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Effect of Hair on the Deposition of Gunshot Residue

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Introduction

A primary element in the analysis of many shooting incidents is distance determination—the distance from the gun muzzle to the entry wound. The criteria most commonly used in this determination is the presence or absence of gunshot residue, the pattern diameter, and the type and distribution of gunshot residue. However, common protocols fail to consider the effect that hair may have upon the deposition of gunshot residue. There have been recent cases in which the absence of gunshot residue on the scalp was classified as evidence of a distant-range gunshot when other evidence supported a close-range gunshot.

In this manuscript, gunshot residue is defined as visible soot deposit particles, not the usual meaning of chemically or instrumentally detected primer and propellant residues.

Hypothesis: The presence of hair can significantly affect the deposition of gunshot residue on skin.

Methodology

Hair

There is substantial variation in the characteristics of artificial hair used in wigs, and there are no available data supporting the relevance of artificial hair to human hair for the type of testing in this experiment. Although it was recognized that there is also considerable variation in human hair (i.e., length, curl, color, diameter, form) charactistics, human hair is a more valid model than artificial hair.

After investigating various sources and types of available human hair, life-sized mannequin heads with individually embedded human hair commonly used by cosmetologists were used. The mannequin heads are made in China and are available from most cosmetology schools.

Figures 1 - 3

The variation in human scalp hair densities is great, from 0/cm for bald men to approximately 400/cm^2 (Olsen et al. 2001). Hair thickness, type, and anatomic location as well as age, gender, and racial characteristics also affect the density. A typical, full-headed human scalp will have a density of approximately 300/cm^2 (McElwe 2001). Mannequin heads have an average density of approximately 325/cm^2, but they are different in follicular density because mannequins have three to ten hairs in each scalp hole, whereas a human scalp will have only one hair follicle per hole. This means that the density of the hair directly above the scalp may be higher on a human head, and the density of the mannequin scalp follicles (the hair shafts protruding from the scalp) will be lower.

This difference is a positive element making the mannequin heads an effective comparison model because if gunshot residue can penetrate through the more dense mannequin hair, it will not likely be shielded by less dense, average, human head hair.

Protocol

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Protocol

One density factor was used so that gunshots at different distances could be compared meaningfully. Test shots were fired at a close range of 1 inch (2.5cm) and at an intermediate range of 4 inches (10cm). The weapon was shot into hair and nonhair areas. The differences in gunshot residue was compared and quantified.

To reduce variables, 24 shots were fired from one firearm and one type of ammunition.

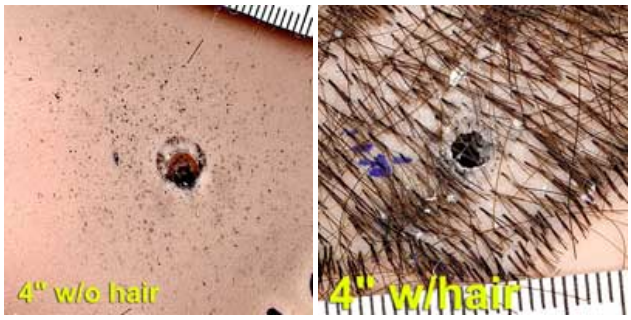
- 24 Shots: 12 shots at 1 inch (2.5cm) and 12 shots at 4 inches (10cm)
- Weapon: Glock Model 19 (9mm)
- Ammunition: Winchester SXT Supreme 9mm, 147gr JHP with flattened ball powder

Results and Discussion

There was no grossly observable gunshot residue present in the areas covered by hair at the close (1 inch/2.5cm) or intermediate (4 inches/10cm) ranges. The hair served as an effective filter preventing the deposition of all forms of gunshot residue including burned and unburned powder particles, sooting, tattooing, and stippling.

Figures 4 and **5** are close-up images of mannequin skin (left) and mannequin scalp (right). The hair has been partially cut for examination purposes. Although there is a normal deposition of gunshot residue on the bare skin, there is no visible residue on the hair-shielded scalp.

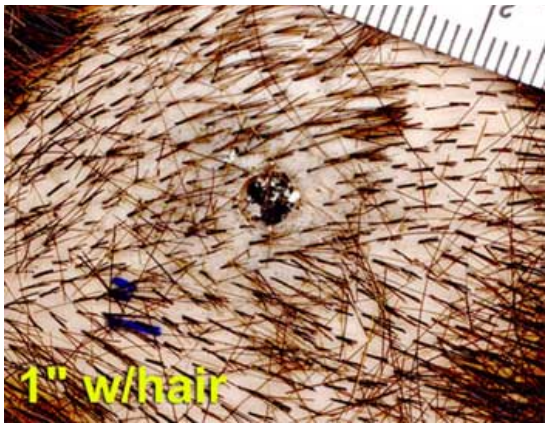
Figures 4 - 5



Figures 6 and **7** are close-up images showing the tests made from a close (1 inch/2.5cm) distance. The skin area has a dense gunshot residue deposit. When the same ammunition and firearm are used at the same distance to fire into a hair-covered scalp, there is no visible gunshot residue present. The hair was partially cut for examination purposes.

Figure 6

Figure 7



Figures 8 and **9** show gunshots with and without intervening hair that clearly display the difference in the presence or absence of gunshot residue deposits. Also note the reduction in the amount of bullet wipe; the hair not only filters out powder particles, but it also absorbs a considerable amount of the carbonaceous bullet-wipe material.

Figure 8

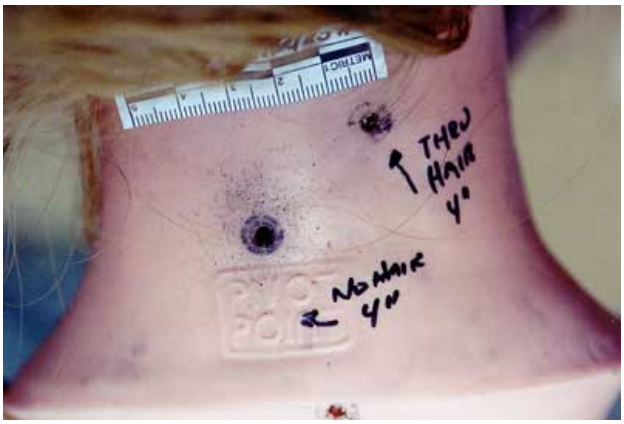


Figure 9

Case Examples

Figure 10 shows a victim shot with a .410 shotgun using disk-flake powder. Stippling and tattooing are visible in the areas near the neck, but in the more hair-dense areas near the top of the head there is an absence of similar gunshot residue stippling or tattooing.

Figure 10

Figure 11 shows a wound caused by a flare gun that fired a homemade 12-gauge shotgun cartridge filled with screws, nuts, and other small metal objects. Although it is not known if all the satellite defects surrounding the central defect are the result of powder particles or small metal projectiles, it is clear that the victim's hair, which has been partially shaved, shielded the scalp from gunshot residue and small projectile impact. Note the difference between the upper, shaved scalp area and the forehead.

Figure 11

Test 1 Into Loose Bangs on Forehead

Figures 12 and **13** show the results of a gunshot from 4 inches (10cm) through hanging hair. The gunshot residue stippling or tattooing on the mannequin skin is clearly visible in the lower areas near the cheek but fades into the upper areas near the top of the head as the density of the hair increases. A close-range shot higher into the forehead could result in a wound without any visible gunshot residue. The ammunition used in this experiment was Luke Haag reference ammunition 9mm FMJ with 8gr of "Accurate No. 7" flattened ball powder (Haag 2000).

Figure 12

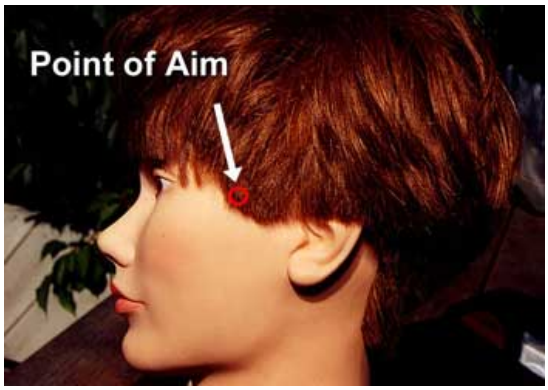
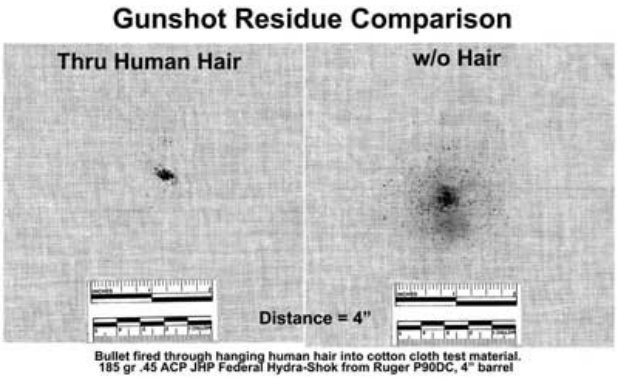


Figure 13

Test 2 Into Cotton Cloth

Many firearms examiners perform pattern or distance testing by shooting into cotton cloth that retains the gunshot residue and allows a visual display of the pattern diameter at different distances. **Figure 14** shows the result of a test using human hair that hung loosely against the cotton test material while the pistol was fired from a 4-inch distance. The hair did block a substantial proportion of the gunshot residue, preventing most of it from reaching the cloth.

Figure 14



Bullet fired through hanging human hair into cotton cloth test material.
185 gr .45 ACP JHP Federal Hydra-Shok from Ruger P90DC, 4" barrel

Observations

Movement of Hair

During the preliminary experiments, it was noted that shots fired from approximately 1 foot (30cm) or less would cause substantial hair movement (**Figure 15**). This suggested that the fast-moving gas preceding the bullet might push loose hair away from the skin and allow gunshot residue to contact the underlying skin.

Figure 15

Figure 16 shows that as a bullet leaves the muzzle, it is preceded by a gas bubble that will at short distances make contact with a victim's hair before the bullet.

Figure 16

Experiments were performed using high-speed photography to analyze the dynamics of the muzzle-gas effect on loose hair. The high-speed images (**Figures 17** and **18**) show the hair before and after firing. Figure 18 shows the pistol has just fired; the slide has started rearward. The bullet has entered and exited the mannequin's head. The hair has not yet moved significantly but has been pushed down against the head, not away from the bullet-strike point.

Figure 17

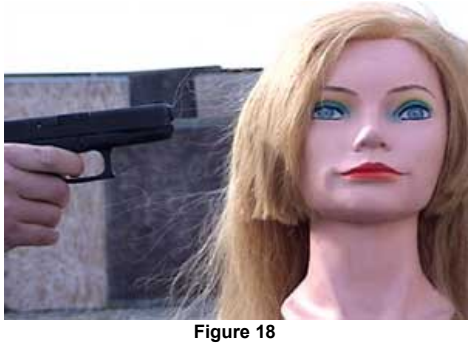


Figure 18

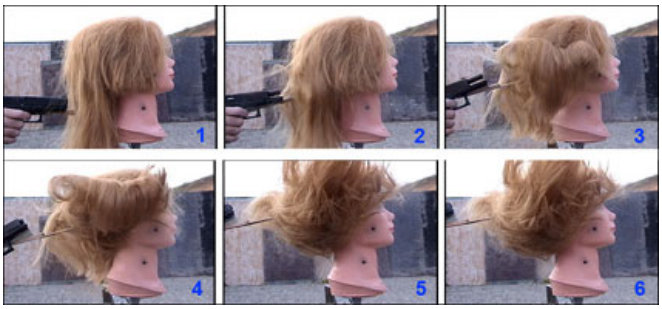
Loose, Hanging Hair Dynamics

Experiments were also performed to test the movement of nonrooted, loose, hanging hair. **Figure 19** shows the movement of loose, hanging hair as the bullet is fired through the hair into the back of the neck. The sequence begins at the top left frame. In the second frame, the gun has fired, and the bullet has exited out

the front neck area. Significant hair movement does not occur until the fourth frame. (Frames show 1/60th

the front neck area. Significant hair movement does not occur until the fourth frame. (Frames show 1/60th second intervals.)

Figure 19

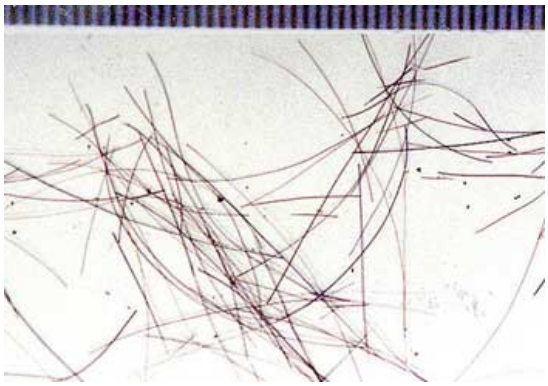


It was determined that the gas preceding the bullet does not move hair away from the bullet strike point. The muzzle gas may actually increase the hair density by flattening the hair against the skin or scalp.

Hair Retains Gunshot Residue

Although hair can act as a shield or barrier against gunshot residue, it also acts as an effective filter retaining much of the burned and unburned powder particles. It is recommended that the hair overlying an entry wound be carefully examined for gunshot residue. A comb should be used to separate and collect residue particles. **Figure 20** shows mannequin hair with gunshot residue particles. Hair over a gunshot wound should always be retained as evidence, even when gunshot residue has not been found. Burnett (1989) suggests that the the particle form can be altered by impact.

Figure 20



Recommendations

Gunshot-range determinations should always include consideration of the presence of hair as an intervening, shielding object. This is particularly true with gunshots into the face and other areas where long hair strands could have been present when the shot was fired.

Bangs or loose hair strands, which may have been in place to shield a portion of a person's face, may no longer be in the same orientation and location when the victim is found. For example, a person with long hair covering part of the face may have been shot through the hair into the cheek or forehead while standing but be found in a prone position with the loose hair away from the face.

Without understanding the dynamics and the gunshot residue-shielding effects of hair, the absence of residue surrounding the face wound in an area possibly shielded by hair could be misinterpreted as a distant shot.

Distance determinations of gunshot-entry wounds under densely hair-covered areas should include an adhesive lifter, transfer, or direct application of colorimetric testing procedures, which may allow the visualization of the gunshot residue pattern (Glattstein et al. 2000A and 2000B). A method for lifting gunshot residue particles from hair and other objects is described in Zeichner and Levi (1993).

Hypothesis and Conclusions

The hypothesis is confirmed. The presence of hair can significantly affect the deposition of gunshot residue on skin.

- Hair can completely prevent the deposition of gunshot residue to the scalp and other hair-covered areas.
- An entry wound without stippling, sooting, or gunshot residue particles cannot be regarded as a distant-range shot without considering the presence of hair as an intervening object.
- Hair acts as an effective filter and will retain gunshot residue.

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