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CASE REPORT

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Ballistic aspects of tandem-loaded cartridges of identical caliber

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Abstract Tandem loading of a cartridge of the same caliber is possible only if the diameter of the barrel is sufficiently wide. This requirement is met by the .22 long shot Anschütz miniature clay pigeon gun. Ballistic experiments with tandem-loaded cartridges of the same caliber as those loaded in the normal way showed the bullet of the regularly loaded cartridge to impact the muzzle-loaded cartridge. On firing a shot, the bullet of the posterior cartridge penetrates the anterior one, expanding the case of the first cartridge to the diameter of the barrel and disintegrating the bullet. Regardless of whether the muzzle-loaded cartridge is ignited or not, the discharge speed of the projectiles (v_0) is considerably below that of single shots. Calculations yielded a theoretical reduction by about 60%. In accordance with the formula $E = \frac{1}{2} * m * v^2$, in terms of the energy released, the elevated mass of the projectile is of secondary importance compared with the reduction of v_0. Although the "projectile" mass is more than twice the normal rate, the energy density is significantly reduced and the biological effect is attenuated. This also became apparent in the failed suicide attempt of a 43-year-old male who used a miniature clay pigeon gun to shoot himself in the forehead at a range of a few centimeters. He had inserted a second cartridge, base to head with the first cartridge, in the factory-bored barrel of the gun. The leading cartridge was destroyed by the regularly loaded one. The pierced and expanded case of the leading cartridge was found nearby the injured man and was at first taken to be the jacket of a larger-caliber bullet.

Key words Tandem loading · Ballistic aspects · Miniature clay pigeon gun · Calibre .22 long shot

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Introduction

Diagnosing a suicidal gunshot wound rarely poses a problem in forensic practice. The range and angle of fire, identification of gunshot residue particles on the shooter's hand, as well as the attendant circumstances (suicide note, motive etc.) often provide conclusive evidence. However, further forensic and/or ballistic examinations are warranted if the wound is inconsistent with being self-inflicted or if unusual weapons, shooting devices, stud guns or unusual types of ammunition are used.

Our systematic examinations were based on the following case:

Case history

A 43-year-old male was found by his daughter lying unconscious on the floor. A .22-caliber Anschütz long shot miniature clay pi-

Fig. 1 Projectile fragment, erroneously considered to be the jacket of a larger-caliber bullet beside the head of the victim

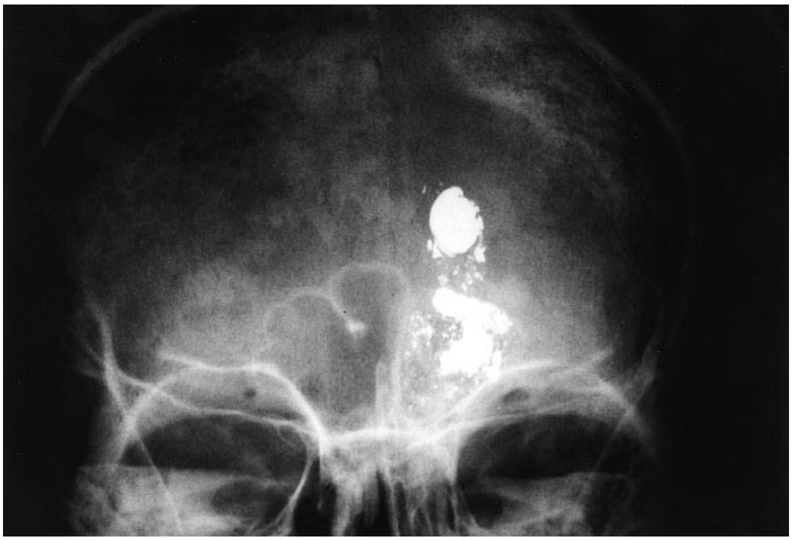
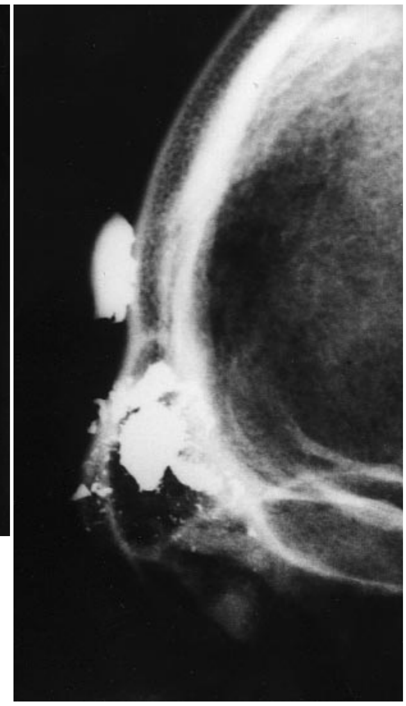

Fig. 2 X-ray of the head. Several heavily deformed metal-dense fragments in the frontal sinus and under the skin; left: antero-posterior view, right: side view

geon gun was found to the left of the body, which he had obviously used to shoot himself in the middle of the forehead. In his suicide note he gave intense pain after an occupational accident as his motive. Approximately 20 cm from the head a 'projectile fragment' was found, which on initial examination did not seem to fit the cartridge case still lodged within the barrel and was therefore considered part of a larger-caliber projectile (Fig. 1).

Radiographic examination of the skull revealed several heavily deformed metal-dense fragments in the frontal sinus and under the skin about 1–2 cm left of the middle of the forehead (Fig. 2). During reconstructive surgery, a comminution of the anterior wall of the frontal sinus measuring ~ 3 × 3 cm was found. A larger deformed lead fragment was lodged under the skin of the forehead slightly above the frontal sinus. Several fragments had penetrated the bone of the posterior sinus wall without perforating it. The total weight of the metal particles removed from the wound was 4.8 g. After uncomplicated healing the patient received psychiatric follow-up care.

Ballistic experiments

Material and methods

Ballistic tests were carried out using the original .22-caliber Anschütz long shot miniature clay pigeon gun with a barrel length of 58 cm. The front section of the smooth barrel is factory-bored to a diameter of 10 mm for a length of 25.2 cm.

For test firing, the gun was first loaded with .22 lr Remington ammunition (n = 10) and subsequently with a second live cartridge of identical caliber inserted through the muzzle (n = 10). Another series of tests was conducted with tandem-loaded cartridges without propellant charge (n = 10). A padded cushion was used as a bullet trap. The velocity of the projectiles was measured using a photoelectric barrier which was positioned 50 cm from the muzzle end. The .22 lr cartridges were composed of a 2.6 g lead bullet with an 0.7 g metal case and 0.05 g of propellant.

Fig. 3 Deformations of the tandem loaded projectiles (.22lr Remington ammunition); left: parts of the normally loaded projectile, right: parts of the muzzle-loaded projectile

Results

Firing of cartridges loaded in the normal way resulted in a mean projectile velocity of 330 m/s (number of shots n = 10). Given a projectile weight of 2.6 g, this is equivalent to an energy of 140 Joule ($E = \frac{1}{2} * m * v^2$) and an energy density of 5.7 J/mm^2 for .22-caliber ammunition (Kneubuehl 1994; Sellier and Kneubuehl 1994).

When a second live cartridge was loaded in front of the regularly loaded cartridge (n = 10), the projectile velocity v_0 dropped to between 37 and 255 m/s (mean: 141 m/s), with considerable variations of the measured values. Firing of tandem-loaded cartridges without propellant yielded speeds between 80 and 290 m/s (mean: 174 m/s).

The projectiles showed characteristic and reproducible deformations, with the posterior projectile penetrating the case of the anterior cartridge and expanding it to the diameter of the barrel (Fig. 3).

Discussion

It is known from shotguns fired at close range that not only projectiles but also other components of ammunition can be found in wound cavities (Ordog et al. 1988; Pollak and Lindermann 1990; Rabl and Eller 1993; Shepard 1980; Walker et al. 1990). By contrast, very few instances of cartridge cases or parts thereof recovered from wounds are documented in the literature.

Kellermann et al. (1995) reported the case of a gunsmith who accidentally ignited the propellant of a cartridge left in the barrel (cal. 8 × 68 S), while soldering a dismantled gun barrel. The shot ‘backfired’, with fragments of the cartridge case injuring the aorta. A suicide by firing the case of a .22 lr rim-fire blank cartridge, inserted in the front part of a blank gun, was reported by Greiner in 1973.

In 1966 Janssen described a suicidal gunshot injury to the head with two entry wounds and one exit wound and evidence of a cartridge case lodged in the skull. Ballistic reconstruction showed that the 7.65 mm gun had an additional 6.35 mm cartridge inserted into the barrel with its base first. The cartridge was ignited when the regularly loaded projectile was fired. A similar case with calibers 7.65 mm and 6.35 mm was described by Schwab (1968), a case involving the calibers .32 and .380 was reported by Mollan and Beavis (1978).

Bentley et al. (1997) recently reported a homicidal gunshot wound to the chest with two bullets of identical caliber but only a single bullet track. It was found that one of the projectiles had become lodged within the barrel and was expelled together with the second bullet. The authors mention similar cases of tandem bullets. Even a barrel cleaning brush can be part of a tandem bullet (Ellis 1997).

From the circumstances and findings of our case it was concluded at first that more than one small-caliber projectile had been fired, especially in view of the high total weight of the lead particles retrieved. The possibility of two single shots through the same bullet hole as described by Hildebrand (1983) was discarded in the further course of the investigation because single bullets fired in the normal way would have penetrated the skull.

During test-firing, the metal fragment found nearby the body was identified beyond doubt as the expanded case of a standard .22 lr cartridge. This was conclusive proof that the man had shot himself in the head only once, with a second cartridge of the same caliber loaded through the muzzle, base to nose with the regularly loaded cartridge.

Velocity measurements carried out on disintegrating tandem-loaded cartridges are problematical because it is quite unlikely that the photoelectric barriers of the measuring system will be stopped by the same part of the projectiles or case that released the barrier. This is confirmed by the wide variations we found in our measurements.

A viable option for arriving at a plausible mean discharge velocity of muzzle-loaded cartridges is provided by the principle of linear momentum (Kneubuehl 1994). It is safe to assume that an inelastic collision occurs when the regularly loaded cartridge hits the muzzle-loaded cartridge at a rate of 330 m/s. On this assumption the velocity of the projectiles emerging from the barrel can be calculated according to the formula

$$v_t = \frac{m_p}{m_p + m_c} \cdot v_p$$

with m_p and v_p indicating the mass and velocity of the regularly fired projectile, m_c standing for the mass of the muzzle-loaded cartridge and v_t denoting the discharge velocity of the projectiles.

From $m_p = 2.6$ g, $v_p = 330$ m/s and $m_c = 3.4$ g a mean discharge speed v_t of 143 m/s is calculated which appears absolutely plausible in view of our firing tests and measurements.

Even if the propellant of the tandem-loaded cartridge were ignited by the posterior bullet, the discharge speed would not rise significantly as the pressure build-up in the leading cartridge would not be normal. The bullet of the muzzle-loaded cartridge would be released from its case at a velocity almost certainly lower than the calculated ~ 140 m/s. This would not increase the overall discharge speed because on ignition, the tandem-loaded cartridge would also generate an impulse in the opposite direction of the shot. The differences in velocities measured with and without propellant must therefore be considered as accidental, an assumption confirmed by a statistical t-test (Kneubuehl 1994).

Calculating the cross-section load and energy density is useful if related to the penetrating projectile or, if the projectile has disintegrated, to its specific fragments. Given the mean velocity, the cross-section load of expanded but unsplintered cases is 0.01 g/mm^2 and the energy density is 0.1 J/mm^2. The deformed cartridge case could just about impact human skin.

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