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Original Article

Determining the Gun shot Entry and-Exit wound on Skulls by using Post-mortem Computed Tomography Techniques

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ABSTRACT

Introduction: The identification of entry and exit hole on skull is not easy it needs precise and detailed examination. It depends upon the expertise of a forensic expert performing postmortem (autopsy) examination. The wound is usually determined by examining the characteristic features of entry and exit whole. The wound is usually measured by simple ruler by placing it next to the entry or exit wound after shaving the head. Post-mortem computed tomography technique develops a virtual 3Dimentional image of the skull. Hence in this study the entry and exit holes characteristics were easily differentiated. A digital autopsy 3D imagining technique used to differentiate between Entry and Exit wound on the skull without opening the skull and the results are accurate.

Objective: To differentiate between entry and exit wholes on skull by using advance 3D imaging technique.

Methods: A study was conducted in Forensic Medicine Department of Khyber Medical College Peshawar. 13 confirmed cases of gunshot wound in head were examined. In this study we used a Post-mortem computed tomography (PMCT) technique to make a three-dimensional image of the skull. As a result of this advance technique, examination of the skull has been improved with accuracy. The study design was a case control study that follows a group of victims who have a similar diagnosis i.e. gunshot injuries on head who underwent autopsy over a period of six months.

Results: The diameter of entry hole due to gun shot in skull is smaller than the exit hole, beveling of inner and outer table is also helpful in identification of entry and exit hole.

Conclusion: Post-mortem computed tomography (PMCT) technique develops a virtual 3Dimentional image of the skull which can help to give accurate dimensions of the wound. Furthermore, this technique can be used for digital autopsy conduction without opening of the body cavities. However, it is expensive and need specialized training.

Keywords: Gunshot wounds; Entrance hole, exit holes, skull injury, beveling, PMCT

Introduction

While performing an autopsy the real challenge for the forensic expert is to determine a difference between entry and exit hole. The size and shape of the entry and exit hole resembles closely as there is minute difference which cannot be easily differentiated by naked eye examination.[1] To give the description of such wounds medical knowledge of wound characters and practical field experience is required.[2].

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The entry and exit wound very closely resembles each other.[3] A digital three-dimensional imaging technique is very useful in creating virtual image of the skull with minute details of each entry and exit hole. In this descriptive study, we studied four characteristics of gunshot wounds on flat skull surface. These characteristics are the (a) clean hole diameter, (b) the chipping effect on the entrance hole, (c) the beveling effect and (d) the keyhole phenomena on the exit hole.

The morphology of the wound on skull depends upon the velocity of a bullet, type of weapon (smooth or rifled), distance of fire and the direction of fire.[4] The skull has two tables (surfaces) inner and external between which there is a spongy bone (Fig 1). In case of entry hole when bullet hits the skull, it makes a dent; the outer table depressed inward due to the

presence of soft spongy bone beneath. In contrary to this when the bullet touches the inner table which is not supported by a spongy bone it chipped off inward in brain. This phenomenon can be visualized only after opening and removal of soft tissue from the skull.[5]

Criteria for Entry wound/hole: In this study, description of gunshot entry and exit hole is discussed. There are four criteria's for describing the gunshot exit and entry wound in the skull.

Size: First, the entrance hole is usually smaller in diameter than the exit hole and shape maybe oval or circular depending upon the direction of impact. Second, the **chipping effect** is seen on both sides of the entry wound. The outer table is supported by inner table the chipping effect on the outer table is inverted.[6] The reason is that the inner table is not supported by the bony layer (table) and the bullet after passing through the spongy bone chip off the bony edges outward (into the cranial cavity). While examining the inner and outer table of entry wound an expert can measure diameter of the holes / wound with accuracy by using Vernier caliper. However, the insertion of Vernier caliper is prohibited into the wound it may cause deformity and contamination. In case of entry hole diameter of the inner table is more than the outer table. **Third, the opposite will be seen on exit wound**, the bullet strikes the inner table first, depressing the bone outward. The inner table is supported by outer table, but the outer table is not supported by any table. The bullet chips off the bone outward and the diameter of outer hole will be greater than the inner hole. Finally**, a key-hole shaped wound** of bone may be seen when a bullet strikes the skull from an angle, producing a sharp semi-circular edge at one end.[7]

These parameters are extremely helpful during autopsy to determine the entry and exit holes. In general routine the wound is grossly examined after the head shaved. The wounds were measured with the help of a ruler. Its dimensions length and width are noted in centimeters. There are certain loopholes in the measurements such as, 1) visual observation of a linear ruler (plastic or paper) for approximate measurements, which lacks accuracy, 2) close-up image details, and 3) 3D image for describing four conceptual principles mentioned above. A better method is much needed for the accurate measurement of both the entry and exit holes for accurate comparison of entrance-exit holes in situ position.[8]

Materials and Methods

In this study 13 skull were examined. There are 13 entry holes and 12 exit holes. The study was conducted at Khyber Medical College Peshawar. The study was conducted on cases of gun shot of various nature. Six cases were of suicide and in seven cases the victim was murdered from more than six feet. All the cases were examined with both conventional and handheld digital method. The handheld digital device captures images of the skull and convert all these images in a 360-degree 3D image. Amacro reverse imaging technology was also used for observing minute details. These digital scanning can be ranked as a near 3D image, providing the macro details, especially on a beveled portion[9].

Results

Thirteen skulls with exit and entry hole were examined both with digital viewer and still photographs were also obtained. The digital imaging magnifier has unique features. It can virtually make a 3D image of the whole skull with an ability to zoom in and out for better view (Fig - 3). The results showed clear differentiation of entry and exit holes as shown in (table -1)

Table 1. Difference between Entery & Exit Wound

Sr.#	Bullet	Entry hole Diameter (cm)		Exit hole Diameter (mm)	
	Diameter (cm)	Outer table	Inner table	Inner table	Outer table
ROUND ENTRY HOLE					
1.	-	0.92	1.13	1.03	1.44
2.	-	1.03	1.05	1.21	1.47
3.	-	0.99	1.06	1.31	1.73
4.	-	1.31	1.42	1.46	1.98
5.	0.9cm	1.39	1.55	-	-
6.	-	1.45	1.51	1.95	2.32
7.	-	1.47	1.57	1.49	1.89
8.	-	1.77	2.10	1.81	2.34
9.	-	1.81	2.05	2.07	2.45
10.	-	2.31	2.39	2.67	3.01
%		22.61%	24.77%	23.47%	29.15%
Sum		14.45	15.83	15	18.63
Avg		1.445	1.583	1.66667	2.07
KEYHOLE ENTRY HOLE					
11.	-	2.46	2.48	2.52	2.95
12.	-	2.47	2.62	3.71	3.77
13.	-	2.94	2.99	2.92	3.48
%		22.50%	24.11%	24.34%	29.06%
Sum		22.32	23.92	24.15	28.83
Avg		1.716923	1.84	2.0125	2.4025

The diameter of the bullet is always smaller than the corresponding hole in the skull. The results showed that the average diameter of the exit hole is always bigger than the entry hole. Similarly, the results of beveled outer table and inner table at entry hole showed that the average diameter of the inner table which is not supported by bony layer is greater than average diameter of the outer table. The inner table is not supported by the bony layer that's why it chips off and leave everted margins with greater diameter. There is only one case with no exit hole. The bullet recovered and the diameter of the entry hole was found bigger than the bullet diameter as shown in table -1.

Direction of bullet was determined by drawing a straight line between the two holes. **Shape:** The angle formed by the bullet when it strikes the skull defines the angulation and forms an elongated hole. The elongated hole was found in three cases with an average diameter of 1.71 cm which is much greater than average diameter of rounded entry hole 1.44 cm. In conclusion, the physical relationship between the two gunshot holes can be summarized as follows: The force of the bullet's entrance increases the intracranial pressure inside the skull, causing the pieces of bone between the radiating fractures to push outwards at the exit. Therefore, the exit hole is always bigger than the entry. The remains of the bone would be depressed inward; similarly, the chipping effect on the inner table was everted Fig-2.

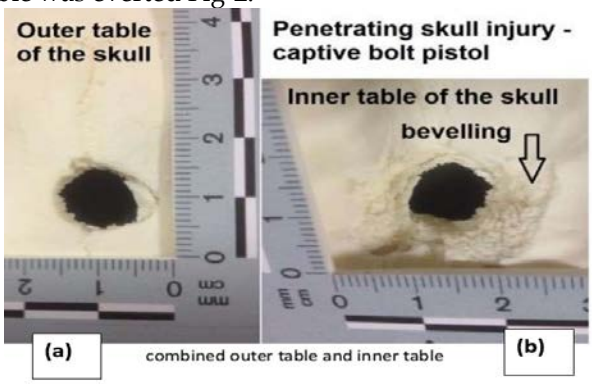

Fig-2: Combined (a) outer table (margins inverted) picture was taken from outside of the skull and (b) inner table (margins everted) picture was taken from inside of the skull during autopsy.

Figure 3(a,b) provides a quantitative foundation for entrance-exit hole determination. Of the two holes, exit holes often tend to be much larger than entrance wounds. **Figure 3 (c,d)** provides a near 3D image of the gunshot hole from the frontal skull, which is a circular hole with an opening at the right eye pocket.

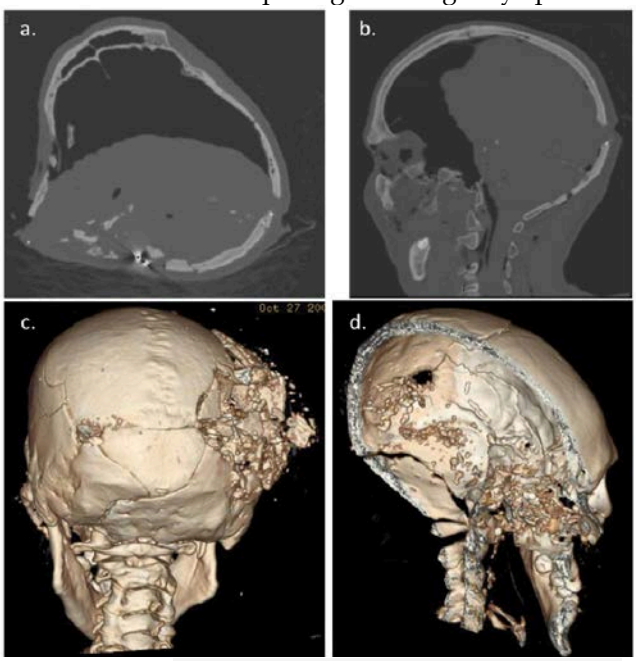

Figure -3(a) The entrance hole in the left parietal bone is well documented by characteristic beveling of the inner table (b) directed towards the inner cluster of bony and metallic fragments (c) Note the pushed-out bone fragments (d) On the exit wound in the right side of the skull, the bullet caused a large loss of brain, leading to a skull shattering

Discussion

The morphological analyses of gunshot holes/wounds on skulls remain a key component and unavoidable portion of the medical examination and crime scene investigation. In most of the cases the entry hole is associated with collar of abrasion dirt collar burning of skin, singing of the hair and inverted margins around. But it is not true in all cases. A researcher Dixon D (2012) observed that, in some cases the path of the bullet can be traced out by examining the carbon sooth particles within the skull. The 3D imagining technique results are extremely reliable and easy to interpret. These records can be presented in court for evidence. The three-dimensional picture also highlights the other features of the wound such as entry and exit hole.[10] Berryman H, Smith O, Symes S found that once the entry hole confirms it becomes easier to determine the manner of death weather homicidal or suicidal.[10]The 3D images with real time measurements at an in-situ position saves time and allow the forensic expert to determine the entry and exit without opening the skull.[11]The main disadvantage of this

study was that the results would be different in case of smooth bore gunshot wound or in case of De-shaped riffled bullet due to external ricocheting. It is recommended that further studies must be conducted to explore the scope of this technique to use it for autopsy purposes for the furtherance of justice.

Conclusion: Post-mortem computed tomography (PMCT) techniques develops a virtual 3Dimentional image of the skull which can help to give accurate dimensions of the wound. Furthermore, this technique can be used for digital autopsy conduction without opening of the body cavities. However, it is expensive and need specialized training.

Conflict of Interest: Authors declared no conflict of interest.

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CONTRIBUTION OF AUTHORS:

- Muhammad Yousaf participated in Conception, Study Designing, Planning Experimentation, Study Conduction, Analysis, Interpretation, Discussion and Manuscript Writing
- Ghulam Mohyuddin participated in Conception, Study Designing, Planning, Experimentation, Study Conduction, Analysis, Interpretation and Discussion
- Hidayat Ur Rehman participated in Experimentation, Study Conduction, Analysis, Interpretation, Discussion and Critical Review
- Faqirullah participated in Analysis, Interpretation, Discussion and critical review
- Tasneem Murad participated in experimentation, study conduction, analysis and discussion
- Sheeba Shabir participated in Conception, Study Designing, Planning, Experimentation, Study Conduction