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# Stellate Clothing Defects with Different Firearms, Projectiles, Ranges, and Fabrics

**REFERENCE:** Alakija P, Dowling GP, Gunn B. Stellate clothing defects with different firearms, projectiles, ranges, and fabrics. J Forensic Sci 1998;43(6):1148–1152.

**ABSTRACT:** ''Stellate'' or ''cruciform'' tears of clothing are conventionally believed due to contact or close-range firearm entrance wounds. However, there are no published studies that actually document and confirm this observation. A Remington Nylon 11 .22-caliber rimfire bolt-action rifle, a Colt Woodsman .22-caliber rimfire auto-loading pistol, a Winchester Model 94 .30-30 Winchester lever-action rifle, and a Remington Model 870 12-gauge pump-action shotgun were test-fired at tight contact, loose contact, 2 cm, 4 cm, 8 cm, 15 cm, 30 cm, and 6 m ranges, using cotton denim, cotton broadcloth, and cotton jersey as targets. The .22-caliber rifle did not produce stellate tearing in these fabrics at any range. The .22-caliber pistol always produced stellate tears at tight contact and loose contact ranges; non-stellate defects were produced by this pistol at ranges of 2 cm or greater. The .30-30 Winchester rifle produced stellate tears at all contact and close ranges up to and including 8 cm. The 12-gauge shotgun only produced stellate tears at loose contact, but was not tested at all ranges. Stellate defects were not produced by any firearm, in any fabric, at ranges greater than 8 cm. These results are specific to the firearms, ammunition, fabric, and conditions selected, and may not reflect findings in situations involving other firearms, projectiles, ranges, or fabrics.

**KEYWORDS:** forensic science, criminalistics, clothing, fabric, stellate tears, firearms, projectiles, range

The examination of clothing damage produced by firearm injuries is important to pathologists and firearm experts in forensic investigations. The information gained by examining damaged clothing may be used, usually in conjunction with other information, to estimate the distance from which the weapon was fired (range) or to determine what type of weapon or projectile was used to produce a given injury. Traditionally, the range and firearm type are often estimated or determined by the distribution of soot or powder deposits on clothing, skin, and tissues; by the pattern of injury present in tissues or other objects that the projectile encountered; and by examination of the recovered projectile (1). The examination of clothing becomes increasingly important when firearm residues and projectiles or soft tissues are no longer available, as in a case where the body of the victim is skeletonized, the projectile is not recovered, and weathering has rendered residue detection on the clothing unreliable. In this type of case, the actual appearance or shape of any firearm defect on the victim's clothing may provide some clues as to the approximate range at which the victim was shot.

It is generally understood that a stellate or ''cruciform'' tear of clothing is produced by medium- or large-caliber weapon at close or contact range in cotton material (1). However, there are no published studies that actually document and confirm these observations. Synthetic fabrics do not generally display stellate tears because they tend to melt or burn under similar condition (1), and were therefore not used in this study. The patterns produced by firearm damage in fabrics such as silk, rayon, or other natural fabrics or blends are unknown. The effect of type of weave or knit of the fabric has not been investigated. The different patterns displayed in wet or dry fabric, or fabrics with or without tension are unknown.

It is important for forensic pathologists to be able to recognize specific clothing defect patterns, just as it is important to recognize patterns of injury in skin. The best way to make conclusions about firearm injuries is with specific ballistic testing with the firearm, ammunition, fabric and range in question. However, there are cases in which some or all of these variables are unknown, and it is helpful to be able to look at research designed to study at least some of the possible variables encountered so that some reasonable conclusions can be made with incomplete information. The purpose of this study was to define and compare the types of defects produced by four different firearms, in three common cotton clothing materials, at varying ranges, and to establish under which of these specific conditions stellate clothing defects were or were not produced.

## Methods and Materials

Pieces of cotton (25 cm × 25 cm) denim (blue jeans), broadcloth (dress shirts), and jersey knit (T-shirts) were stapled, without tension, to a target backing consisting of Dip-Pak® (Fidelity Chemical Products Corporation, Newark), cotton denim, and clear polyethylene plastic (Fig. 1). Dip-Pak® is a petroleum-based product used commercially as a protective coating for metal tools and machinery. It can be melted and molded into reusable backing for firearm targets. The denim and plastic wrapping allowed for easier reuse of the backing material.

The fabric samples were oriented on the backing according to how these materials are usually used in clothing manufacturing

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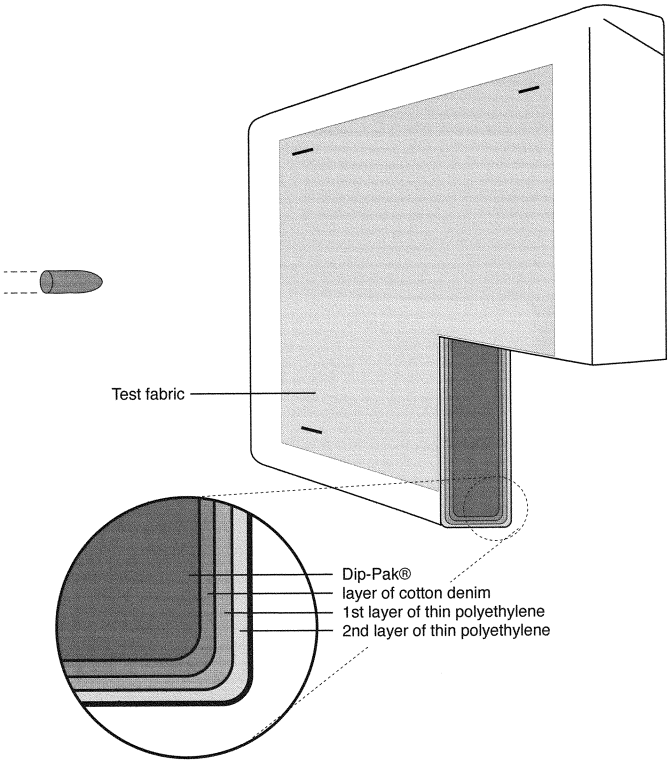


FIG. 1—*Materials used as backing for fabric.*

and how they are worn. Denim is an uneven twill weave in which the warp (the stationary, tight threads running away from the loom operator during manufacturing) of the fabric is usually oriented parallel or perpendicular to the long axis of limbs and the trunk in clothing. In denim blue jean material, the warp usually consists of the white threads. The weft (the loose, mobile threads that are inserted in between the warp) is usually blue in denim blue jean material, and is generally oriented parallel to the long axis of the trunk and limbs when making clothes. Broadcloth has a plain weave, and the warp is parallel or perpendicular to the long axis of the trunk and limbs. Jersey is not a weave, but rather a knit in which parallel rows of thread are looped around nearby rows of thread. In T-shirts, these rows of thread are oriented perpendicular to the long axis of the trunk or limbs. In half of the test firings with denim and broadcloth at contact range and with the .22-caliber pistol, the orientation of the fabric target was rotated by 90 deg.

Test-firings were performed with a Remington Nylon 11 .22-caliber rimfire bolt-action rifle and a Colt Woodsman .22-caliber rimfire auto-loading pistol, using Winchester high-velocity 40-grain Lubaloy-coated cartridges; a Winchester Model 94 .30-30 Winchester lever-action rifle, using Winchester Power Point 150-grain cartridges; and a Remington Model 870 12-gauge pump-action shotgun, using Winchester 1.25 oz. #4 birdshot cartridges.

The weapons were fired at a 90-deg angle to the fabric target at tight contact, loose contact, 2 cm, 4 cm, 8 cm, 15 cm, 30 cm, and 6 m ranges, at least three times at each distance. The ranges were measured from muzzle-to-target with a metric measuring tape or ruler just prior to each test firing. The fabric targets were numbered, and the test-fire defects were then categorized with the analyst being blinded to firearm type and range.

Stellate tears were defined as complete or partial. A complete stellate tear had more than two tears originating from the edges of the projectile defect, each tear having a length equal to or greater than the diameter of the central defect (Figs. 2*a*, *b*, and *c*). A partial stellate tear had only two tears originating from the edge of the projectile defect (Fig. 2*d*). Non-stellate defects had a round, square, or irregular central defect with no radiating tears, or, at most, a single radiating tear (Figs. 3*a*, *b* and *c*). The shotgun defects studied were single defects. For example, the shot produced one complete stellate defect at loose contact (Fig. 3*d*), rather than multiple defects by each pellet.

## Results

The weave or knit of the cotton material (i.e., denim, broadcloth or jersey knit) made little or no difference to the ability of a given weapon to produce stellate versus non-stellate defects. Partial stellate defects were produced in denim under the same conditions that produced complete stellate defects in broadcloth or jersey knit. For example, contact ranges with the .22-caliber pistol always produced partial stellate tears in denim, and always produced complete stellate tears with the broadcloth and jersey knit. The two radiating arms of a partial stellate tear in denim were always in the direction of the weft and never in the direction of the warp, even when the weft was rotated 90 deg so that it was parallel to the floor rather than perpendicular to the floor. The warp is perpendicular to the floor when denim is worn in standard blue jeans.

The consistency of fabric defects produced by each weapon at each range was excellent. Only four out of 72 possible firearm-fabric-range combinations (not including the shotgun) produced defects that were not 100% consistent between the three test-firings. Test-firings were not repeated three times with the shotgun due to extensive destruction of the targets produced by this weapon. The ranges tested with the shotgun were also limited for the same reason.

The .22-caliber rifle did not cause either complete or partial stellate tearing in any of the tested fabrics at any range (Table 1). Only single small round defects were produced.

The .22-caliber pistol produced complete stellate tears in cotton broadcloth and cotton jersey at tight contact and loose contact ranges. Partial stellate tears were produced in cotton denim at tight contact and loose contact. Only single small round defects were produced at all ranges greater than loose contact (Table 1).

The .30-30 Winchester rifle produced stellate tears in all three fabrics at tight contact, loose contact, 2 cm, and 4 cm ranges, with the exception of one non-stellate defect at 2 cm. Cotton denim showed no stellate tearing at ranges greater than 4 cm. At 8 cm, a complete stellate tear was produced in one of three test-firings through cotton broadcloth, and partial stellate tearing was observed in two out of three test-firings through the cotton jersey knit. All other ranges produced non-stellate defects (Table 1).

The 12-gage shotgun produced complete stellate tears in all three fabrics only at loose contact (Table 1).

## Discussion

Examination of clothing is a crucial component of any forensic autopsy, and is of particular importance in deaths due to firearm injuries. The clothing can provide clues as to the class of firearm used, the direction of fire, and the range of fire. In cases where underlying soft tissues have decomposed, and firearm projectiles are not recovered, the clothing may be the only source of reliable information available for the interpretation of suspected firearm injuries. One distinctive form of clothing defect seen with firearm

injuries is the so-called stellate or ''cruciform'' defect or tear. This consists of a round central defect (produced by the firearm projectile) with two or more (usually four) tears radiating outwards from the edges of this defect. Forensic pathologists and firearm experts generally understand that these are entrance defects produced when some firearms are discharged at contact or close range (1). However, there are no published studies that actually document the circumstances under which stellate clothing defects are found.

In this study, four different firearms were test-fired at ranges of tight contact up to 6 m, using targets made from cotton denim, cotton broadcloth, and cotton jersey knit. Each of these is a common fabric used in clothing manufacturing. Cotton denim is used to make jeans, cotton broadcloth for dress shirts, and cotton jersey knit for T-shirts.

Depending on the weapon and range used, each fabric was found to be capable of producing a stellate entrance defect, but the defects could be partial or complete. In a partial stellate defect, only two tears radiated away from the central round defect in completely opposite directions. A complete stellate defect had three or more tears radiating away from the central hole, in two right-angle

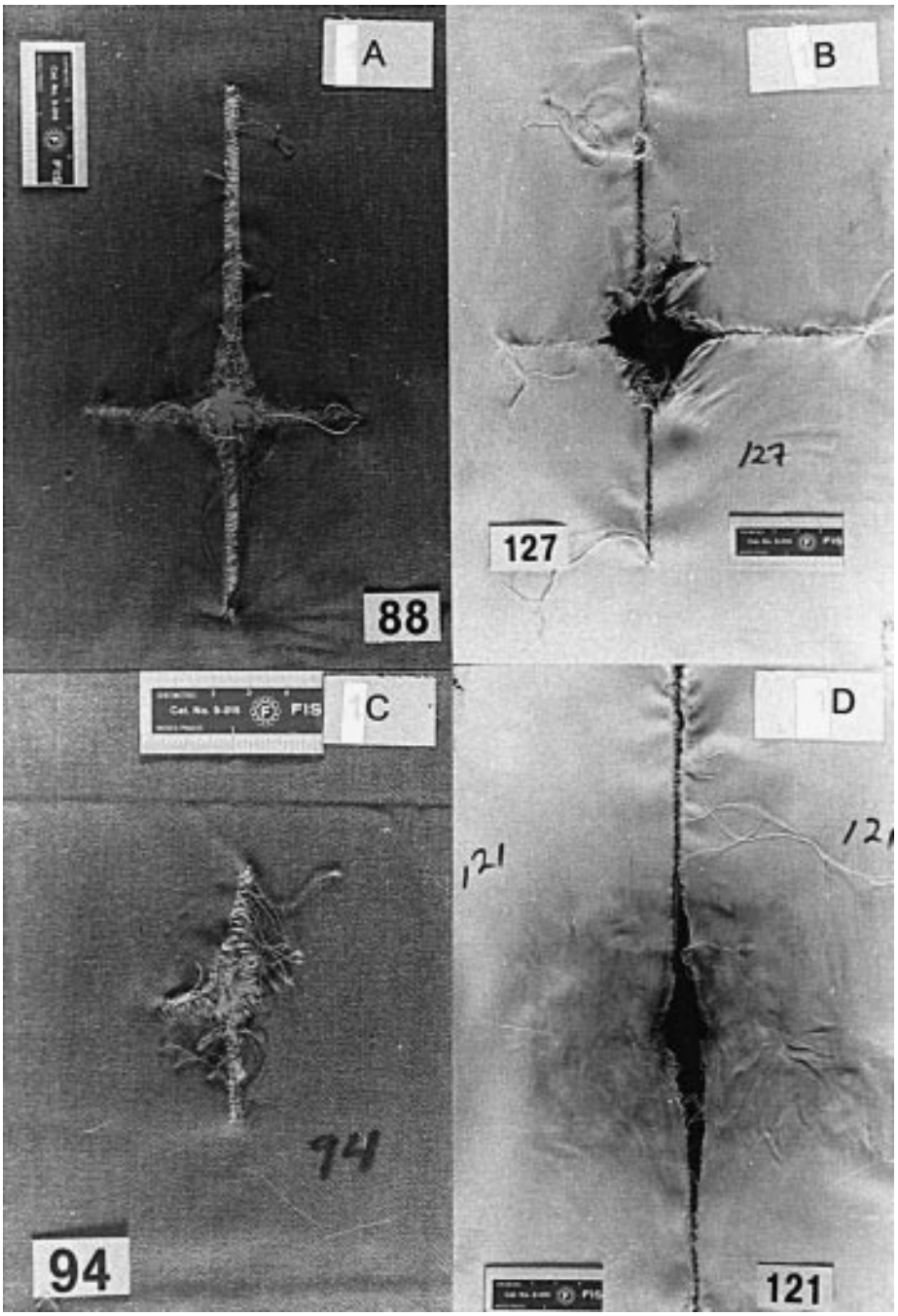


FIG. 2*a—Complete stellate defect, denim, loose contact, .30-30 Winchester rifle; 2b—complete stellate defect, broadcloth, loose contact, .30-30 Winchester rifle; 2c—complete stellate defect, denim, tight contact, .30-30 Winchester rifle; and 2d—partial stellate defect, broadcloth, 4 cm, .30-30 Winchester rifle.*

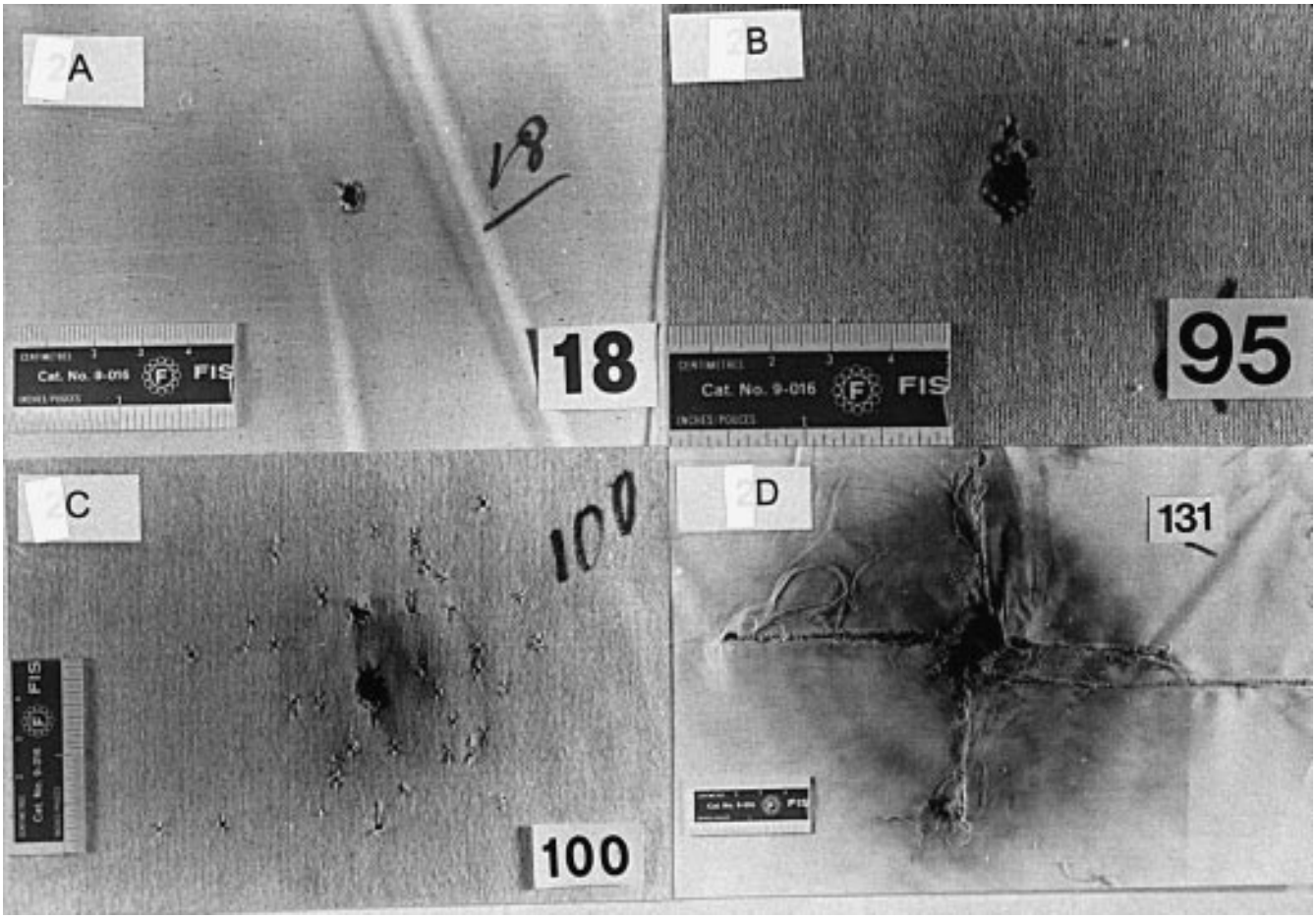


FIG. 3*a—Non-stellate defect, broadcloth, 30 cm, .30-30 Winchester rifle; 3b—non-stellate defect, jersey knit, 30 cm, .30-30 Winchester rifle; 3c—non-stellate defect, jersey knit, 15 cm, .30-30 Winchester rifle; and 3d—complete stellate defect, broadcloth, loose contact, shotgun.*

TABLE 1—*Defects produced in fabric by selected firearm at varying ranges.*

| | .22-Caliber Rifle | | | .22-Caliber Pistol | | | .30-30 Winchester | | | 12-Gauge Shotgun | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Range | d | b | j | d | b | j | d | b | j | d | b | j |
| Tight | ooo | ooo | oooo | //// // | xxxx xx | xxx | xxxx | xxxx | xxxx | o | . . . | . . . |
| Loose | ooo | ooo | ooo | //// // | xxxx x | xxx | xxx | xxx | xxx | x | x | x |
| 2 cm | oooo oo | oooo oo | oooo oo | oooo oooo o | oooo oooo | oooo oo | xxo | xxx | xxx | . . . | . . . | . . . |
| 4 cm | ooo | ooo | ooo | ooo | ooo | ooo | xxx | xx/ | xxx | o | . . . | . . . |
| 8 cm | ooo | ooo | ooo | ooo | ooo | ooo | ooo | xoo | //o | o | . . . | . . . |
| 15 cm | ooo | ooo | ooo | ooo | ooo | ooo | ooo | ooo | ooo | . . . | . . . | . . . |
| 30 cm | ooo | ooo | ooo | ooo | ooo | ooo | ooo | ooo | ooo | . . . | . . . | . . . |
| 6 m | ooo | ooo | ooo | ooo | ooo | ooo | ooo | ooo | ooo | . . . | . . . | . . . |

NOTE—Fabric targets: d = cotton denim, b = cotton broadcloth, j = cotton jersey knit. Defect produced in fabric: o = non-stellate defect, / = partial stellate defect, x = complete stellate defect (each o, /, or x indicates a separate test-firing).

planes. Interestingly, the plane of the two radiating arms in a partial stellate defect on cotton denim was in the direction of the weft and never in the direction of the warp. This effect was not seen with cotton broadcloth.

Of the weapons tested, a .22-caliber rifle did not produce any form of stellate tear at any range, including tight contact. In each case, this weapon simply produced a small round hole in the fabric. A .22-caliber pistol always produced stellate tears at tight contact and loose contact; non-stellate defects were produced by this pistol at ranges of 2 cm or greater. The .30-30 Winchester rifle produced stellate tears at all contact and close ranges up to and including 8 cm. The 12-gage shotgun only produced stellate tears at loose contact. No partial or complete stellate tears were produced by any firearm, in any fabric, at ranges greater than 8 cm.

The one non-stellate tear obtained in denim using the .30-30 Winchester rifle at 2 cm was incongruous with other results obtained with this weapon, range, and fabric. All other test firings with that rifle produced stellate tears in all fabrics at all ranges under 8 cm; therefore, a non-stellate tear at 2 cm was unexpected. This was possibly caused by other factors such as manufacturing defects in cartridges or variability in the strength of the fabric within the same bolt of material. Apart from this, there was excellent reproducibility of results between each of the weapons at all ranges and for all fabrics.

The stellate/non-stellatetears obtained with the .30-30 Winchester rifle at 8 cm are explained by the interpretation of 8 cm being a ''transition'' range. All ranges below 8 cm producing stellate tears, and all ranges greater than 8 cm resulting in non-stellate defects.

The shotgun caused such extensive damage to the target backing that three test-firings of this weapon at each range were not deemed to be feasible (or particularly safe in our firing range setting). It is interesting to note that the 12-gauge shotgun produced stellate tears when the muzzle was held loosely against the fabric (loose contact), and did not produce a stellate tear when the muzzle was pressed firmly into the fabric (tight contact). Thus, for firearms, ammunition and fabrics used in our study, in situations where cotton clothing is the only intermediate target between a firearm and a victim, the presence of a partial or complete stellate tear on the clothing would seem to indicate that the firearm was discharged at contact or close range. Generally, one will also have soot and/or gunpowder deposits around the defect to confirm the range as being close. In some cases, however, the clothing may be so weathered or stained as to render assessing the presence or absence of these residues virtually impossible. In this circumstance, the presence of a stellate clothing defect may serve as a valuable clue to the possible range of fire.

There are a number of variables that this study did not explore, such as fabric tension, moisture, non-cotton fabrics, the angle of entry of the firearm projectile, the presence of intermediate targets, and other varieties of firearms and ammunition. Each one of these variables may affect whether or not stellate defects are produced, the defect size, and at what range they are seen. Finally, this study has worked under the assumption that all stellate clothing defects produced by firearms are entrance defects. Given that one of the authors (B.G.) has observed a small stellate clothing defect produced by an exiting bullet, it would also be worthwhile to explore the circumstances under which stellate defects are seen on clothing overlying an exit wound.

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