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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Appearance and characteristics of the gunshot wounds caused by different fire weapons – animal model

Anisa Gradaščević[1], Ivan Soldatović[2], Anes Joguncic[3], Miroslav Milosevic[4], Nermin Sarajlić[3]

[1]Odenwaldkreis Health Center, Internal Medicine, Erbach, Germany;
[2]University of Belgrade, Faculty of Medicine, Institute of Medical Statistics and Informatics, Belgrade, Serbia;
[3]University of Sarajevo, Faculty of Medicine, Department of Forensic Medicine, Sarajevo, Federation of Bosnia and Herzegovina, Bosnia and Herzegovina;
[4]University of Priština – Kosovska Mitrovica, Faculty of Medicine, Institute for Forensic Medicine, Kosovska Mitrovica, Serbia

SUMMARY

Introduction/Objective Gunshot residue (GSR) on the skin of a victim are important evidence, with far better precision, for reconstructive questions in the forensic investigation of cases involving gunshot wounds.

The aim of this experimental study was to analyze if there was any significant difference in macroscopic characteristics of wounds that were caused with different types of weapons from three different distances.

Methods This study was conducted at the Department of Ballistic and Mechanoscopic Expertise, Federal Police Directorate. Experiments were done on pigskin and 55 samples were made. Shooting was conducted using a system for safe firing. Samples of the pigskin were shot by firing projectiles from four different weapons and from three different distances, (contact wound, five centimetres and 10 centimetres).

Results At the contact range, wounds caused by automatic rifle had horizontal, vertical diameters larger than those made by pistols. Diameters on the wounds that were caused with different pistols, were similar. At the range of five centimetres, the narrowest part of contusion ring significantly differs even through pistol wounds. Diameters at the range of 10 centimetres are in favor of these results. Gunpowder residue scattering area was statistically different depending of type of weapon ($p = 0.004$).

Conclusion Wound diameters and surface area are useful for differentiation between pistol and rifle caused wounds. It is unsecure method for determination of pistol caliber or fire range. GSR have much greater potential for future analyses, but even GSR cannot be used to determine pistol caliber.

Keywords: gunshot wounds; gunshot residue; macroscopic examination; caliber; fire range

INTRODUCTION

Throughout history, ballistics experts and forensic medicine experts have classified gunshot wounds with respect to range by a variety of methods. All of these methods include inspection and comparison with test firings or patterns of gunshot residue (GSR) at the wound site [1]. Firearm-related injuries are a leading cause of morbidity and mortality in the world. In many shooting cases, bullets hit surfaces of various parts of the human body (often the head) directly. For assessing the shooting distance, most of the forensic literature describes only visual/microscopic methods for examination of the wound appearance and discharge particle patterns around. Shooting distances from human body surfaces can be divided roughly into four ranges: contact, near contact range, intermediate range and distant range [2, 3]. In contact wounds, the muzzle of the weapon is held against the surface of the body at the time of shooting. The appearance of tearing, scorching, soot, or the imprint of the muzzle characterizes contact wounds. In near contact wounds, the muzzle of the weapon is not in contact with the skin, being held a short distance away (a few centimeters). A characteristic of this kind of gunshot is a wide zone of powder soot overlaying seared blackened skin around the entrance wound. Intermediate range gunshot wound is one in which the muzzle of the weapon is held away from the body at the time of discharge, but is still close enough, so that gunpowder expelled from the muzzle can produce "powder tattooing" on the skin [4].

An impact velocity of only 150 to 170 fps is required to penetrate the skin. Most entrance wounds, regardless of the range, are oval to circular with a punched-out clean appearance and are often surrounded by a zone of reddish damaged skin (the abrasion ring). While powder tattooing of the skin implies a close-range wound, the fact that there are different forms of propellant powder makes this unreliable finding. In addition, indicative of a close-range injury is a cherry hue appearance of underlying muscle due to carboxyhemoglobin, formed by carbon monoxide release during combustion [5].

Wound diameters and visual analysis of dispersion of GSR only are used in practice, like

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Correspondence to:
Anes JOGUNČIĆ
Trg Barcelone 4
71000 Sarajevo
Bosnia and Herzegovina
anes.joguncic@outlook.com

some kind of screening method, just to check if it fits to the known story from crime scene, fire range etc. Previous studies have distinguished that the caliber of the bullet that caused the entrance wound in the skin cannot be determined by the diameter of the entrance. A .38-caliber (9 mm) bullet can produce a hole having the diameter of a .32 caliber (7.65 mm) bullet and vice versa. The size of the hole is not only due to the diameter of the bullet, but also to the elasticity of the skin and the location of the wound. An entrance wound in an area where the skin is tightly stretched will have a diameter different from that of a wound in an area where the skin is lax. Bullet wounds may be slit-shaped in areas where the skin lies in folds or creases [2].

The size of the entrance hole in bone cannot be used to determine the specific caliber of the bullet that perforated the bone though it can be used to eliminate bullet calibers. Thus, a bullet hole of 7.65 mm in diameter would preclude it having been caused by a 9 mm (.38 caliber) weapon. Bone does have some elasticity, however, so that a 9 mm bullet may produce an 8.5 mm defect.

Previously, researchers tried to prove the potential usage of wound size, its surface area, but results were very inconclusive. GSR on the skin of a victim is important evidence, with far better precision, for reconstructive questions in the forensic investigation of cases involving gunshot wounds [3]. Powder soot may help to differentiate between entrance and exit wounds, draw conclusions on the muzzle-to-target distance and on the muzzle-target angle [5, 6]. GSR consists of particles composed of antimony, barium, and lead that arise from the condensation of primer vapors and soot debris consisting of carbon and metallic fragments [3, 6]. In recent times, there have been no studies that tried to determine, or exclude, the type of weapon or distance between body, and weapon with only wound characteristics.

The aim of this experimental study was to analyze if there was any significant difference in macroscopic characteristics of wounds that were caused by different types of weapons from three different distances.

Figure 1. Pigskin is used as a subject in this study due to its similarity with human skin

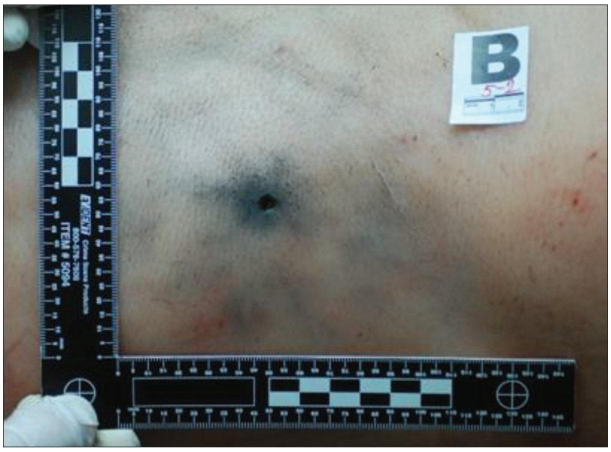

Figure 2. Sample of pigskin, shoot from CZ M70 pistol

Figure 3. System Verifier – The Secure Firing Device, Twin Tooling, Canada

METHODS

This study was conducted at the Department of Ballistic and Mechanoscopic Expertise, Center for Forensic and Information Support, Federal Police Directorate. This study is performed in accordance with the ethical principles in compliance with the law on the protection of animals of Bosnia and Herzegovina. The study was approved by the Ethical committee of the Medical Faculty, at the University of Sarajevo, and used data is part of the author's PhD thesis (Figures 1 and 2).

The sample subject is pig (Figure 1). In total, 30 shooting pigskins were used, on which 60 shootings were made, but five of them were not included in the analyses due to technical error. Part of the pig's body size is approximately 120 × 45 × 20 m composed of skin, subcutaneous and muscle tissue, areas of the chest and abdomen, which is attached to a solid surface. Shooting was conducted using a system for safe firing from the firearm Verifire (The Secure Firing Device, Twin Tooling Inc., Gormley, Canada) (Figure 3). Samples of pig skins were shot by firing bullets from four different weapons and from three different distances (contact wound, and near contact wound, centimeters cm and 10 centimeters) (Figure 4). The weapons used in the experiment were most commonly used in the Balkan region in last 10 years according to the Federal and local police. Characteristics of weapons and projectiles are presented in (Table 1, Figure 3). Because it was conducted under experimental conditions, and used firearm devices, all samples were included in analyses (Figure 3, Table 1).

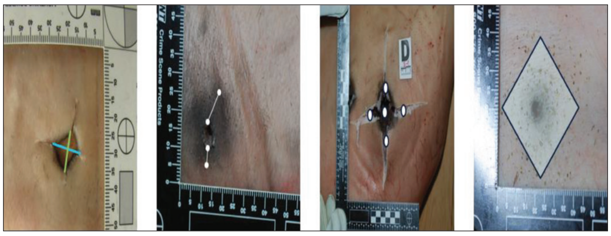

Figure 4. Examined characteristics of the wound; dimensions of the wound, contusion ring and the scattering area of gunshot powder particles were measured after shooting; based on these dimensions we have calculated the wound area; the size of the wound was determined using five points; one central point, was taken and around it the others; in one clockform, up to three, six, nine, and 12 hours; the values of surface area were calculated using the rhombus as a model

After shooting, the dimensions of the wound, contusion ring (CR), and the area of scattering of gunshot powder particles were measured. Based on these dimensions we have made calculation of the wound area. As a model of surface, rhombus was taken into account (Figure 4).

Statistical analysis

Results are presented as count (percent) or median (interquartile range) depending on data type. Fisher's exact test was used to assess significant differences between groups regarding nominal variables. Mann–Whitney U-test was used to test the differences between different weapons regarding interval data. No adjustment method for p values was used due to the small sample size and experimental nature of the study. All data were analyzed using SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA) and R Foundation for Statistical Computing version R 3.4.2. (R Core Team, Vienna, Austria).

RESULTS

In total, 55 wounds were analyzed, caused with four different weapons and from three different distances. Distribution based on the range was very similar, with no statistically significant difference in distribution, Fisher's Exact test $p = 0.992$ (Table 2).

First, we tested if there was any significant difference in any of examined characteristics of the wound in total, without considering range of firing. No significant difference was found in the horizontal or vertical diameter of the wound, nor the surface between four different calibers. CR in the narrowest and in the widest diameter had significantly different values; furthermore, the area of GSR was significantly different between tested calibers (Table 2.). We compared wound characteristics caused by pistols, and based on that, we have concluded that the widest and narrowest parts of CR significantly differs (widest $p = 0.002$, narrowest $p = 0.005$), as do GSR scattering area $p = 0.036$.

At the contact range, wounds caused with automatic rifle had horizontal, vertical diameters, significantly larger than wounds made by pistols ($p < 0.05$ *vs.* tested pistols). Diameters on gunshot wounds that were caused with different pistols, were very similar and none of them was statistically different ($p > 0.05$) (Table 3).

Table 1. Weapons of the experiment

Weapons	Caliber (mm)	Ammunition	Mark missiles	Manufacturer	Notation of sample
Pistol *Crvena zastava* M70	7.65	7.65 × 17 mm (0.32 AUTO)	PPU 0.32 AUTO	*Prvi partizan*, Užice, Serbia	A
Pistol *Crvena zastava* M57	7.62	7.62 × 25 mm	PPU 2001	*Prvi partizan*, Užice, Serbia	B
Pistol *Češka Zbrojovka* Model CZ 85 B	9 Luger	9 × 19 mm Luger	PPU 9 mm Luger	*Prvi partizan*, Užice, Serbia	C
Automatic rifle *Zavod Crvena zastava* M70AB2	7.62	7.62 × 39 mm	IK 91	*Igman*, Konjic, Bosnia and Hercegovina	D

Table 2. General characteristics of examined wounds

Parameters	Weapon			
	[a]Pistol CZ M70 (n = 14)	[b]Pistol CZ M57 (n = 13)	[c]Pistol CZ 85B (n = 13)	[d]Rifle CZ M70AB2 (n = 15)
Range				
Contact	4 (28.6%)	3 (21.4%)	3 (21.4%)	5 (33.3%)
5 cm	4 (28.6%)	5 (35.7%)	5 (35.7%)	5 (33.3%)
10 cm	6 (42.8%)	5 (35.7%)	5 (35.7%)	5 (33.3%)
Wound horizontal diameter (mm)	4.3 (2.7)	4 (1.65)	3.2 (2.5)	4.5 (15)
Wound vertical diameter (mm)	4.7 (1.3)	4.5 (1.5)	4 (2)	4.5 (18)
Surface area (mm^2)	21.2 (16.5)	20 (10.5)	12 (26.1)	20 (376.5)
Wideset part of CR (mm)	4.3 (3)[b,d]	9 (5.8)[a,d]	4 (7)[d]	20 (15)[a,b,c]
Narrowest part of CR (mm)	2.2 (2)[b,d]	4.5 (2)[a,c]	1.7 (1.5)[b,d]	4 (12)[a,c]
GSR scattering area (mm^2)	2034 (2037)[c,d]	1606 (1595)[c,d]	903 (724)[a,b,d]	4108 (2740)[a,b,c]

CR – contusion ring; GSR – gunshot residue;
[a] significant difference compared to Pistol CZ M70 at level $p < 0.05$;
[b] significant difference compared to Pistol CZ M57 at level $p < 0.05$;
[c] significant difference compared to Pistol CZ 85B at level $p < 0.05$;
[d] significant difference compared to Rifle CZ M70AB2 at level $p < 0.05$;
data are presented as median (interquartile range) or count

Table 3. Comparison of wound diameters based on the type of a gun and range

Parameters	Weapon			
	[a]Pistol CZ M70	[b]Pistol CZ M57	[c]Pistol CZ 85B	[d]Rifle CZ M70AB2
Contact (n)	4	3	3	5
Horizontal diameter (mm)	6.8 (3.1)[d]	6.5 (3)[d]	6 (1)[d]	19.5 (2)[a,b,c]
Vertical diameter (mm)	5 (3)[d]	5 (1.5)[d]	7 (3)[d]	26 (7.5)[a,b,c]
Wound surface area (mm²)	30.7 (40.2)[d]	28 (15.7)[d]	42 (13)[d]	507 (193)[a,b]
Widest part of CR (mm)	4.5 (1.5)[d]	13 (12)	11 (4)	12 (2)[a]
Narrowest part of CR (mm)	2.5 (1)[b,c]	6 (7)[a]	8 (2)[a,d]	4 (1)[c]
GSR scattering area (mm²)	567.5 (144.2)	1,000 (76.6)	627 (487)	1,575 (483)
5 cm (n)	4	5	5	5
Horizontal diameter (mm)	4.2 (1.8)	4 (1)	3 (0.7)	4 (1.8)
Vertical diameter (mm)	4.7 (2.3)	4 (2.5)	4 (1)	4.5 (0)
Wound surface area (mm²)	21.2 (13.9)	20 (10)	12 (6)	18 (5.6)
Widest part of CR (mm)	6.5 (2.1)[d]	8.1 (1)[d]	6 (5)[d]	29 (6.5)[a,b,c]
Narrowest part of CR (mm)	3 (0.3)[b,d]	4.5 (1)[a,c,d]	2 (0.5)[b,d]	15 (0)[a,b,c]
GSR scattering area (mm²)	2,144.7 (602)	1,710 (2,480.6)	558 (771)[d]	4,180 (1208)[c]
10 cm (n)	6	5	5	5
Horizontal diameter (mm)	4 (2)[c]	3.3 (1)	3 (1.8)[a]	3 (0.5)
Vertical diameter (mm)	3.8 (2.5)	4.5 (1.2)[c,d]	2.8 (1)[b]	2.5 (1)[b]
Wound surface area (mm²)	17.6 (14)	18 (5.6)[c]	8 (4.6)[b]	8.7 (3)
Widest part of CR (mm)	2.7 (0.5)[b,d]	12 (5.8)[a,d]	3 (0)[d]	21 (8.5)[a,b,c]
Narrowest part of CR (mm)	1 (1)[b,d]	4 (2)[a]	1.5 (0.3)[d]	3.5 (1)[a,c]
GSR scattering area (mm²)	2,534.5 (2,676.1)	2,012.5 (964)[d]	1,053 (350)[d]	4,444.0 (302.5)[b,c]

CR – contusion ring; GSR – gunshot residue;
[a] significant difference compared to Pistol CZ M70 at level $p < 0.05$;
[b] significant difference compared to Pistol CZ M57 at level $p < 0.05$;
[c] significant difference compared to Pistol CZ 85B at level $p < 0.05$;
[d] significant difference compared to Rifle CZ M70AB2 at level $p < 0.05$

Furthermore, wound surface area from automatic rifle was significantly larger than surface areas created with different pistol calibers (*vs.* CZ M70 p = 0.016, *vs.* M57 p = 0.036; *vs.* CZ 85 B 9 mm p = 0.036). At the contact, the values of widest and narrowest part of CR around the wound in total are significantly different (p = 0.003 and p = 0.004 retrospectively). We found that values of CR at close range (contact) had similar widest part diameter when firing from pistol with 7.62 mm, pistol with 9 mm or with automatic rifle with 7.62 mm caliber (p > 0.05). Gunpowder residue scattering area significantly differs between weapons when firing from close contact (p = 0.007). Pistol CZ M70 7.65 mm had smallest GSR scattering area, while wounds from automatic rifle had biggest GSR scattering area, but the size was very inconsistent.

At the range of 5 cm, there was not any significant difference in the diameters of the wound, or even in wound surface: horizontal diameter (p = 0.526); vertical diameter (p = 0.898), surface area (p = 0.903). The widest part of CR was significantly larger when wounds were caused with an automatic rifle (p = 0.001). Furthermore, there was not any difference between wounds caused by pistols. The narrowest part of CR was statistically different between wounds (p = 0.015). The narrowest part of CR was different on pistol wounds. Gunpowder residue scattering area was statistically different when firing with different weapons from 5 cm range (p = 0.007), with wounds from automatic rifles standing out.

In addition, diameters at the range of 10 cm are in favor of these results, with very similar results (p > 0.05). Horizontal diameters between pistol CZ M70 and pistol CZ85B were significantly different. Vertical diameter of wound caused with pistol CZ M57 (7.62 mm caliber) is significantly larger when it is caused with a 9 mm pistol or an automatic rifle. At the range of 10 cm, wounds had significantly different diameters of widest part of CR (F = 17.819, p = 0.001). Regarding the narrowest part of CR there was no statistically significant difference (F = 3.608, p = 0.063). Gunpowder residue scattering area was statistically different depending of type of weapon (F = 10.231, p = 0.004). What is interesting is that there was no statistically significant difference between GSR surface area around wounds that were caused by pistols.

Analyses of wounds caused by the same caliber but from different ranges were tested. Wounds caused by a 7.65 mm caliber pistol, had similar dimensional characteristics, and range of firing did not have any influence. Wounds caused by pistols CZ M57 with 7.62 mm caliber had significantly different horizontal diameter (p = 0.001). There was significant difference between horizontal diameters when firing with direct contact on skin and from 5 cm range (p = 0.04), also comparing wounds from direct contact between pistol and skin and those from 10 cm range, there was significant difference (p = 0.007). Horizontal diameters of wounds did not statistically differ when comparing those from 5 cm and 10 cm range.

A 9 mm caliber pistol caused much smaller wounds when firing from 5 or 10 cm than those that were caused from direct contact (*vs.* 5 cm p = 0.001; *vs.* 10 cm p = 0.001). In addition, vertical diameter was significantly smaller on wounds caused from 10 cm range than from direct contact (p = 0.004). Surface area of the wound is decreasing with the increase of the distance (p = 0.001).

The widest part and narrowest part of CR differed when using a 7.65 mm caliber pistol, measuring from three different fire ranges (p = 0.005). GSR surface area had significantly different values (p = 0.002), with trend of GSR area increasing with increase in distance. GSR surface area had significant change in value due to the change of fire range (p = 0.049). This was due to the smaller size of GSR scattering area when firing at the direct contact.

Statistically different values of widest (p = 0.007) and narrowest part of CR (p < 0.001) were measured on wounds caused with 9 mm pistol from different distances. GSR scattering area significantly differ based on distance (p = 0.002). An automatic rifle had statistically different values of widest and narrowest part of CR, based on distance (p = 0.002 and p = 0.057 respectively). There was no difference between wounds that were caused from 5 and 10 cm ($p > 0.05$). GSR surface area also significantly differ between different distances, as surface widens with the increase of distance ($p = 0.027$).

DISCUSSION

A small number of papers is done on this topic. In practice, we are searching for efficient, practical, and cheap methods that could be used for determination of firing distance and caliber.

Berryman et al. [7] compared wound diameters in head injuries, with diameters measured on skulls. They have concluded that there is no significant difference between .22 (5.6 mm) caliber and .25 (6.35 mm) caliber at close range wounds, while the .38 caliber (9 mm) wounds were significantly different ($p < 0.001$).

In our experiment, no matter which weapon we used, there was no significant difference between 5 and 10 cm range. Both of these values are categorized in near contact range, but diameters are decreasing with the increase of distance. There have been no papers testing close-range wounds so far.

Sahu et al. [8] had similar gunshot patterns in wound caused by a 9 mm pistol, in their study on a cotton cloth sheet. Horizontal diameter was wider for all the patterns at 5 cm range, but at 10 cm blackening was more dominant.

In our study, we used the geometrical shape of a rhombus. Matoso et al. [9] in their study have proven that different morphologies in the entrance holes are produces by three different calibers, using the same skull at the same shot distance of 10 cm. A 9 mm caliber wound was irregular and triangular, while a 10 mm caliber wound was round.

At the contact, the comparison of wounds caused by different weapons, the values of widest and narrowest part of CR around the wound in total, are significantly different ($p = 0.003$ and $p = 0.004$ retrospectively). Independently, we found that CR at close range had similar widest part diameter when firing from a 7.62 mm pistol, a 9 mm pistol or with a 7.62 mm caliber automatic rifle ($p > 0.05$).

Gunpowder residue scattering area differ significantly between weapons when firing from close contact ($p = 0.007$). Turillazzi et al. [10] showed that at 0.2 cm distance there was circumferential blackening with soot deposited in zone around entrance, while at 5 cm, a wide zone of powder soot overlying seared blackened skin was evident in the wound. Median area was not significantly different between 7.65 mm and 9 mm caliber. These results are in accordance with our results. The authors have proven that GSR deposits in the skin surrounding the entrance wounds strictly correlate with the shooting distance. In our study, GSR surface area had significantly different values ($p = 0.002$) when comparing calibers, with the trend of GSR area increasing with increased distance. This is explained by the fact that both ranges of 5 and 10 cm are categorized as near contact range. Intermediate range has a smaller GSR area, and in contact wounds with 0° angle GSR is in the wound channel [10].

The narrowest parts of CR could be used for determination between calibers, even between pistols. There is almost no difference between 7.65 mm caliber and 9 mm caliber.

Creating computer software for calculating wound area is one of the future goals. Petruk et al. [11] discussed multispectral method and means for determining the distance of the shot on the skin tissues. Using the computer model, they made an output of the expert system to generate diagnostic solution in the form of the distance to the target. They made a neural network. Multispectral improved method and means for determining the distance of shooting on the basis of the study gunshot injuries of the skin tissues, which allows to register the skin damage biological tissue forensic expert and use the findings as an evidence base.

The possibility to use unburned propellant powder for shooting-distance determination is analyzed in multiple articles. Hofer et al. [12] have concluded that infrared luminescence inspection of gunshot residue is an easy and reliable method for the detection of propellant particles in target tissue for about 80–90% of ammunition types. The quantification of unburned propellant particle densities can be used to draw shooting distance curves. The curve slope strongly depends on the morphology of the propellant particles. Muzzle-to-target distances could be determined up to 1.5 m for pistols and up to 3 m for revolvers.

Nowadays, GSR is the most used method for determining fire range. Even micro computed tomography analyses are based on GSR. Giraudo et al. [13] has described, “By increasing the firing distance, micro computed tomography analysis demonstrated a clear decreasing trend in the mean GSR percentage, particularly for shots fired from more than 15 cm. For distances under 23 cm, the powder particles were concentrated on the epidermis and dermis around the hole and inside the cavity, while at greater distances, they were deposited only on the skin surface. Statistical analysis showed a nonlinear relationship between the amount of GSR deposits and the firing range, well explained by a Gaussian-like function.” In our study, GSR area is also in correlation with the firing range.

Hlavaty et al. [14] have analyzed histologic findings when estimating the fire range. They have proven that although variations existed, dark material of GSR was histologically identified in many skin and soft tissue, as well as bone sections at all ranges with tested calibers. These nonparallel results decrease the dependability of histology for range of fire estimation and reinforce using gross observation.

This study included a small number of samples and only three ranges. In future studies, intermediate range and long-range gunshot wounds should be taken into account and analyzed. In addition, we made this experimental study on pigskin, and more precise data would be collected from an experiment done on cadaver skin.

CONCLUSION

A new study should be conducted on a larger sample, which would include not only experimental conditions, but also the real conditions. Computer software that automatically analyzes wound dimensions should facilitate the work. Based on this small sample, vertical and horizontal diameters, and wound surface area are useful for differentiation between pistol and rifle wounds from contact and near close range. It is an insecure method for determination of pistol caliber or fire range.

GSR has much greater potential for future analyses, but even GSR cannot be used to determine pistol caliber. It can be used to determine rifle inflected wounds, as it had significantly higher values then GSR scattering area around the pistol-inflicted wounds. In case there is a known weapon, GSR scattering area can be used to determine range. Since real-time shots were made at various angles, it is necessary to introduce a correction coefficient.

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Изглед и карактеристике рана нанесених пројектилима из различитог ватреног оружја – анимални модел

Аниса Градашчевић[1], Иван Солдатовић[2], Анес Јогунчић[3], Мирослав Милошевић[4], Нермин Сарајлић[3]

[1]Здравствени центар Оденвалдкрајса, Интерна медицина, Ербах, Немачка;
[2]Универзитет у Београду, Медицински факултет, Институт за медицинску статистику и информатику, Београд, Србија;
[3]Универзитет у Сарајеву, Медицински факултет, Катедра за судску медицину, Сарајево, Федерација Босне и Херцеговине, Босна и Херецеговина;
[4]Универзитет у Приштини – Косовска Митровица, Медицински факултет, Институт за судску медицину, Косовска Митровица, Србија

САЖЕТАК
Увод/Циљ Расип барутних честица (РБЧ) на кожи жртве је важан доказ, са високом прецизношћу, коришћен да би се добили одговори о реконструкцији догађаја, те да би се објасниле ране изазване ватреним оружјем.
Циљ ове експерименталне студије је била анализа макроскопских карактеристика рана насталих пројектилима из ватреног оружја, а зависно од калибра и врсте оружја те удаљености.
Метод Студија је спроведена у Одељењу за балистичка и механоскопска вештачења Федералне управе полиције. Експеримент је спроведен на 55 узорака свињске коже. Експериментална пуцњава је вршена помоћу система за сигурну пуцњаву. Пуцање је вршено са три удаљености: контакт, 5 *cm* и 10 *cm*.
Резултати Приликом прислона оружја, ране настале пуцањем из аутоматске пушке имале су хоризонталне и вертикалне дијаметре знатно веће од оних нанесених пуцањем из пиштоља. Дијаметри рана узрокованих различитим пиштољима су имали сличне карактеристике, без значајне разлике. На удаљености од пет центиметара најужи део нагњечног прстена је имао различите вредности и међу ранама нанесеним испаљивањем пројектила из пиштоља. Дијаметри рана изазваних пројектилима са удаљености од 10 *cm* иду у корист претходно наведеним резултатима. РБЧ је статистички значајно различит и овисан о врсти оружја ($p = 0{,}004$).
Закључак Дијаметри и површина ране корисни су показатељи у разликовању између рана нанесених пројектилима из пиштоља односно аутоматске пушке. Метода је несигурна у утврђивању калибра и удаљености пуцања. РБЧ има много веће могућности за будуће анализе, али и оне не могу бити коришћене за утврђивање калибра пројектила испаљеног из пиштоља.

Кључне речи: ране нанесене ватреним оружјем; расип барутних честица; макроскопски преглед; калибар; удаљеност пуцања