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Radiological findings in gunshot wounds caused by hunting ammunition. An experimental study

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Abstract Experimental gunshots were made with hunting ammunition using a dummy model made of skin and foam rubber as the target. After penetration of intermediate targets of wood by the bullets, the characteristics of the wounds changed and their dimensions increased. The morphology of the wounds presented a very varied spectrum. When the gunshots had initially passed through wood 50 mm thick, radiographs of the skin showed a quantity of metallic residues of between 10 µm and 1 mm. The metallic particles were wiped off the surface of the projectile by the target itself, whereby the best "wipe-off effect" was achieved with skin. The experimental findings suggest that the formation of the fine metallic residues is analogous to the development of the bullet wipe formed by lead bullets. Larger fragments flew into the target independently of the bullet and depending on the distance between the intermediate and final targets. A case example is documented.

Key words Skin · Wound ballistics · Intermediate target · Gunshot residues · Hunting ammunition · X-ray · Image analysis

Introduction

The reason for the research described was the unfortunate death of a man who was accidentally shot by a hunter from a distance of about 30 m while walking in the forest. The weapon concerned was a rifle produced by Blaser, and the ammunition used was 7 × 65 R of the "Nosler" type produced by Hirtenberger. To prove that the shot was really fired from the assumed distance, the clothing and skin were radiographed (Böhm et al. 1969; Stone and Petty 1991; Schyma 1995). The victim's polyester jacket did not show any traces of gunshot residues, and even the edges of the entry hole in the jacket, which measured 8 mm × 15 mm, were free of black discoloration. However, the entrance wound, which was situated under the right costal arch, had an unusual form, with a diameter of 12 mm and a serrated edge. Unexpectedly, it contained many metallic fragments of different sizes (Fig. 1). We were endeavoured to find out where the metallic residues had come from. Backspattering was excluded, because the ribs under the entrance wound were not fractured. Systemic experiments were conducted to elucidate the problem.

Materials and methods

The weapon used for the experiments was a rifle produced by Merkel, calibre 7 × 65 R, with a barrel length of 65 cm. The test

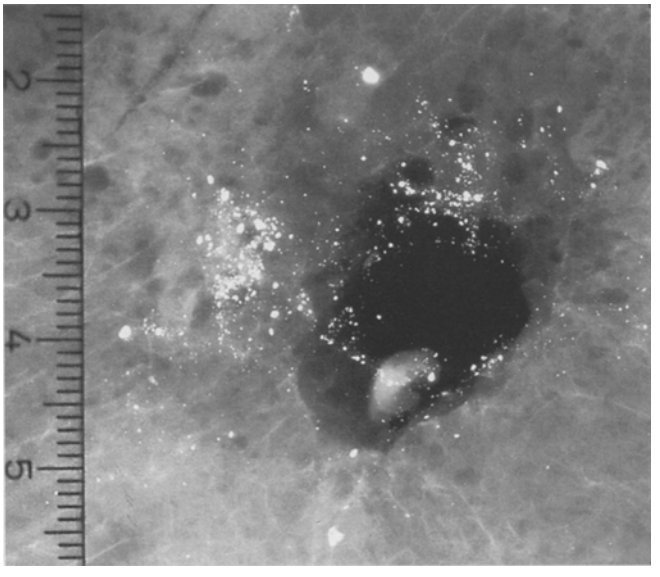

Fig. 1 Case example. Radiograph of the entrance wound

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Table 1 Characteristics of the test ammunition (*RWS* Rheinisch-Westfälische Sprengstoffwerke, Germany, *KS* Kegel spitz, *TIG* Torpedo Ideal Geschoß)

Manufacturer	Calibre	Type of projectile	Nose shape	Weight	Velocity v_0	Diagram of construction
Hirtenberger[a]	7 × 65 R	Nosler	Cone	11.3 g 175 grains	785 m/s	
RWS	7 × 65 R	Semijacket	Rounded	11.2 g 173 grains	770 m/s	
RWS	7 × 65 R	H jacket	Hollow point	11.2 g 173 grains	830 m/s	
RWS	7 × 65 R	Brenneke TIG	Cone	10.5 g 162 grains	870 m/s	
RWS	7 × 65 R	Brenneke TIG	Cone	11.5 g 178 grains	820 m/s	
RWS	7 × 65 R	KS	Pointed cone	10.5 g 162 grains	860 m/s	

[a] Hirtenberger, Austria

ammunition, i.e. bullets of calibre 7 mm, is shown in Table 1. The firing distance was always 25 m. The target was composed of a piece of pig skin (20 cm × 20 cm) and a block of foam rubber. The skin was fixed tightly over the foam rubber by eight pins (Fig. 2). In the first series, direct gunshots were fired at the targets, while for the second series of gunshots a plank of wood 25 mm thick was placed 3 m from the target. Each plank was used only once. The marksman had to aim at the plank and to hit the target behind it. In the third experiment the 25-mm-thick plank was replaced by one 50 mm thick. For the last experiment, the 50-mm-thick plank was placed 6 m from the target (Fig. 2). The skin and the block of foam rubber were radiographed with a microfocus tube by 30 kV X-ray.

Results

The direct gunshots did not show any particular findings. The entrance wounds measured between 5 mm and 7 mm and the edges of the wounds were always smooth. Through X-ray the bullet wipe was easily discernible as a fine metallic ring but no other traces of metal were found.

With interposition of the 25-mm plank the characteristics of the wounds changed distinctly. The diameter of the lesion was always larger than 7 mm, the calibre used. A few bullets were recovered, the front parts (nose) of which were deformed. Radiography revealed fine particles of metal in the region of impact. A few larger fragments (up to 1 mm) were detected up to 10 cm from the point of impact. The angle of bullet deflection was between 1° and 2°, which caused a deviation of between 50 mm and 100 mm from the desired centre of target. The most significant differences in the wounds were observed after the penetration of the 50-mm-thick plank of wood. The KS bullet caused the only circular entrance hole with a diameter of 13 mm (Fig. 3). The edges were finely serrated and powdered with black particles. The other types of bullets left much larger entry holes, with diameters of up to 25 mm and with various forms; some were shaped like figures of eight, some B shaped, some keyhole shaped (Fig. 4) and some banana shaped. In all cases, the edges of these entrance wounds showed pennon-shaped irregularities and black discoloration. Most of the TIG bullets disassembled into two parts, which hit the target at a distance of about 75 mm. Both wounds had finely serrated, blackened edges and were 12–13 mm in diameter (observed at a distance of 3 m between intermediate and final targets). The radiographs revealed a great many metallic particles arround the entrance wound (Fig. 5). Further radiographs were taken in two planes, in the direction of firing and verti-

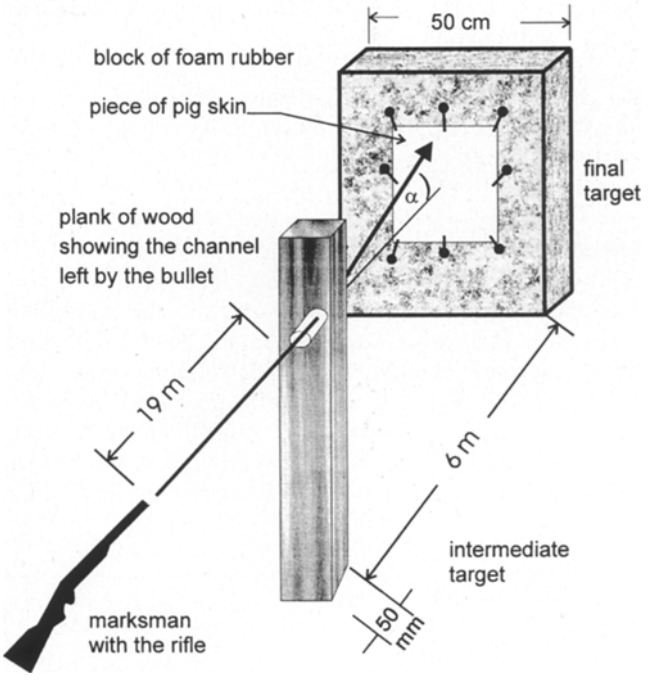

Fig. 2 Sketch of positioning for the experiments (α angle of bullet deflection)

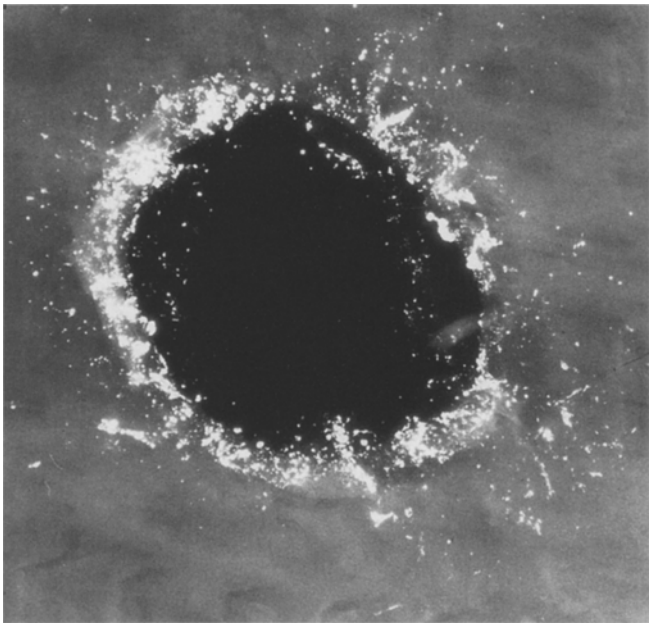

Fig. 3 Radiograph of the pig skin. Entrance of a KS bullet after penetration of wood 50 mm thick. Inner diameter 13 mm

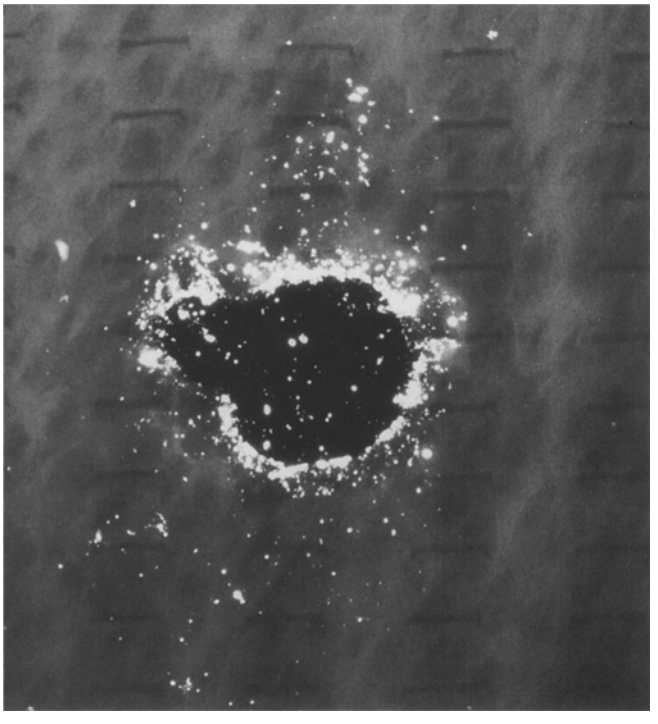

Fig. 4 Radiograph of the pig skin. Entrance of the H-jacketed projectile after penetration of wood 50 mm thick, measuring 12 mm × 17 mm

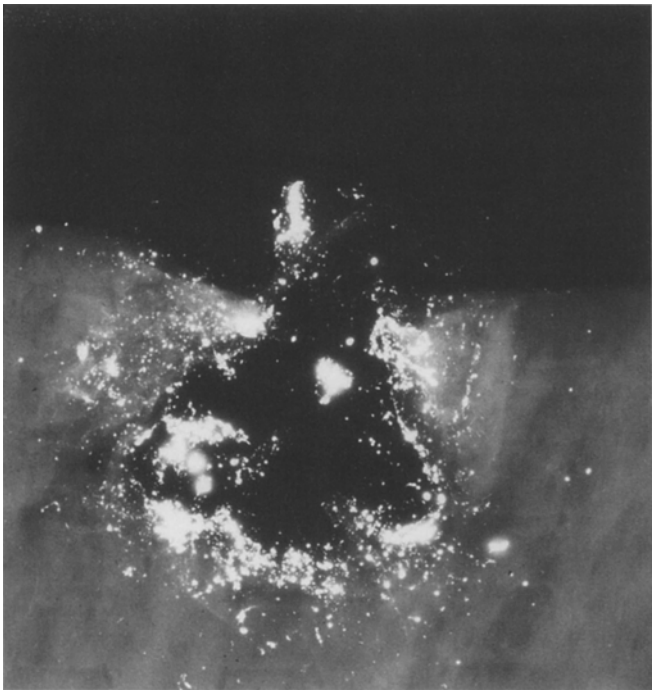

Fig. 5 Radiograph of pig skin and foam rubber. Entrance of the 11.5 g TIG projectile after penetration of wood 50 mm thick. The *black background* is the foam rubber. Largest diameter 17 mm

Fig. 6 Nosler bullet recovered in the cotton wool filled butt after penetration of 50 mm thick wood. The nose *(left)* is destroyed, and the jacket peeled back

cally to the direction of firing. Their analysis confirmed the presence of metallic traces over and under the skin. Figure 6 shows a Nosler bullet recovered from the cotton wool filled butt after penetration of the 50-mm wooden plank. The upper part of the projectile was completely destroyed, and the jacket was peeled back into pennons.

The last series of experiments (6 m distance between the plank and the final target) was the most difficult to realize because the angle of deflection of the bullets was 2°–3°. In most cases, the deviation from the centre of the target was more than 25 cm. Consequently, approximately

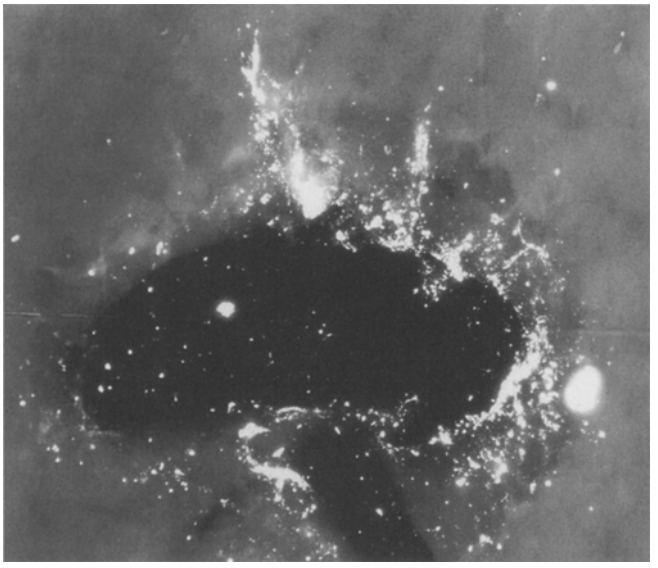

Fig. 7 Radiograph of the pig skin. Entrance of the Nosler bullet after penetration of wood 50 mm thick. Note the radial metallic stripes. The wound measures 8 mm × 18 mm

70% of the gunshots did not hit the 50 cm × 50 cm butt. At a distance of 6 m between the targets, particles were present only in the direct area of the entry hole. In the case of the TIG bullets, there was 125 mm between the impacts of the fragments. The X-ray analysis showed similar impacts with a large amount of metallic residues (Fig. 7), but the traces were concentrated around the entrance wounds. The largest particles measured up to 2 mm, and the finest dust only 10 μm.

Discussion

Examination of gunshot residues with high-resolution radiography (Bajanowski et al. 1991; Schyma 1995) has the great advantage of showing up not only primer residues, but also metallic particles of any other origin, in such a way that their form and distribution can be recognized. In the present case, this made it possible to discover the metallic traces (Fig. 1). The fact that the anorak was free of gunshot residues proved that the shot must have been fired from a distance of more than 3 m. Therefore, the particles observed on and under the skin could not have been primer residues, but could only have been transferred by the bullet. By comparison, the direct gunshots left no metal traces other than the bullet wipe. The incident in question occurred in a forest, and reconstruction at the scene revealed that there was a tree nursery between the hunter and the victim, which suggested the hypothesis that a tree or a branch was in the trajectory of the projectile. Systematic experiments proved that intermediate wooden targets (at least 50 mm thick) caused a similar pattern of metallic traces in the skin. At first, it was assumed that the bullet divided into large and fine fragments, which sprayed onto the target in cone form after penetration of the wood. However, given a distance of 3 m between the plank and the final target there were few metallic fragments on the skin, the largest amount being found under the skin. DiMaio (1985) described this phenomenon for ricocheting bullets, but no comparable reports exist concerning incidents with distance of more than 1 m between intermediate and final targets. When the final target was 6 m behind the interposed plank there were only minimal metal traces on the skin and they were concentrated in the region of the impact wound. These repeated observations led to the conclusion that most of the metallic fragments were transferred onto and under the skin by the projectile itself after penetration of the wood. A similar process has been observed with the bullet wipe of lead bullets, which showed large amount of metal residues. To elucidate the formation of metal traces in the target, various textiles, skin, foam rubber and gelatin were shot at through an intermediate target consisting of a 50-mm-thick wooden plank. Each of the above materials showed more metal particles than one would expect to find in the bullet wipe of a direct gunshot, but only skin contained the high concentration of metal particles described. One explanation for this is the elasticity of the skin, which provides the necessary conditions for formation of the patterns observed. The hypothesis is that the bullet was deformed by the penetration of wood, the jacket being partially peeled back and the lead core, "scrubbed". The loosened, but not mobile, particles were wiped from the surface of the bullet by the skin. This explanation is supported by Fig. 5 which shows an impact at the edge of the skin. The metallic traces were only in the skin and not in the foam rubber radiographed at the same time. The radial stripes of metallic residues in Fig. 7 documented the wiping-off procedure of the projectile.

The division of the TIG bullets in two pieces was to be expected after penetration of the wood, and caused each bullet to make two impacts. This phenomenon is not peculiar to TIG projectiles but can also be observed with other hunting ammunition (Clément et al. 1992; Sauvestre et al. 1994). The separation of jacket and core after penetration of an intermediate target is well known (DiMaio 1985).

This experimental study confirmed that the morphology of the wound was atypical when the bullets had passed through intermediate targets (DiMaio 1985). Systematic investigation showed that these findings are regularly associated with hunting ammunition and intermediate wood targets. After penetrating wood the different types of hunting bullets caused various wounds, but they left metallic particles in a similar characteristic manner. Stone and Petty (1991) emphasized the importance of recognizing interposed targets for the correct interpretation of gunshot wounds. Only visual evidence of gunshot residues, e.g. by X-ray, avoids misinterpretation of the origin of metallic particles (Schyma and Bittner 1995).

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