Int J Legal Med (2017) 131:173–177
DOI 10.1007/s00414-016-1462-9

ORIGINAL ARTICLE

Bullet fragmentation preceding a contour shot: case study and experimental simulation

V. Sterzik[1,2] · B. P. Kneubuehl[3,4] · M. Bohnert[2] · F. Riva[4] · M. Glardon[4]

Received: 8 August 2016 / Accepted: 5 October 2016 / Published online: 15 October 2016

Abstract In medico-legal literature, only a small number of publications deal with lethal injuries caused by shots with modified guns. This might lead to the conclusion that such cases are extremely rare. However, there are cases again and yet again. During the investigation process, the modified gun is of particular importance since it can show an unusual ballistic behaviour. The present paper reports on a suicide of a 60-year-old man, committed with a modified revolver and a lead bullet. The man had a single gunshot wound with entrance at the right temporal bone. Autopsy revealed that the bullet had fragmented into two major parts. The smaller one stood outside the cranial cavity and pushed its way alongside between the cranial bone and scalp to its end position in the left temporal area. The bigger part entered the cranial cavity and ended in the left parietal lobe. In shots on ballistic soap and on a head-model, the ballistics of the weapon and lead bullet were characterized. The angle necessary for bullet fragmentation was determined by shots on ballistic soap and turned out to be 55°–60° at a velocity of around 200 m/s. This knowledge was transferred to contact shots on a head-model consisting of a layered polyurethane sphere filled with 10 % ballistic gelatine and covered with a skin-like cap almost all around. The resulting injury pattern corresponded to the one of the suicide person. The bigger bullet part entered the skull while the smaller part pushed its way alongside between skin and skull causing an outer contour shot. Furthermore, the revolver was documented firing off two bullets by one trigger pull—a phenomenon of importance for forensic casework the authors have not found reported in forensic literature.

Keywords Contour shot · Ballistics · Bullet fragmentation · Gunshot injury · Suicide · Modified gun

✉ V. Sterzik
vera.sterzik@uni-wuerzburg.de

[1] Institute of Forensic Medicine, Kantonsspital St. Gallen, Rorschacher Str. 95, 9007 St. Gallen, Switzerland

[2] Institute of Forensic Medicine, Julius-Maximilians-University, Versbacher Str. 3, 97078 Würzburg, Germany

[3] BPK Consultancy GmbH, Forstweg 25, 3603 Thun, Switzerland

[4] Center of Forensic Physics and Ballistics, Institute of Legal Medicine, University of Berne, Bühlstrasse 20, 3012 Berne, Switzerland

Introduction

To determine the direction and distance of fire, gunshot wounds must be interpreted correctly and carefully. Therefore, the morphological characteristics of entrance wounds [1–4] as well as those of exit wounds [3, 5–10] can reveal important information. When interpreting the wounds, the bullet itself and its ballistic characteristics have to be taken into account. If a gun was modified, special attention has to be paid to the resulting changes in ballistics. Furthermore, a bullet can fragment into two (or more) parts during the process of hitting a target and cause atypical injuries. The fragmentation of bullets has mainly been described due to an unstable and tumbling flight after hitting another target first [11–13]. In the case presented, a modified revolver was used to fire off a lead projectile. The bullet fragmented into two major parts without having hit another target first. The smaller part pushed its way alongside between the cranial bone and scalp (outer contour shot), while the larger part entered the cranial cavity. Literature about contour shots is very scarce. When the bullet hits the cranial bone from its inside, the concave bone structure causes a progressive change of the bullets direction [14]. The bullet then pushes its way alongside the internal concave

bone structure between Dura and brain surface [14]. During test shots to investigate the case, the modified revolver fired two bullets with one shot—a phenomenon not described before. Based on the case, the authors asked themselves the following questions:

- Which velocity and which angle cause the fragmentation of a lead bullet when hitting the cranial bone?
- Is the fragmentation of lead bullets into two parts reproducible?

Case history

A 60-year-old man has been found with a single gunshot wound to his head. He died 3 days later at the hospital. Because of the background, a suicide was assumed.

Weapon and ammunition

A modified 45-year-old gas revolver (type RG6, calibre .22 Short) was found next to the body (Fig. 1). The barrel had been exchanged for one including grooves and lands. The locking devices inside the cylinder had been removed to be able to insert longer and live bullets. Furthermore, adding a ring for support had strengthened the cylinder. The ammunition used was a .22 Short lead round nose bullet.

Autopsy findings

The man showed a retained gunshot with entrance wound at the right temporal bone with a small soot cave as sign of a contact shot. The bullet had fragmented into two major parts. One part (the smaller one) remained outside the cranial cavity and pushed its way alongside between the cranial bone and scalp to its end position in the left temporal area. Furthermore, a deformed lead fragment was located within the left parietal lobe. The left orbital bone was fractured with bleeding into the surrounding tissue. The lungs were oedematous and also showed chronic emphysema. The right coronary artery and the ramus circumflexus were constricted. The heart weight brought about the critical value of 500 g. Autopsy results were compatible with the assumption of suicide.

Material and methods

Weapon and ammunition

All shots were fired with the modified revolver and lead bullets (.22 Short lead round nose bullets from Remington and Winchester, mass 1.8 g). The velocity was measured 2 m after the muzzle with two infrared light screens (LS 06, Drello GmbH).

Muzzle velocity and impact angle determination

The function of the weapon, the bullet stability, and the overall precision were assessed firing through the velocity measurement devices at a cardboard target. The shots were then fired on ballistic soap with an embedded 6-mm bone simulant (polyurethane plate, PR0114.G, Synbone AG) at different angles. The soap was arranged in a way that allowed both major parts of a fragmenting bullet to be captured (Fig. 2). The angles of incidence causing bullet fragmentation were determined and documented (Fig. 2). To transfer the gained

Fig. 1 Modified gas revolver

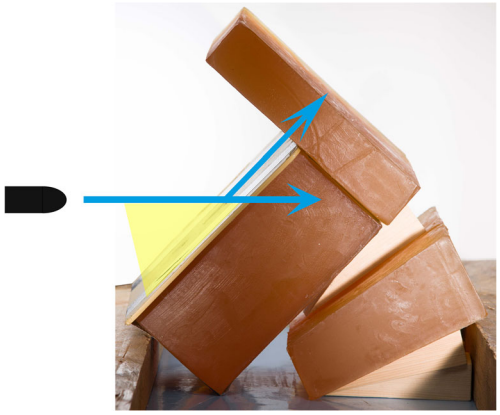

Fig. 2 Shot (*blue arrows*) fired on ballistic soap with an embedded 6-mm bone simulant. The soap was arranged in a way that allowed to capture both parts of a fragmenting bullet (*blue arrows*) and to determine the angle (marked in *yellow*)

knowledge about angles to the situation of a headshot, contact shots were fired on a head-model. The model consisted of a layered polyurethane sphere (7-mm sphere model, PR0110.G, Synbone AG) filled with 10 % ballistic gelatine and covered with a skin-like cap (made of silicone with an integrated matrix, also from Synbone AG) almost all around. All shots were video-documented by means of a high-speed motion camera (IDT X3) from a 90° side view.

Results

The bullets had an average muzzle velocity of 202 m/s and average muzzle energy of 37 J.

The bullets started to fragment into pieces at an angle of 60° (Fig. 3). At an impact angle of 55°, the resulting pieces were comparable to those found in the case with two major parts (Fig. 4).

The angles of fragmentation at the plane bone-like/soap surface were transferable to the head-model. Bullets of shots at an angle of approximately 55° fragmented into two parts when hitting the bone-like structure. The smaller part continued its way outside the cranial cavity between the bone and skin for a distance of 3–5 cm. The bigger part entered the cranial cavity and ended there (Fig. 5).

On two given positions of the cylinder, the modified revolver fired off two bullets for a single trigger pull. One bullet was fired through the barrel, and with a little delay, a second one was fired directly out of an adjacent cartridge chamber of the cylinder. High-speed images showed that the recoil of the cylinder squeezed and ignited the annular primer of the second cartridge. The flight of the second bullet is unstable, due to the absence of gyroscopic stabilization.

Reproducibility of two bullets being fired off

In total, 24 shots have been fired. The double shot happened twice unexpectedly during the function test of the weapon. The double shot could again be reproduced twice while being filmed. When firing at the simulants, the faulty cylinder positions were avoided to be able to reproduce the single impact to the head of the victim.

Discussion

Investigators have to be aware that modifications of a gun can change the initial ballistics completely, turning even a non-lethal device into a lethal or life-threatening gun [15–17]. Modified guns are repeatedly used and encountered in forensic casework, especially in suicide cases [17–27]. By modification, the mandatory control and registration of firearms are avoided [16]. The study presented focused on the ballistics of

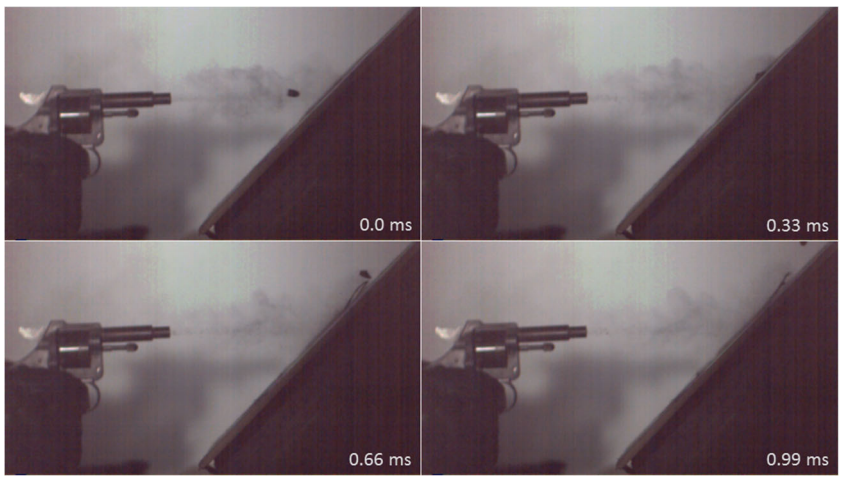

Fig. 3 High-speed picture of the bullet separation

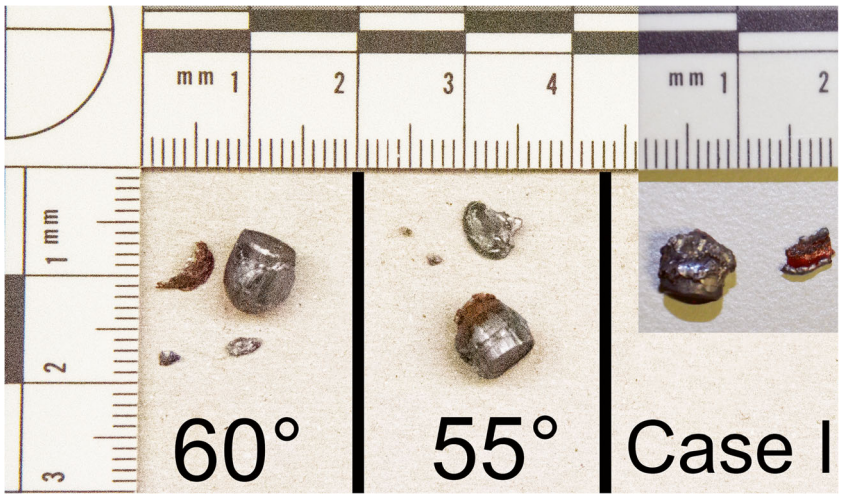

Fig. 4 Impact angles and resulting lead pieces

lead bullets fired from a modified revolver used for suicide. It was shown that the tested lead bullets can fragment into two major parts when they hit the head-model with an angle of 55°–60°, what can easily be achieved when pointing the gun to someone's own head in order to commit suicide. The fact that lead bullets can fragment into two pieces when hitting the skull was reported before without investigating the range of angle necessary for fragmentation [28]. In this study, a skin-skull-brain model was used [29] to document and analyse the behaviour of lead projectiles in the course of grazing shots [28]. In this previous study, the skull had not been covered with a skin replacement for the shots with lead bullets [28].

Fig. 5 Schematic mechanism of bullet fragmentation and resulting injury pattern

The ballistics of the fragmenting bullet was described as follows "Due to the bullet–body interaction with the polyurethane bone a small part of the projectile is torn off. This fragment flies outside of the skull. The main part of the projectile continues traveling within the artificial skull and leads to the blow out of a large portion of the skull" [28]. The head-model used in our study was covered with a skin-like material almost all around. The advantage, compared with the skin-skull-brain model presented earlier [29], lies in a more realistic way of simulating the natural conditions. Since the skin-like material encloses the skull almost completely, it is fixed by itself like the skin surrounding the head of a live person. Therefore, the effect of the bullet part that remained outside the skull could be investigated more closely. In all test shots, the smaller part of the bullet remained outside the skull and pushed its way alongside between skin and skull for a varying distance of 3–5 cm. In a living person, the consequence will be an outer contour shot, as there was in the case presented. Unlike other test shots with lead bullets [28], the skull in our model did not fracture nor did the skull of the person committing suicide. This may be due to the fact that the modified revolver in our study had a muzzle energy of 37 J compared to 227 J in the other test shots [28]. Moreover, the curvature of the head-model does not mirror the shape of a natural skull exactly. Nevertheless, it has proven to be usable as a model since the injury mechanism could be reproduced.

As side result in our test shots, the modified revolver turned out to be able to fire off two bullets by a single trigger pull. This was possible because rim fire cartridges were used. In literature, no comparable data is reported. Still, this is an exciting phenomenon that forensic investigators should be aware of when they reconstruct shooting incidents and must assess whether a particular case is a homicide or suicide. Indeed, had the decedent fired one of the faulty positions, he

would have showed two impacts, with one seemingly originating from a destabilized shot. This also shows the importance of performing test shots with the questioned weapon in cases with atypical wounds or modified firearms.

Conclusions

- Lead bullets (.22 Short lead round nose bullets) fragment into two major parts when they hit a bone-like material with an angle of 55°–60° and a velocity around 200 m/s.
- The bigger part enters the skull while the smaller part pushes its way alongside between skin and skull causing an outer contour shot (Fig. 5).

Acknowledgments The study was supported by a grant of the Interdisciplinary Centre for Clinical Research IZKF of Julius-Maximilians-University of Würzburg.

The authors thank Katrin Moosbrugger for the graphic works.

References

1. Grosse Perdekamp M, Vennemann B, Mattern D, Serr A, Pollak S (2005) Tissue defect at the gunshot entrance wound: what happens to the skin? Int J Legal Med 119:217–222
2. Pollak S (1982) Macro-and micromorphology of bullet wounds caused by handguns. Beitr Gerichtl Med 40:493–520
3. Sellier K (1969) Schusswaffen und Schusswirkungen I, 2nd edn. Schmidt-Römhild, Lübeck
4. Sellier K (1969) Bullet entry studies of the skin. Beitr Gerichtl Med 25:265–270
5. Thierauf A, Glardon M, Axmann S, Kneubuehl B, Kromeier J, Pircher R, Pollak S, Grosse Perdekamp M (2013) The varying size of exit wounds from center-fire rifles as a consequence of the temporary cavity. Int J Legal Med 127:931–936
6. Besant-Matthews PE (2000) Examination and interpretation of rifled firearm injuries. In: Mason JK, Purdue BN (eds) The pathology of trauma, 3rd edn. Arnold, London, pp 47–60
7. Apfelbaum JD, Shockley LW, Wahe JW, Moore EE (1998) Entrance and exit gunshot wounds: incorrect terms for the emergency department? J Emerg Med 16:741–745
8. Karger B (2004) Schussverletzungen. In: Brinkmann B, Madea B (eds) Handbuch gerichtliche Medizin. Springer, Berlin, pp 593–682
9. Kneubuehl BP, Coupland RM, Rothschild MA, Thali M (2011) Wound ballistics: basics and applications. Springer, Berlin
10. Grosse Perdekamp M, Pollak S, Thierauf A, Strassburger E, Hunzinger M, Vennemann B (2009) Experimental simulation of reentry shots using a skin-gelatine composite model. Int J Legal Med 123:419–425
11. Farrugia A, Raul JS, Geraut A, Tortel MC, Ludes B (2009) Destabilization and intracranial fragmentation of a full metal jacket bullet. J Forensic Leg Med 16:400–402
12. Thali MJ, Kneubuehl BP, Dirnhofer R, Zollinger U (2001) Body models in forensic ballistics: reconstruction of a gunshot injury to the chest by bullet fragmentation after shooting through a finger. Forensic Sci Int 123:54–57
13. Uzar AI, Dakak M, Saglam M, Ozer T, Ogunc G, Ide T, Oner K, Sen D (2003) The magazine: a major cause of bullet fragmentation. Mil Med 168:969–974
14. Pollak S (2015) Schussverletzungen. In: Madea B (ed) Rechtsmedizin, 3rd edn. Springer, Berlin Heidelberg, pp 245–262
15. Pazardzhikliev DD (2014) Multiple-projectile penetrating neck injury from a modified nail-containing gas pistol. Balkan Med J 31: 254–256
16. Di Nunno N, Viola L, Colucci M, Di Nunno C, Constantinides F (2009) A case of suicide using a home-modified gun. Am J Forensic Med Pathol 30:52–56
17. Karger B, DuChesne A (1995) Suicide with a signel pen gun. Int J Legal Med 107:323–325
18. Nikolic S, Zivkovic V (2015) Suicidal Krönlein shot with a home manufactured firearm. Forensic Sci Med Pathol 11:297–299
19. Hejna P, Safr M (2010) An unusual zip gun suicide—medicolegal and ballistic examination. J Forensic Sci 55:254–257
20. Definis Gojanovic M (1995) Fatal firearm injuries caused by handmade weapons. J Clin Forensic Med 2:213–216
21. Alessi G, Aiyer S, Nathoo N (2002) Home-made gun injury: spontaneous version and anterior migration of bullet. Br J Neurosurg 16:381–384
22. Cunliffe CH, Denton JS (2008) An atypical gunshot wound from a home-made zip gun—the value of a thorough scene investigation. J Forensic Sci 53:216–218
23. Goonetilleke UK (1982) Suicide by home-made gun. Med Sci Law 22:111–114
24. Hiss J, Shoshani E, Zaitsew K, Giverts P, Kahana T (2003) Self inflicted gunshot wound caused by a home-made gun—medico-legal and ballistic examination. J Clin Forensic Med 10:165–168
25. Karger B, Teige K, Brinkmann B (1995) Zwei Suizide mit selbstgefertigten Schussapparaten: Kriminaltechnische und einschussmorphologische Besonderheiten. Arch Kriminol 195: 147–152
26. Mackley P, Püschel K, Turk EE (2010) Suicide by shooting with a tiling hammer. Int J Legal Med 124:75–77
27. Maxeiner H, Horn W, Beyer W, Mittelhaube V (1986) Rekonstruktion eines Suizids mit einer selbstgefertigten Schußwaffe. Arch Kriminol 177:19–28
28. Thali MJ, Kneubuehl BP, Zollinger U, Dirnhofer R (2003) A high-speed study of the dynamic bullet-body interactions produced by grazing gunshots with full metal jacketed and lead projectiles. Forensic Sci Int 132:93–98
29. Thali MJ, Kneubuehl BP, Zollinger U, Dirnhofer R (2002) A "skin-skull-brain model" for the biomechanical reconstruction of blunt forces to the human head. Forensic Sci Int 125:195–200