ORIGINAL ARTICLE

EXPANDING .308 WINCHESTER CALIBRE AMMUNITION AND SOFT TISSUE INJURY

Amunicja ekspandująca kalibru .308 Winchester a obrażenia w tkance miękkiej

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Abstract

Introduction and objective: The aim of the study was to analyse injuries inflicted by Scenar bullets, which resemble dum-dum (expanding) projectiles in their design. Particular attention was paid to the impact of bullet velocity on the shape of the temporary cavity in soft tissue and the possibility of predicting wound profile parameters at comparable kinetic energies of the bullets. **Materials and methods:** An experiment was conducted using a block of ballistic gelatin cooled to 6°C. The block was fired at from a distance of 25 m using an Oberland Arms OA10 rifle, calibre .308 Winchester. The velocity of the bullet and its movement in the gelatin were recorded using a high-speed Phantom Miro 310 camera at 20,000 frames per second. The expansion and fragmentation of the bullet, as well as the effect of kinetic energy on the formation of the temporary cavity were assessed. **Results:** A description of the phenomena was presented, the process of permanent and temporary cavity formation created by the Scenar bullet was discussed, and photographic documentation was presented. **Conclusions:** The velocity of the Scenar bullet affects the shape of the temporary cavity within the soft tissue. A lighter bullet (167 gr) with lower kinetic energy produced a larger temporary cavity compared to a heavier bullet with higher energy (185 gr) due to loss of stability.

Streszczenie

Wprowadzenie i cel: Celem badania była analiza obrażeń powodowanych przez pocisk Scenar, który swoją konstrukcją przypomina pociski ekspandujące typu dum-dum. Szczególnie skoncentrowano się na wpływie prędkości pocisku na kształt jamy chwilowej w tkance miękkiej oraz na możliwości przewidywania parametrów profilu rany przy porównywalnej energii kinetycznej pocisków. **Materiał i metody:** Przeprowadzono eksperyment, wykorzystując blok żelatyny balistycznej schłodzonej do 6°C. Ostrzelano go z odległości 25 m, używając karabinu Oberland Arms OA10 kaliber .308 Winchester. Rejestrowano prędkość pocisku i jego ruch w żelatynie za pomocą szybkiej kamery Phantom Miro 310 z prędkością 20 000 klatek na sekundę. Analizowano sposób ekspansji oraz fragmentacji pocisku, a także wpływ energii kinetycznej na tworzenie się jamy chwilowej. **Wyniki:** Przedstawiono opis zjawisk, omówiono proces tworzenia się kanału trwałego i jamy chwilowej wywołany przez pocisk Scenar oraz zaprezentowano dokumentację fotograficzną. **Wnioski:** Prędkość pocisku Scenar wpływa na kształt kanału chwilowego w tkance miękkiej. Lżejszy pocisk (167 gr) o mniejszej energii kinetycznej, dzięki utracie stabilności, wytworzył większą jamę chwilową w porównaniu z pociskiem cięższym o wyższej energii (185 gr).

Keywords: international humanitarian law; dum-dum bullet; Scenar bullet

Słowa kluczowe: międzynarodowe prawo humanitarne; pocisk dum-dum; pocisk Scenar

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Introduction

Expanding bullets, commonly referred to as dum-dums, are projectiles designed to increase the impact on soft tissue. As they expand within the body, they tend to produce more extensive damage compared with full metal-jacketed (FMJ) projectiles [1]. During penetration, these projectiles transfer energy to the surrounding tissues, resulting in injury, the severity of which depends on factors such as loss of stability and the degree of deformation. This process may also lead to projectile fragmentation, thereby increasing the risk of internal injuries [2]. Consequently, injuries inflicted by expanding projectiles present a significant challenge for surgeons [3].

The ban on the use of expanding bullets was introduced in 1899 under the Hague Declaration concerning Expanding Bullets that expand or flatten easily in the human body. The authors of this document were inspired by the 1868 St. Petersburg Declaration, which sought to prohibit excessively cruel weapons in response to the development of the dum-dum projectiles [4]. The wording of Article 8(2)(b) and Article 8(2)(e) was derived from the 1899 Hague Declaration and referred to bullets with a hard envelope (jacket), bullets in which the core was not fully covered, and bullets with scoring.

In the current geopolitical context, some countries oppose further expansion of the ban on the use of expanding projectiles. Public arguments have emerged suggesting that the use of such ammunition is necessary and particularly useful in counterterrorism operations. This argument is often supported by the notion that operations conducted in urban environments (dynamic operations) using semi-jacketed or hollow-point ammunition during efforts to restore public order may offer certain advantages [5]. The primary advantage of such projectiles, compared with standard FMJ bullets, is their tendency to remain within the assailant's body. This reduces the risk of injury to bystanders. It is also worth noting that, due to their design, expanding bullets exhibit substantial 'disabling power,' defined as the ability to immediately incapacitate an attacker after a single hit, thereby preventing them from firing a shot [6]. Despite ongoing controversy, defence companies are developing controlled-expansion ammunition. Efforts are focused on identifying solutions that will maintain the advantages of this type of ammunition while increasing its predictability and limiting injuries.

From the point of view of international humanitarian law and ethical principles, the use of expanding projectiles in military operations remains controversial. The distinction between evaluating their use in counterterrorism s (restoring public order) vs military operations arises from two separate branches of law. According to Melzer, one possible, though imperfect, explanation is that there is greater tolerance for 'collateral damage' in warfare than in counterterrorism operations [7]. The situation looks different in the United States, where such ammunition, when used for private purposes, such as hunting, personal protection, or law enforcement, is not subject to international conventions. An example is the 9 mm RIP™ radically invasive bullet, the use of which would theoretically fall under the scope of international restrictions [8], yet the U.S. does not fully recognize these limitations [9]. The bullet in question consists of eight segments, referred to by the manufacturer as 'trocars' (a term originating from a surgical instrument). These segments are designed to fragment upon entry and penetrate soft tissue, thereby maximizing the severity of damage [10].

The group of bullets referred to as deforming or expanding includes lead-core bullets, jacketed soft-point (JSP) bullets, and semi-jacketed hollow-point (SJHP) bullets. From a physical standpoint, the mechanism of incapacitation can be described as controlled expansion, which involves fragmentation. Manufacturers achieve controlled expansion by creating a hollow point in the bullet's tip.

Upon impact, the expansion process begins at the projectile's tip, leading to an increase in its cross-sectional diameter and the amount of energy dissipated in the soft tissue (Fig. 1). These projectiles exhibit minimal change in trajectory following soft tissue penetration [11], because the tip deforms upon striking the target, taking on a mushroom-like shape [12]. As a result of this deformation, the projectile's centre of mass shifts closer to the point at which hydrodynamic drag forces act, thereby increasing its stability. The magnitude and pattern of expansion depend on the size and shape of the hollow point (air void), as well as on the projectile's material and construction.

Aim

The aim of the experiment was to investigate the damage inflicted by the Scenar projectile, which is similar in design to dum-dum projectiles. The following research questions were formulated:

- Does bullet velocity affect the shape of the temporary cavity in soft tissue?
- Will bullets with comparable kinetic energy produce identical parameters and an identical shape of the temporary cavity in soft tissue?

Figure 1. A schematic image of a projectile deforming in a controlled manner (by G. Motrycz)

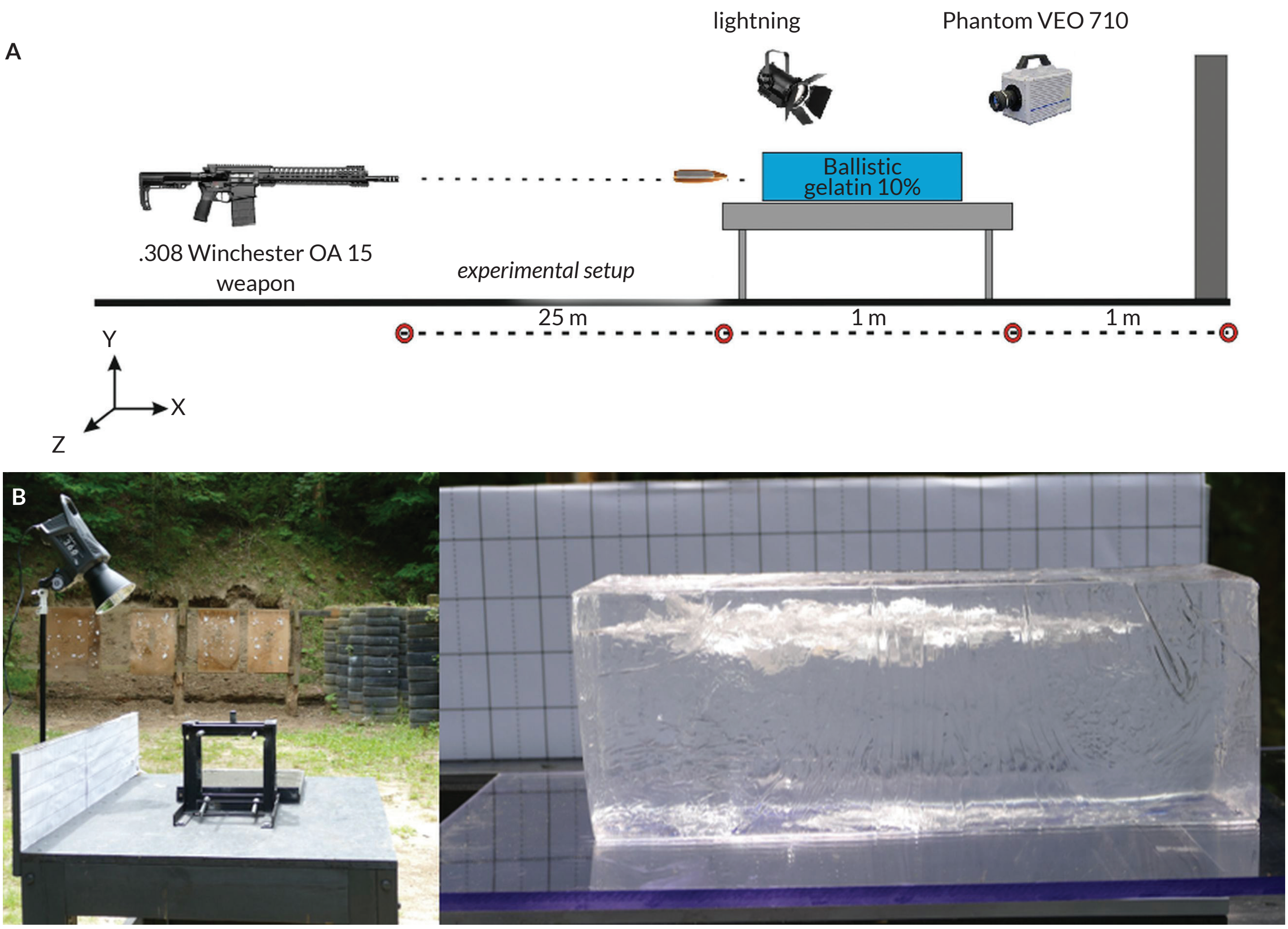


Figure 2. A. Schematic diagram of the experimental setup (prepared by G. Motrycz). **B.** Ballistic gelatin block on the experimental setup. Image taken by G. Motrycz / K.J. Helnarska

Materials and methods

The experimental setup is shown in Figure 2, located at the shooting range in Dąbrówka. The atmospheric conditions during the experiment were as follows: temperature 23–26°C, no wind, and atmospheric pressure of 1,015 hPa. The projectiles were fired at a block of ballistic gelatin from a distance of 25 meters, aimed at a point approximately 7 cm from the edge of the block, in its midpart.

During the experiment, the projectile's velocity was measured, and its travel through the gelatin was recorded using a Phantom Miro 310 ultra-high-speed camera, which captured images at 20,000 frames per second at a resolution of 1,280 × 800 pixels. The camera and its lens were positioned to provide a field of view of 40 cm × 60 cm. A board with a printed grid of markers spanning 100 cm was placed behind the ballistic gelatin block to enable calibration of horizontal and vertical distance measurements and precise determination of the projectile's position. The resulting video footage was analysed with an accuracy of 0.1 ms. Before the experiment, the ballistic gelatin was cooled to 6°C.

The experiment used Scenar bullets manufactured by the Finnish company Nammo Lapua Oy, designated GB422 and GB432. These are full-jacket, hollow-point boat-tail bullets featuring a hollow point at the tip and a tapered base. Their design incorporates a hollow point which, when combined with the shape of its surface, directs the pressure wave outward upon impact. This causes the bullet to expand at the front and increase its diameter. The core is made of a lead alloy with an antimony additive, which increases hardness and strength, thereby promoting extensive fragmentation upon impact with soft tissue. As a result, the bullet splits into two or three pieces, and the jacket separates from the core. A cross-section of the .264-caliber Scenar projectile, illustrating its design, is shown in Figure 3. Technical specifications are presented in Table 1. During the experiment, two shots were fired using Scenar bullets weighing 10.85 g (167 gr) and 12.00 g (185 gr), achieving muzzle velocities of 836.5 m/s and 766.3 m/s, respectively. This corresponds to energies of 3,796 J and 3,523 J, respectively, a difference of 273 J.

The experiment was conducted using a German Oberland Arms OA10 sniper rifle chambered in .308 Winchester (7.62 × 51 mm), equipped with a 0.64 m long four-groove barrel, as shown in Figure 4.

Based on individual images captured at 0.1 ms intervals, it was possible to track the bullet's expansion and fragmentation, which is crucial for assessing ammunition effectiveness and characterizing injuries in the clinical context. The process of temporary cavity formation was

Figure 3. A cross-sectional image of .264, 123 gr. Hollow Point Boat Tail, Lapua Scenar. Source: https://reloaders.eu/lapua-scenar-a-good-hunting-bullet/ [13]

also analysed. This phenomenon is important for the pathophysiology of wound formation and has a direct impact on the extent of soft tissue damage. Furthermore, the analysis focused on the bullet's stability during tissue penetration, its trajectory and rotation, all of which affect the accuracy and effectiveness of the ammunition.

Results

Recording the projectile's travel through ballistic gelatin using a high-speed camera delivered important data on terminal ballistics, which may be relevant in both military and medical contexts. Individual frames captured by the high-speed camera are shown in Table 2.

The 167 gr Scenar bullets, striking soft tissue at 836.5 m/s, begin to tilt after traveling approximately 170 mm (0.0002 s). Simultaneously, pressure acting on the hollow point initiates controlled expansion, resulting in the separation of jacket and fragmentation of the projectile. In contrast, a 185-gr bullet striking soft tissue at 766.3 m/s with an energy of 3523 J penetrates the tissue in a stable manner. Differences in bullet behaviour within

Table 1. Technical parameters of the projectiles used in the experiment [14, 15]

	10.85 g / 167 gr Scenar (GB422)	12.0 g / 185 gr Scenar (GB432)
Muzzle velocity	820 m/s	755 m/s
Muzzle energy	3648 J	3420 J
Mean pressure	<415 MPa	<415 MPa
Maximum one-time pressure	<477 MPa	<477 MPa

Figure 3. .308 Winchester OA-10 sniper rifle. Image taken by G. Motrycz

Table 2. Stages of soft tissue penetration by a Scenar projectile

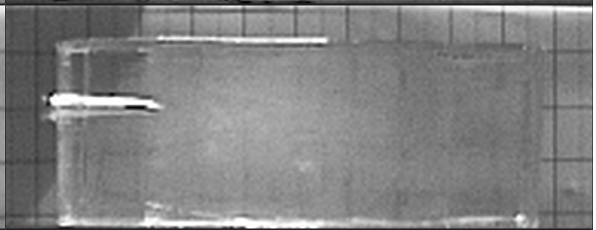
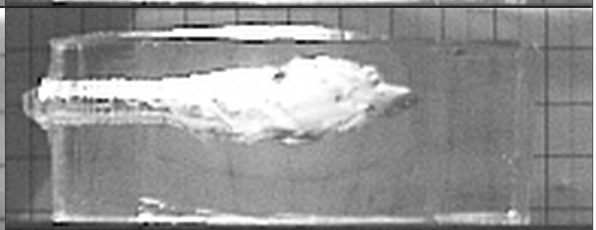
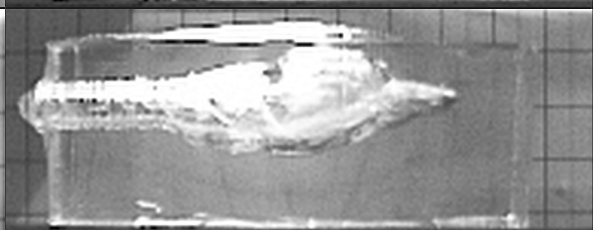
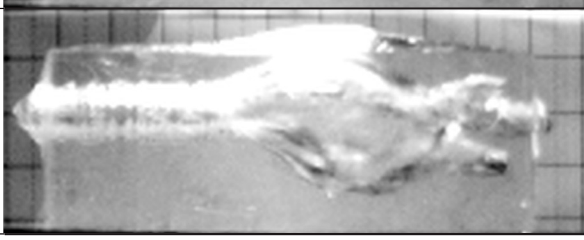
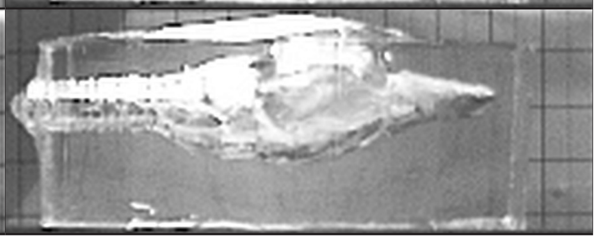
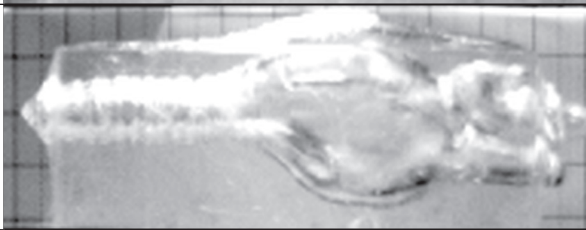
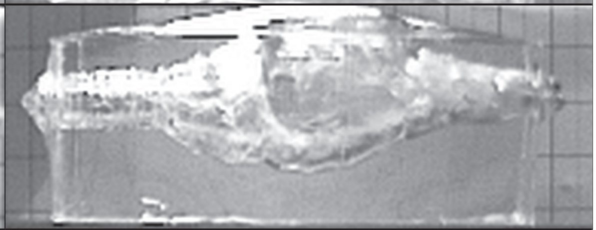
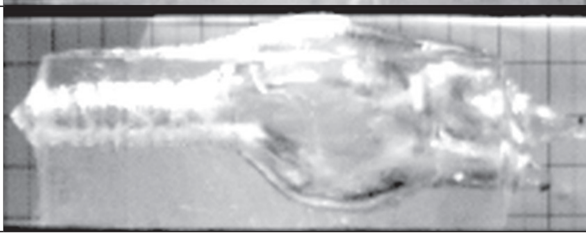
Time (s)	Scenar 10.85 g /167 gr	Scenar 12.00 g /185 gr
0.0000		
0.0001		
0.0002		
0.0003		
0.0004		
0.0005		
0.0006		
0.0007		

Table 2 (cont.). Stages of soft tissue penetration by a Scenar projectile

Time (s)	Scenar 10.85 g / 167 gr	Scenar 12.00 g / 185 gr
0.0008		
0.0009		
0.0010		

soft tissue result from the rotational motion imparted by the grooved barrel around the projectile's longitudinal axis of symmetry, known as rotational stabilization. Proper rotational velocity is crucial: if it is too low, the bullet may tumble, whereas excessively high rotational speed causes the projectile's longitudinal axis to maintain the same spatial orientation and undergo precession, leading to a loss of stability. The rotational stabilization of the projectile is influenced by factors such as its shape, mass distribution, density of the penetrated medium, as well as translational and rotational velocities.

As a result of the loss of rotational stabilization of the 167-gr bullet and the initiation of the expansion process at 0.0003 seconds, a hydrodynamic wave develops, leading to fragmentation. Formation of a large temporary cavity is a secondary effect. Despite the tumbling effect, the 185-gr bullet maintains sufficient angular velocity to allow for stable exit from the ballistic gelatin block. Controlled expansion occurs only in the final phase of penetration, approximately 35 cm from the entry wound, which may result in a less severe injury.

Figure 5 shows a permanent cavity formed after Scenar projectiles pass through ballistic gelatin. Once the 167-gr Scenar projectile (Fig. 5A) impacts the gelatin, it travels steadily across approximately 170 mm, creating a narrow permanent cavity. Then the projectile starts to tumble, as a result of loss of stability, producing an approximately 90 mm-wide elliptical channel. The cavity diameter reaches its maximum value when the projectile has rotated 90°, resulting in the greatest drag force exerted by the ballistic gelatin on the projectile.

The fragmenting bullet rotates nearly 180° in the vertical plane before exiting the gelatin. At a depth of approximately 340 mm, it leaves behind pieces of jacket, with small fragments of the lead–antimony alloy core seen in this area. These fragments contaminate the wound and cause additional damage by acting as secondary projectiles.

The Scenar 185-gr projectile (Fig. 5B) strikes ballistic gelatin and travels steadily for approximately 160 mm, creating a narrow permanent cavity. Subsequent loss of

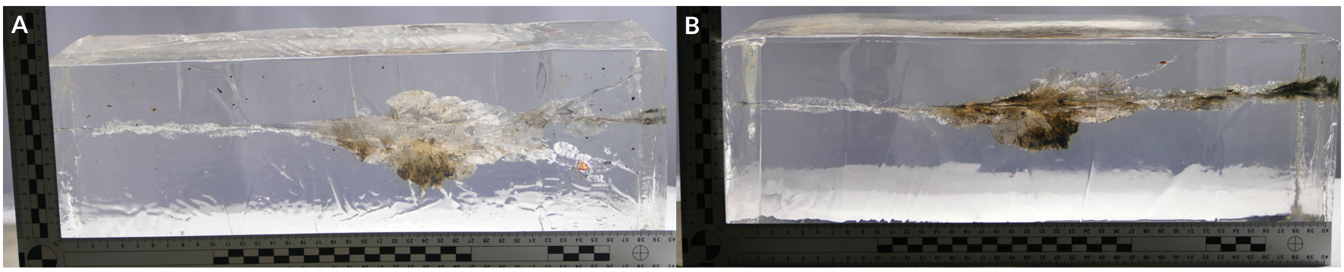


Figure 5. Ballistic gelatin blocks penetrated by the projectile: **A.** Scenar 10.85 g (167 gr); **B.** Scenar 12.00 g (185 gr). Image taken by G. Motrycz / K.J. Helnarska

stability causes it to tumble, producing an oval-shaped channel approximately 45 mm wide while maintaining its rotational velocity. As it tumbles, a portion of the jacket separates at a depth of approximately 300 mm. In this case, the core remains intact, indicating an absence of fragmentation.

Conclusions

Fragmentation of the Scenar projectile and the accompanying formation of a temporary cavity is the primary mechanism leading to tissue injury. If the projectile further loses its rotational speed and begins to tumble, the extent of the injury increases. Based on the conducted experiment, it can be concluded that projectile velocity influences the shape of the temporary cavity in soft tissue. It is important, however, to consider not only the projectile's forward velocity but also its rotational speed and degree of stabilization. As the projectile penetrates soft tissue, the rotational velocity imparted by the barrel's rifling decreases, and once it falls below the threshold required for gyroscopic stability, the projectile begins to tumble. In this case, the soft tissue acting on the projectile's tip (hollow point) causes its expansion, partial jacket separation, and progressive deformation of the core, ultimately leading to fragmentation. The combined effect of these processes has a significant impact on the shape and extent of the temporary cavity.

The next research question addressed whether bullets with comparable kinetic energy can yield identical parameters and wound channel morphology within the soft tissue. The experiment used Scenar bullets of identical shape but differing mass and muzzle velocity. Although the kinetic energy differed by only approximately 7.7% (273 J), it was initially hypothesized that the bullet with higher energy (185 gr) would generate more extensive tissue damage. However, due to the loss of rotational velocity and the resulting loss of stability, the lighter 167 gr bullet, despite having lower kinetic energy, produced a larger temporary cavity, indicating potentially greater severity of tissue damage.

In contrast, the 185 gr bullet (3,523 J) penetrated the entire 40-cm gelatin block and initiated controlled expansion only at a depth of approximately 35 cm, just before exiting the block.

The results of the experiment may serve as a reference point for further optimization of ammunition and the development of new projectile designs aimed at minimizing unnecessary tissue damage and better aligning with the requirements of international humanitarian law.

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