Case Report

Journal of Forensic Chemistry and Toxicology
Volume 9 Number 2, July-December 2023
DOI: http://dx.doi.org/10.21088/jfct.2454.9363.9223.3

Postmortem Computed Tomography: A Supplant Technique to Autopsy for Firearm Injuries in the Head

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How to cite this article:

Karthi Vignesh Raj K, Abhishek Yadav, Sudhir K Gupta *et al.*/Postmortem Computed Tomography(PMCT): A Supplant Technique to Autopsy for Firearm Injuries in the Head/J Forensic Chemistry Toxicol. 2023;9(2):93–100.

Abstract

Background: Autopsy is more time consuming if the bullet/bullets are lodged at the difficult to access sites of the head especially maxillofacial regions. The procedure of suturing the deceased becomes even more difficult after the retrieval of bullets post dissection of facial tissues. The altered aesthetics psychologically and emotionally disturbs the already bereaved next of kin. The authors explored the utility of PMCT and propose a methodology of targeted dissection/minimally invasive approach to retrieve the bullet. The authors discussed the feasibility to conclude the cause of death in cases of single/multiple firearm injuries tothe head using PMCT alone.

Methods: The authors evaluated three cases of firearm deaths at a distance lesser than close range to the head. The deceased was subjected to PMCT scanning using a 16 slice Multi-Slice CT spiral scanner and findings were analyzed using the Vitrea software v.6.9.1 with the slice thickness ranging from 0.5mm to 5mm. A routine conventional autopsy was conducted post-scanning. Two of the three cases were suicide and succumbed to a single firearm injury while the third case was a homicide due to multiple firearm injuries.

Conclusion: PMCT alone can beutilized and relied upon in deaths due to a single shot to the head and suggest a combined methodology of PMCT evaluation and minimally invasive approach in cases of multiple firearm injuries for better correlation of wound track. Lastly, PMCT helped in a targeted approach to reach the in situ bullets more precisely than any other radiological technique which upholds the humanitarian forensic aspect.

Keywords: Firearm; Bullets; Wound Ballistics; PMCT; Autopsy; Minimal Invasive Autopsy; Head Injury.

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Received on: 10.07.2023 **Accepted on:** 30.08.2023

INTRODUCTION

Ballistics is a word derived from Greek, which means "the study of objects that are thrown and of their trajectories". The "fir earm" is a common term that means all processes related to the motion of a bullet. The field of forensic medicine is mainly concerned with a part of terminal ballistics referred to as wound ballistics which is concerned primarily with the effects of a bullet after penetration into a person's body.[1] Autopsy is a conventional

procedure for understanding the wound ballistics of the deceased who succumbed to gun shot wounds.[2,3] It is time consuming if the bullet/bullets are lodged at the difficult to access sites of the head especially maxillofacial regions. The procedure of suturing the deceased becomes even more difficult after the retrieval of bullets post-dissection of facial tissues. The altered aesthetics psychologically and emotionally disturbs the already bereaved next of kin, even though the autopsy surgeons try their best to restore the original look of the deceased.

Postmortem Computed Tomography (PMCT) has evolved as a promising tool in the field of forensic medicine in recent years.[4,5] The scanned images being highly objective has the ability to be as evidence post-cremation and answer most of the medicolegal queries by up holding the dignity of the dead. Several studies have proven that the diagnostic yield using PMCT increases, especially to detect fractures, hemorrhage, and gas collections, such as pneumothorax, pneumoperitoneum, and pneumocephalus which could alone be the cause of death in most man-made and accidental scenarios, when PMCT is considered as a screening technique prior to the conduction of an autopsy.[6-10] Considering the humanitarian forensic aspects, the authors explored the utility of PMCT and propose a methodology of targeted dissection/minimally invasive approach to retrieve the bullet. The authors discussed the feasibility to conclude the cause of death in cases of single/multiple firearm injuries to the head using PMCT alone and a combination of techniques as well.

Methods

The authors evaluated three cases of firearm deaths at a distance lesser than close range to the head. Two of the three cases were suicide and succumbed to a single firearm injury while the third case was a homicide due to multiple firearm injuries. The authors analyzed the efficacy of PMCT alone with the combination of both techniques to conclude the cause of death in the following cases.

PMCT Examination: All the deceased were subjected to PMCT scanning using a 16-slice Multi-Slice CT spiral scanner, Toshiba America Medical Systems, Inc Aquilion Lightning TSX-035A CT. Scanning parameters were 120kV and 70 mAs. 16 x 1 mm collimation was used for all the cases for data acquisition. The findings were analyzed using the Vitrea software v.6.9.1 with the slice thickness ranging from 0.5mm to 5mm. The reconstructions were performed in the soft tissue, bone, and lung window for the thorax (FC18).

The dissection procedure was carried out by three forensic specialists and included a detailed external examination followed by a complete internal examination. Virchow's & Ghon's Technique of dissection was performed in suicide cases where injuries were only to the head. However, all cavities were dissected even in cases where firearm injury was limited to head alone. The Letulle method (En-masse) of dissection was performed in the homicide case so as to interpret the wound track. A routine conventional autopsy was conducted post-scanning and wherever the bullets were insitu, PMCT scans were referred for the exact location of the bullets there by minimizing unwanted dissection of tissues.

CASE HISTORY

Case 1

Alleged history of self-inflicted firearm injury by a 30-year-old male using arifle.

Autopsy findings: An irregular bullet entry wound with an elliptical abrasion collar was present over the left temple region 6 cm below the left frontal eminence and 3.5 cm from the lateral end of the left eyebrow. Singeing of hair, blackening, and tattooing of skin were present (Fig. 1A, Yellow colored arrow shows the direction of bullet entry). Bevelling of the inner table of the skull is present underlying the entry wound (Fig. 1B). The track of the wound runs upwards, backward, and to the right and passing through the left temporal, parietal lobes, and right parietal lobe and exiting through the right parietal region of the scalp. A comminuted fracture is present involving the left tempo-parietal, frontal, right parietal, and occipital bones (Fig. 1C, yellow arrows mark the direction of the wound track). The comminuted base of skull fracture is present involving the bilateral roof of the orbit and the body of sphenoid bones. The entire wound track was hemorrhagic. Anir regularly shaped exit wound of size was present over the right parietal region of the scalp 3 cm from the parietal eminence (Fig. 1D). The exit wound was at a higher level than the entry wound. A Bevelling outer table of the skull was present underlying the exit wound.

PMCT Findings: The 3D volume rendered technique (3D VRT) of the skull showsa comminuted fracture surrounding the entry wound without artefactual displacement of fragments (Fig. 2A). The presence of Pneumocranium is seen and displaced bone fragments are noted in the parenchyma between the entry wound at a lower level on the left

temporal region and the exit wound higher level on the right parietal region. The direction of the track is depicted by the displaced fractured fragments from left to right (Fig. 2B). Yellow colored arrow denotes the direction of the pathway of the bullet. However, the wound track is not clearly seen due to the loss of parenchyma. The sagittal section of the Head and neck in the soft tissue window shows the presence of air in the spinal column from the head continuously at the cervical level (Pneumorrhachis) (Fig. 2C). The 3D VRT skull in skeletal filter shows the comminuted fracture of the right parietal region surrounding the exit wound without artefactual displacement of fragments (Fig. 2D).

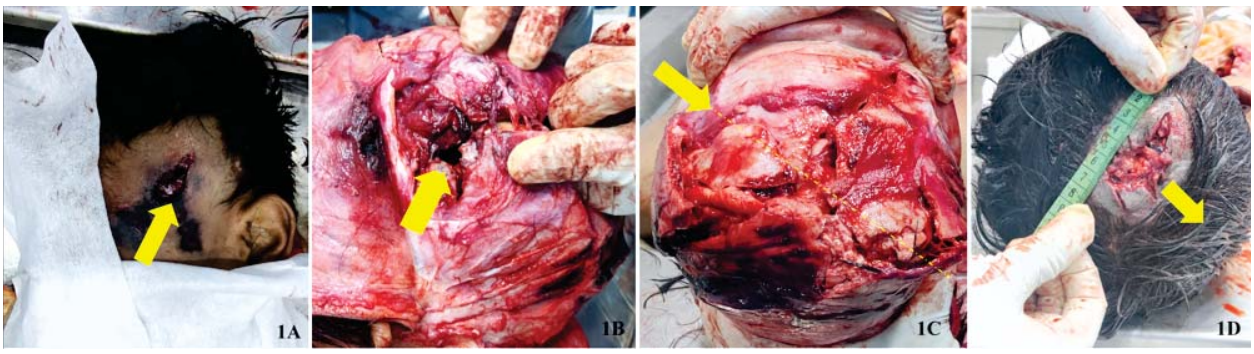

Fig. 1: *Case 1* Conventional Autopsy Findings

1A: Bullet entry wound over the left lateral forehead. **1B:** Communited fracture surrounding the stellate shaped defect. **1C:** Communited fracture seen from head end. **1D:** Bullet exit wound on right parietal region.

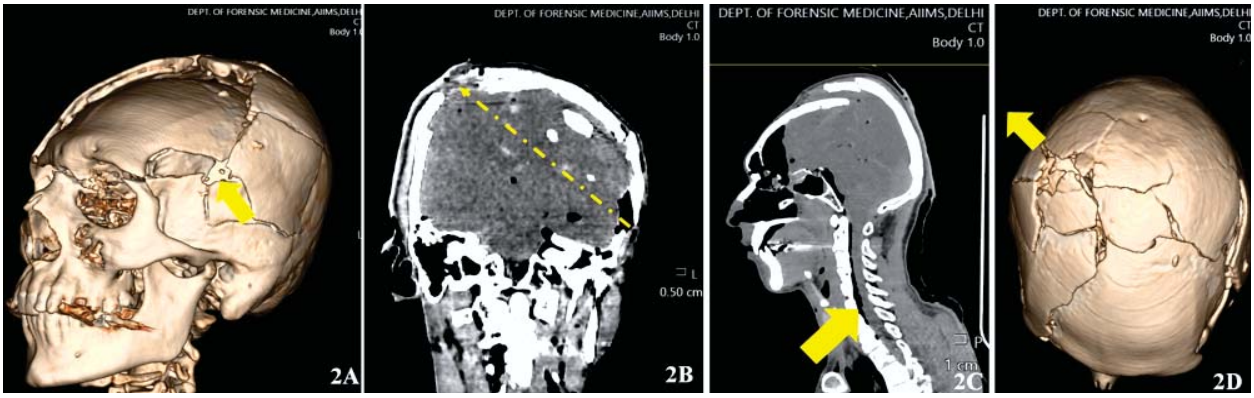

Fig. 2: *Case 1* Virtual Autopsy findings.

2A: Communited fracture surrounding the entry. **2B:** PMCT (coronal) head - Pneumocranium and displaced bone fragments. **2C:** Pneumorrhachis. **2D:** Communited fracture of skull vault along the direction of bullet.

Case 2

Alleged history of self-inflicted firearm injury by a 30-year-old male using a pistol. The room in which the incident happened was locked from the inside and he was last seen alive a few minutes back by his colleagues sitting in the living hall. He was declared brought dead and an autopsy was requested.

Autopsy Findings: An irregularly shaped firearm entry wound was present on the left temporal region, with an oval abrasion at the base suggesting muzzle impression with associated tattooing and singeing of the hairs (Fig. 3A, yellow colored arrow showing the direction of bullet entry). A bony defect with bevelling in wards was present on the left temporal bone surrounded by a depressed comminuted fracture involving the left temporoparietal region (Fig. 3B). Two linear fractures of lengths 15 cm and 9 cm are radiating from the bony defect and extend on the skull vault towards the right frontal and right occipital bones respectively. The above-mentioned comminuted fracture on the left temporoparietal region extends into the middle cranial fossa, as a fissure fracture involving the bilateral greater wing of the sphenoid through the pituitary fossa (Type I Base of skull fracture). The wound track

extends from the above mentioned entry wound in an upward and backward direction through a contused laceration of the left temporal lobe, left parietal lobe, bilateral lateral ventricles, and right parietal lobe of the brain (Fig. 3C). A stellate shaped firearm exit wound is present on the right parietal region (Fig. 3D). A bony defect is present on the right parietal bone measuring with everted edges surrounded by a comminuted fracture of the right temporoparietal region overlying the laceration on the right parietal lobe (Fig. 3E, Yellow colored circle denotes a mismatch between the autopsy image and PMCT image).

PMCT Findings: 3D-VRT shows the comminuted fracture surrounding the entry wound without artefactual displacement of fragments (Fig 4A). The presence of Pneumocranium is seen and the hyperdensity of brain parenchyma is due to hemorrhagic contusion along the wound track. The entry wound (left) and exit wound (right) both lie at the same level; the direction is depicted by the inward displacement of bone fragments near the entry wound and outward displacement near the exit wound. Yellow colored arrow denotes the direction of the pathway of the bullet (Fig 4B). The sagittal section of the Head and neck in the soft tissue window shows the presence of air in the spinal column from the head continuously at the cervical level (Fig. 4C). The 3D-VRT of the skull in the skeletal filter shows the comminuted fracture of the right parietal region surrounding the exit wound without artefactual displacement of fragments. (Fig. 4D)

Fig 3: *Case 2* Conventional autopsy findings.

3A: Entry wound on left temporal region. **3B:** Communited fracture surrounding the entry wound. **3C:** Wound track in brain parenchyma. **3D:** Exit wound on right parietal region. **3E:** Bevelled-out margins of exit wound.

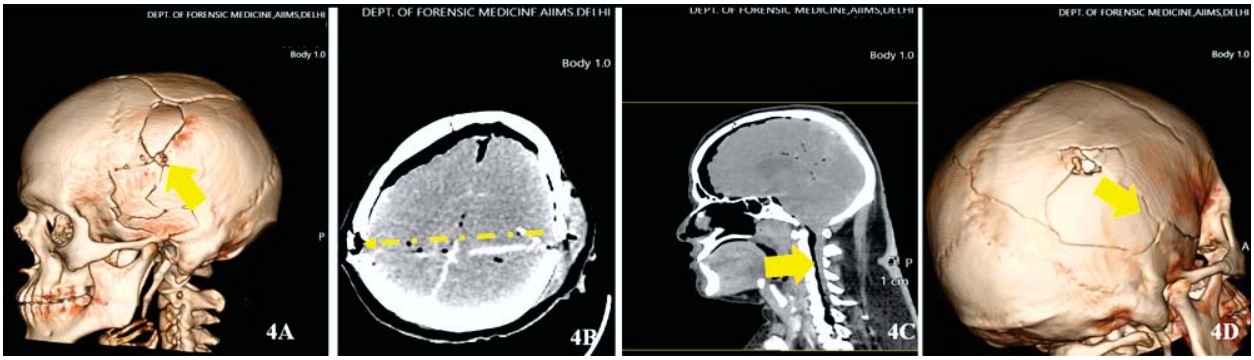

Fig 4: *Case 2* Virtual autopsy findings.

4A: Communited fracture surrounding entry wound. **4B:** Pneumocranium-anterior part, hyperdensity of brain parenchyma along wound track. **4C:** Pneumorrhachis. **4D:** Exit wound showing bevelled margins.

Case 3

Alleged history of the deceased being shot by multiple persons from multiple directions using country made guns.

Autopsy Findings: There were multiple injuries all over the body, only the injuries sustained to the head are discussed below.

- A bullet entry wound with irregular margins surrounded by an abrasion collar was present over the left occipital region, directed forwards medially and downwards (Fig. 5A, 1). The track passes through the left occipital lobe, and right temporal lobe and exits through the skull through an exit wound on the lesser wing of the sphenoid (Fig. 5B, yellow circle depicts laceration and yellow arrow depicts the bullet direction). The track ends below the scalp, a bullet was retrieved (Fig. 5C, 1).

- A bullet entry wound with irregular margins surrounded by an abrasion collar was present over the left side of the lower lateral face with associated tattooing on the skin surrounding the left ear (Fig. 5A, 2). The wound was directed medially upwards from left to right. The track passes through the ramus of the left side of the mandible making a comminuted fracture and then through the left maxilla further progressing through the right side of the maxilla. The track ends subcutaneously in the right zygoma area, a bullet was retrieved from the subcutaneous tissue just below the temporal process of zygomatic bone (Fig. 5D, 2).
- A bullet entry wound with irregular margins surrounded by an abrasion collar was present over the left side of the lower lateral face (Fig. 5A, 3). The wound is directed medially upwards from left to right. The track passes through the ramus of the left side of the mandible making a comminuted fracture, further progressing through the left maxilla, the right side of the maxilla with associated maxillary sinus fractureto exit through an exit wound in the maxillary areaof the right side of the face (Fig. 5 E, 3). The entire base of the brain had subarachnoid hemorrhage due to the effects of the bullet (Fig. 5F).

PMCT Findings: 3D-VRT of the skull in skeletal filter showed irregularly defined defects on the left occipital region and the left ramus of the mandible associated with the fracture due to the entry of a bullet (Fig. 6A) The coronal section of the PMCT head shows the presence of hyperdense objects confirmed as bullets due to high Hounsfield units (HU) at the subcutaneous plane on the right temporal region due to entry wound '1' and the second bullet underlying to right zygomatic process from the entry wound '2'. Yellow arrows show the tracks of the wounds '1, 2 & 3' (Fig. 6B). The sagittal section of the PMCT in the soft tissue window shows the non-continuous presence of air in the spinal column at the thoracic level (Fig. 6C).

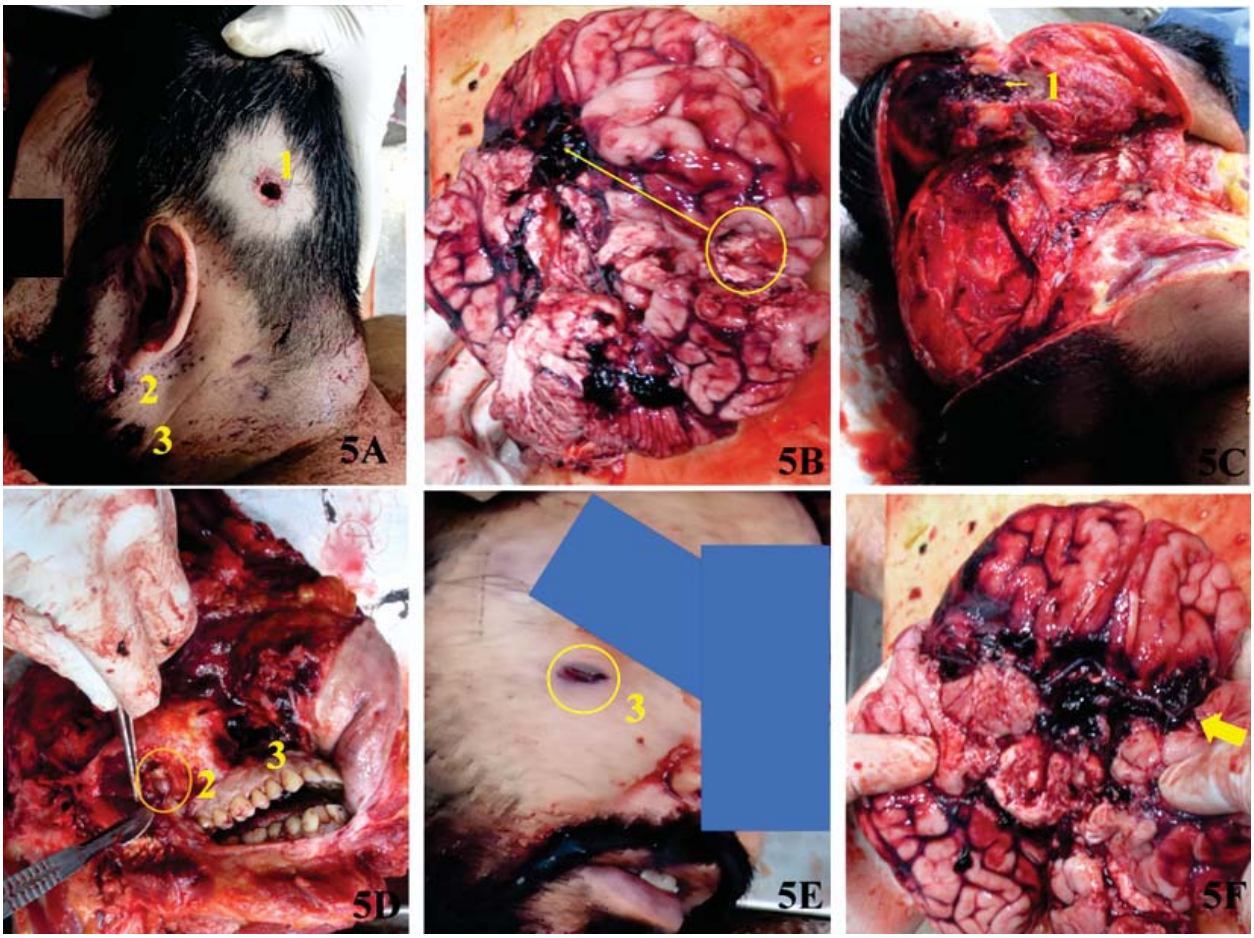

Fig 5: *Case 3* Conventional Autopsy findings

5A: Entry wound (1,2,3). **5B:** Laceration on left occipital region. **5C:** Insitu Bullet temporal region. **5D:** Fracture of right maxillary sinus. **5E:** Exit wound. **5F:** Intracranial hemorrhages on the base of skull.

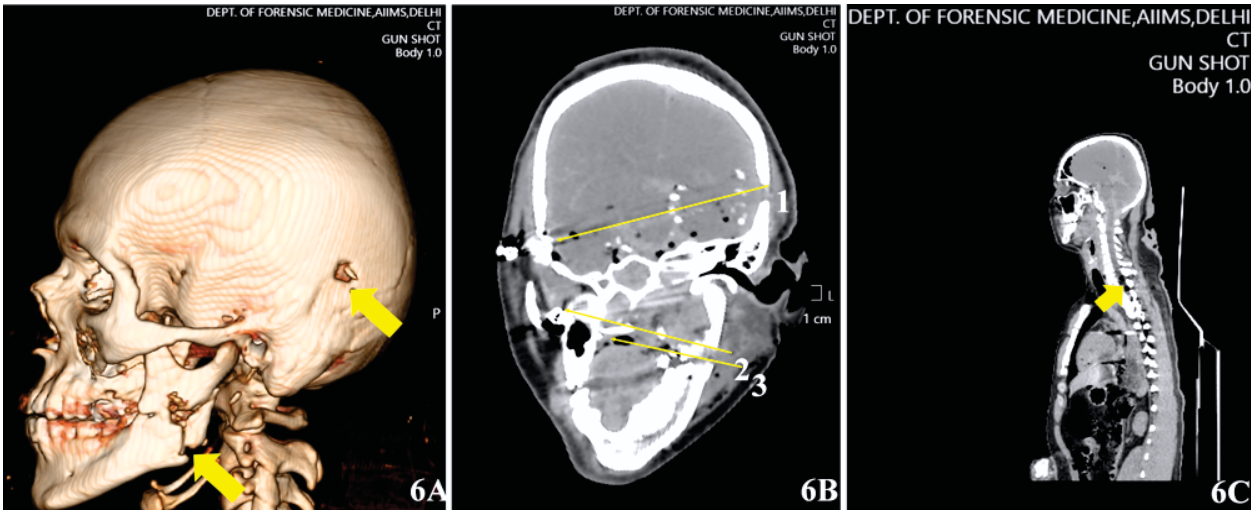

Fig 6: *Case 3* Virtual Autopsy findings.

6A: Entry wound on occipital region and mandible. **6B:** Foreign bodies at right temporal region due to entry wound (1) and under right zygomatic process from the entry wound (2). **6C:** Pneumorrhachis.

DISCUSSION

The current discussion related to firearms is not the first. Researchers had explored several aspects of PMCT and concluded that PMCT could be a good complementary tool for the determination of the cause of death and for localization and diagnosis of different types of lesions in gunshot injuries.[11-14] The authors with the help of these cases would like to compare the utility of PMCT in a single gunshot and multiple gunshots to the head region. The entry wound was present on the left side of the head in both suicide cases. In the first case, the room in which the incident happened was locked from the inside and he was last seen alive half an hour back by his colleagues during dinner. Upon breaking open the room, the deceased was lying on his back with his left upper limb crossing his body at the chest level holding the barrel of the rifle pointing towards his shoulder. The right hand was in an extended position with the presence of a cadaveric spasm in the triggering position on his right hand. It was concluded from the crime scene that he was sitting on the cot near by while performing the act of triggering, following which he fell down from the cot. There was the presence of shattered cement from the roof at places over his body and floor. An empty cartridge and a fired bullet were found inside the room. The cadaveric spasm in addition to the crime scene images helped in concluding the case as a suicide. In the second case, the muzzle imprint was at the entry wound on the left side. It was confirmedin the investigation that the deceased was ambidextrous in handling the pistol. There were no other external wounds over the body other than the entry and exit. It was correlated from the history and confirmed by external examination at autopsy that a single firearm was fired. The role and advantage of PMCT in these types of cases is to document the internal findings in a detailed manner. In the authors' experience, using PMCT.

- The entry and exit wounds can be confirmed by the direction of displaced fragments and can be precisely measured.
- The comminuted fractures of the vault were exactly seen devoid of iatrogenic artifacts.
- The level of entry and exit was accurately seen which helps in correlating the wound track externally.
- Internally the wound track was interpreted by the presence of hyperdensity suggestive of hemorrhage along the lacerated parenchyma in the brain.
- Lastly, PMCT had the benefit of witnessing air inside the cranial cavity (Pneumocranium) and air inside the spinal canal (Pneumorrhachis) which is not possible by the conventional autopsy.

The third case was a case of homicide due to multiple firearm injuries from multiple directions. It was noted from the CCTV videos, the range was a close range shot to the face fired by the same individual multiple times. The challenge faced here was to identify the track and retrieve the insitu bullet from the face. The X-ray is highly efficient in demonstrating the presence of a bullet inside the body but is not as equally efficient as PMCT. The reason being the difference of planes the exact

location is difficult to understand and approach in dissection.The authors felt that even though PMCT alone is considered highly efficient in single firearm cases to head, it was difficult alone in PMCT aloneto handle multiple firearms to head. The reason was the abnormal positioning of the hefty deceased and the development of rigor mortis. In this scenario, there would be multiple fractures and mispositioning would create additional queries while correlating the wound track. Therefore, we suggest a combined approach of minimal dissection together with the correlation of the findings seen to interpret the track.

Hence, the authors propose the following methodology in cases of single firearm wounds which would answer all the medicolegal queries.

- A proper history needs to be elicited from the investigation officer.
- A thorough external examination must be conducted to rule out any other injuries.
- Collection of required evidentiary material collections like Nail clippings, Gun Shot Residue (GSR) collection in the form of swabs from hands and wounds, peripheral blood, vitreous humour, or cerebrospinal fluid as per need and protocols.
- A complete screening of PMCT images for the presence of foreign bodies like a bullet.
- A minimal targeted dissection if the bullet is present inside the body and if the bullet is not present the dissection could be curtailed.

CONCLUSION

The authors briefly conclude that the PMCT alone can be utilized and relied upon in deaths due to a single shot to the head. PMCT identified the exact location of the bullet in the subcutaneous tissues of the head and underlying the zygomatic process. It has the ability to preserve the altered anatomy of the disrupted skull post-bullet entry and exit there by avoiding artefactual fracture interpretation. The wound tracks in the head could be interpreted at PMCT by the presence of the displaced bone fragments, hemorrhage along the disrupted parenchyma together with the presence of air along the track in cases of single firearm shot. We suggest a combined methodology of PMCT evaluation and a minimally invasive approach in cases of multiple firearm injuries to the head for better correlation of wound track as it would be difficult on PMCT alone due to postmortem changes. Lastly, PMCT helps in a targeted approach to reach the insitu bullets more precisely curtailing unwanted dissection than any other radiological technique which up holds the humanitarian forensic aspect.

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