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Colour contrast in ballistic gelatine

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A B S T R A C T

Gelatine is a reliable tissue simulant in wound ballistic experiments. The projectile penetrating the gelatine transfers energy and causes radial cracks according to the temporary cavity. Thus the crack length is a function of the energy spent in the medium. In practice the fissures are poorly contrasted for which reason an enhancement of contrast was searched.

A series of six shoots with expanding bullets (9 mm × 19 Action-5, 9 mm × 19 Quick Defense 1, 5.56 mm × 45 Styx Action) was realized on 10% gelatine blocks at 4 °C temperature. Three blocks were marked with acryl paint on the front, three blocks were shot native. The blocks were cut in slices of 1 cm thickness and optically scanned. The evaluation was performed according to Fackler's wound profile, the total crack length method and the polygon method. The paint was soaked into the block by the collapse of the temporary cavity and transported with diminishing intensity to the end of the trajectory. Colour contrast was successfully realized in all the shots which made easier to measure the length of the fissures. The comparison of the shots with and without paint gave a better reproducibility of measures with colour contrast. Using paint the energy transfer began earlier so that the curve of the wound profile was shifted by 1 cm to the entry which is explicated by the paint pad put on the block. The maximum crack lengths did not significantly differ with and without paint. All evaluation methods profited from colour contrast but the total crack length method the most of all. Further experiments showed that colour contrast is also successful in 20% gelatine and is not dependent of the type of projectile.

1. Introduction

Since many decades gelatine is used in ballistics to simulate soft tissue [6,11]. By shooting into gelatine blocks the material is perforated along the trajectory of the projectile. If the missile has enough energy the gelatine is displaced in lateral direction and so a temporary cavity is created by the energy transfer. In order to analyze the effects of the bullets the gelatine blocks are cut in slides vertically to the shooting direction. Whereas the directly perforated zone remains as a hole (permanent cavity) in the slice, the temporary cavity has collapsed after a few milliseconds. Only cracks of the gelatine show where the gelatine was stretched by the temporary cavity. Because the crack length depends on the intensity of stretching and also of the toughness of the gelatine Fackler [3] established a standard for ballistic gelatine to make ballistic experiments reproducible and comparable [5]:

- gelatine type 250A Kind & Knox;
- gelatine 10% solution;
- preparation avoiding heat excess;
- shooting on blocks of 4 °C temperature;

Shooting tests on such standard gelatine blocks with ammunition of lower energy – especially up to 500 J – produced cracks which were in part difficult to discern [7]. Therefore a method was searched to enhance the contrast of the tears in gelatine.

2. Material and methods

10% standard gelatine blocks were prepared following Fackler's instructions. They were cut into blocks of 15 cm height, 15 cm large and 30 cm length. Just before shooting red or blue acryl paint was put on the front of the block in a circle of ca. 3 cm diameter and covered by three layers of thin cotton textile. To avoid splashes of paint in the room – especially on the gauges – the gelatine block was placed in a cardboard box. The shooting distance was 5 m. 25 cm in front of the block a speed measuring device was installed to record the velocity of the projectile. After the block another speed measuring device took the rest velocity of bullets which penetrated the block. All the blocks were cooled at 4 °C temperature. Two series of three shots were effectuated, with and without paint.

Table 1 gives the technical details of the weapons and ammunition used.

After the test shootings the blocks were photographed and cut into consecutive slices of 1 cm thickness. Images of the slices were made with a scanner (Epson Perfection 3200) at 300 dpi resolution. The images were evaluated on a personal computer using the software analySIS 3.2 (Münster, Germany). The following evaluation methods were applied:

- The Total Crack Length (TCL) method [4,9]: the length of each tear is measured from the middle of the permanent cavity and all crack lengths in a slice are added up and then the results of all the slices are added up all over the block (total damage) (Fig. 1).

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Table 1
Technical data of weapons and ammunition.

Weapon	Calibre	Ammunition manufacturer	Bullet type	Bullet material	Bullet weight
Pistol Glock 17	9 mm × 19 (Luger)	M.E.N.	Quick Defense 1	Copper alloy	6.1 g
Pistol Glock 17	9 mm × 19 (Luger)	RUAG	Action-5	Brass	6.1 g
Assault Rifle G36 C	5.56 mm × 45 (.223 Rem.)	RUAG	Styx Action	Semijacketed hollow point Lead core	4.5 g

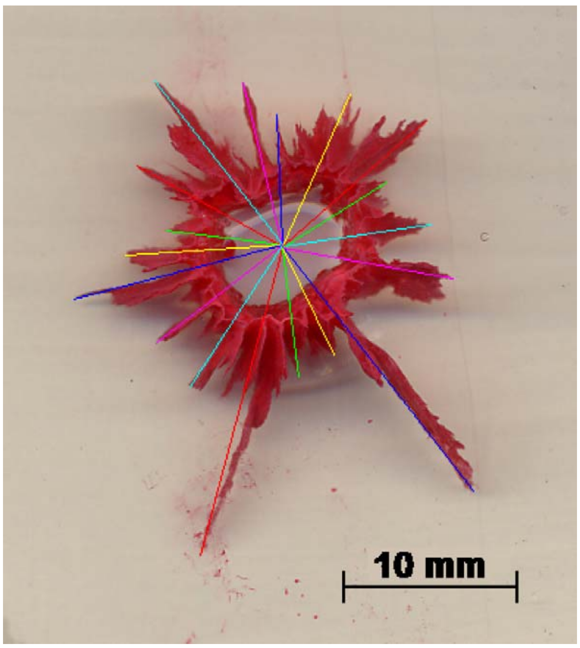

Fig. 1. TCL method demonstrated in the 3 cm slice of a red coloured shot with the Quick Defense 1. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

- Fackler's wound profile (WP) [1]: the two greatest cracks in a slide are added up and then the results of all the slices are added up all over the block (total damage) (Fig. 2).
- The polygon-procedure (PP) [11]: the ends of the tears are linked by lines which create a polygon. The polygon perimeter is taken as value of damage for each slide. The polygon perimeters of all the slices are added up all over the block (total damage) (Fig. 3).

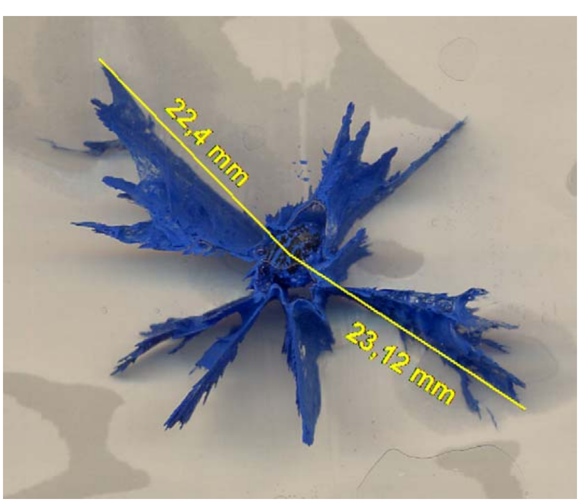

Fig. 2. Fackler's wound profile demonstrated in the 4 cm slice of a blue coloured shot with the Action-5. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

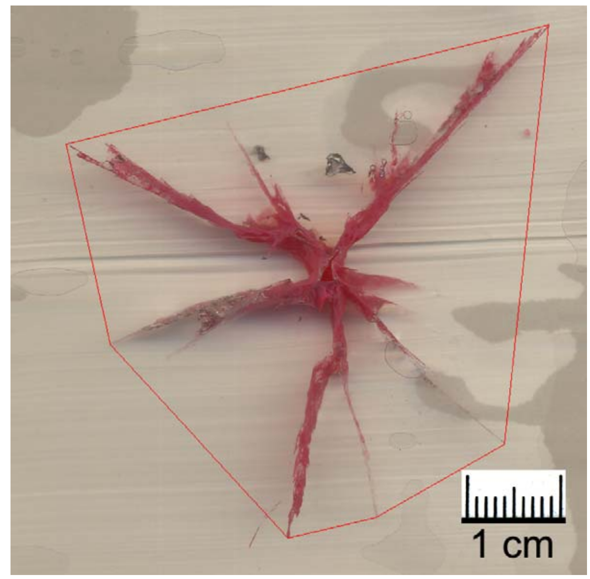

Fig. 3. The polygon method demonstrated in the 14 cm slice of a magenta coloured shot with the Styx Action rifle bullet. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

3. Results

The two shooting series with each three shots had the following basic data (Table 2).

In all the three shots with paint application on the block a part of the paint was transferred into the block. The greatest intensity was noted in the first centimetres of the trajectory where the paint filled literally the cracks (Figs. 1 and 2). There was a sensible difference between the 9 mm Luger shots (about 500 J) and the .223 rifle shot (energy about 1000 J). With the pistol ammunition the paint reached also deeper in the block the ends of the tears in gelatine (Fig. 4). From ca. 15 cm to the end the intensity of colour was diminishing. But paint was observed in each slice up to the end of the trajectory. However in the track left by the rifle bullet the intensity of colour was all in all weaker (Figs. 3 and 5) and ended at 20 cm depth.

Whereas it was very difficult to measure the correct length of the cracks – especially the finest ones – in the blocks without paint there was no problem to find the red or blue coloured tear ends. The paint emphasized the three-dimensional character of the

Table 2
Basic data of the shots.

Projectile	Colour	Velocity	Rest velocity	Energy transferred
Quick Defense 1	None	408 m/s	None	508 J
Quick Defense 1	Red	406 m/s	None	503 J
Action-5	None	422 m/s	None	543 J
Action-5	Blue	414 m/s	None	523 J
Styx Action	None	670 m/s	35 m/s	1007 J
Styx Action	Magenta	677 m/s	Failed	<1031 J