the FBI standard called clear ballistic gel is used most of the time in popular experiments [1,2]. It is very clear, affordable and much easier to handle. The FBI standard gel test differs somewhat from the clear ballistic gel due to deeper penetration and less expansion in the clear ballistic gel. Most experimentation done by law enforcement, FBI or enthusiasts implies using either of the ballistic gels. The FBI Standard was set in 1987 with the goal of 12 to 18 inches of penetration for a specific projectile to be acceptable as a self-defense round [3]. FBI ballistic gelatin simulates penetration through porcine muscle. It does not by all means simulate penetration, loss of energy, expansion and woundability of human or porcine tissue including skin, muscle, fascia, bone or lungs in combination [4].

Evaluation of the 380 ACP ("pocket pistol") has been limited by the absence of studies employing realistic near human biological models [5]. Since this round and pistol are becoming increasingly popular due to its smaller size and concealability, a scientific biologic wounding ability test is warranted. The 380 ACP round, also known as the 9 mm short, was developed by John Browning in 1908.

The domestic porcine tissue model from Sus scrofa is used in this experiment due to its tissue characteristics very similar to human tissue, hence the term near-human.

Due to ethical resistance and criticism of using human cadaver tissue, even if donated or using live animals, the tissue used was sourced from non-frozen commercial products, therefore very similar in size and weight.

Hypothesis
The 380 ACP projectile will not have sufficient penetration to reach vital organs under all circumstances, especially to reach lethal penetration in the complex extended tissue model.

Materials and Methods
A porcine model was designed in three different experiments. In the first model, commercially available specimens of similar weight and size were selected to build the entire model, comprising of porcine skin, muscle of equal thickness, ribs anterior, lung, ribs posterior and skin posterior, all held together by two layers of cotton placed in similar-size cartons with copy paper as a backstop (Fig. 1).

The second bone experiment was set up very similar, comprising of the humerus of the Sus scrofa. The model comprised of skin, muscle anterior, tubular bone (2.5 cm diameter), muscle posterior and skin posterior (Fig. 2).

The third model combined the forementioned two, simulating penetration from lateral through the shoulder muscle including the humerus into the thorax. It comprised of skin, muscle simulating the deltoid, humeral bone, a double layer of skin simulating the axilla, muscle simulating pectoralis major, ribs anterior, lung, ribs posterior, skin surrounded by two layers of cotton and a copy paper backstop.

All projectiles were fired from a popular self-defense distance of 5 yards. Muzzle velocity was measured with a QKVCX chronograph and the ammunition comprised of Federal Hollow Point Punch 85 grain, Federal Full Metal Jacket 95 grain, Buffalo Bore hard cast 100grain, Underwood Xtreme Defender 68 grain and G9 Defense External Hollow Point 70 grain.

All projectiles were fired through a Smith and Wesson Bodyguard 2.0 with a 2.75 inch barrel. The recordings made are included in Table 1.

The porcine bone model included young animals with a long bone diameter and thick cortices imitating an average adult humerus. On the bone specimens the following aspects were recorded: post impact damage to the bone, fragment shape, distribution and crack mapping, beveling, cortical flaking and bone whitening. Whenever possible the ballistic projectile or fragments were retrieved and photographed [6-9].

Only the Federal Punch Jacketed Hollow Point (JHP) and Federal Full Metal Jacket (FMJ) were tested in the first chest model. All projectiles were tested in the bone and extended tissue models. All tests were performed at the same ambient temperature, (46°F).

Figure 1: Chest model with the sequence: anterior skin, muscle, ribs, lung and followed by posterior ribs, muscle and skin.

Figure 2: Example of a bone model with the humeral bone visible on the top.

	380 ACP FMJ	380 Federal Punch	Buffalo Bore +P	G9	380 ACP Underwood
	95 Grain	85 Grain	100 Grain	70 Grain	68 Grain
Ant. Skin Cavity	3 mm	4 mm	5 mm	5 mm	5 mm
Muscle Cavity	1 cm	15 mm	3.5 cm	4 cm	4 cm
Bone Cavity					
	Pulverized 2.5 cm	Stuck inside bone, 4 cm Pulverized bone	Pulverized 4 cm	10 cm	6 cm
	Fractured 6 cm long		Fractured 5 cm	Pulverized bone	
Post. Skin Cavity	3 mm	NA	10mm	3 mm	5 mm
Cardboard Entered	Yes	NA	Yes	Stopped in cardboard	Yes
Copy Paper Entered	5 mm	NA	4.5 cm	No	4 mm
Condition of Projectile	Deformed with some fragments	Perfect expansion	Slightly deformed	Pristine	Pristine
Ant. Rib Penetration	NA	NA	NA	NA	NA
Post. Rib Penetration	NA	NA	NA	NA	NA
Lung Penetration	NA	NA	NA	NA	NA
Velocity	876.7	862.4	1072.5	1016.4	1174.5

Table 1: Bone model.

Results

In the chest (first) model, the permanent wound channel of the FMJ was consistently smaller in all tissue samples than of the JHP wound channel (Fig. 3). As an example, the wound channel through muscle was 15 mm by the FMJ and 90 mm by the JHP. The posterior rib channel was 12 mm by the FMJ and 30 mm by the JHP. In the lung it was 5 mm (FMJ) and 13 mm (JHP). Both projectiles penetrated through posterior cotton and carboard into the copy paper-12 mm in the FMJ and 4 mm in the JHP case.

In the second bone experiment, the Federal FMJ penetrated through all layers, pulverized 2.5 cm of bone, caused a fracture of the bone 6 cm long and penetrated copy paper 5 mm deep. The Federal JHP penetrated the anterior skin, muscle and fractured the bone and was lodged inside the bone. It did not penetrate posterior muscle or skin. It caused a very large, comminuted fracture of the humerus pulverizing the center 4 cm wide (Fig. 4).

The Buffalo Bore +P hard cast 100 grain projectile penetrated through all tissue layers anteriorly and posteriorly. It pulverized the bone for 4 cm and caused an additional fracture 5 cm long. It penetrated into copy paper 4.5 cm. The Buffalo Bore tainted the tissue black especially the bone block. It was also slightly deformed.

The G9 defense external hollow point penetrated through skin and muscle and bone, it exited and stopped in the cardboard short of the copy paper. The G9 defense external hollow point caused the largest bone defect literally pulverized the bone for 10 cm (Fig. 5). The projectile was not deformed at all. The Underwood Xtreme Defender penetrated skin, muscle, bone and penetrated the copy paper 4 mm. The projectile was pristine and not deformed. Fig. 6 represents lead in the projectile. A similar finding was published by BJ Henwood, et al., [5].

In the third experiment an extended (combined) tissue model with humerus bone and chest tissue was utilized. The Federal FMJ 95 grain penetrated through the bone model, also passed through the chest model and entered the copy paper 4mm deep. It was deformed with little loss of the metal jacket, but largely intact.

The G9 defense external hollow point penetrated the bone and literally destroyed the bone. It was lodged in the posterior muscle of the bone model and did not advance into the chest model. The projectile was not deformed at all.

The Buffalo Bore +P 100 grain penetrated through both specimens, i.e. the bone and chest specimens. It pulverized the bone 4cm wide, caused a fracture 6 cm long and penetrated the copy paper 4 mm deep. It tainted the tissue black and was slightly deformed. Also, a small portion of the base of the projectile fragmented off (Fig. 7).

The Underwood Xtreme Defender penetrated through both specimens but failed to exit the posterior muscle. It was retrieved in the posterior muscle (Fig. 8).

Lung tissue is very elastic and closes up, especially after FMJ penetration. Muscle on the other hand almost explodes after projectile penetration with a permanent measurable cavity much larger than the projectile diameter. This is summarized in Table 1 and Table 2.

Figure 3: Limited muscle damage by the Federal FMJ round.

Figure 4: Federal JHP stuck inside the bone

Figure 5: Devastating damage done to the bone due to the G9 projectile.

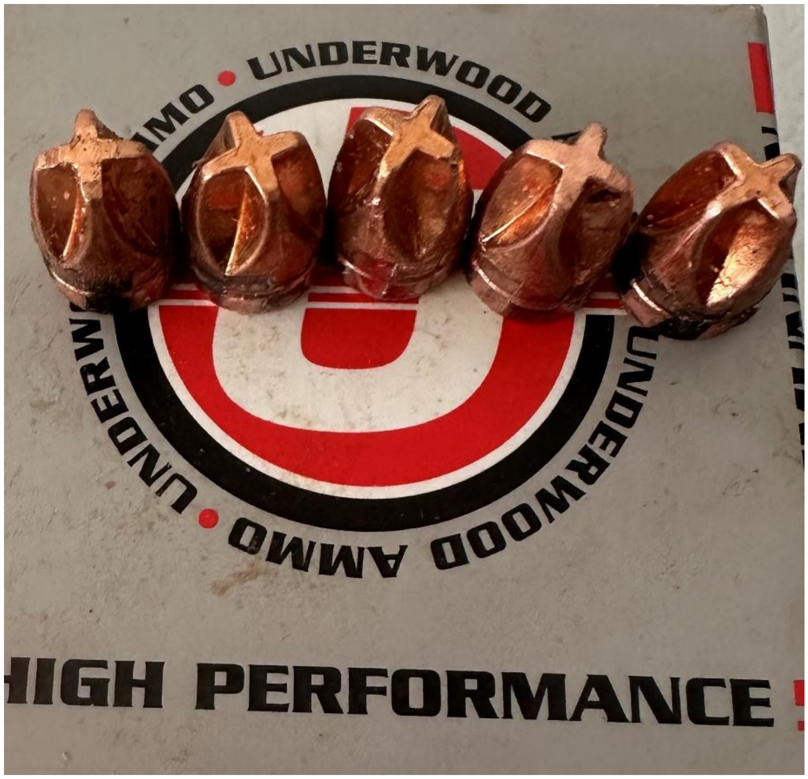

Figure 6: Copper alloy projectiles from Underwood Xtreme Defender penetrated without any deformation or fragmentation.

Figure 7: Buffalo Bore +P fired rounds showing slight deformity and fragmentation of the base.

Figure 8: The Underwood Xtreme Defender projectile stuck in the most distal muscle of the chest model.

	G9	Buffalo Bore +P	FMJ	Underwood
	70 Grain	**100 Grain**	**95 Grain**	**68 Grain**
Ant. Skin Cavity	6 mm	7 mm	6 mm	6 mm
Muscle Cavity	4 cm	5 cm	1 cm	3.5 cm
Bone Cavity	Pulverized 4 cm	Pulverized 4 cm	Pulverized 2 cm	4.5 cm
Post Skin Cavity	No	5 mm	5 mm	5 mm
Cardboard Entered	No	Yes	Yes	No
Copy Paper Entered	No	Yes, 4mm	Yes, 4mm	No
Condition of Projectile	Pristine	Slightly deformed	Fragmented	Pristine
Ant. Rib Penetration	No	3 cm	1.5	6 mm
Post. Rib Penetration	No	1.5 cm	1.5	6 mm
Lung Penetration	No	1.5 cm	1 cm	1 cm
Velocity f/s	1016.4	1072.5	876.7	1174.5

Table 2: Extended model.

Discussion

The experiment clearly demonstrates the differences in projectile construction and design to cause variance in tissue damage and penetration. The JHP is designed for rapid expansion to create a large wound channel but not over penetrating. It functions well if a bone structure is not penetrated. In this experiment it failed to reach vital organs after cortical bone penetration, but it caused devastating tissue damage.

The FMJ round is effective to penetrate deep through all layers of tissue and reach vital organs even after penetrating through solid cortical bone and thick muscle. The permanent wound channel was much smaller.

The Buffalo Bore +P round which comprised of a hard cast lead alloy, was powerful enough to penetrate with ease through all tissue layers and even exited the extended tissue model into copy paper. The round, due to its high velocity and hardiness, will penetrate and exit through any human being regardless of structure and size. It deformed only slightly after penetration.

The Underwood and G9 defense rounds comprise of a solid fluted copper brass projectile that causes tissue damage by causing a hydrostatic wave expanding and disrupting tissue far beyond its diameter. The Underwood round had enough energy and hardy construction to penetrate vital organs even after penetrating through bone. The G9 did not deform at all but failed to reach the vitals (chest model) after bone penetration. This experiment clearly proves a solid copper projectile construction to be hardier than all others by not deforming or fragmenting.

This experiment proves the hypothesis to be correct for the Federal Jacketed Hollow Point (JHP) and G9 defense external hollow point. These projectiles spent all their energy in bone and could not penetrate vitals after cortical bone contact. The hypothesis was incorrect for the Federal FMJ, Buffalo Bore hard cast and Underwood extreme defender in the 380 ACP caliber. These rounds were constructed robust enough with enough velocity and energy to act as a formidable self-defense round in the near human porcine combined model.

The performance of a projectile through ballistic gelatin cannot be directly compared to its performance in different densities of biological tissue. The standardized FBI ballistic gel plays an important role in comparing different projectile performances; however, it is advisable for the FBI and Law Enforcement in their testing also to use the combined model as a final test given its proximity to real human multilayered tissue [10,11]. Also, clear ballistic gelatin has an average 48% deeper penetration than the FBI standard [3].

The solid copper projectiles offer superior validity as a self-defense round, its fluted design allows for tissue expansion comparable to hollow points.

Despite slight deformation and small fragment formation, the Buffalo Bore +P was the hardest hitter. Also, it did not have the fastest velocity (Underwood was fastest) yet it penetrated the deepest. The fluted design of the G9 defense round proved itself superior in creating the largest wound channel size but lacked deep penetration when it encountered cortical bone.

It is difficult for manufacturers to strike the perfect balance between adequate penetration but not over penetration but at the same time create a large wound channel. This balance is difficult to reach due to the variance of body size and diameter, as well as bone structure differences in humans.

The Federal FMJ projectile proved itself as a deep penetrator by penetrating slightly deeper than the Underwood but the projectile deformed. It did lose mass, but the lead core stayed bonded. Given its structure it will penetrate deep in a self defense scenario, however, its construct may fragment. Due to modern advanced ballistic projectile engineering and design generalizations cannot be made and each projectile must be tested individually to make accurate deductions. Also, ballistic rounds produced a few years back may not be of the same quality. This experiment also emphasizes the difficulty of extrapolating a caliber size based on wound damage present in tissues.

Conclusion

Certain projectiles from the 380 ACP caliber did penetrate through all tissue layers including bone due to their modern design and modern propellants used, rendering them with enough energy to be effective under all circumstances. These projectiles tested proved to have adequate penetration in the near human model. The Federal FMJ surprisingly could achieve enough penetration through all tissue layers. This experiment proves that in the 380 ACP caliber Federal JHP and G9 defense external hollow point were inadequate to penetrate deep enough when cortical bone is encountered.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethical Statement
All porcine products were sourced from commercial food grade sources. Due to the sourcing of the material no IRB/IACUC approval is required as no living animals were manipulated or experimented on at any time.

Informed Consent Statement
Informed consent was obtained from all participants included in the study.

Authors' Contributions
All authors contributed equally to this paper.

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