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## Tissue defect at the gunshot entrance wound: what happens to the skin?

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**Abstract** To investigate the question what happens to the tissue lost at the entrance wound, experimental studies were performed on composite models consisting of dyed pig skin and gelatin blocks. For the test shots to the skin–gelatin preparations, cartridges calibre .38 spec. with different bullet types (round nose, hollow point, flat nose, truncated cone) were used. In all shots, a multitude of coloured skin particles were macroscopically discernible along the bullet tracks. In addition, small cell aggregations could be demonstrated microscopically even in those sections of the bullet paths which did not show skin fragments visible to the naked eye. The distribution of the skin particles showed certain peculiarities depending on the type of projectile.

**Keywords** Gunshot wound · Entrance hole · Bullet track

### Introduction

Even in the old textbooks on forensic medicine, a roundish or oval skin defect was described as a characteristic feature of gunshot entrance wounds. Moreover, it has been known

for a long time that there is no direct relationship between the size of the entrance hole and the calibre of the causative projectile [1–3]. More recent studies showed that the size of an entrance hole is not only determined by the diameter and shape of the bullet head, but also by the anatomical and physical properties of the target tissue (especially its elasticity) [4]. Essential contributions to the understanding of biomechanical processes in the formation of gunshot entrance wounds were made by Sellier [5, 6]. Pictures taken with high-speed cameras showed, inter alia, that material from the edge of the entrance wound is ejected backwards against the line of fire. The question what happens to the remaining tissue from the area of the entrance hole has hardly been discussed in the forensic literature. To visualize the path and the final position of the skin particles carried along by the projectile, real conditions were simulated by means of test shots to composite models of pig skin and gelatin.

### Materials and methods

Pieces of skin measuring 5×5 cm from the belly region of slaughtered pigs (maximum storage time 3 days) were incubated with hemalum at 4°C to dye them blue (Fig. 1c). Then the skin specimens were attached to the front sides of rectangular gelatin blocks (Fig. 1d).

The pig skin was dyed by means of submerging it in a hemalum bath for 60 min (Mayer's hemalum, Merck KGaA, 64271 Darmstadt, Germany). Subsequently, the dyed pieces of skin were dried with absorbent paper and stored in airtight containers at 4°C until the test shots were performed.

Gelatin blocks 22×12×12 cm in size were made from gelatin powder (250 Bloom, type A, grain 20/60, 10% concentration) of Naumann-Gelatine und Leim GmbH (Memmingen), and the processing and storage current guidelines were observed [7, 8].

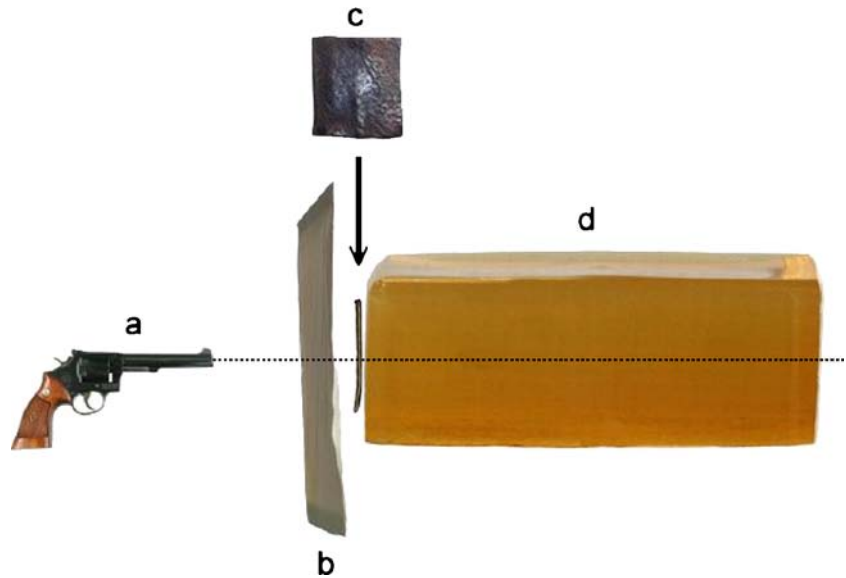
The shots were fired from a revolver (six-shot double-action revolver Smith & Wesson, model 14-1; Fig. 1a), calibre .38 spec., from a distance of 1 m using different bullet types (Table 1).

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**Fig. 1** Schematic illustration of the experimental studies: **a** revolver Smith & Wesson, mod 14-1, **b** filter paper, **c** blue-coloured skin from pigs, **d** gelatin block



**Table 1** Ammunition data of the cartridges used for test shots

Bullet shape	Bullet type	Bullet mass (g)	Bullet velocity (m/s)	Bullet energy (J)	Manufacturer
Round nose	Lead bullet	10.2	260	345	Hirtenberger AG A-2552 Hirtenberg
Hollow point	Semi-jacketed bullet	6.2	335	248	Winchester-Olin IL-62024 East Alton/USA
Flat nose	Wadcutter (lead bullet)	10.2	230	270	Winchester-Olin IL-62024 East Alton/USA
Truncated cone	Semi-jacketed bullet	8.1	288	336	Omark Ind. a Blount, Inc. Co., ID-83501 Lewiston/USA

To visualize backscatter of tissue particles, sheets of filter paper (size 20×20 cm; Fig. 1b) moistened with distilled water were mounted in front of the composite skin–gelatin models at a distance of 1 cm. The filter papers were examined with a stereomicroscope on the side facing the pig skin; the detected deposits were preserved and partly processed histologically.

After firing the shots, the gelatin blocks were laminated in 1-cm-thick layers. Subsequently, each layer was examined for its content of blue-coloured pig skin particles, and the number and size were evaluated semiquantitatively (score 0–3, cf. Table 2). Larger deposits were also examined

histologically. In the sections categorized as “0” (no macroscopically discernible skin particles), the gelatin around the bullet path was punched out and centrifuged; from the resulting sediment, thin smears were taken for microscopic examination.

**Results**

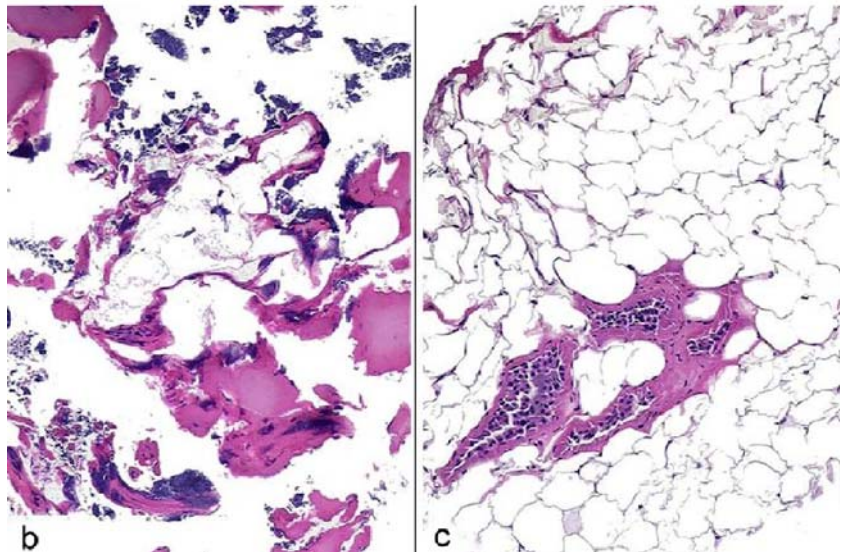
Backscatter of tissue particles up to 1 mm in size was demonstrated on all the filter papers with declining distribution density towards the periphery (Fig. 2a). Fragments

**Table 2** Semiquantitative evaluation of the number and size of skin particles lodged in the consecutive layers of the gelatin block

Score 0 No particles visible to the naked eye, Score 1, 2, and 3 low, medium, and high density, respectively  
\*Final position of the hollow point bullet

Bullet	Distance from bullet entrance hole (in cm)																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Round nose 1	2	2	1	0	0	0	1	1	2	1	2	1	1	1	0	1	1	2	3	1	1	1
Round nose 2	3	3	2	1	1	2	1	1	1	0	1	2	0	1	1	0	1	1	2	3	1	1
Round nose 3	3	3	2	2	3	1	1	1	2	0	1	1	1	1	0	1	1	1	0	1	1	2
Round nose 4	2	3	2	2	1	1	1	1	0	0	1	0	0	0	1	2	0	0	1	2	2	2
Round nose 5	2	3	2	2	1	1	1	1	1	1	0	1	0	0	1	0	1	1	1	1	1	2
Hollow point	2	2	2	3	2	1	1	1	1	1	1	1	0	0	0	1	0	0	*			
Flat nose	3	2	2	2	1	1	1	2	2	2	1	1	1	1	2	1	1	1	1	1	1	2
Truncated cone	3	3	3	1	2	2	1	1	2	2	0	1	0	0	1	0	1	0	0	0	1	1

**Fig. 2** **a** Stereomicroscopical view of the filter paper with adhering backspatter from the blue-coloured skin, **b** scales from the horny layer, epidermal cells, corium structures (hemalum eosin; 200×), and **c** subcutaneous tissue (hemalum eosin 100×)



from the horny layer, aggregations of epidermal cells, and structures from the corium and even from the subcutis could be differentiated (Fig. 2b, c).

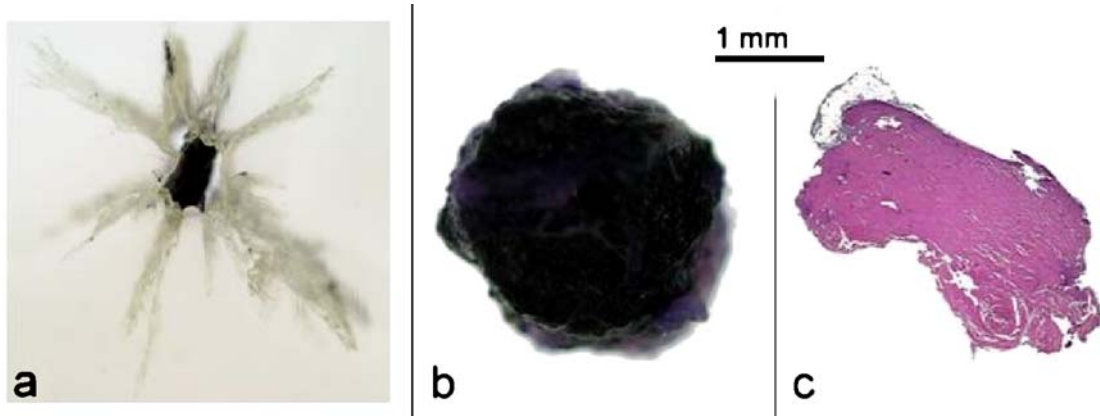
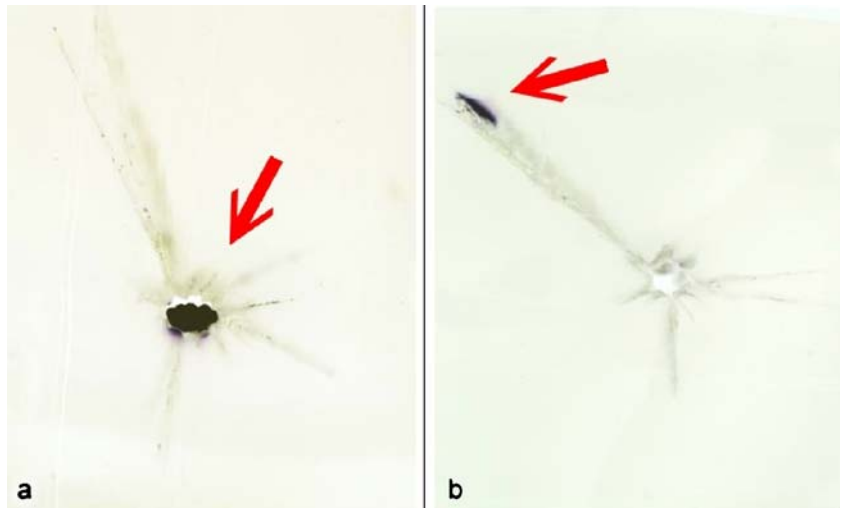
Round nose bullets, flat nose bullets, and truncated cone bullets all penetrated the full length of the 22-cm-long gelatin blocks, whereas the hollow point projectile did not reach beyond 19 cm. In all bullet paths, skin particles were detected macroscopically; apart from final positions within the permanent bullet path (Fig. 3a), there were also localizations in the tear-like radial slits (corresponding to the peripheral parts of the temporary wound cavity; Fig. 3b). The largest particle size (3×3×2 mm; Fig. 4a–c) was observed after the test shot with the hollow point projectile. In all gelatin slices in which no skin particles were clearly visible to the naked eye, small cell aggregations or cell particles could at least be visualized in the smears (Fig. 5a, b).

### Projectile-related characteristics

According to the different bullet types, some peculiarities of skin particle deposition were noted (Table 2).

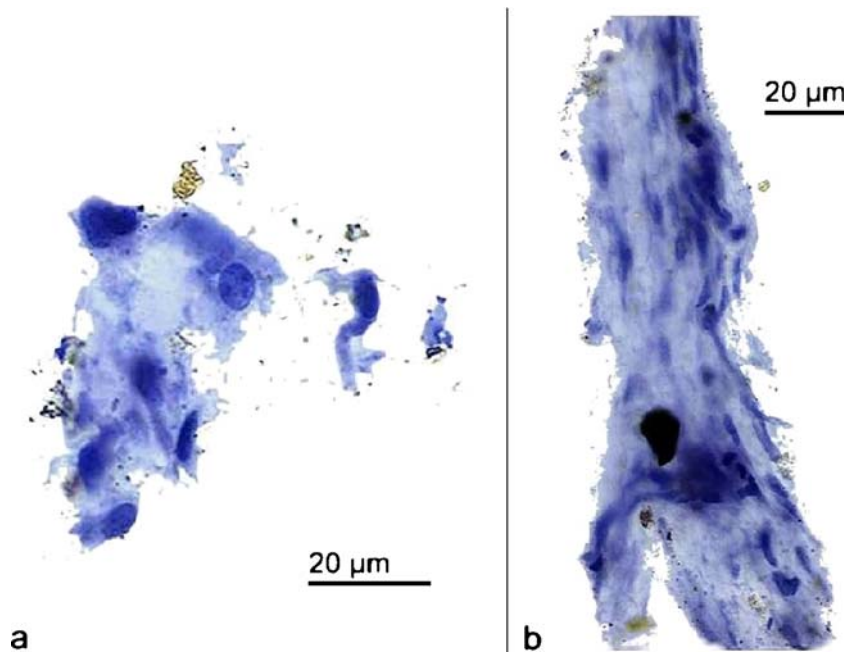
- With round nose lead bullets, the particle density was high in the first and the last section of the bullet track.
- With the hollow point bullet, particle density decreased continuously along the bullet path. In the fourth gelatin slice, a particularly large skin particle was found corresponding to the diameter of the hollow point of the bullet head.
- The track produced by the flat nose bullet was characterized by a relatively even particle distribution and the presence of macroscopically discernible skin particles in all sections.
- In shots with truncated cone projectiles, particle density decreased markedly after 10 cm.

**Fig. 3** **a** Skin particle (2×2×1 mm) lodged in the geometric bullet path; **b** skin particle (2×1×1 mm) at the end of a radial slit



**Fig. 4** Largest skin particle (3×3×2 mm): **a** in its final position, **b** in stereomicroscopical view, and **c** histological section (hemalum eosin)

**Fig. 5** **a, b** Smear with cell aggregations deriving from the skin (out of a gelatin layer which did not contain macroscopically visible skin particles)





## Discussion

In forensic medical practice, the demonstration of biological material (blood droplets and/or tissue particles) ejected backward from a gunshot entrance wound is of great significance (e.g. 9). The distribution and morphology of such microparticles (up to 0.5 mm in diameter) and macroparticles ( $\geq 0.5$  mm) were discussed in detail by Karger et al. [10, 11]. In accordance with the experimental gunshot studies published by Sellier [5, 6] and Pollak [12], our test shots also produced backspatter of skin particles to the filter papers fixed in front of the blocks. Histological investigation of these particles showed that they did not only consist of epidermis and corium [12], but included also cell aggregations from the subcutaneous fatty tissue.

The main part of the skin from the bullet entrance is carried along, broken up into fragments, into the depth of the bullet track. Apart from the transport of tissue fragments by the bullet itself, it is to be assumed that the sucking effect of the negative pressure within the temporary cavitation also influences the final deposition of the skin particles. Histological investigations sporadically showed skin particles up to the size of a pinhead, which had maintained their original arrangement of layers, but mainly smaller skin particles sized only a few tenths of a millimeter were found. The presence of cell aggregations only visible by microscope could be demonstrated in all the smears examined. Accordingly, it seems that all sections of the bullet track contain at least microscopic cell aggregations from the entrance region even in the absence of macroscopically discernible skin particles. Similar cell aggregates were demonstrated by Knudsen [13] on full-metal-jacketed bullets after shots to anesthetized pigs. We are presently investigating the transport of microorganisms from the skin surface into the depth of the bullet track. The possible transport mechanisms of skin bacteria will be the subject of another paper.

The observation that skin particles are found not only along the permanent bullet path but also in the radial tears of the gelatin block (which reflect the maximum extent of the temporary cavitation) is in line with investigations on the distribution of bone fragments after gunshots to composite models [14]. These final positions are attributable to the secondary collapse of the temporary cavitation.

A comparison of the results revealed certain peculiarities depending on the type of projectile. The fact that particle density increased again towards the end of the bullet track in round nose lead projectiles may be due to tumbling after a longer passage through a dense medium. The tumbling of the projectile with an increased delivery of kinetic energy was shown by the presence of long radial tears in the simulant. As the projectile assumes an upright position, this may lead to a separation of tissue particles which the bullet head had transported into the depth of the track. When a hollow point bullet was used, the shape and size of the largest skin particle corresponded to the hollow point at the bullet head, which is a particularly characteristic feature similar to a punch. A comparable punch effect could not be

demonstrated for flat nose bullets, although it is possible that the respective skin particle left the 22-cm-long bullet track through the exit hole. With the truncated cone projectile, the density distribution showed a marked decrease after 10 cm.

The presented investigation is a morphological study contributing to a better understanding of the well-known finding “skin defect produced by gunshot”. As an important result, it could be confirmed that small tissue particles are ejected in the direction opposite to that of the shot (“backspatter”). However, this phenomenon, which has been known for a long time, cannot fully explain the loss of tissue in the area of the gunshot entrance hole. Our findings prove that both macroscopically discernible and microscopically small skin particles are carried along the whole length of the permanent bullet track including the temporary cavitation. The results presented give a plausible explanation for the presence of a skin hole with a permanent loss of tissue at the bullet entrance due to the backspatter and forward displacement of dermal particles.

A review of the forensic literature shows that, surprisingly, little attention has been given to the aspect described in this paper. As far as we know, no systematic investigation has been conducted on the question what happens to the skin which got “lost” at the gunshot entrance site, although this problem—as shown by us—is solvable by a simple technical experiment. The observations reported here and in other publications [15–21] show that the possibilities in forensic wound ballistics are by no means exhausted at the beginning of the 21st century.

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