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Case review

The mechanism of the keyhole lesion reassessed: An experimental approach

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ABSTRACT

The initial description of the keyhole defect was detailed as a peculiar gunshot entrance wound in the cranial vault due to firearm discharge in a tangential path. This injury may be described in two parts: a rounded section with inner table beveling and a triangular section with outer table beveling.

We report a case of a gunshot skull wound "keyhole" shaped, appeared to have been made perpendicularly to the bone. Performing an experimental study on cranial bones with shots made perpendicularly to the skull approved this hypothesis, and bone injuries were then architecturally characterised using high-resolution micro computed tomography.

The singular link between the tangential gunshot path and the keyhole pattern has been refuted several times, and some authors have hypothesised that there is an important role for concentric fractures that occur far away from the initial impact point of the bullet. Micro computed tomography analysis of the bone showed these keyhole defect features with a particular high description. Then, the whole pattern has a spider-web effect, and these concentric fractures could explain the keyhole pattern even in a perpendicular gunshot path.

1. Introduction

Spitz and Fischer first described the classical gunshot keyhole wound in forensic anthropology.[1] This initial observation was described as a peculiar gunshot entrance wound in the cranial vault due to a firearm discharged in a tangential path. This injury can be described in two parts: first, a rounded section, with inner table beveling, and second, a triangular section, with outer table beveling in the cranial vault (Fig. 1). Spitz and Fischer described the rounded part as the "entrance" and the triangle part as the "exit", and they implied that the bullet entered and exited (totally or partially) the vault in a tangential path.

After this historical description, several scientists quoted the gunshot keyhole wound in forensic literature describing the cranial vault and sometimes for long bone.[2–7] However, Spitz and Fischer described the keyhole gunshot wound as a tangential path; this anthropological injury was sometime interpreted a gunshot entrance or exit wound.[4,6] Consequently, the injury mechanism of the keyhole gunshot wound is not unique in the scientific literature.

We report an original case of a double firearm shot in the cranium with a keyhole entrance gunshot wound in a perpendicular path. This case is highlighted by a theoretical physical description of the keyhole gunshot wound mechanisms, a review of the literature, and above all, by a micro-computed tomography study of the keyhole gunshot wound that specifies the mechanism of injury.

2. Forensic and experimental case reports

2.1. Forensic case report

An unresponsive 71-year-old man was found at home by his daughter. The body was seated on a chair in a locked, secured and clean home (in the garage), with a farewell letter discovered on a table (Fig. 2). Two guns were found near the cadaver. A 22 LR replica of a semi-automatic gun was on a table in front of the corpse, and a 22 LR replica of a revolver was on the floor on the left side of the cadaver.

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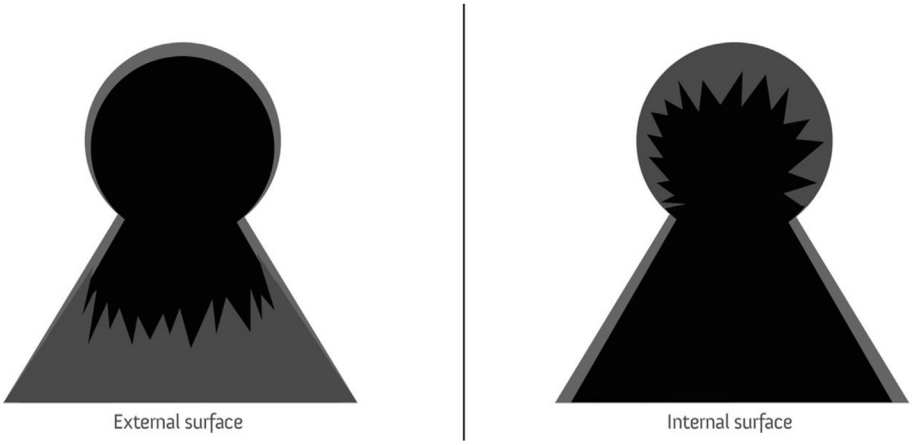

Fig. 1. Keyhole pattern with an outer bevelling in exo-cranial view (left side) and an inner beveling in endo-cranial view (right side).

Fig. 2. Crime scene with two guns discovered (sign 1 and 2).

Digital radiography showed two projectiles located in the cranium. An autopsy revealed two gunshot trajectories (Fig. 3). The entrance wounds exhibited specific contact range features (a firearm barrel print on the skin, abrasions and skin burns), and pathological examinations showed burns and black steel or powder sediments that confirmed the contact range pattern.

2.1.1. First bullet trajectory

This 1st gunshot entrance wound was located on the left temporal skin area, above and to the back of the left ear (17 cm distance between this wound and an anatomical median line). It was circular, with a 0.7 cm diameter. Under the skin defect, the bone entrance wound was circular and measured 1 cm in diameter. The wound had inner beveling. This 1st bullet was found in the right temporal brain area, and it appeared to have been made perpendicular to the bone in a left to right direction.

2.1.2. Second bullet trajectory

The 2nd entrance gunshot wound had an oval skin shape of 1 × 0.8 cm, located 11 cm on the right side of the mid−sagittal plane, above and in front of the right ear auricle. Under the skin defect, the bone entrance took the shape of a “keyhole lesion” and consisted of two parts: a rounded portion measuring 0.6 cm in diameter and a triangular portion measuring 0.7 × 1.3 cm (Fig. 4). This bone entrance had internal beveling on the rounded portion, while the triangular portion showed slight external beveling, particularly on the lower portion. The brain parenchyma was crushed and shredded in the right temporal area, and the bullet path extent into the third ventricle and then into the left temporal area. In this area, we noticed a bone exit wound that demonstrated typical external beveling who was located near the 1st entrance gunshot wound previously described. A damaged bullet was highlighted under the scalp skin, without an exit wound through the skin. Therefore, the shot appeared to have been made perpendicular to the bone in a right to left direction.