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EXPERIMENTAL STUDY TO DETERMINE ANGLE OF FIRE ON SELECTED SOLID TARGETS BY 9MM SEMI-AUTOMATIC PISTOL

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ABSTRACT

Crimes involving the use of firearms represent a significant area of forensic investigation. In legal proceedings of criminal events that involve the use of firearms and ammunitions, the expert forensic officer should be able to produce crucial information to the court. The existence of bullet holes is a significant aspect in crime scene reconstruction. It is a terminal ballistics study using various solid targets. The study is aimed to conduct an experimental firing study by using 9 mm pistol fired on selected solid targets viz. plywood, ceramic tiles, glass plate, aluminium metal sheet and PVC sheet and examined the damaged characteristics. The range of firing was fixed as 10m in all shooting exercises. The shooting exercise was conducted at Sungai Buloh shooting range by trained firearms experts, Polis Di Raja Malaysia, Bukit Aman. Kuala Lumpur. The result of the investigation showed that the angle of impact is below 90 degree in all the targets.

Key words: Forensic science, firearms, 9 mm pistol, solid targets

INTRODUCTION

In the law procedure of criminal event that requiring the role of firearms and ammunitions, the expert forensic officer able to produce an important element as an evidence to the court of law for a legal view. In comparable condition, peculiar interest is normally attracted to an appraisal matter linked with guns and mutual clue like bullet holes impact morphologies (Romolo & Margot, 2010). An existence of bullet holes impact is a significant aspect in crime scene reconstruction of series of an event. It is shown that the diameter of exit wound holes is larger than the entry wound (Naik, 2011; Harshwardhan, 2016). Like blood pattern evidence, the reconstruction of shooting incidents relies on the certainty of trigonometric calculations combined with the intuition seasoned crime scene investigators and bring to the investigation. The circumstances and nature of violent crimes frequently produce a variety of bloodstains that, when carefully studied and evaluated with respect to their geometry and distribution, may provide information of considerable value to assist the investigator with the reconstruction of the scene (Stuart, 1991; Haag, 2006). In 1955, Dr. Paul Kirk of the University of California at Berkeley prepared an affidavit regarding his findings based upon bloodstain evidence to the Court of Common Pleas in the case of the *State of Ohio vs. Samuel Sheppard*. Dr. Kirk was able to establish the relative position of the attacker and victim at the time of the administration of the beating. He was also able to determine that the attacker administered blows with a left hand, which was significant in that Dr. Sheppard was right-handed. The angle of impact is the acute or internal angle formed between the direction of a blood drop and the plane of the surface it strikes (Stuart, 1991). The identifying directionality is blood droplets

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allow the analyst to more fully understand specific events that occurred during an incident (Tom & Ross, 2002). Dr. Victor Balthazard, and later Dr. Herbert Leon MacDonell, realized that the width-length ratio of the ellipse is the sine of the impact angle (Bevel, 2008). Accurate measurement of the stain thus allows easy calculation of the impact angle. The researchers have attempted to study the relationship between the distance of the gun and intended target using surface damage analysis (Nattapontangtawee *et al.,* 2015).

Firing a weapon produces combustion of both the primer and powder of the cartridge. The residue of the combustion products, called gunshot residue (GSR). Earlier researchers interested in the identification of GSR collected from the fired targets such as tiles and wooden boards. (Santos, 2014). The size of bullet holes on the targets are affected by various factors such as the caliber of the bullet, speed of bullet and elasticity of the targets (Denton, 2009). It is possible to determine the angle of impact from bullet holes by using the same trigo-nometric relationship between the major and minor axis of the observed bullet hole, as concluded by Balthazard for determin-ing the angle of impact for a blood droplet (Kenton & John, 2013). Hence the present study is aimed to determine the angle of impact from bullet holes fired with 9mm semi-automatic pistol on selected targets like plywood, glass panel, and aluminium sheet.

MATERIALS AND METHODS

The shooting experiment was conducted at Sungai Buloh shooting range, Selangor state by trained firearms experts, Polis Di Raja Malaysia, Bukit Aman. Kuala Lumpur. The target materials used were 3 numbers of 12mm plywood board (n=3), 14mm soda-lime silica window silica window glass panels (n=3), and 6 mm aluminum metal sheet (n=3). A 9 mm Springfield semi-automatic pistol was used for the firing experiment. The aforementioned ammunition was fired at a distance of 10m and three bullet holes were produced in each target medium with three sheets. The length and width of the holes were accurately measured using Vernier caliper. After the fire, targets like glass panel and plastic sheets have been broken targets and the broken pieces reconstructed to the original shape and made the measurement. The angle of impact can be calculated using the formula, Angle of impact (AOI) is the arc sin of width of bullet hole divided by its length. AOI = arc sin (w/l). The weight of the targets before and after the firing were also noted and recorded.

RESULTS & DISCUSSION

Figure 1 shows the illustrative example of length measurements of a bullet hole (Bevel, 2008) to determine the angle of impact. The angle of impact may provide a valuable information in identifying the directionality of the shooter in real crime scenarios. Figure 2 shows the entry and exit bullet holes in three plywood board fired by PDRM office in the shooting range. The targets were arranged as per the instruction of Police officer with range of firing of 10m. The three entry holes were measured and calculated the angle of impact using the stated formula. Table 1 shows the length and width measurements of the entry holes (in cm) after fired at a distance of 10m. The weight of the boards was recorded before and after firing the target which indicated the loss of weight. The angle of impact is ranged from 12º to 19º for three plywood boards. Figure 3 shows the entry and exit bullet holes in three aluminium sheets used as target material for

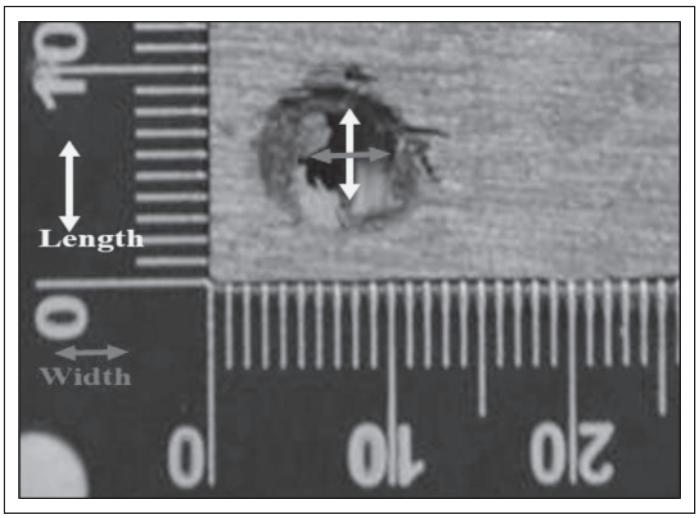

Fig. 1. Illustrative example showing the length and width measurements in an entry hole.

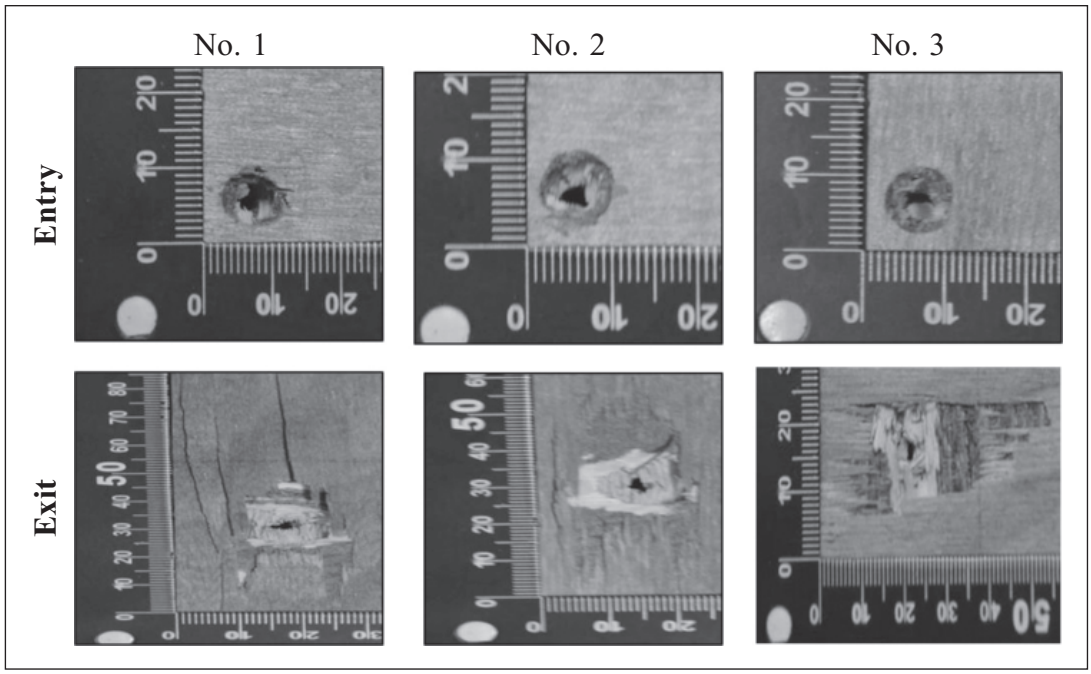

Fig. 2. Entry and exit holes on three samples of plywood.

Table 1. Descriptive statistics of measurements in length, width of entry holes, angle of impact, and weight of plywood boards before and after the shot

No.	Weight of the target (kg)		Length (mm)	Width (mm)	Angle of impact
	Before firing	After firing			
1	21.00	19.50	88.05	19.02	12°
2	21.00	15.45	61.55	20.34	19°
3	21.00	18.03	52.60	16.13	17°

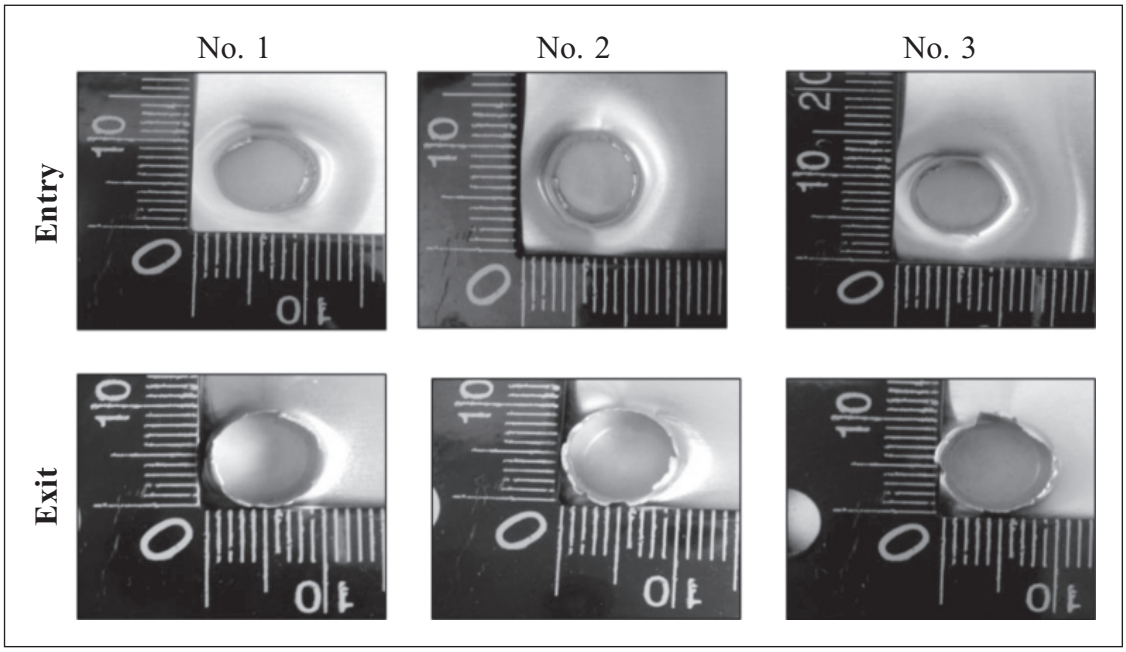

Fig. 3. Entry and exit holes on three samples of aluminium metal sheets.

the firing exercise in the shooting range. The range of firing is 10m and the entry and exit bullet holes are almost like circular because of strong metal sheet rather than plywood. The three entry holes were measured and calculated the angle of impact using the stated formula. Table 2 shows the length and width measurements of the entry holes (in cm) after fired at a distance of 10m. The weight of the aluminium were recorded before and after firing the target which indicated the loss of weight. The weight loss is comparatively lesser than plywood and because of the strength of the targets viz. metal is stronger than plywood. The angles of impact are ranged from 58º to 69º for three metal sheets.

Figure 3 shows the entry holes formed on glass sheets. The glass sheets that broken into pieces were reconstructed, and subsequently the entry hole was measured and recorded. Cases involving shooting through glass occur quite frequently (Mohan, 1963). One of the important problems that demands solution in such cases is the estimation of angle of impact. The result of the angle of impact can clearly provide an indication to the crime scene investigators. The shape of the holes are irregular unlike the entry holes observed in plywood and metal sheets. The entry holes were measured and determined the angle of impact. Table 3 shows the length and width measurements of the entry holes (in cm) after fired at a distance of 10m in glass panes. The weight of the glass panes was recorded before and after firing the target which indicated the loss of weight. The weight loss is about 50% in all three glass panes and this is because of fragile targets. Anyhow the reconstruction of glass is one of the forensic tool that can be used to measure the length and width and to estimate the angle of impact. The recorded angles of impact are 76º, 80º and 72º respectively for the three targets. Haag (2004) suggests that four basic substrate categories useful in considering the potential for reconstructive information from impact surfaces that include a) unyielding targets or surfaces such as concrete, stone tile, or steel plate, b) yielding / malleable surfaces such as sand, sod, asphalt, wood, or metal sheet, c) frangible, yielding surfaces such as cinder block, bricks or concrete and d) liquid surfaces, a homogenous yielding surface. In the present investigation, the shooting test was conducted by using malleable/yielding group targets (plywood boards, aluminium metal sheets) and non-malleable/unyielding group target (glass). The class and individual characteristics on test fired cartridge from ten pistols with consecutive serial number were shown that the individual characteristics within the firing impression, breech face mark of all ten pistols were found to be significantly different (Saribey, 2012). Also the reproducibility of fired cartridges was investigated for the purpose of identification. The result showed that fired cartridges cases can be used as a reliable means of identification (Mayland, 2012).

The aspect of target damage to fired projectiles can add a valuable indicator of the type of targets struck during the projectile's flight and usually confirms any trace evidence implanted in or adhering to the projectile's surface (Rathman, 1993). Based on the angle of impact calculation, it is found that all the angles of impact are below 90º in all

Table 2. Descriptive statistics of measurements in length, width of entry holes, angle of impact, and weight of three aluminium metal sheets before and after the shot

No.	Weight of the target (g)		Length (mm)	Width (mm)	Angle of impact
	Before firing	After firing			
1	500	485	23.53	22.01	69º
2	500	445	30.52	26.07	58º
3	500	465	32.65	29.63	65º

Table 3. Descriptive statistics of measurements in length, width of entry holes, angle of impact, and weight of three glass pans before and after the shot

No.	Weight of the target (kg)		Length (mm)	Width (mm)	Angle of impact
	Before firing	After firing			
1	2.00	1.00	33.92	32.09	76º
2	2.00	1.16	31.16	31.16	80º
3	2.00	1.18	59.74	59.74	72º

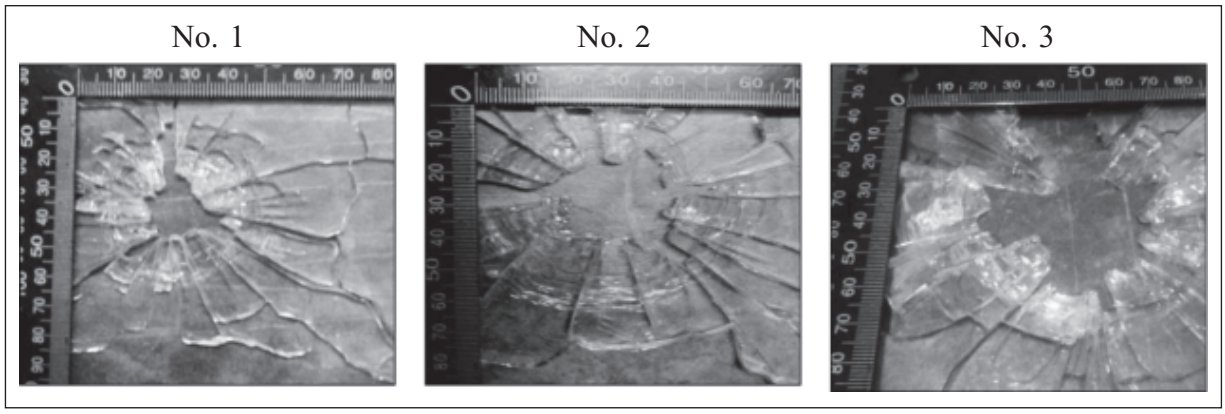

Fig. 4. Reconstructed the entry holes on three panes of glass sheets.

targets. The shape of the bullet holes on the targets may be oval or elliptical when the angle of impact is below 90º. The bullet holes on the target become circular when the angle of impact is 90º. In the present study all bullet holes are oval shaped and the exit holes are wider than the entry holes. From the size of the entry and exit hole, one can determine from which direction a bullet was shot. From the angle of impact, one can determine the position of the shooter. The angle of impact for plywood ranges from 12º to 19º, while aluminium sheet from 58º to 69º and glass from 72º to 80º showing the various position of the shooter.

CONCLUSION

Depending on the target media, the production of the bullet holes caused by the impact of the bullet may result in tearing and destruction of the target media because the original cross-sectioned spherical shape of the bullet may become deformed as the bullet distorts upon impact into the target. It is possible to determine the angle of impact from bullet holes by using the same trigo-nometric relationship between the length and width of the observed bullet hole, as concluded by Balthazard for determin-ing the angle of impact for a blood droplet. The relationship of determining the impact angle for bloodstains and defects created by bullets is the same.

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