

CASE REPORT

Graeme P. Dowling,¹ M.D.; John A. H. Dickinson²; and
Clive T. Cooke,³ M.B.B.S.

Shotcup Petal Abrasions in Close Range .410-Caliber Shotgun Injuries

REFERENCE: Dowling, G. P., Dickinson, J. A. H., and Cooke, C. T., "Shotcup Petal Abrasions in Close Range .410-Caliber Shotgun Injuries," *Journal of Forensic Sciences*, JFSCA, Vol. 33, No. 1, Jan. 1988, pp. 260-266.

ABSTRACT: Shotcup petal abrasions centered around a shotgun wound of entrance are generally thought to occur at a range of 30 to 90 cm. A suicidal .410-caliber shotgun injury of the right eye is described in which typical petal abrasions were noted around the entrance wound. However, significant soot deposition around the wound suggested that the range of fire was less than 30 cm and perhaps closer to 15 cm. Test-firing of the weapon and ammunition used by the decedent showed some spread of the shotcup petals at a range of 7.5 cm, progressing to maximum spread at 30 to 52.5 cm. Further testing with other .410 ammunition, containing shotcups, confirmed the spread of shotcup petals at ranges less than 30 cm, irrespective of manufacturer, shotshell length, and birdshot size. When a variety of shotguns were tested, it was found that one weapon with a very short barrel and cylinder bore did not exhibit petal spread until a range of 30 cm was reached. The remaining shotguns, with longer barrels and full choke, all demonstrated definite petal spread at a range of 12.5 cm. The long, narrow configuration of .410 shotcup petals may explain their early spread and the production of petal abrasions at ranges of less than 30 cm.

KEYWORDS: pathology and biology, shotguns, ballistics, wound ballistics, shotcup abrasions, petal abrasions

Petal abrasions centered around a shotgun wound of entrance, and produced by the wings of a plastic shotcup striking the skin, are one characteristic of a shotgun injury which can be used to aid in estimation of the range of fire. Di Maio states that petal abrasions are usually evident at ranges of 30 to 90 cm [1]. The authors recently examined a suicidal .410-caliber shotgun injury of the face and noted shotcup petal abrasions around the wound. Evidence from the scene and from the injury itself suggested that the range of fire was less than 30 cm. Test-firing of the weapon and ammunition in question, as well as of other types of .410

Received for publication 12 March 1987; revised manuscript received 27 April 1987; accepted for publication 26 May 1987.

¹Clinical assistant professor, Universities of Alberta and Calgary and deputy chief medical examiner, Office of the Chief Medical Examiner, Edmonton, Alberta, Canada.

²Staff-sergeant in charge of firearms section, R.C.M.P. Forensic Laboratory, Edmonton, Alberta, Canada.

³Associate forensic pathologist, Office of the Chief Medical Examiner, Edmonton, Alberta, Canada.

shotguns and ammunition, was undertaken to determine the range at which shotcup petal abrasions might be expected to appear.

Case Report

The body of a 38-year-old woman was found lying supine in bed at her residence. All doors of the house were locked. A U.S.S.R.-made .410-caliber Baikal Model 18M shotgun with 68-cm barrel, 7.5-cm (3-in.) chamber, and full choke was present between the deceased's legs. There was an obvious shotgun injury to the right eye. The pattern of blood spattering on the wall immediately above and behind the woman's head suggested that she was sitting up at the time of discharge of the weapon and subsequently slumped downwards and to the left. An empty .410 shotshell was recovered from the chamber of the weapon, and a box of 24 unfired I.V.I. Imperial shotshells, measuring 6.4 cm (2½ in.) in length and containing 14 g (½ oz) of No. 7-½ birdshot each, was found in the bedroom. No implement which could have been used to assist in pushing the trigger was identified.

Investigation of the decedent's background revealed a long history of depression. She had presented to a local hospital in a severely depressed state on the day before her death, but had refused admission. The woman had purchased the shotgun and one box of ammunition without the knowledge of family members, eleven days before her death.

At autopsy, a shotgun wound of entrance, measuring 1.0 cm in maximum diameter, was centered on the right upper eyelid. There was soot deposition around the margins of the wound, and powder stippling on the right side of the face over an area measuring 11 cm in diameter. Three equally spaced rectangular shotcup petal abrasions extended from the edges of the entrance wound (Fig. 1). Maximum tissue destruction was present in a pathway extending through the roof of the right bony orbit, through the right frontal and parietal

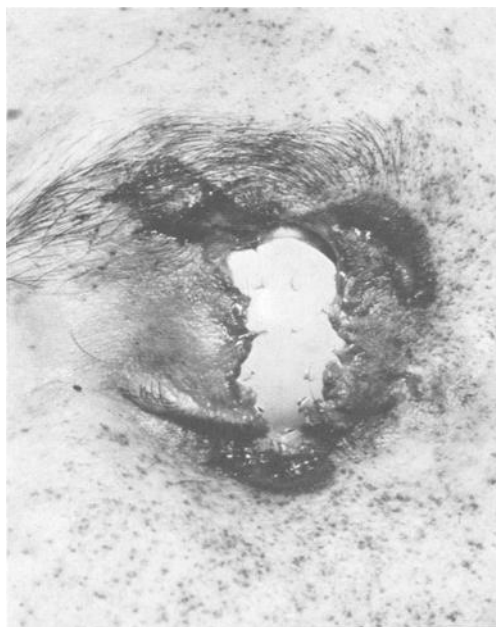


FIG. 1—Close-up view of right eye of deceased showing three shotcup petal abrasions and stippling of skin centered around shotgun wound of entrance. Wound has been cleaned and orbit replaced by eye cap.

lobes of the brain, and exiting the right parietooccipital region of the skull. Thus the direction of fire was from front to back and slightly upwards, with little or no right-to-left angulation. There were multiple basal and cranial vault skull fractures, together with lacerations of the right parietal and occipital regions of the scalp and extensive damage to the brain. Numerous small birdshot pellets and a portion of a plastic shotcup were recovered from the cranial cavity.

Based on these findings, and particularly the presence of significant soot deposition around the wound, the range of fire was estimated to be less than 30 cm (12 in.) and possibly closer to 15 cm (6 in.).

Methods

The deceased's weapon and ammunition were test-fired using white Foam Core (two sheets of heavy paper separated by 0.4-cm-thick polystyrene filling) or heavy white posterboard sheets as targets. Single shots were fired at ranges between 5 and 150 cm (2 in. and 5 ft) using 2.5-cm increments between 5 and 30 cm, 7.5-cm increments between 30 and 60 cm, 15-cm increments between 60 and 90 cm, and 30-cm increments between 90 and 150 cm.

The deceased's weapon was then fired at a range of 12.5 cm, and in some cases at 20 cm, with the following .410-caliber ammunition:

- (1) I.V.I. Imperial, 7.6-cm (3-in.) length with 19.5 g ($^{11}/_{16}$ oz) of No. 7- $^{1}/_{2}$ birdshot;
- (2) I.V.I. Imperial, 7.6-cm length with 19.5 g of No. 4 birdshot;
- (3) Remington-Peters, 7.6-cm length with 19.5 g of No. 7- $^{1}/_{2}$ birdshot; and
- (4) Federal, 7.6-cm length with 19.5 g of No. 6 birdshot (with roll crimp and overshot wad).

Finally, the deceased's ammunition was fired at a range of 12.5 cm, and in some cases 20, 25, and 30 cm, with the following .410-caliber shotguns:

- (1) Remington Model 812, 70.8-cm barrel, 7.6-cm chamber, full choke;
- (2) Cooney Model 810, 66.0-cm barrel, 7.6-cm chamber, full choke;
- (3) Savage Model 24H, 60.9-cm barrel, 7.6-cm chamber, full choke; and
- (4) Koon Snake Charmer, 46.1-cm barrel, 7.6-cm chamber, cylinder bore.

Instrumental velocities of the Baikal and Koon shotguns using IVI Imperial ammunition at a range of 305 cm (10 ft) were measured using an Electronic Counter Incorporated Model 4010 velocity computing chronograph with Model 6100 photoelectric screens.

Shotcups were removed from single unfired I.V.I. Imperial, Remington-Peters, and Federal .410-caliber and 12-gauge shotshells. These were weighed on a Mettler Model PL200 electronic balance, and measured using Mitutoyo dial calipers.

Results

The Foam Core was an excellent medium for demonstrating the spread of shotcup petals. Each petal punched a roughly rectangular hole in the target at its site of impact, so that viewed as a whole, three equally spaced rectangular defects could be seen at the edges of a central round defect (Fig. 2). The posterboard tended to tear more as a result of muzzle blast, but petal defects were easily seen.

Test-firing of the deceased's weapon and ammunition demonstrated spread of the shotcup petals at a range of 7.5 cm (3 in.) between the muzzle and target (Fig. 2). At shorter ranges, muzzle blast caused tearing of the target material and made petal defects difficult to discern. With increasing range between muzzle and target, progressive spread of the shotcup petals was noted, and at distances of 30 to 52.5 cm (12 to 21 in.) the petals were completely splayed.

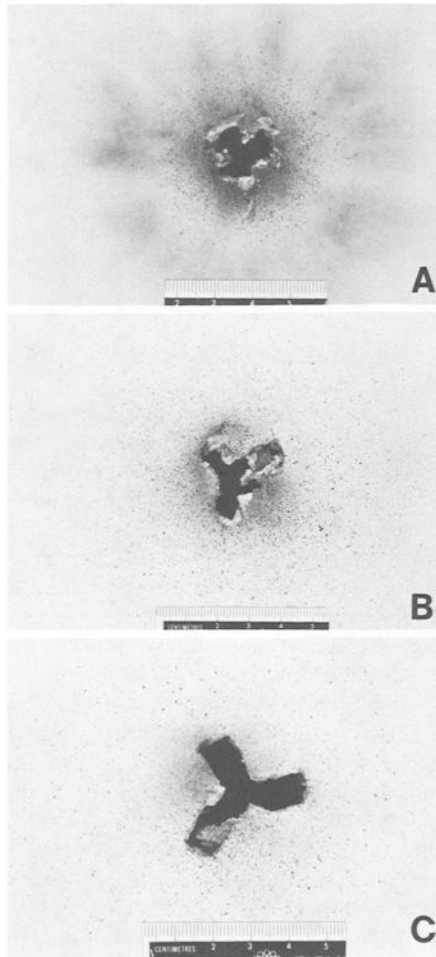


FIG. 2—Close-up views of shotcup petal defects produced by decedent's weapon and ammunition at ranges of: (a) 7.5 cm (3 in.), (b) 20 cm (8 in.), and (c) 30 cm (12 in.).

At 60 cm (2 ft) only two partial petal defects were evident, suggesting that the petals were almost folded completely backwards. A larger central defect with drifting of the shotcup, causing it to strike the edge of the hole before entering, was noted at ranges of 90 and 150 cm (3 and 5 ft). A minimal amount of soot deposition was still evident out to a range of 30 cm. Unburned powder particles appeared at a range of 5 cm (2 in.) and were still present, albeit to a minimal degree, at a range of 150 cm. Comparison of the deceased's wound appearance with test patterns indicated that the probable range of fire was 20 cm (8 in.).

When the deceased's weapon was fired using different ammunitions, spread of shotcup petals was noted at a range of 12.5 cm (5 in.) in all but one case. Muzzle blast produced by Remington-Peters ammunition at this range rendered interpretation of petal defects difficult, but they were definitely present at a range of 20 cm (8 in.). Thus, birdshot size and shotshell length and manufacturer did not appear to alter the spread of shotcup petals to any significant degree.

Test-firing of the deceased's ammunition in different shotguns also produced obvious spread of shotcup petals at a range of 12.5 cm, with one exception. The Koon Snake Charmer with a short barrel and cylinder bore (as opposed to the full choke of all other weapons) did not demonstrate three clear petal defects until a range of 30 cm was reached. Shot velocity did not appear to be a factor in this difference as the instrumental velocity of the Baikal and Koon shotguns, using I.V.I. Imperial ammunition, was comparable at 358.5 and 348.1 m/s (1176 and 1142 ft/s), respectively.

The weights and measurements of shotcups from I.V.I. Imperial, Remington-Peters, and Federal shotshells are found in Table 1.

Discussion

Wad abrasions, produced by the fiber or plastic wads of a shotshell as they strike the skin, have been well described in the forensic science literature [2-5]. Only recently, however, has any attention been paid to the distinctive abrasions caused by the plastic cup which encloses the pellets in many modern shotshells [1,6]. This cup serves to reduce contact between the pellets and barrel upon discharge thus minimizing shot deformation and producing a denser, more uniform pattern [1]. The cup may be an integral part of the wad (for example, .410-caliber shotcups and Remington-Peters Power-Piston®), although quite often it is separate from the wadding. Most large bore shotcups have four arms or petals, whereas the .410-caliber shotcup has three petals. When a shotshell is fired the petals of the shotcup meet with air resistance after leaving the barrel, and start to spread radially. The petals can impact the skin around an entrance wound and produce typical rectangular abrasions. These abrasions will form a Maltese cross configuration around the entrance wound for all but the .410 shotgun which produces three equally spaced abrasions. This pattern of abrasion is generally thought to occur at ranges of 30 to 90 cm (1 to 3 ft). At less than 30 cm, the wings have often not opened sufficiently to produce an abrasion, while at ranges greater than 90 cm, the petals are completely folded back as a result of air resistance [1].

In the case described above, shotcup petal abrasions were noted around a suicidal .410 shotgun wound of the right eye. This finding, taken by itself, might suggest a range of 30 cm or greater. However, the presence of a significant degree of soot deposition around the entrance wound was thought to be more consistent with a range of less than 30 cm and perhaps closer to 15 cm. Findings at the scene were inconclusive in determining the range of fire. Taking into consideration the length of the shotgun barrel, the fact that at least a few centimetres separated the muzzle and the eye at the time of discharge, and the fact that no imple-

TABLE 1—Weights and measurements of shotcups from .410-caliber and 12-gauge shotshells.

Ammunition	Weight, g	Measurements, cm			
		Total Length	Petal Length	Petal Width	Petal Thickness
.410-caliber					
I.V.I. Imperial	0.74	3.89	2.87	1.07	0.05-0.10
Remington-Peters	0.63	4.62	3.63	1.07	0.04 (central ribs 0.08)
Federal	0.70	3.84	2.90	1.07	0.08
12-gauge					
I.V.I. Imperial	1.02	2.39	1.65	1.25-1.56	0.06-0.07
Remington-Peters	2.14	3.78	1.36	1.34	0.05-0.06 (central ribs 0.19)
Federal	1.10	2.90	1.74-1.84	1.36-1.46	0.07

ment was found at the scene which could have been used to push the trigger, it would seem most likely that a toe was used to fire the shotgun. Given this, the shotgun could easily have been discharged at a range of greater than or less than 30 cm.

The deceased used I.V.I. Imperial ammunition in which the shotcup also acts as an overpowder wad (Fig. 3). Test-firing of this ammunition in the deceased's weapon showed that spread of the shotcup petals begins at a range of 7.5 cm (3 in.) and progresses to maximum spread at a range of 30 to 52.5 cm (12 to 21 in.). At a range of 60 cm (2 ft), the petals appear to be bent completely backwards, while at greater ranges the shotcup is tumbling and may strike the side of the entrance defect before entering. Comparison of test patterns indicate that the deceased had probably shot herself at a range of 20 cm (8 in.) which was thought to be more consistent with the scene and autopsy findings than a range of 30 cm or greater.

A variety of .410 shotguns and ammunition all showed obvious spread of shotcup petals at a range of only 12.5 cm (5 in.), with one exception. The short barreled Koon Snake Charmer had no well-defined petal defects until a range of 30 cm was reached. We are uncertain whether this was the result of the short barrel length or the cylinder bore of this weapon. Shot velocity did not appear to be a factor in this difference.

Shotcups from .410-caliber and 12-gauge I.V.I. Imperial, Remington-Peters, and Federal ammunition are demonstrated in Fig. 3 and their weights and measurements compared in Table 1. In all three .410-caliber rounds the shotcup also acts as an overpowder wad. They are lighter than the 12-gauge shotcups, and the .410 petals are longer and narrower but not necessarily thinner than the petals of the 12-gauge shotcups. Note that the petals of the Remington-Peters .410 shotcup have an internal central rib on the petals, and that the petals

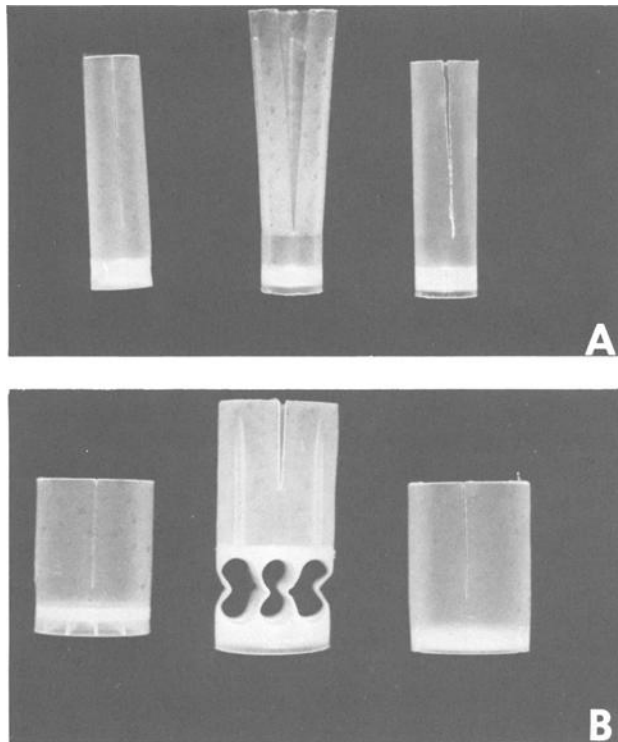


FIG. 3—Shotcups from (left to right) I.V.I. Imperial, Remington-Peters, and Federal shotgun ammunition: (a) .410 caliber and (b) 12 gauge.

appeared to be preflared when compared to the I.V.I. Imperial and Federal shotcups (Fig. 3). The light weight, greater length, and narrowness of the shotcup petals in .410-caliber ammunition, as compared to 12-gauge ammunition, may allow for faster spread of the petals. This in turn would result in the production of petal abrasions at ranges less than the 30 cm seen with 12-gauge shotcups. Indeed, our test-firings indicate that petal flaring can occur at ranges of only 7.5 cm (3 in.) with a .410 shotgun. Experiments on live animals would need to be performed to confirm that petal abrasions are visible at this close range.

This study, once again, reinforces the need to carry out test-firing, using the original weapon and ammunition, in cases of firearms injuries where there is an apparent discrepancy in autopsy or scene findings.

Acknowledgments

The authors would like to thank the Office of the Chief Medical Examiner of the Province of Alberta for granting permission to publish this case, Robert Gratton and Cyril Chan for their photographic assistance, and Deanna Van Dusen for typing the manuscript.

References

- [1] Di Maio, V. J. M., "Gunshot Wounds," in *Practical Aspects of Firearms, Ballistics, and Forensic Techniques*, Elsevier Science Publishing Co. Inc., New York, 1985, pp. 195-196.
- [2] Guerin, P. F., "Shotgun Wounds," *Journal of Forensic Sciences*, Vol. 5, No. 3, July 1960, pp. 294-318.
- [3] Breitenecker, R., "Shotgun Wound Patterns," *American Journal of Clinical Pathology*, Vol. 52, No. 3, Sept. 1969, pp. 258-269.
- [4] Fatteh, A., *Medicolegal Investigation of Gunshot Wounds*, J. B. Lippincott Company, Philadelphia, 1976, p. 110.
- [5] Hirsch, C. S., "Shotgun Wounds," in *Forensic Pathology: A Handbook for Pathologists*, R. S. Fisher and C. S. Petty, Eds., Castle House Publications Ltd., Tunbridge Wells, 1980, pp. 144-150.
- [6] Petty, C. S., "Death by Trauma: Blunt and Sharp Instruments and Firearms," in *Modern Legal Medicine, Psychiatry, and Forensic Science*, W. J. Curran, A. L. McGarry, and C. S. Petty, Eds., F. A. Davis Company, Philadelphia, 1980, pp. 362-489.

Address requests for reprints or additional information to
 Graeme P. Dowling, M.D.
 Deputy Chief Medical Examiner
 Office of the Chief Medical Examiner
 P.O. Box 2257
 Edmonton, Alberta, T5J 2P4, Canada