The Formation Mechanism of Projectile Entry Wound on Skin

József Volarics[1]

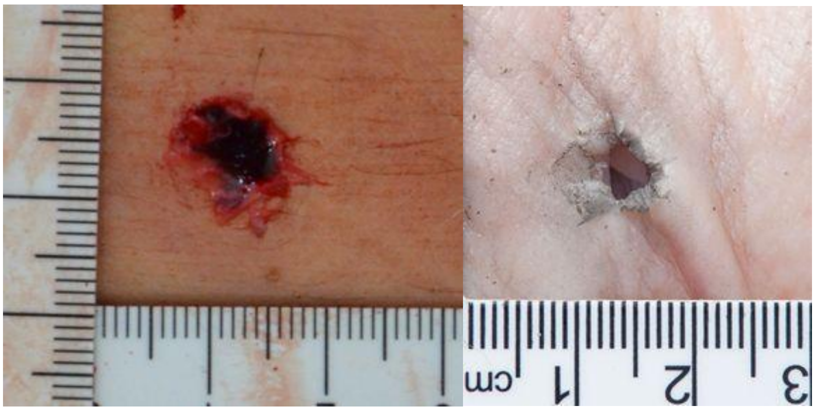
The background of the article is a shooting experiment, which was carried out in 2017. According to our experiences, the classical explanation of the formation mechanism of entry wound on skin is not adequate. The goal was to perform a new experiment to document and analyse the formation mechanism of entry wound. The secondary topic was a comparison of the GRS and traces of smokeless propellant and black powder. Different firearms and a bow were used. The velocity of the projectiles were measured, and was calculated an average for each weapon. During the test pork knuckles were shot from the same distance. The hits were documented with a high-speed camera. The high-speed - 16-30,000 fps record shows the impact of the projectile and the reaction of the skin surface in detail. Taking into account the results, the classical explanation must be modified.

Key words: wound ballistics, human skin, entry wound, axis rotation

I. Introduction

In 2017 I was requested to participate writing a textbook in field of criminal ballistics for University of Public Service, in Hungary. I worked as a co-author with Pol.Lt.Col. dr. Miklós Angyal, who is expert of forensic medicine. We finished the textbook, but due changes in circumstances, it was not released at the university.
The textbook was entered for the competition of Police Scientific Council in 2020, where it won a prize. It was eventually published online in 2021.
We made a shooting test to modelise the projectile entry wounds on skin. During this process we used pigskin to replacement the human skin. As that known these two types of skins are very similar, that we can see on the pictures. There is an entry wound on human skin from crime scene (Picture 1), and an entry wound on pig skin (Picture 2). Both of them were caused by 9 mm Luger FMJ projectile from 1 m distance.The charasteristic of these entry wounds are very similar.

Picure 1 and 2: Entry wounds on human and pig skin



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During the shooting test, we modelised the main types of entry wounds. There are two examples of these. The first is a contact shot with muzzle imprint, and stellated, blackened margin. This stellated or star shaped entry wound was created by the effect of gases which penetrated under the skin (Picture 3). [2]

Picture 3: Contact entry wound

The entry wound on the third picture is from an arrow „shot" from a crossbow. The arrow was equipped with a field point. This type of arrowhead has no blade or edge, but is conical and similar to the projectile of a firearm. The result was very interesting, beause the entry wound looked like a stab wound (Picture 4).[3] We knew the reason of this charasteristic was the velocity. But we didn't know, what happened exactly. The speed of arrows shot from bows and crossbows is significantly lower than that of projectiles from firearms, and they are usually wing stabilized.

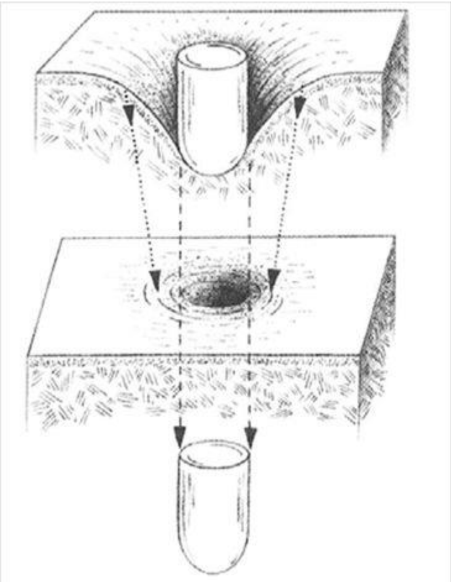
Picture 4: Entry wound of an arrow

[2] Forensic ballistic study submitted for the competition of Police Science Council, 58

[3] Forensic ballistic study submitted for the competition of Police Science Council, 53

Forensic medicine provides an explanation for the mechanism of entry wound formation (Picture 5)[4]: The impacting projectile is pressing in the surface of the skin. The skin is streching in the shape of a cone (as an elastic material)**.** The projectile is breaking the skin in the center, destroying the skin tissue by the axis rotation.

Picture 5: Schema of the formation mechanism of projectile entry wound



But the known datas of the projectile's flight also show there is something wrong about the classic theory:

- Muzzle velocity of 9 mm Luger projectile: 350 (- 400) m/s
- Axis rotation: 3000/sec

What does it mean? Approximately 116 (-133) mm of flight during an axis rotation. During the modelling experiment we shot at various materials, not only pigskin. The projectile entry holes were documented. The original goal was to establish of a collection as a database for the crime scene investigators. That's when we experienced the second interesting result. The entry hole on tire is very different from an entry wound on skin. On the tire we can see a round inprint, and a small hole with 1-2 mm diameter. If according to the classical explanation, skin behavies as an elastic material, why did't regain its original shape like a tire (picture 6).[5]

[4] In: Examination of physical injuries (*Testi sérülések vizsgálata és véleményezése, Bűnügyi-Technikai füzetek I.*), 9

[5] Angyal Miklós, Volarics József: Forensic ballistics Part II (*Kriminalisztikai Ballisztika*), 120. In: Rendőrségi Tanulmányok - 4. évf. 3. sz. (2021.) https://epa.oszk.hu/04000/04093/00016/pdf/EPA04093_rendorsegi_tanulmanyok_2021_3_094-134.pdf 2023.09.21.

Picture 6: Entry hole on tire

I found an objection in the literature: „The inertia of the hit skin precludes significant deformation of the skin at impact speeds of 200 to 300 m/s."[6] A new test was needed to answer the question.

II. Method and participants

According the plan we used to shoot with different firearms, aproximately 9 mm caliber. Except for the AK carbine in caliber 7,62 mm, which was used demonstrating the effect of high-speed impact. By using a projectile velocity measurement device we calculated the average muzzle velocity of each firearm. The human skin was replaced by pig skin this time as well. We documented the hits with a high-speed camera.

The test was a team-work. The team members were:

- Pol. Maj. Gábor Gönczöl from the Rapid Response Special Police Services, National Bureau of Investigation, Criminal Forensics Department. He is an expert of firearms, supervisory officer, crime scene investigator. His role was practical organisation, and managing modern firearms.
- Mr. Tamás Szabolics, lead development engineer, communications officer at Fusion Plasma Physics Department, Atomic Energy Research Institute, Centre for Energy Research, Eötvös Lóránd Reasearch. They work on the emergency stop system of fusion plasma powerplant which will be builded in France in 2050. They lent us a high-speed camera, which was managed by Mr. Szabolics.
- Dr. Bálint Morlin, Assistant professor, historical reenactor from Budapest University of Technology and Economics, Department of Polimer engeenering. He lent a percussion revolver, and shot with the muzzle loaders as a specialist.
- Pol. Lt. Col. József Volarics, expert of firearms, supervisory officer, CSI, from the RRSPS NBI Criminal Forensics Department. The mastermind of the test, practical organisation, and using the bow as a historical reenactor.

Finally, a special thank you to those who were not present during the test but helped with the work.

[6] Ferenc Halasi (1998): Wound ballistics (*Sebballisztika*), Bolyai János College of Military Technology, Department of Military Sciences, Budapest, 40-45.

- Pol.Lt.Col. Attila Szakács, expert of firearms at Central Police Headquarters of Budapest. He lent a projectile velocity measurement device.
- Mr. Balázs Németh, history teacher, specialist of historical shooting, sport shooter, hunter. Owner of „Kapszli Pont”. He lent a Model 1777 flintlock pistol, and propellant for muzzle loaders.
- Zsolt Ujvári forensic expert, botanist at Hungarian Istitute For Forensic, Directorate of Forensic Expertise. He took the macroscopic pictures of human hair.

III. Test shooting

A First „Shot”

The first used weapon was a nomadic bow, with 38 pounds draw weight[7]. The arrows was made with conical metal arrowheads, without blades and edges, these forms are similar to a projectile of modern firearm. The average starting velocity of the arrow was 35 m/s. We used it to modelise the effect of an extreme low velocity projectile in descending branch of the trajectory. The hits were recorded by high speed camera, the framing rate was 16,000 fps[8]. On the record we can see the point of the impacting arrow is pressing in the surface of the skin, which is is streching in the shape of a cone. Finally the arrow is stabbing through the skin in the center (Picture 7).

Picture 7: The impacting arrowhead

On the on hand, it corresponds the classic explanation of the formation mechanism of the projectile entry wound. The only different is that there is no axis rotation, because the projectile is a wing stabilized arrow. On the other hand, the mechanism as the same than the formation mechanism of the stabbing wound.

B Second „Shot”

The second used weapon was the first real firearm, a Pietta's replica of Colt Navy. It is a single action, percussion revolver with rifled barrel. It's caliber is .36, which is approximately 9 mm. All of the charges contained parabolic lead projectile, corkwood wad, black powder, and percussion cup. Chambers were closed by wax based ointment to prevent the chain fire. The average muzzle velocity was 170 m/s, which can be considered low.

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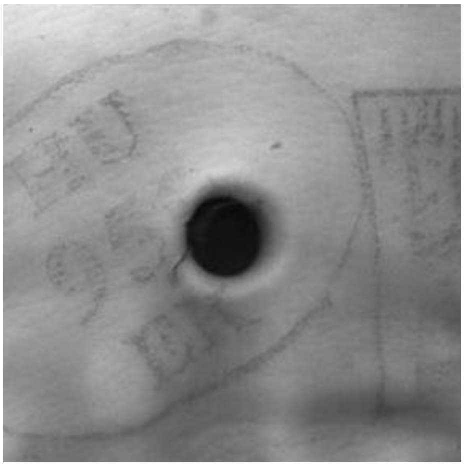
7 Draw weight is the amount of force needed to pull a bow.

8 Frame per second

The hits were recorded by high speed camera, the framing rate was 16,000 fps. We can see when the projectile is impacting on the surface of the skin, and is breaking trough it. During the hit the skin is not stretching, but the impact is starting a concentric shockwave on the surface of it (Picture 8).

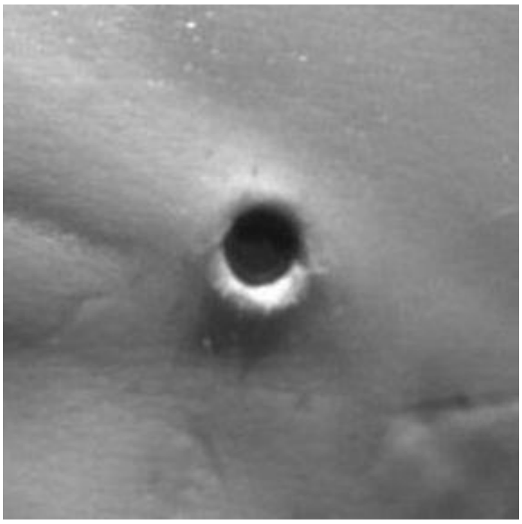
Picture 8: The impact of a .36 caliber projectile



C Third „Shot”

The third weapon was a .380 ACP (9 mm Browning short) caliber, FÉG[9] B9RK semi-automatic pistol. The average velocity of the parabolic FMJ[10] projectile was 270 m/s. The hits were recorded by high speed camera, the framing rate was 16,000 fps. Can be seen in the record, when the projectile is impacting, the particles of skin tissue is splassing out in shape of a coronet around the projectile which breaking through the the skin. At the same time the impact is starting a shockwave on the surface of the skin (Picture 9).

Picture 9: The .380 ACP caliber projectile is impacting

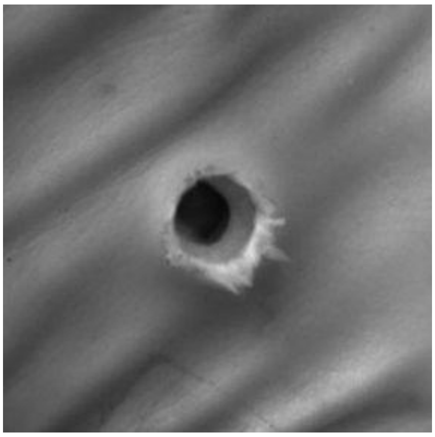


[9] Fegyver és Gázkészülék Gyár, Hungary
[10] Full Metal Jacket

D Fourth „Shot”

The fourth weapon was a 9 mm Luger (.38 Luger) kaliber CZ[11] P-07 semi-automatic pistol. The average velocity of the parabolic FMJ projectile was 350 m/s. The hits were recorded by high speed camera, the framing rate was 16,000 fps. In the record we can see when the impacting projectile is breaking through the surface of the skin, and the skin tissue splashing out in coronet shape. The formation of a shock wave is possible, but it does not appear in all cases. After the hit the temporary cavity is pushing out the surface of the skin around the entry wound, but the temporary cavity is not the subject of this study, it will be formed after the entry wound (Picture 10).

Picture 10: The impacting 9 mm Luger caliber projectile

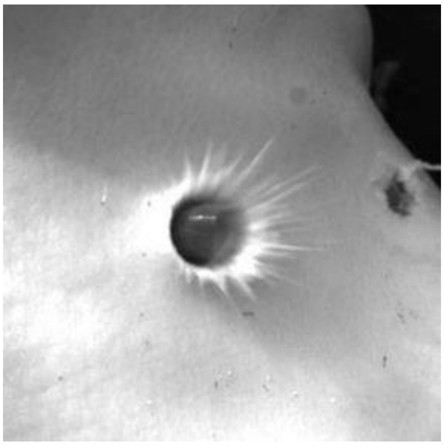


E Fifth ”Shot”

The fifth weapon was a 7,62 x 39 mm (43 M) FÉG ÖR SA85M semi-automatic carbine, which is a sport version of the famous AK assault rifle. The average velocity of the ogival FMJ projectile was 700 m/s.

The hits were recorded by high speed camera, the framing rate was 30,000 fps. Can be seen in the record, when the projectile is impacting on the surface of the skin, and breaking trough it. The coronal spillage is very distinctive - as if the skin was a liquid surface. After the hit the temporary cavity is pushing out the surface of the skin around the entry wound (Picture 11).

Picture 11: The impact of a 7,62 mm (43 M) caliber projectile

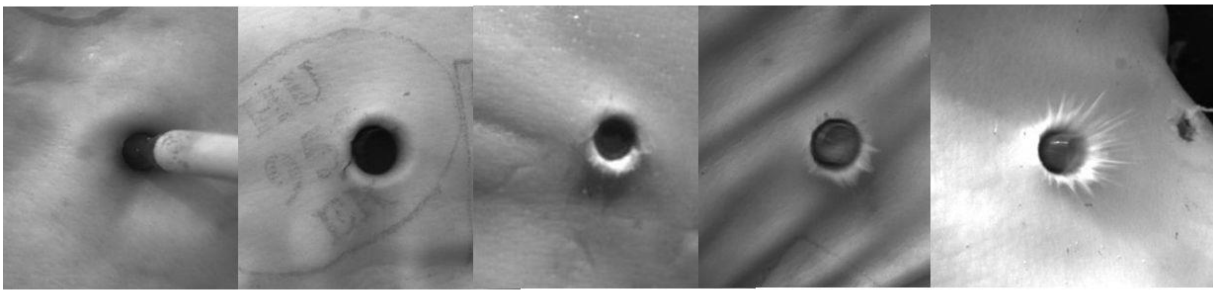


[11] Ceska Zbrojovka, Czech Republic

IV. Conclusion

During the test skin is only in case of extreme low - 35 m/s velocity projectile behaved as an elastic material. There is no any evidence of role the axis rotation during the entry wound formation. The video records show that the shock wave from the projectile destroys the skin tissue (Picture 12).

Picture 12: Comparison of the impacting of projectiles



V. References

Miklós Angyal, József Volarics: Forensic ballistic study (*Kriminalisztikai Ballisztika*) Submitted for the competition of Police Science Council, 2020.

Angyal Miklós, Volarics József: Forensic ballistics Part II (*Kriminalisztikai Ballisztika*), In: Rendőrségi Tanulmányok - 4. évf. 3. sz. (2021.) On line: https://epa.oszk.hu/04000/04093/00016/pdf/EPA04093_rendorsegi_tanulmanyok_2021_3_094-134.pdf

Ferenc Halasi (1998): Wound ballistics (*Sebballisztika*), Bolyai János College of Military Technology, Department of Military Sciences, Budapest.

Examination of physical injuries (*Testi sérülések vizsgálata és véleményezése, Bűnügyi-technikai füzetek I.*),