

Analysis of Gunshot Residue Presence and Diameter of Bullet Hole on Different Surfaces

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ABSTRACT: Gunshot residue is important evidence in forensic ballistics. In criminal cases involving the use of firearms, the reconstruction of the shooting incident is of paramount importance. However, there is still lack of studies on gunshot residue as well as the diameter of bullet's entrance and exit holes on different surfaces. These studies were carried out to observe the presence of gunshot residue and the difference in diameter of bullet hole penetration on various surfaces. The sample surfaces used in this studies were 6 mm woodboard (n=10), 18 mm woodboard (n=10) and tiles (n=10). Each sample surface was shot from a distance of 10 feet using 9 mm full jacketed metal bullets in a semi-automatic pistol. Sodium rhodizonate test was performed to determine the presence of gunshot residue on surfaces. The diameter of bullet entrance and exit hole were measured using Image J software. Positive indication using sodium rhodizonate and the diameter of bullet's hole observed were recorded. The results showed the presence of gunshot residue on surface of 9 tiles. Significant difference between 6 mm tile surface and 8 mm board ($p<0.05$) were observed. Diameter of bullet exit holes showed significant difference between 6 mm board and 8 mm board ($p<0.05$). The presence and absence of gunshot residue could also be observed on all sample surfaces. There were difference in the diameter of the bullet's entrance hole between 6 mm tile surface and 18 mm wood board. The surfaces of the 6 mm and 18 mm wood boards were also different when diameter of bullet exit hole were compared.

Keywords: Gunshot residue, bullet entrance, bullet exit

Introduction

Gunshot residue is vital evidence in the cases involving firearms. Gunshot residues found on scene could used to reconstruct the sequence of events in a firearm cases. Gunshot residue was also used to identify the entry and exit wounds, estimation of shooter distance, type of ammunition; trajectory of projectile and individual involved in the shooting incidents [1].

Gunshot residues are composed of burned and unburned particles which are propellant powder, particles of ammunition primer, smoke, grease, lubricants and metals from cartridge and from weapon itself [2-3]. The elements commonly found in gunshot residues are antimony (Sb), barium (Ba), and lead (Pb). These elements were used as indicator to detect the presence of gunshot residue on shot surface. Sodium Rhodizonate test was used to

identify lead contain in gunshot residue. This test will show positive result by changing colour from dark yellow to pink indicating the presence of gunshot residue where the lead comes from primer inside the bullet.

The presence of bullet holes is an important aspect in rearrangement of sequence of events at a scene. The shot wound on victim's body were used to determine wherever its entry or exit wound, direction of shooter, distance of shooter and type of projectile used to cause the wound [4]. The bullet holes on garment were influenced by the type of fabric. For instance, clothes made from neoprene will affect the size of bullet holes due to its ability to stretch according to the shape of body. The size of gunshot wound as a result of the entry and exit of the projectile from the target is influenced by factors such as the size of the bullet, bullet speed and elasticity of the targets [5]. The size of exit wound is larger than the

size of the entry wound may not be true [6] since it depends on the distance of the shot, calibre and type of firearm used [7]. The shapes of entry wound that form on the skin surface tend to be uneven because the bullet shape experiences changes during the process of leaving the target [8].

This study was carried out using tiles and boards of different thickness to observe the presence of GSR and the differences in diameter of bullet hole.

Materials and Methods

In these studies, three different surfaces were used as the target, namely the 6 mm wood, 18 mm wood and tiles of 76.2 cm width. The surface was labelled with firing number 1 until 10. The pre-labelled surfaces were brought to the target field in Mantin, Negeri Sembilan.

Sodium rhodizonate test was used to determine gunshot residues adherence on the surfaces. This test will detect lead residue presence by changing colour to pink when buffer solution was sprayed on the surface. The shooting was performed by officers from Malaysian Maritime Enforcement Agency (MMEA) using Glock type semi-automatic pistol with 9 mm metal jacketed bullet.

The surface was divided into four parts by drawing a line using a black marker pen. The surface was upheld at wooden bar prepared by MMEA. A 10 feet distance was measured from the shooter to the target as far as 10 feet. One shot were fired at each surface. The surface was then tested by spraying sodium rhodizonate solution for the detection of gunshot residues. Results were indicated by the colour change on the surface; all the test results were recorded.

Using an L shaped ruler sized 12" x 12", the entry and exit bullet holes created on the surface were measured. The images were also captured using camera which were subsequently used to measure the inner and outer diameter using Image J software. Data of entry and exit diameter of the bullet generated from Image J software was recorded. Finally, all data were analysed using the Statistical Package for Social Sciences (SPSS, 17.0 Edition). ANOVA and independent samples *t* test ($p < 0.05$) were performed.

Results and Discussion

Sodium rhodizonate test

Table 1 shows the presence of gunshot residue on nine tile surfaces, whereas no gunshot residue was detected on the surface of tile number 4, all wood boards 6 mm, and 18 mm.

Table 1: The presence of gunshot residue on different surface

Firing Number	Wood 6 mm	Wood 18 mm	Tile
1	No	No	Yes
2	No	No	Yes
3	No	No	Yes
4	No	No	No
5	No	No	Yes
6	No	No	Yes
7	No	No	Yes
8	No	No	Yes
9	No	No	Yes
10	No	No	Yes

The presence of gunshot residue on the surface is influenced by bullets used in this study. The 9 mm full-jacketed bullets contain high level of iron (Fe), and a lower level of zinc (Zn), copper (Cu), lead (Pb), barium (Ba), antimony (Sb) and nickel (Ni) [9]. The sodium rhodizonate test has low accuracy in detection of Pb as it also gave positive results when react with barium, cadmium, lead and silver [10]. Therefore, gunshot residue detected by positive colour change on the tile surface was due to the presence of other elements.

In addition, the direction and speed of the wind affects the results of the study. Wind causes gunshot residue leaving the fired weapon is not directed to the surface, this causes little or no gunshot residue to attach to the surface. Wong's study (2012) noted that wind reduced the gunshot residue attached to the surface of the pigs, and resulted in minimal discolouration, being observed using sodium rhodizonate tests [11].

Entry hole examination

There were difference in diameter of entry of bullet to tiles surface (mean: 3.60 cm), 6 mm wood surface (mean: 0.83 cm) and 18 mm wood surface (mean: 0.86 cm) (Figure 1). There was a difference in diameter of entry bullet hole's between tiles (mean: 3.60 cm \pm 0.62) with 6 mm wood and 18 mm wood using one-way ANOVA. However, there was no significance difference in bullets entry hole's diameter between 6 mm wood (mean 0.83 cm \pm 0.05) and 18 mm wood (mean: 0.86 cm \pm 0.03).

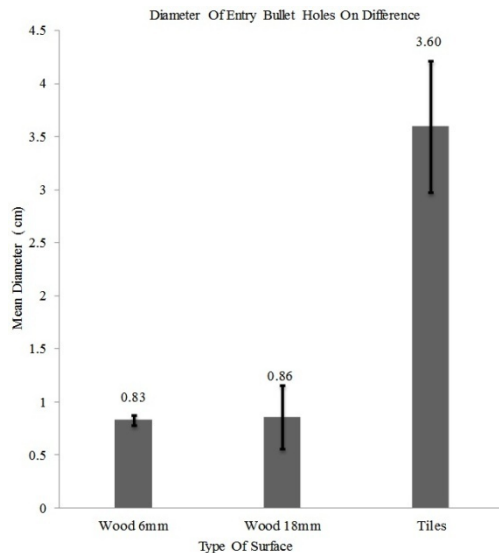


Figure 1: Diameter of entry bullet holes on differences surface

(Note: bar= standard deviation)

Shooting distance used in this study was 10 feet. The increase in distance caused the quantity of available gunshot residue on the surface to decrease. This is because the detection gunshot residue with sodium rhodizonate shots can only be used for a distance of 12 inches which yields a light little pink colour change. In distance above 12", pink colour gradually disappeared indicating decrease in the amount of lead on the surface [12].

The difference between the diameter of the bullet hole on tile compared to 6 mm wood and 18 mm wood was mainly due to cracked and broken tile surface when bullet penetrated the surface. This causes variation to the tiles surfaces where the same structure could not be formed after the shot and movement of the broken residues complicates the arrangement of the original position. On the other hand, the 6 mm and 18 mm wood contains mainly natural organic matter, namely cellulose which has high tensile resistance and its covered by lignin matrix which has natural ability to withstand compressive forces [13]. The surfaces of cracked and broken tiles have been less resistance to compressive forces when the bullet penetrates the surface. Meanwhile, the 6 mm and 18 mm wood have the tensile stress and their ability to withstand compressive forces increase. This causes the 6 mm and 18 mm boards to have the nearly same diameter as the bullet passes through the surface.

Exit hole examination

The exit hole of the bullet between 6 mm wood (mean: 0.96 cm) and 18 mm wood (mean: 1.93 cm) were found different (Figure 2). The independent *t* test showed there were differences between exit diameter of bullet holes between 6 mm wood and 18 mm wood. The test gave a significant value ($p < 0.05$). Thus, the average diameter of bullet exit holes for the wood surface 6 mm (mean 0.96 cm ± 0.31) showed difference where (confidence interval 95% = ± 0.33) with the surface of 18mm wood (mean 1.93 cm ± 0.381).

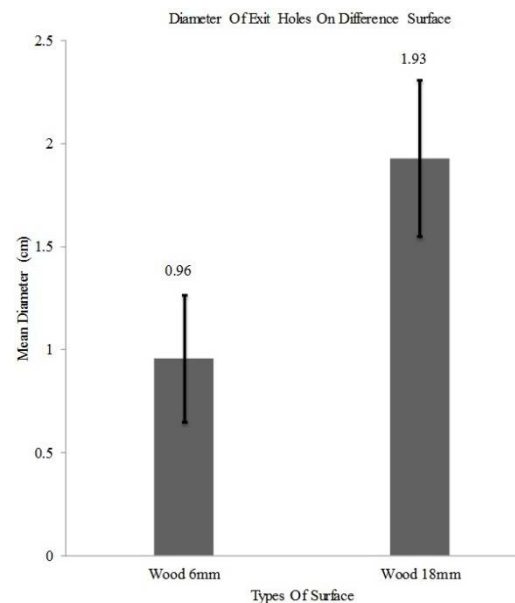


Figure 2: Diameters of exit bullet holes on differences surface

(Note: bar= standard deviation)

Thickness could be a factor affecting the difference in exit bullet holes. The surface of 18 mm wood was thicker than 6 mm wood, the resulting kinetic energy spread of the movement more ammunition scattered on the surface of 18 mm wood. Kinetic energy spread and expansion when the bullet penetrates the surface forms shape on the wood surface as it expands and larger diameter of bullet exit holes forms. In addition, the direction of the current bullet penetration to the surface affects the diameter of the bullet exit hole. This is because when a bullet was fired from different angles, the bullet could experience a drastic change in the rotation and cause the exit diameter holes of bullets to be different [11].

The 18 mm wood consists of many thin layers of wood bonded together with resin. When the bullet penetrates through the thick surface several layers of thin wood and resin, it will affect the spin and change the direction of rotation of the bullet from right angle to the acute angle. Therefore, the diameter of the bullet holes of 18 mm wood will be larger than 6 mm wood with a thinner layer of wood.

Conclusion

This study shows the presence of gunshot residue also affected by the type of bullet, distance of gunshot and chemical tests used to detect the presence of gunshot residue on a variety of surfaces. Therefore, forensic ballistics analysis shall take into account various factors when doing a gunshot residue examination, especially in detection of the presence of gunshot residue on the shot surfaces in the scene involving the structure of a building or home. In addition, variable surfaces yield different diameter of entry and exit holes due to the surface contains different material composition and arrangement. This provides different effects when the bullet passes through a surface.

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