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Comparison of injuries caused by the pistols Tokarev, Makarov and Glock 19 at firing distances of 10, 15 and 25 cm

Delia Lepik[a,*], Vitaly Vasiliev[b]

[a]*Department of Pathological Anatomy and Forensic Medicine, University of Tartu, Ravila 19, 51014 Tartu, Estonia*
[b]*Estonian Bureau of Forensic Medicine, Narva mnt 46, 10150 Tallinn, Estonia*

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Abstract

Firings at cloth targets and at human skin from autopsy material were performed from the pistols 7.62 mm Tokarev (TT), 9 mm Makarov (PM) and 9 × 19 mm Glock 19 with common ammunition. The differences were in the soot deposit pattern, the degree of scorching of the synthetic fibres on the edges of the entrance hole and in the findings of the soot and the gunpowder particles. The results were similar on the cloth and on the skin targets.

In the case of the TT and the PM, the soot deposit patterns reminded of a blossom or shafts of rays or fans, or the bullet wipe had four narrow and four wide sections regarding the number of lands and grooves. The TT left a large amount of soot and many gunpowder particles and caused the melting of the synthetic fibres on the edges of the entrance hole, producing a defect of the material 0.1–0.3 cm in diameter and defects of textile fibres around the entrance hole. In the skin the TT caused many intraepithelial tears, folds of the epidermis and recesses of the epidermis containing soot. Firings from the PM and the Glock 19 caused the melting only of the ends of individual synthetic fibres on the edges of the entrance hole. The PM left a large amount of soot and only a few gunpowder particles. The Glock 19 gave the least soot and the greatest number of gunpowder particles and also caused tears and recesses in the epidermis. Only in the case of the Glock 19, hexagonal or polygonal zones were seen in the soot deposit pattern.

The differences in the soot pattern were more distinct at the firing distance of 10 cm. By increasing the distance from 10 to 15 cm, the intensity of soot diminished and began to disappear at 25 cm, but remained more visible in the case of the TT. The gunpowder particles could be found in the epidermis and deeper in both layers of the dermis at all distances fired from the TT and the Glock 19. In the case of firings from the PM, at the distance 10 cm some of the gunpowder particles had penetrated into the dermis and most of them were in the upper layer of the dermis. At the firing distance of 15 and 25 cm, the gunpowder particles were only on and in the stratum corneum.

Keywords: Gunshot wounds; Firing distance; Cloth and skin injuries

1. Introduction

In the case of close-range and medium-range shots, deposits of soot, gunpowder, metallic and other particles can be found on clothes or skin. The intensity and distribution of these deposits is related to the firing distance, and therefore,

* Corresponding author. Tel.: +372 737 4293; fax: +372 737 4292.
E-mail address: delia.lepik@ut.ee (D. Lepik).

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they can be used to estimate the distance. The firing distance and other factors, such as the barrel length, the type of ammunition, the calibre of the weapon, the angle of the muzzle to target, the target material, the type of the weapon, and the form of the rifling, influence the residue patterns [1–3].

The purpose of our study was to find out the differences between bullet entrance injuries caused by the pistols Tokarev and Makarov (four lands and grooves) and the Glock 19 (hexagonal rifling) at firing distances of 10, 15 and 25 cm. The above-mentioned pistols are the most common pistols in Estonia, and for test firings also we chose the most common makes of ammunition in Estonia.

2. Materials and methods

We used the pistols 7.62 mm Tokarev (TT), 9 mm Makarov (PM) and 9 × 19 mm Glock 19 and common ammunition: TT – 7.62 × 25 mm, 5.5 g (manufactured in Poland); PM – 9 × 18 mm, 6.1 g (Russia); and Glock – 9 × 19 mm, 7.5 g (Fiocchi, Italy). All bullets were full metal-jacketed. Throughout the firings with the same pistol we used the same make and lot of ammunition. Before shooting at targets we measured muzzle velocities of 10 bullets fired from these pistols by an Oehler ballistic chronograph Model 35P. Average velocities were: TT – 430 m/s; PM – 301 m/s; and Glock – 328 m/s.

At distances of 10, 15 and 25 cm, we made five shots from each pistol at white cotton and synthetic (polyester) cloths (∼20 cm × 30 cm) and 1–4 shots at human skin (autopsy material 6 cm × 10 cm, 5 cm × 15 cm or 6 cm × 15 cm). The pieces of skin were taken from the thigh region and the thickness of the stratum corneum was 10–40 μm. The shots were performed at right angle to the targets. During the firing, the pieces of cloth and skin were fixed to a rest. We photographed (Olympus C-2000 digital camera) all targets with injuries and analysed these photographs by using the computer program AnalySIS Pro 3.0. We examined the soot, the gunpowder and other particles and injuries on the cloth under a stereomicroscope Nikon SMZ800. The skin samples were fixed in 10% formaldehyde solution, and after embedding in paraffin, 3–4 μm sections were made. The haematoxylin and eosin stained slides were examined under a microscope Olympus BX60. We examined both the cloth and the skin by 1 cm × 1 cm areas from the right-hand and left-hand side of the bullet entrance hole (starting at 1 cm from the centre of the entrance hole).

3. Results

3.1. Soot deposit pattern on cloth targets

In the soot deposit pattern, we distinguished three zones: central (the most intensive, grey or black), intermediate (light zone without soot or little soot) and peripheral (light grey or light brown).

The TT: for 10 cm distance, around the entrance hole, there was a bullet wipe and a black star-like soot deposit surrounded by greyish-brown wave-like shafts of rays. On some targets, the lighter grey intermediate zone was visible. The peripheral zone was similar to a blossom with four petals. For 15 and 25 cm distances, three zones of soot deposit could be detected. Rings of diminishing intensity surrounded the darker central zone. In general, the soot deposit pattern was blossom-like.

The PM: the bullet wipe had four narrow and four wide sections. Around the entrance hole, the soot deposit was black and blossom-like. The central zone was generally round-shaped on the cotton cloth or slightly square-like on the synthetic cloth with a sharp outer contour. For 10 cm distance, more peripheral soot deposits resembled rays or four fans. On some targets, these fans were fragmentary and they formed the intermediate zone. For 15 cm, the intermediate zone was a ring on the cotton cloth or a rhomboid on the synthetic cloth. The peripheral zone looked like rings (10 and 15 cm), which were laterally less intensive and beginning to fade. For 25 cm, the zones were difficult to distinguish. The bullet wipe and the central zone were better distinguished.

The Glock 19: the soot deposit was less intensive and greyish-brown. For 10 and 15 cm, three zones of soot deposit were detected. The entrance hole was surrounded by a bullet wipe. The central zone was round-shaped with a wavy outer contour. In general, the bullet wipe and the central zone were similar to a blossom but the corolla had many petals. For 10 cm, the intermediate zone was polygonal and the peripheral zone formed rings of different intensity. For 15 cm, on the cotton cloth the intermediate zone was hexagonal and the peripheral zone was polygonal or hexagonal and on the synthetic cloth they looked like concentric arcs. For 25 cm, the soot deposit was beginning to fade. The intermediate zone was polygonal and the peripheral zone resembled concentric arcs (similar to a rose) or soot was not seen (Figs. 1 and 2).

The bullet entrance holes were round-shaped and without tears of the cloth. On the cotton cloth, we found the defect of fibres 0.1 cm in diameter in the case of the TT (some shots at a distance of 25 cm) and the PM (at 10 and 15 cm and some shots at 25 cm). On the other targets, the ends of fibres on the edges of the entrance hole are less damaged. On the synthetic cloth, in the case of using the TT, we found that the fibres on the edges of the entrance hole were hard, partly turned up (at 10 cm and some shots at 15 cm), melted together and the ends of the individual fibres were melted into globules. The diameter of the defect of the fibres was 0.1–0.3 cm (at 10 and 15 cm) and 0.1–0.2 cm (at 25 cm). The PM and the Glock: only the ends of individual fibres were melted.

3.2. Deposition of gunpowder residue particles on cloth targets

To determine the distribution and density of the gunpowder residue particles, we counted the particles of the

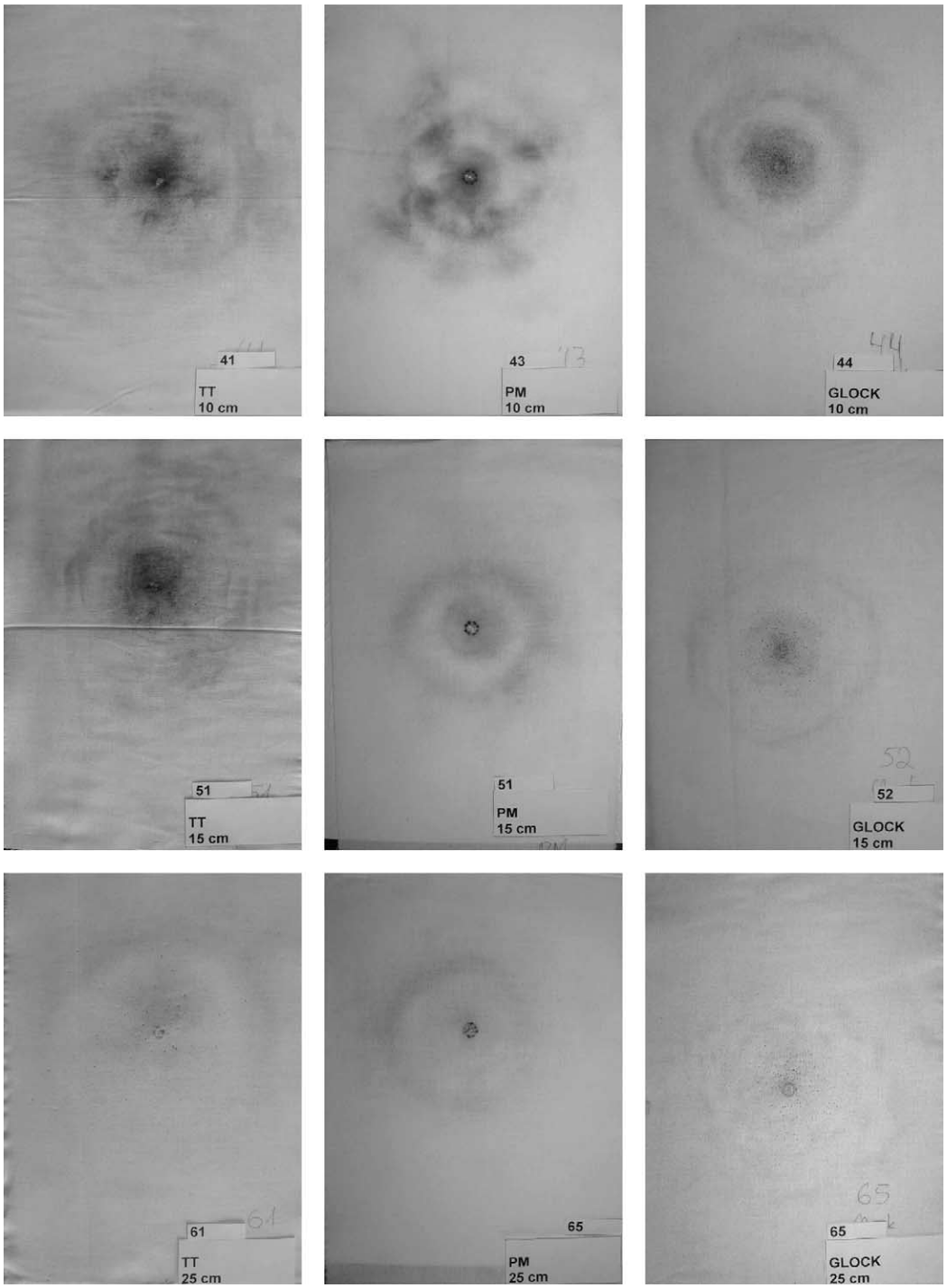

Fig. 1. Macroscopic pattern of soot and gunpowder residue particle distribution on cotton cloths.

size of at least half of the cotton cloth fibre width and at least one-third of the synthetic cloth fibre width. We also counted the marks left by these particles after the impact or penetration through the fibres, and also defects of the fibres (absence of some part of the fibre) caused by the particles. Figs. 3–5 present the results found on five targets of the same material on the left-hand and right-hand side of the bullet entrance hole. In addition, we found much fine soot

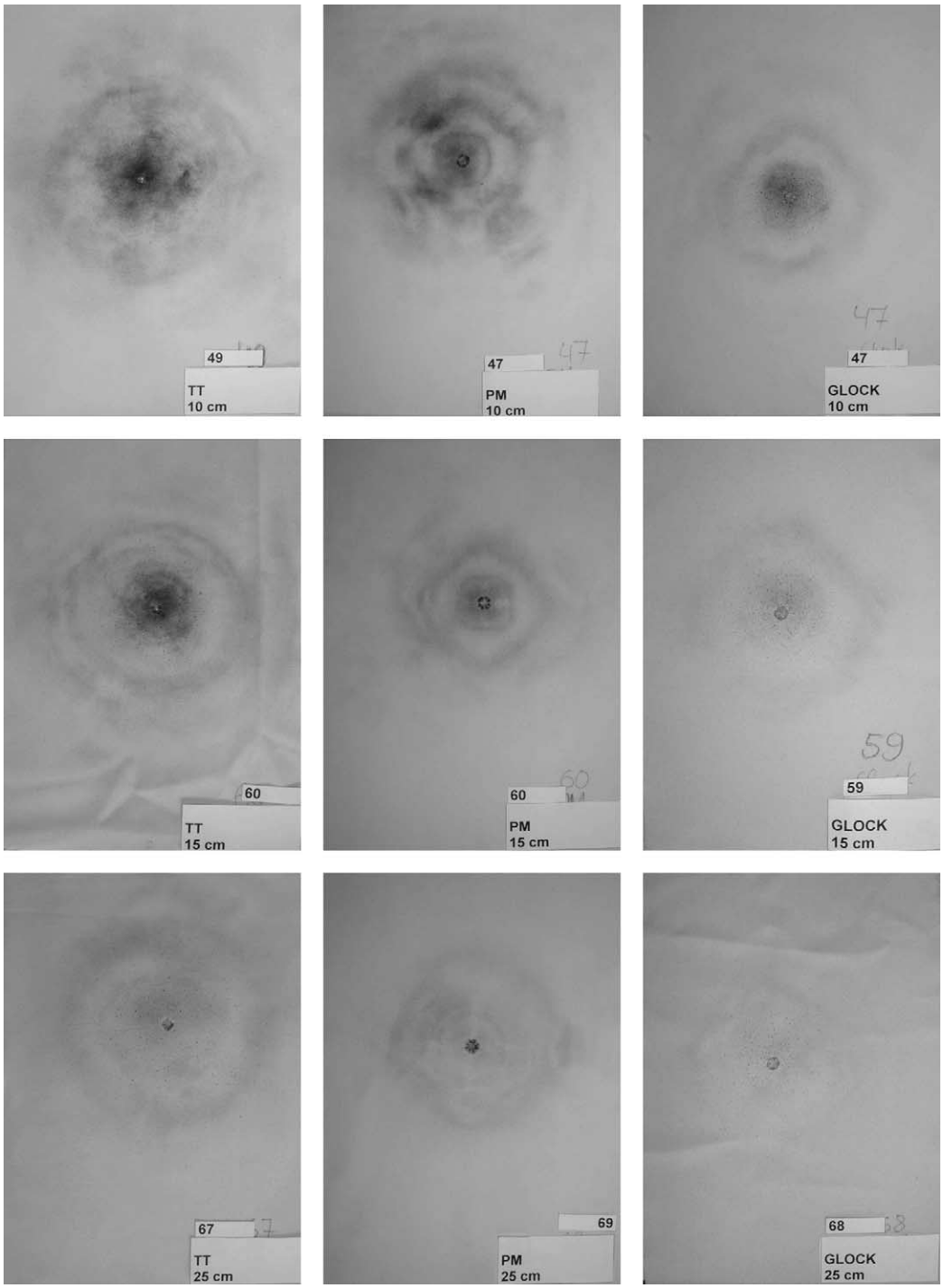

Fig. 2. Macroscopic pattern of soot and gunpowder residue particle distribution on synthetic cloths.

and some other residue particles in the case of the TT and the PM.

The TT left many gunpowder particles covered with soot, and caused defects of fibres of the material. For 10 cm distance, the maximum diameter of the deposited area was 9.5 cm, but defects of fibres could be found mainly around the entrance hole. For 15 and 25 cm, particles were dispersed all over the cloth targets (the diameter of the area 17.0 and 18.0 cm). Comparing the target material, we found that more often the particles had perforated the cotton cloth

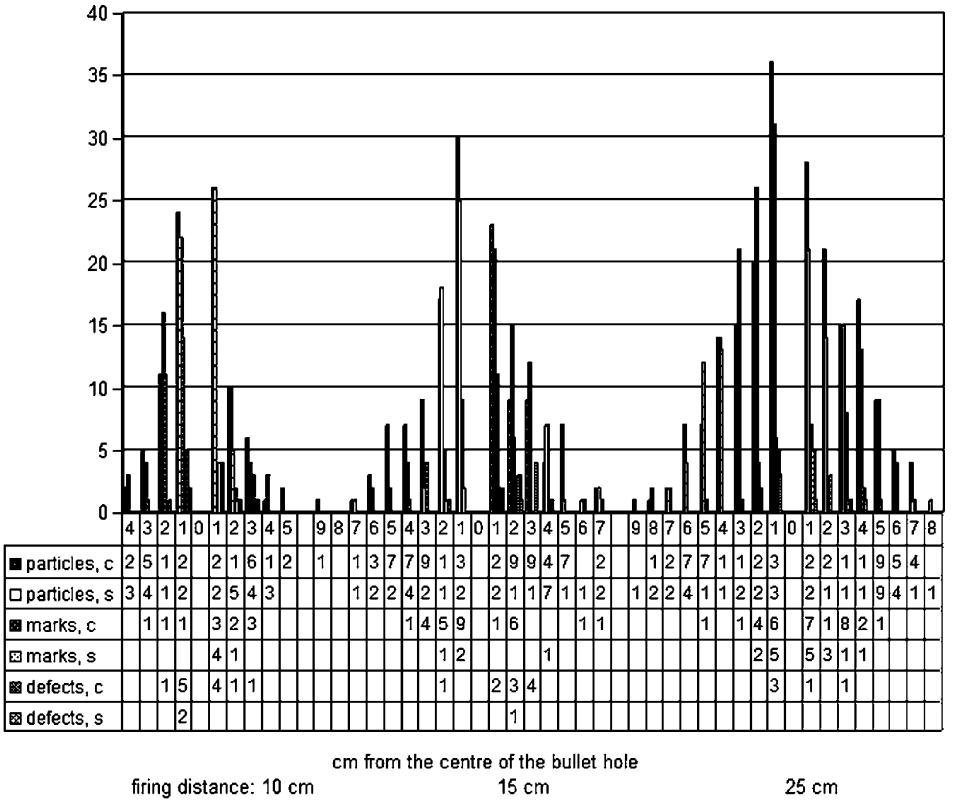

Fig. 3. Number of gunpowder particles, marks and defects caused by the particles on the cotton (c) and synthetic (s) cloths from the 7.62 mm Tokarev.

leaving the marks and defects of fibres, whereas on the synthetic cloth, the particles of different size had adhered to the area of impact.

The PM: the lowest number of gunpowder particles, mainly on a limited area around the entrance hole, but some of the particles could be found all over the targets (the diameter decreased from 15.5 to 14.0 cm).

The Glock 19: the number of greenish-yellow gunpowder particles was the greatest and they were located mostly around the entrance hole (especially at 10 and 15 cm). No defects of fibres were found. The maximum diameter of the deposited area decreased from 15.0 to 13.0 cm (Figs. 3–5).

3.3. Macroscopic findings of the skin

The TT: a large amount of soot (especially at 10 and 15 cm), gunpowder particles and yellow marks left by gunpowder grains. In the soot deposit patterns the central and the intermediate zones were better seen. The soot and gunpowder particles covered the entire targets (the pieces of skin were 6 cm × 10 cm).

The PM: a large amount of soot (especially at 10 cm) and a few gunpowder particles and powder marks. With increasing the distance, the density of gunpowder particles decreased, and at 25 cm predominantly the marks were seen. The round-shaped central zones (at 10 and 15 cm) and bullet wipes were clearly visible.

The Glock 19: the least soot and the greatest number of gunpowder particles and marks at all distances. At 10 and 15 cm, the gunpowder particles and marks were most densely located around the entrance hole, but at 25 cm there were less particles and marks and they were more equally dispersed on the skin surface.

3.4. Microscopic changes of the skin

The TT: a large amount of soot and many light greyish gunpowder residue particles could be found at all distances, especially at 10 cm. They were present on the histological preparations, which originated at 1–4 cm from the centre of the bullet entrance hole, and they had penetrated into the epidermis and deeper into the stratum papillare and the stratum reticulare of the dermis. In the dermis, the soot was combined with gunpowder particles. We could also find many intraepithelial tears, folds of epidermis, and recesses containing soot. With increasing the distance, the number of gunpowder residues was smaller and at 25 cm they were located more superficially and they were more dispersed on the skin (Fig. 6).

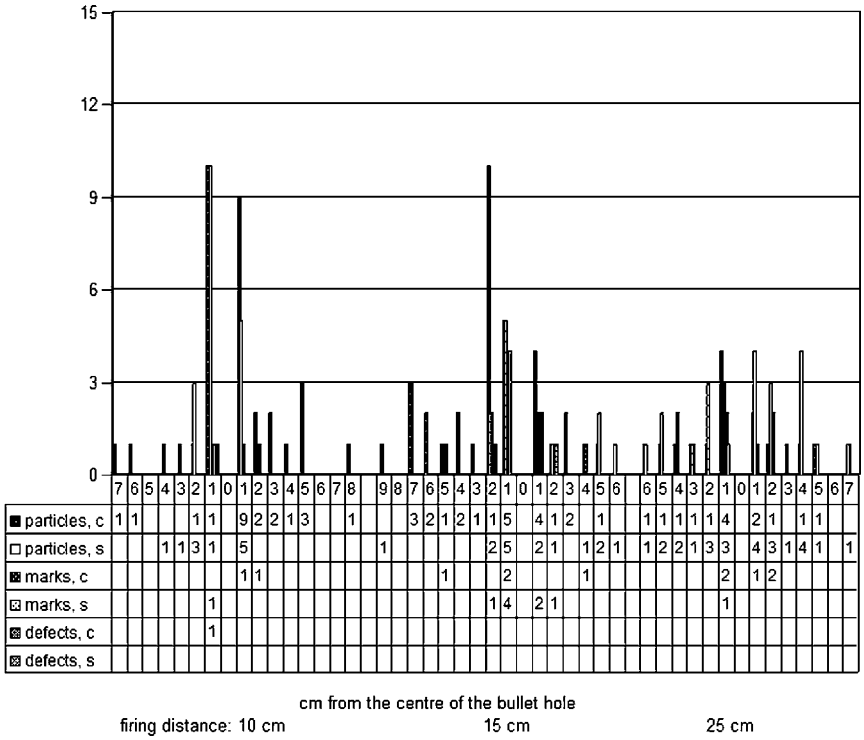

Fig. 4. Number of gunpowder particles, marks and defects caused by the particles on the cotton (c) and synthetic (s) cloths from the 9 mm Makarov.

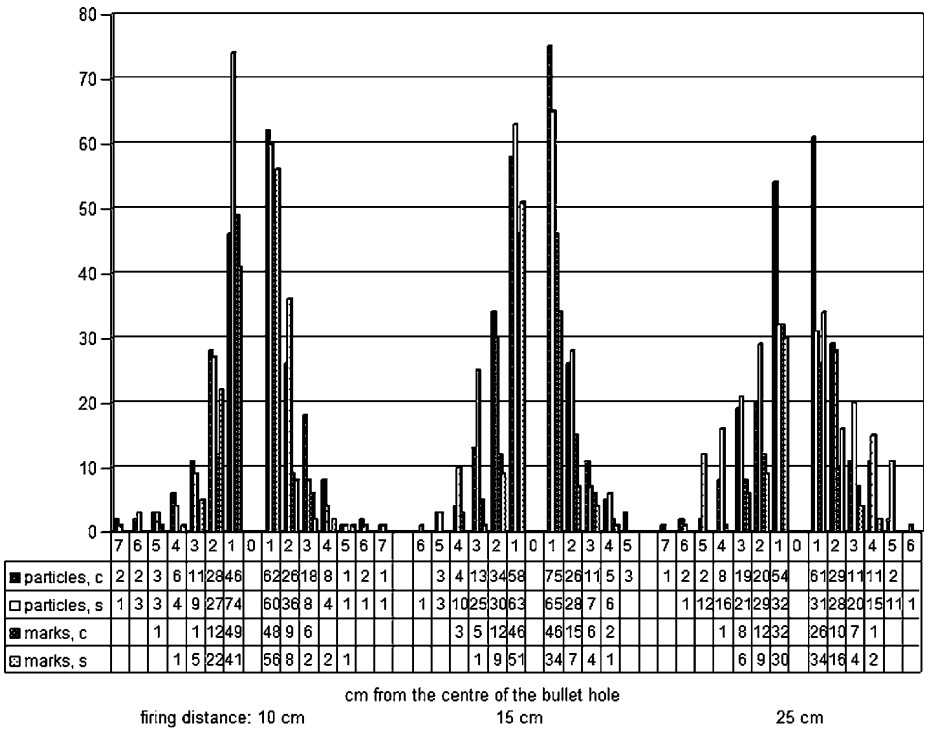

Fig. 5. Number of gunpowder particles, marks and defects caused by the particles on the cotton (c) and synthetic (s) cloths from the 9 × 19 mm Glock 19.

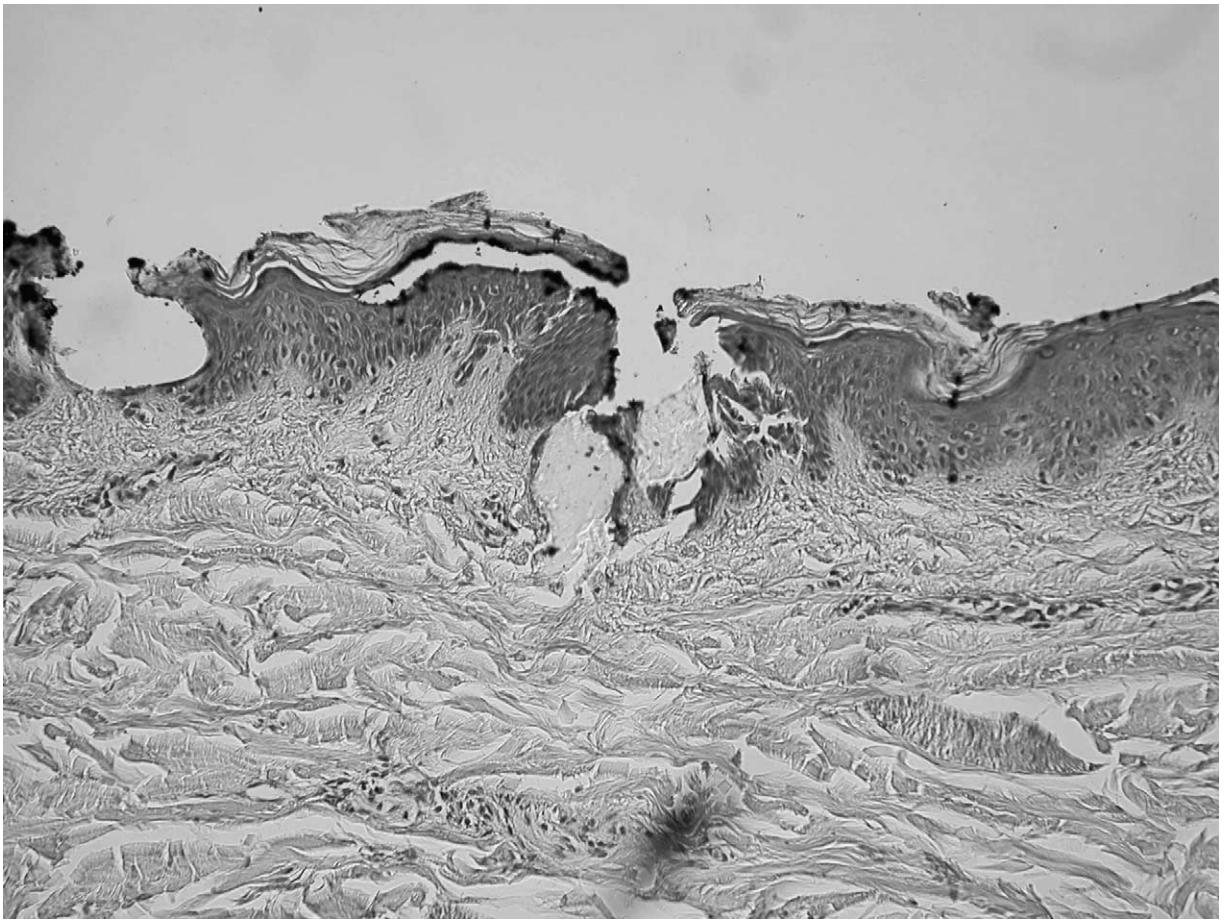

Fig. 6. Soot and gunpowder residues on the surface of the skin and in its layers at a firing distance of 10 cm with the 7.62 mm Tokarev.

The PM: fine soot particles could be found at 1–4 cm, but more intensively at 1–2 cm from the centre of the bullet entrance hole and they were deposited on and in the stratum corneum. The number of gunpowder particles was the smallest, and they were mainly in the nearest area at the bullet entrance hole. At distances of 10 and 15 cm, some of them were more peripheral. For 10 cm distance, some of the gunpowder residues had penetrated into the dermis and most of them were in the upper layer of the dermis. For 15 and 25 cm distance, they were on and in the stratum corneum (Fig. 7).

The Glock 19: the least soot deposits were left on and in the stratum corneum. We could find many gunpowder particles of different size in all layers of the epidermis, in the stratum papillare and the stratum reticulare of the dermis and we also found the tears and recesses in the epidermis. At a distance of 10 cm, the soot and gunpowder particles were 1–5 cm and at a distance of 15 cm 1–3 cm from the centre of the bullet entrance hole. At a distance of 25 cm, soot was beginning to disappear, and gunpowder particles were found in the nearest area to the bullet entrance hole (Fig. 8).

4. Discussion

Beyond the range of 1–2 cm, the soot deposit begins to take the shape of a blossom or a petal. As the range from the muzzle to the target increases, the size of the zone of powder soot blackening will increase, whereas the density will decrease. The pattern reaches the maximum size, and then gradually begins to shrink and fade, disappearing by 15–25 cm of range. The maximum distance at which powder soot deposition occurs for most handguns is 20–30 cm [2]. In the case of the TT, soot occurs up to 15–30 cm, according to some data up to 40–50 cm. In the case of the PM, soot can be found up to 25–30 cm, according to other data up to 40, and many gunpowder particles can be found up to 30–40 cm on the white cloth. The colours of the soot deposit are dark grey and sometimes black or brownish on white cloth. The intensity of the soot deposit is not homogenous. In the soot deposit more intensive central zone and less intensive peripheral zone pattern can be distinguished. At the firing distance of 5–10 cm, a ray-like intermediate zone can be seen between these zones [4].

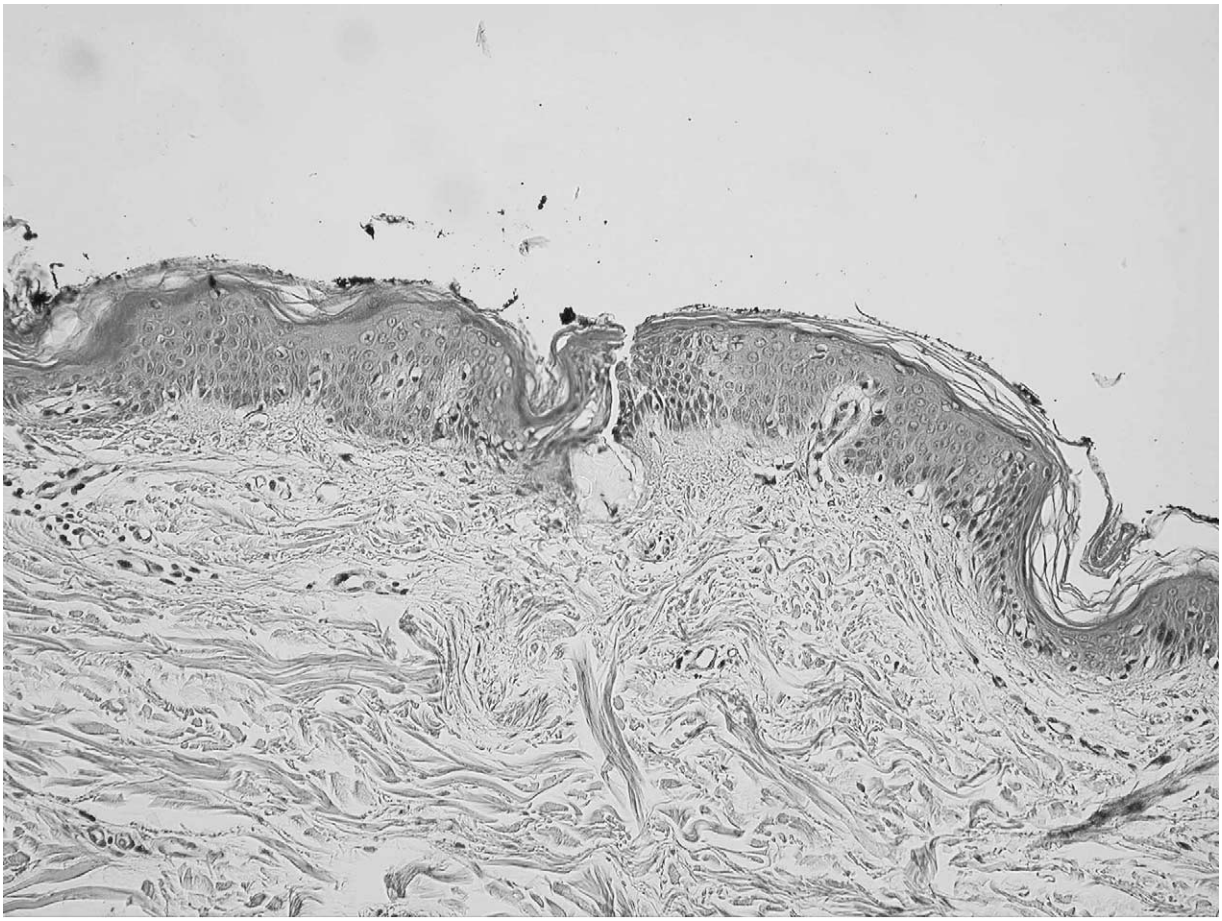

Fig. 7. Soot and gunpowder residues on the surface of the skin and in its layers at a firing distance of 10 cm with the 9 mm Makarov.

In the soot deposit pattern, we have distinguished three zones, too. At 25 cm, these zones remain more visible in the case of the TT. The colours of the soot deposit are black or greyish-brown (TT and PM) and less intensive greyish-brown (Glock).

At close ranges, lands and grooves produce a residue fallout pattern similar to a star or a blossom, which may allow deductions regarding the number of lands, grooves and the direction of twist [5]. But in some cases the attempts to associate the number of rays of soot pattern and the number of lands and grooves have failed. For example, in the case of shooting from the PM, up to 16–20 rays of soot deposit were found [4]. Besides the shape of the soot deposit pattern the appearance of the bullet wipe mark may be one of the additional features of the type of the rifling. In test firings at the white cotton material, 7.62 and 9 mm bullets frequently leave bullet wipe marks indicating four lands and grooves of the barrel. In real cases, such bullet wipes are rarely seen [6].

We found a soot deposit similar to a star or a blossom with four petals (TT) and a soot deposit similar to a blossom or rays or four fans (PM). The bullet wipe has four narrow and four wide sections (PM). In the case of the Glock 19, findings are different: the bullet wipe and the central zone of the soot deposit are similar to a blossom but the corolla has many petals. Other zones of the soot deposit are hexagonal or polygonal or remind of concentric arcs.

Tests with various materials show that with increasing the thickness of the material and smoothness of the surface, the intensity and the diameter of the smoke-stained area decrease (first in the outer zone and then in the centre) in relation to the reduced density of the material [7].

We found that on the synthetic cloth the diameters of the central and the intermediate zone were smaller than on the cotton cloth in all firings from the TT and at distances of 10 and 15 cm from the PM. The total diameter of the soot deposit from the TT and PM was also smaller on the synthetic cloth at a distance of 25 cm. In the case of the Glock, all central zones are 5.0–5.1 cm in diameter, but the intermediate zone and the total diameter of the soot deposit are smaller on the synthetic cloth.

The scorching of synthetic and mixed fibre textiles, which occurs in the carbonisation of fibres or melting the ends of fibres into globules, turning up and sticking the

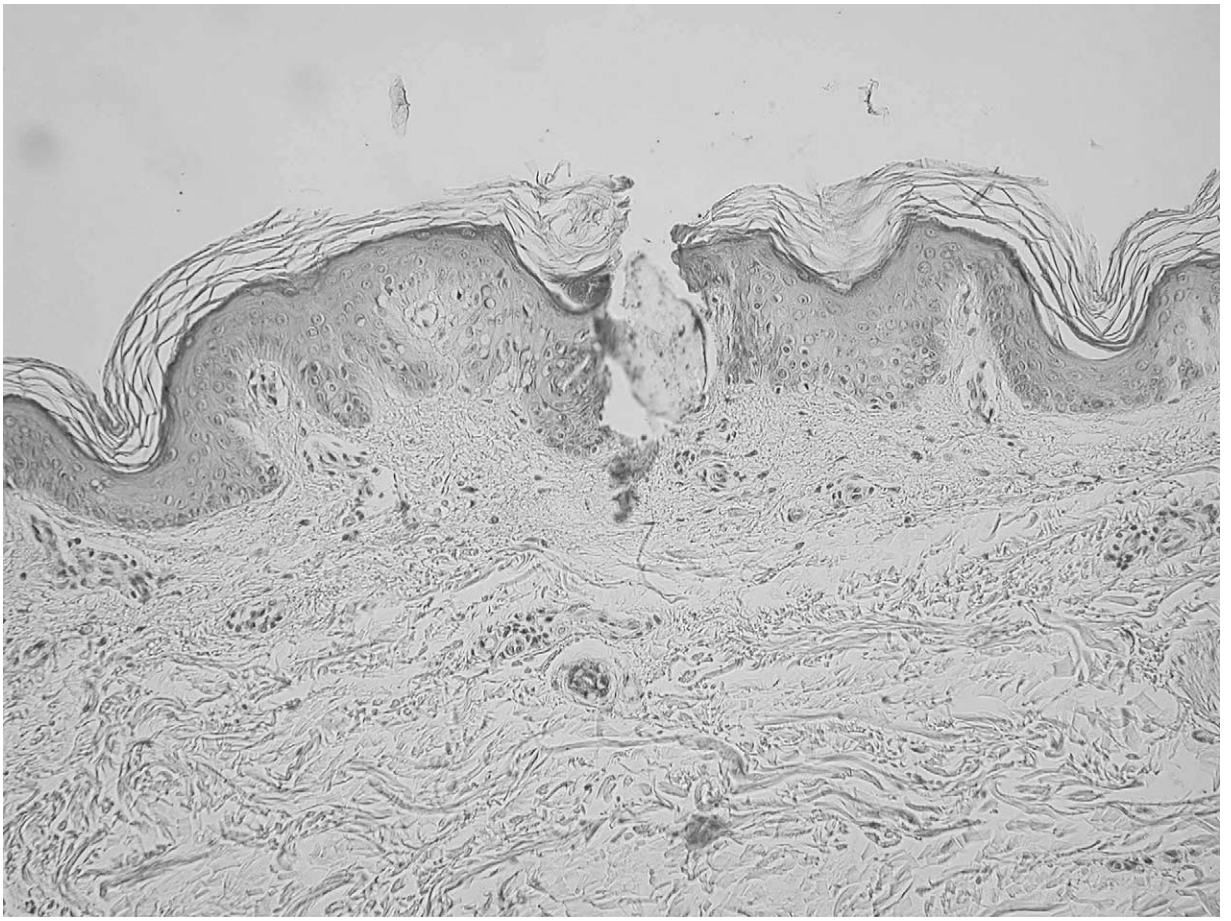

Fig. 8. Soot and gunpowder residues on the surface of the skin and in its layers at a firing distance of 10 cm with the 9 × 19 mm Glock 19.

fibres, can be detected up to the distance of a few centimetres. In woollen or cotton textiles, the fibres are more resistant to heat [8]. Melting of the ends of fibres does not occur only at close-range shots, but can be seen up to a distance of a few metres on the margins of the entrance hole [9].

In our tests, the shots from the TT caused a significant melting of the synthetic fibres on the edges of the entrance hole, producing a defect of the material 0.1–0.3 cm in diameter. In the case of the PM and the Glock, only the ends of individual fibres were melted.

Taking into account the capability of gunpowder particles to perforate the clothing, we found defects of fibres around the bullet entrance hole in the case of the TT. These defects were more visible on the cotton cloth, whereas on the synthetic cloth the particles remained at the place of impact.

Gunpowder may leave marks on the skin postmortem, but these marks are grey or yellow in appearance, and they are less numerous than powder tattooing produced in a living being at the same range. The injuries caused by gunpowder particles are generally confined to superficial layers of the epidermis. Depending of the physical form of the powder and a number of other variables, gunpowder may penetrate into the upper layer of the dermis [10,11] or more deeper into the stratum reticulare of the dermis [4]. The soot particles not only deposit on the surface of the skin, but can also be found in the epidermis and sometimes in the stratum papillare of the dermis [4]. Microscopic changes of the skin structures occur in all layers of the skin around the entrance wound in real cases and also in experimental firings. The extent and the frequency of manifestation of these changes depend on the distance of the examined area from the margins of the bullet entrance hole [12].

We found soot on the skin surface (PM and Glock) and also, in combination with gunpowder particles, deeper in both layers of the dermis (TT). The gunpowder particles were in the epidermis and in both layers of the dermis at all distances in the case of the TT and the Glock. In the case of the PM, some of the gunpowder particles had penetrated into the dermis (10 cm) or were only on and in the stratum corneum (15 and 25 cm). The findings about gunpowder residues on the cloth and on the skin are similar with some exceptions: at 25 cm in the case of the Glock, gunpowder particles were found only at 1–2 cm from the centre of the bullet entrance hole in the skin. It is probably due to their

slight deposition only on the skin surface, which causes their loss during making histological preparations.

5. Conclusion

We performed test firings from different pistols – the Tokarev, the Makarov and the Glock 19 – with common ammunition at distances of 10, 15 and 25 cm.

Comparing the bullet entrance injuries, we found differences in the soot deposit pattern, the degree of scorching of synthetic fibres on the edges of the entrance hole, and also in the findings of the soot and gunpowder particles. The results were similar on the cloth and on the skin targets.

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