THE CHARACTERISATION OF BULLET HOLES IN HELMETS MADE OF COMPOSITE MATERIALS: A CASE STUDY

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ABSTRACT: A simple method is presented for the estimation of the diameter of the entrance bullet holes in military helmets made of laminated composite materials. The novel part of this method includes the use of steel spikes of various diameters as gauges for the bullet's diameter. It was found that the highest diameter spike, successfully inserted into the bullet hole, gives an indication of the diameter of the bullet. In addition, colour tests for lead and copper are also used for determining whether the hole is from bullet entrance or exit.

KEY WORDS: Forensic science; Military helmets; Composite materials; Bullet holes; Bullet calibre.

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INTRODUCTION

The identification of bullet holes is based, besides the morphology of the hole in question, on the presence of gunshot residue and of blackening in the vicinity of the hole. In the Israeli Police Toolmarks and Materials Laboratory, bullet hole identification is usually based upon two colour spot tests for the presence of lead and copper residue in the margins of the hole [4]. This colour test method is also used to estimate the diameter of entrance bullet holes in a variety of materials, by measuring the colour rings developed [1]. The laboratory had already reported also the use of this method for the characterisation of bullet holes at a shooting scene [2].

The present case demonstrates the advantages and limitations of the results obtained by using the spot test method when applied to military helmets. It also presents a simple method for the estimation of the bullet entrance hole diameter in such helmets.

CASE SUMMARY

A soldier was killed by a single shot to his head during a military manoeuvre. A military physician, examining the victim in the field, discovered two wounds in the victim's head, one in his forehead and the other in the occipital area. In the back of the soldier's helmet, in a location corresponding to the hole in the occipital area, a hole was found having the characteristic morphology of a bullet hole (Figures 1 and 2).

Fig. 1. The victim's helmet. The arrow points to the hole found in the back of the helmet.

Fig. 2. A closer view of the hole in back of the victim's helmet (scale in cm).

During the investigation of this unfortunate incident it was learned that during the manoeuvre, two other soldiers were shooting from about 30 meters behind, while the victim soldier was lying in his position. One of these soldiers shot a 7.62 mm FN MAG machine gun and the second shot a 5.56 mm "Gallil" assault rifle.

The questions confronting the investigators were:

1. Is the hole in the victim's helmet a bullet hole?
2. Is it from bullet entrance or exit?
3. Estimating the bullet hole diameter – is it from 5.56 mm or from 7.62 mm bullet?

METHODS AND RESULTS

The victim's helmet and combat vest were submitted for examination in the Toolmarks and Materials Laboratory. The helmet was made of a laminated composite material.

Visual examination

It was found that the size of the hole in the back of the helmet was about 1 cm. The fibres in the margins of this hole were, surprisingly, pointed towards the outside in the outer side of the hole, as well as towards the inside in the inner part of it. This finding is in contrary to "regular" bullet entrance holes, where the direction of the margins of the hole is towards the exit. In addition, the damaged plastic fibres blocked the passage of the bullet, so it was not possible to estimate the bullet diameter by measuring the bullet hole. A 10 cm long tear was found on the back pouch of the victim's combat vest (Figure 3).

Spot tests for lead and copper

The outer and inner sides of the bullet hole in the helmet and the tear in the combat vest were examined. A positive colour reaction for copper, 0.5 cm in size, was observed in the outer side of the bullet hole in the helmet. A positive colour reaction for copper, 1 cm in width, was also observed along the tear on the pouch of the vest (Figure 4). No lead was detected in the margins of these holes, and no copper was observed in the inner side of the helmet bullet hole.

Using these results, several conclusions were reached, regarding the bullet path and calibre. A positive colour reaction for copper in the outer side, and a negative one in the inner side, indicate that the hole in the helmet is the entrance hole. The presence of copper in the margins of the tear indicates

Fig. 3. The tear found in the back pouch of the victim's combat vest (scale in cm).

Fig. 4. The positive colour reaction for copper observed along the tear in the back pouch (scale in cm).

that it was caused by a bullet. The direction of the long axis of this tear is pointing towards the bullet hole in the helmet (Figure 5), being an additional indication that the bullet hole in the back of the helmet is indeed from entrance.

The calibre of the bullet, however, could not be estimated based on the spot test for copper. There was a need to conduct test firing using similar helmets.

Fig. 5. The combat vest and the victim's helmet. The longer axis of the tear in the back pouch of the vest is pointing towards the hole in the back of the helmet.

Test firing

Test firing was performed, under conditions similar to this case, to characterise bullet holes in helmets. The test shots were fired from a distance of 30 m. Seven shots were fired by a "Gallil" assault rifle and eleven shots – by "MAG" machine gun.

The morphology of the bullet entrance holes in the test shooting was similar to the outer side of the hole in the victim's helmet. The fibres in the margins of the helmets were pointed towards the outside from the outer side of the holes and towards the inside from the inner side of the hole.

A measurable colour reaction was obtained only for copper in both ammunition types. The dimension of the copper colour reaction for 5.56 mm ammu-

nition was between 0.4–0.6 cm and for 7.62 mm – 0.5–1.3 cm. It was impossible to estimate the bullet calibre by the diameter of the copper colour reaction. The lead colour reaction gave vague spots of unmeasurable dimensions, for both callipers, and it could not be used for calibre estimation.

In the following section a method for the estimation of calibre in entrance bullet holes in helmets will be described.

Study of spike penetration

Three spikes, made of stainless steel, were prepared, in diameters of 6, 7 and 8 mm. The possibility of pushing these spikes, serving as gauges, through the bullet holes was examined (Figure 6), and the results are presented below.

Fig. 6. Pushing a steel spike, serving as a gauge, through a bullet hole in one of the test shot helmets.

The 5.56 mm ammunition holes: The 6 mm spike was pushed through 2 of 7 test holes. The 7 mm spike did not pass through any of the test holes.

The 7.62 mm ammunition holes: The 6 mm spike was pushed through all 11 test holes. The 7 mm spike was pushed through 10 of the 11 test holes. The 8 mm spike was pushed through 3 bullet holes.

The bullet hole under examination: Based on these results it was assumed that this method might be applied for estimating bullet calibre in the

present case. All three spikes, 6, 7 and 8 mm, were pushed through the bullet hole in the victim's helmet.

DISCUSSION

Based on these results it was possible to reconstruct the bullet's trajectory and its calibre. The presence of both copper and lead in the outer side of the bullet hole indicates that the fatal bullet hit the victim from behind. In addition, the tear in the back pouch of the victim's combat vest supports this conclusion.

The composition of the helmet (laminated composite material [5, 6]) made it difficult to estimate both the direction of the bullet and its calibre by visual examination of the hole. The phenomenon that the fibres in the bullet hole vicinity point towards the inside of the helmet as well as towards the outside has already been described [3]. The penetration of the bullet causes the separation of the fabric laminae, the blocking of the bullet hole and the resultant fabric separation. It was possible to estimate the bullet calibre by forcing the pointed spikes into the bullet hole.

CONCLUSIONS

1. The morphology of the hole, the positive colour test for copper in the hole, and the tear in the vest, enabled examiners to determine that the bullet hole in the helmet was an entrance hole.
2. By pushing spikes of various diameters in entrance bullet holes in the helmets, one can estimate bullet calibre.
3. It can be concluded, that the calibre of the ammunition in the case under consideration was 7.62 mm.

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References:

1. Bergman P., Even H., Argon N. [et al.], Estimation of a bullet's diameter using the bullet hole identification kit (BTK), *Journal of Forensic Sciences* 1987, vol. 32, pp. 866–879.

2. Bergman P., Springer E., Bullet hole identification kit: Case report, *Journal of Forensic Sciences* 1984, vol. 32, pp. 802–805.
3. Gafni Z., Failure mechanisms in composites under ballistic loading, Israel Institute of Technology, Haifa 1995 [unpublished doctor's dissertation].
4. Steinberg M., Leist Y., Tassa M., A new field kit for bullet hole identification, *Journal of Forensic Sciences* 1984, vol. 29, pp. 169–176.
5. Twaron helmets, Internal report, Edition 1995/1, Akzo Nobel Faser AG, Wuppertal, Germany.
6. Twaron in soft body armour, Internal report, Edition 1995/1, Akzo Nobel Faser AG, Wuppertal, Germany.