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Analysis of Fracture and Gunshot Entrance Pattern of Skull caused by 0.22-caliber CZ 75 and 0.38-caliber Smith & Wesson

Bhoopesh Kumar Sharma[1], Mayssa Hachem[2], Sharmila Narayanan[3], Jenvita Castelino[3], Subbah Sharma[3] and Jacinth Simeon[4]
[1]Associate Professor, Department of Forensic Science, Amity University Dubai (Dubai), UAE.
[2]Assistant Professor, Department of Forensic Science, Amity University Dubai (Dubai), UAE.
[3] Forensic Science, Department of Forensic Science, Amity University Dubai (Dubai), UAE.
[4]BDS, PGDFO, PGDCR, North Carolina Dental Practice, Dubai (Dubai), UAE.

(Corresponding author: Bhoopesh Kumar Sharma)
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ABSTRACT: During shooting incident reconstruction, the assessment of the firing range and determination of entrance and exit wounds are critical. However, when the firing is done on a harder surface of the human body such as the skull, it becomes difficult for the forensic examiner and the ballistic expert to determine the range of firing and caliber of the bullet through the severity of the fracture of the skull. The fracture pattern of the skull depends upon a number of factors like site of the fracture, distance of firing, any intermediate target, type and nature of the projectile, etc. The present study aimed to investigate the fracture pattern on the imitated human skull using different types of firearms and ammunition at a defined firing distance. The firing was initiated using 0.22-caliber CZ 75, 0.38-caliber Smith & Wesson firearms. The range of firing was fixed to 10 meters. The frontal and temporal positions of the skulls were chosen for the study. The projectile impact ratio of length and width at the entrance wounds were studied and compared for both the firearms. There was no significant difference observed in the projectile impact ratio of the entrance wound of skulls fired with 0.22-caliber at the frontal and temporal position. However, due to the immense damage of the skulls shot by 0.38-caliber, we could determine the projectile impact ratio for only one skull fired at temporal position. Altogether, our findings provided a better understanding of the range of firing and firearm caliber through the fracture pattern on the imitated human skulls.

Keywords: Shooting incident, human skull, fracture pattern, projectile impact ration, range of firing, firearm caliber.

I. INTRODUCTION

In forensic investigation, during a shooting case, the first question to be answered is: “Who shot the firearm” or “Are we sure that the victim or the suspect actually fired the gun?”. The second point of evaluation is the distance of firing from the victim when the shot was fired. This distance between the point of departure from the muzzle of the gun and the point of explosion of a bullet is called as range of firing [1]. The range of firing is a primordial factor to be evaluated in forensic investigation of shooting cases. Determining the range of firing is possible if accurate photos, sketches, description of the injuries, the suspected firearm and the ammunition are available. Despite this, a number of factors can affect the determination of the range firing. Estimating the range of firing can help in reconstructing the events leading the shooting [2-4].

Another important factor to investigate in shooting incident is the evaluation of the amount and distribution of gunshot residues (GSRs) [5, 6]. Examining the gunshot wounds is also important in forensic ballistics. The physical characteristics of gunshot wounds rely on different elements and deposition of GSR. These consist of the firearm type, missile type, projectile velocity, range of firing, the effect of intermediary objects including clothing, and the site of the body where the individual was targeted [7].

However, when firing is impacted on hard surface of human body such as head, the medico-legal examiner and the ballistic expert will face difficulties in determining the range of firing and the caliber of bullets due to different fracture patterns of the skull. Hence, this study focuses on the importance of investigating shooting of human skulls in respect to forensic ballistics.

A number of researchers have studied different anatomy-morphological skull model to simulate features of real gunshot trauma to the cranium [8, 9]. Various approaches have been used in many studies to develop suitable skull models to simulate features of real gunshot trauma to the cranium. These include the use of post-mortem skulls, animal substitutes and synthetic material to mimic the gunshot head injuries. While animal substitutes have been considered, ethical constraints and diverse configuration have limited the use of such animal specimens.

Powell *et al.*, have used porcine skulls to conduct low and high velocity impact experiments to understand and predict fracture patterns on bone and sutures [8]. Current literature describes no good substitute, for experimental purposes, for human skin [9]. The researchers mainly attempted to assess fracture patterns by developing a prototype by 3D mapping of skull features [9]. This was done by comparing models made of different polymer constituents such as polyurethane material, and resultant skulls were experimented. In one research, when comparing the fracture patterns on blunt impacts between polyurethane skull representations and post mortem human specimen, found the patterns to be different [10]. Comparative skull simulations using finite element models in studies were realized by Matoso, R. *et al.,* (2014) [11]. The authors observed differences in the morphology of projectile wounds displayed by bullets of different calibers [12, 13]. Despite all researches in the forensic ballistic area, more investigation is needed to better understand the fracture pattern of human skull when fired in shooting cases.

The objective of the present study was to correlate the range of firing with the fracture pattern created on the artificial human skulls by using different types of firearms and different types of projectiles.

II. MATERIALS AND METHODS

A. Synthetic Human Skulls

A total number of twelve artificial human skulls were procured. These skulls were made up of polyresin, and are usually used in medical colleges for anatomical studies. The skulls' dimensions were 6.5-inches Long × 4.25-inches Height × 4.62-inches Width with a 0.2-inches Thickness. The skulls were fixed on stainless stands to avoid any movement and then were shot at the frontal and the temporal positions. All the skulls were shot from a fixed firing distance, 10 meters.

B. Types of Firearms and Ammunitions

All licensed firearms and ammunitions used for the experiments were provided by Sharjah Golf and Shooting Club in UAE for the purpose of study. A 0.*22*-caliber CZ 75 semi-automatic single action pistol and, 0.*38-caliber Smith & Wesson 686* Smith and Wesson revolver was used.

C. Experiment Setup

The polyresin skulls used in the present study were shot from a distance of 10 meters. The range of firing was kept constant to understand the difference in fracture pattern by using different firearms and ammunition. A small firing range of 10 meters has been chosen to maintain the accuracy. The skulls were targeted at two different positions: the frontal position and the temporal position as shown in Fig. 1 (a), (b). Once targeted, the skulls were photographed and the analysis of the fracture patterns of the skulls were realized using photo grammetry. The measurement of the entrance wounds, including the length and width, allowed the calculation and comparison of the projectile impact ratio of the skulls.

(a) (b)

Fig. 1. Artificial skulls used for forensic ballistic experiments. Two different positions of firing were chosen for the experiments: (a) Frontal position, (b) Temporal position.

D. Statistics

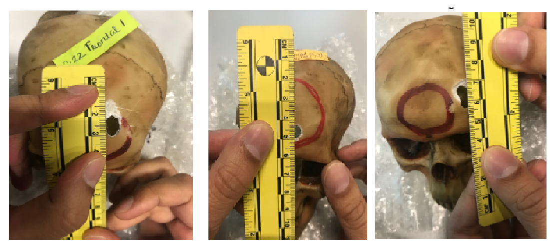
Results are means ±SD values of n = 3. Data with p value lower than 0.05 are different at $P<0.05$, according to the students test.

III. RESULTS AND DISCUSSION

For the analysis of the pattern injuries of skull by using two types of firearms and different calibers of ammunitions (0.22 and 0.38-caliber), two considered target positions of the skull (frontal and temporal) were chosen. After the firing, images were taken and dimensions of the injuries including the length and width of the entry point were measured to define the projectile impact ratio (Length/width).

A. Analysis of gunshot entrance pattern of skulls fired at frontal position with 0.22-caliber at 10 m firing range

Fig. 2 illustrated the gunshot entrance pattern of three skulls fired at frontal position with the 0.22-caliber CZ 75. The length and width of the entrance wounds were measured. These values allowed the calculation of the projectile impact ratio which was respectively (1 Fig. 2 (a), 1.143 (b) and 1 (c). The average value of the projectile impact ratio was 1.048 +/–0.039.



(a) (b) (c)

Fig. 2. Gunshot entrance pattern of three different artificial skulls fired at frontal position with 0.22-caliber at 10 m firing range.

Fig. 2 (a-c) shows respectively the measurements taken for the entrance wounds allowing the calculation of the projectile impact ratio for each skull.

B. Analysis of gunshot entrance pattern of skulls fired at temporal position with 0.22-caliber at 10 m firing range

To investigate the impact of the position on the pattern injuries, three skulls were fired with the ammunition .22-caliber but on the temporal position of the skull instead of the frontal one.

(a) (b) (c)

Fig. 3. Pattern injuries of three different artificial skulls fired at temporal position with 0.22 caliber at 10 m firing range. Fig. 3 (a), (b) (c) showed respectively the measurements taken for the entrance wound allowing the calculation of the projectile impact ratio for each skull.

Fig. 3 (a), (b), (c) showed respectively the pattern injuries of the three skulls fired at temporal position with 0.22- caliber. The dimensions of entrance wounds including the length and width were measured and the projectile impact ratios were determined.
When looking to the dimensions of the entrance wound and the projectile impact ratio of the skulls, we noticed that these ratios were respectively: 1 (Fig. 3a), 1 (Fig. 3b) and 0.875 (Fig. 3c) for the three fired skulls. The average value of the projectile impact ratio was 0.958 +/– 0.034.
When comparing the effect of the firing position on the entrance pattern by comparing the projectile impact ratio, no significant differences were observed between the frontal and temporal position when firing with 0.22-caliber. The p-value was 0.115 greater than 0.05. Data with p value lower than 0.05 are significantly different at $P<0.05$, according to the students test.

C. Impact pf the Type of Ammunition and Firearm on the fracture pattern

To study the impact of the ammunition and firearm on the fracture pattern of the skulls, we fired the skulls at frontal or temporal positions with 0.38-caliber, with three skulls for each position. Fig. 4 showed the pattern injuries of skulls fired at frontal position. The measurements for the entrance wounds were not possible due to the damage of the frontal part as shown in Fig. 4.

(a) (b) (c)

Fig. 4. The fracture pattern of three different artificial skulls fired at frontal position with 0.38-caliber. Fig. 4 (a), (b), (c) shows respectively the fracture injury for each skull.

To study the impact of the position, three skulls were used for studying the fracture pattern when fired at the temporal position with 0.38-caliber ammunition. We could measure the dimensions of the entrance wound only for one skull as shown in Fig. 5 whereas the other fired skulls had an immense damage of the skull reflecting the effect of the type of the ammunition on the fracture pattern. The projectile impact factor was 0.84.

Fig. 5. The fracture pattern of a skull fired at temporal position with 0.38 caliber.

The figure shows the measurements taken for the entrance wound allowing the calculation of the projectile impact ratio for the skull.

IV. CONCLUSION

In forensic ballistic investigation, determining the firing range is a very important factor. It becomes further challenging when the range of firing is other than the contact shot. Information about distances that a firearm was seized from a person when it was discharged could be a vital feature during investigations whether in suicide or homicide case [14]. A forensic ballistic examiner who knows the distance between the weapon and the victim, can answer queries concerning self-inflicted wound matters and self-defense statements. These knowledge’s can help in reconstructing the events leading the shooting [2].
The evaluation of the range firing is dependent upon different factors including the muzzle pattern, the ejecta inside the wound, the soothing patterns, the scorching, the gunshot residues GSR, the blackening, the tattooing, the metallic residues, the wad distribution(in cases of shotgun cartridges), the pellet pattern, the direction of wound, the injuries and the marks [5]. When exploring the GSR to find out the range of fire, firing distance estimation is based on the examination of the appearance of the bullet entrance wound as well as the examination of the GSR patterns around the wound. This can be accomplished by using various techniques including visual/microscopic test, color tests, instrumental analysis of bullet entrance hole and the GSR pattern around them. However, estimating the shooting range through GSR depends upon the type of firearm that is being used since there is a difference between the standard and the country-made firearms. The dispersion pattern of GSR can help in determining the distance of firing [15]. In criminal cases, only an approximation of shooting distance can be made through the GSR pattern. This can be done by firing the suspected firearm and suspected ammunition into a similar target with varying ranges. Thus, one can determine the range by comparing the questioned pattern to test fired target.
To better understand the fracture pattern of the human skulls in forensic ballistics, a number of researchers have developed skull models to mimic the features of real gunshot trauma. These include the use of post-mortem skulls, animal substitutes and synthetic material to mimic true to form gunshot head injuries [8, 9].
The objective of our study was to explore the fracture pattern injury of the human skull when exposed to a 10 m range of firing, using .22-caliber and .38-caliber firearm as mentioned. The aforementioned firearms have been selected for our experiment because these are readily available firearms and most commonly used in the commission of crimes especially homicides. The selected positions are most commonly targeted in criminal cases. When examining the fracture pattern of the skulls fired at the frontal position with 0.22 caliber, we observed that the three different fired skulls had almost a similar injury pattern at the entry point with a projectile impact ratio respectively 1, 1.14 and 1. These values showed the consistency of the impact of firing with 0.22-caliber firearm. The average value of the projectile impact ratio was 1.048 +/–0.039.

Then, to study the impact of the position, the fractures pattern of three skulls were examined when fired at the temporal position with same firearm. The projectile impact ratio was respectively 1, 1 and 0.875 with an average value of 0.958 +/–0.034. When comparing the effect of the firing position on the projectile impact ratio, no significant difference was observed between the frontal and temporal position when firing with 0.22-caliber.

In conclusion, this paper will add more knowledge about the fracture pattern on the human skull when fired with such types of firearms, ammunitions and at varying firing ranges. Altogether, our results will help the forensic examiner and the ballistic expert up to an extent during their investigations in shooting cases.

V. FUTURE SCOPE

Different perspectives can be proposed for this study. In the analysis of the fracture pattern, we focused on examining the entrance wounds of the bullets. The examination of the exit wounds is also crucial for better understanding of the impact of such ammunitions on the fracture pattern of the skulls [16]. Only reports findings with two ammunition type fired at 10 m distance were examined. Other weapon systems or ammunition types with different range of firing may be tested and can produce different results under the same experimental conditions. [17-18]. Finally, the artificial skulls used in our experiments can be replaced with artificial one filled with gelatin to mimic the human brain.

Conflict of Interest. No Conflict of Interest.

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