

Detecting Patched Bullet Holes in Painted Drywall

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Abstract: Reconstructionists must sometimes deal with crime scene evidence that has been cleaned, moved, or repaired. The extent of these alterations can greatly impair efforts to understand the events surrounding the commission of a crime. In the worst of scenarios, repairs or alterations to the evidence will effectively render it “undetectable”. Such is the case with patched bullet holes. This paper examined three non-destructive methods for detecting patched bullet holes in drywall.

Keywords: Shooting reconstruction, crime scene reconstruction, terminal ballistics, trajectory analysis, x-ray, alternate light source, patched bullet hole, forensic science

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Introduction

Patched bullet holes represent a unique challenge to shooting reconstructionists. In the absence of recognizable bullet defects it may be impossible to determine trajectory, directionality, stability of the projectile at the time of impact. Lack of recognizable bullet defects can impact the recovery of not only the projectile itself, but also other evidence that may be associated with the defect such as bloodstains, fibers, and other trace evidence. Ideally, a qualified shooting reconstructionist or crime scene analyst will properly investigate the scene prior to any repair. Such is not always the case. The investigation of shooting scenes with patched bullet holes may be infrequent but there are several scenarios that may create these conditions.

1. Unreported shootings revealed af-

ter time by informants, witnesses, or co-conspirators.

2. Shooting scenes investigated by novice or inexperienced law enforcement personnel or private investigators in which no trajectory analysis was completed before the release of the scene and subsequent repair.

3. Discovery of new evidence or information during the investigation making it necessary to revisit a shooting scene that has already been repaired.

The authors hypothesized that an ultra-violet luminescence/absorption variance or a density variance between the patch material and undamaged drywall would be detectable using ultra-violet light or x-ray emission, respectively. The authors also wanted to test the feasibility of detecting





▲ **Figure 1:** Side view of test wall showing grid designations.

▶ **Figure 2 (upper right):** Test wall 1 with one 9mm bullet hole and one .22 caliber bullet hole in each grid square. The pistols used are also pictured.

▶ **Figure 3:** Close-up of gunshot residue around 9mm bullet hole produced with a muzzle-to-target distance of about 6 inches (15cm) in grid 1A, test wall 1.

gunshot residue surrounding the bullet defects by physically removing the overcoats of paint.

Materials and Methods

In order to investigate possible detection methods of patched bullet holes the authors constructed a twenty-four inch (61 cm) wall. The wall was constructed of half-inch (1 cm) drywall framed with two-inch by four-inch (5x10 cm) pine studs. The drywall was painted with two coats of Kilz® primer followed by two coats of brown colored KWAL® interior latex paint following manufacturer's recommended drying times. No texturing was done on the wall. The wall was then divided into four equal twelve-inch square (30 cm²) sections: 1A, 1B, 2A, and 2B (figure 1).

Two handguns were used to create the bullet defects. A .22 caliber Smith and Wesson Model 41 pistol and a 9mm Luger (9x19mm) Glock Model 17 pistol. Ammunition used was Remington .22 long rifle (LR) caliber cartridges loaded with a 36-grain hollow-point bullet and Remington 9mm Luger (9x19mm) cartridges loaded with a 115-grain full metal jacket bullet. The calibers were selected for commonality in the market place. Fired shots were made approximately orthogonal to the wall. This was done to create the smallest defect possible for detection. A single shot from each weapon was made into each twelve-inch unit. By design, the fired bullets passed completely through the drywall and were not embedded in the pine wood studs. The authors also wanted to test the feasibility of recovering gunshot residue evidence by removing layers of paint after any defect detection. Authors varied the range of the shots to the wall from six to twenty four inches (15-61 cm) (figures 2 & 3), which resulted in visible gunshot residues on the painted drywall.

Two patching materials were selected



for use in the study. One was commercial DAP® spackle and the other was Crest® toothpaste. The toothpaste was selected as a patching material because of its availability as a "quick fix" home repair product. Those making repairs may not have commercial patching products in the home nor wish to shop for it following a shooting. Bullet holes in the 1A and 2B units were patched with toothpaste and units 1B and 2A were patched with the DAP product. The products were allowed to dry and then lightly sanded with fine grit sandpaper. Special care was taken to disturb as little of the gunshot residue as possible. After drying, the wall was repainted with two coats of the brown latex paint.





Initial Testing and Results

Testing began with examinations using ultraviolet light. These devices are commonly used to detect latent stains such as semen, saliva, and urine in forensic laboratories and crime scene processing. Ultraviolet light has been used to successfully detect neat bloodstains under multiple layers of paint [1-3]. A few of the bullet defects were visible using strong oblique lighting, however, this study tested techniques with the assumption that no bullet defects could be discerned with the naked eye. A SPEX™ CS-16-500, Lynn Peavey™ UV LED Black Light flashlight, and a hand-held long/short wave UV lamp were used. The wall was examined at various wavelengths using red, yellow, and orange goggles. There was no detectible variance between the patching material and surrounding undamaged dry-wall.

A SceneScope® Advance™ Reflective Ultraviolet Imaging System (RUVIS) was also used in an attempt to detect any indication of the impacts. The wall was viewed from a wide variety of angles using an ultraviolet light for illumination and the imager with and without the included ultraviolet filter. None of the defects were revealed.

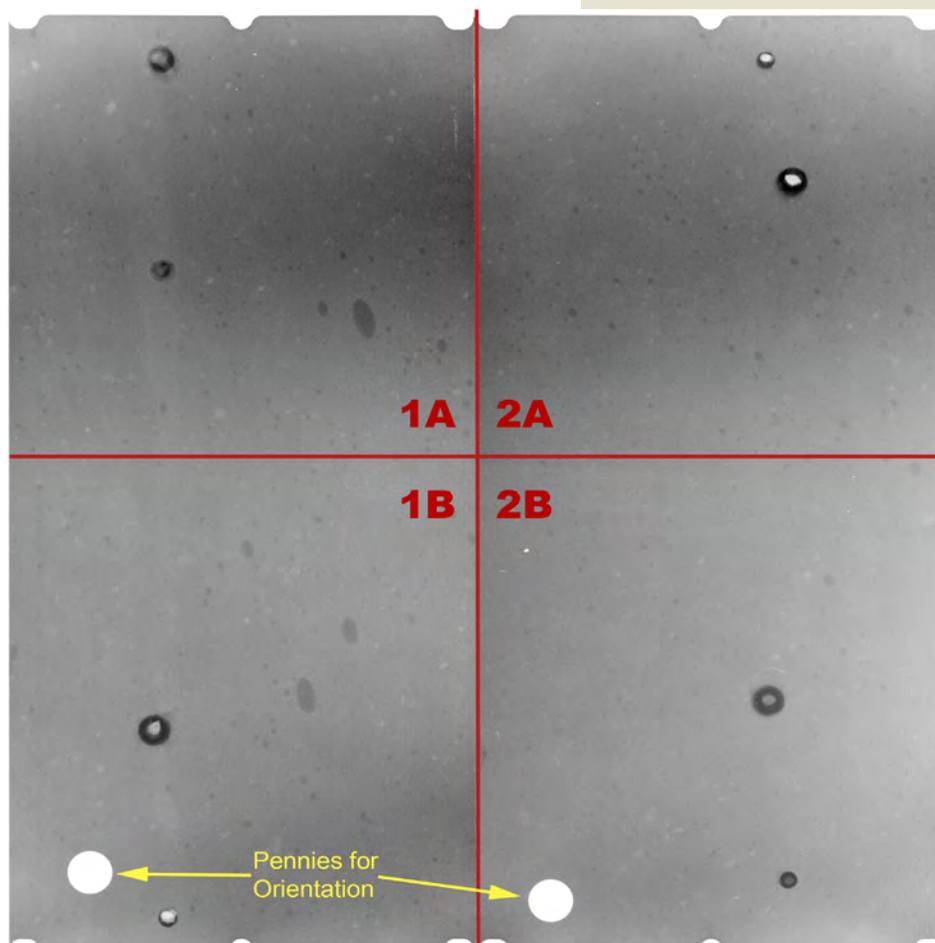
The authors then employed a portable x-ray device. The Logos Digital Imaging

System was used for all testing. The Logos device is a portable digital x-ray device that comes contained inside a hard-sided case. This includes a reader, two image plates, erasing light, and power supply. The image plates were 8x17 inches (20.3 x 43.2 cm) with a maximum resolution of 300 dpi. These plates are positioned behind the object to be x-rayed and exposed to an x-ray source. Once exposed the plates are inserted into the Logos reader that produces an image that is downloaded via USB cable to a laptop running proprietary software that can be used to stitch together images from multiple plates and apply various software filters to enhance the image. These Logos units are commonly used by local, state, and federal bomb disposal teams throughout the United States.

Two 8x17 inch image plates were placed behind the bullet defects with the x-ray source positioned perpendicular to the

◀ **Figure 4: X-ray set-up showing x-ray source in foreground and test wall 1 with patched bullet holes in background.**

Figure 5: Stitched x-ray images from two plates showing bullet impacts from both 9mm and .22 caliber bullets. The large white circles in the lower left of each plate are pennies taped to the plate for orientation purposes.



drywall (figure 4). The manufacturer's software allowed technicians to stitch together two plate images to give a complete view of the wall (figure 5). The larger circles on the bottom of the image were pennies placed on the image plates for orientation purposes. The bullet defects were clearly visible using this method. Close inspection of the defects on the x-ray film revealed that the spackle was significantly lighter in color than the drywall, indicating that the spackle is more radio-opaque than the drywall. However, the centers of the toothpaste-patched holes were very close to the same color as the drywall. In both cases, a dark ring around the periphery of the defect further highlighted the holes on the x-ray images, which was particularly helpful in visualizing the toothpaste-filled holes. The cause of these dark rings was not immediately apparent, but was addressed in additional testing described below.

Several techniques were used in an attempt to remove the layers of paint covering the gunshot residue in unit 1A. Adair has previously reported on detecting blood evidence under four coats of paint as well as several effective restoration techniques to recover the evidence [3]. Both scraping/peeling and sanding methods described in that study were used in this study. Neither technique was effective in revealing the gunshot residue. This may be due in part to the shorter intervals between paint coatings and the use of the same paint product between the base and cover layers. These methods should be considered however to reveal possible blood evidence that may be present surrounding the bullet defect should one be detected.

Additional Testing and Results

Following the positive results from the use of the portable x-ray device, the authors prepared a second drywall to conduct additional tests. For these tests, the drywall was shot with a .40 S&W caliber Sig Sauer Mod-

el P229 pistol firing Winchester .40 S&W caliber cartridges loaded with 165-grain full metal jacketed bullets and a .223 Remington caliber Colt M-16A1 rifle firing Winchester .223 Remington caliber cartridges loaded with 55-grain jacketed soft point bullets. Orthogonal shots were fired from each weapon into quadrants 1A, 1B, and 2A. In quadrant 2B, two low angle shots were fired into the drywall with the .40 S&W caliber pistol with the intent of perforating the 2x4 wood frame. The first shot grazed the board, but the second shot was a clean perforation. All shots were fired from a distance of approximately 20 feet (~6 m).

Finally, additional holes were made in 1A and 1B using a plastic dowel rod to manually punch through the drywall and a hole was drilled in 1B using an electric drill. These non-bullet holes were added to determine if there would be any discernable differences in their appearance when x-rayed.

The holes in 1A were patched using a DAP Acrylic Latex caulking, the holes in 2A were patched using Oatey® plumber's putty, and the holes in 1B and 2B were patched with Phenomenal Brands™ all-purpose spackling paste, which was a different product than used in the first round of tests. All these patching materials were common commercially available products purchased in a local hardware store. It was noted that of these filler options, the spackle performed the best. The caulking contracted slightly when it dried and left a concave appearance that would be visible, particularly if observed under oblique lighting. Additional application of caulking would be necessary to compensate for this contraction. The plumber's putty was difficult to apply because it did not adhere well to the sides of the bullet holes and left a slight gap when the putty was wiped flush with the hole with a putty knife. The solution was to smooth the putty away from the center of the hole and outward by hand.

Figure 6: Plumber's putty extruded through the backside of the bullet hole during the patching process.



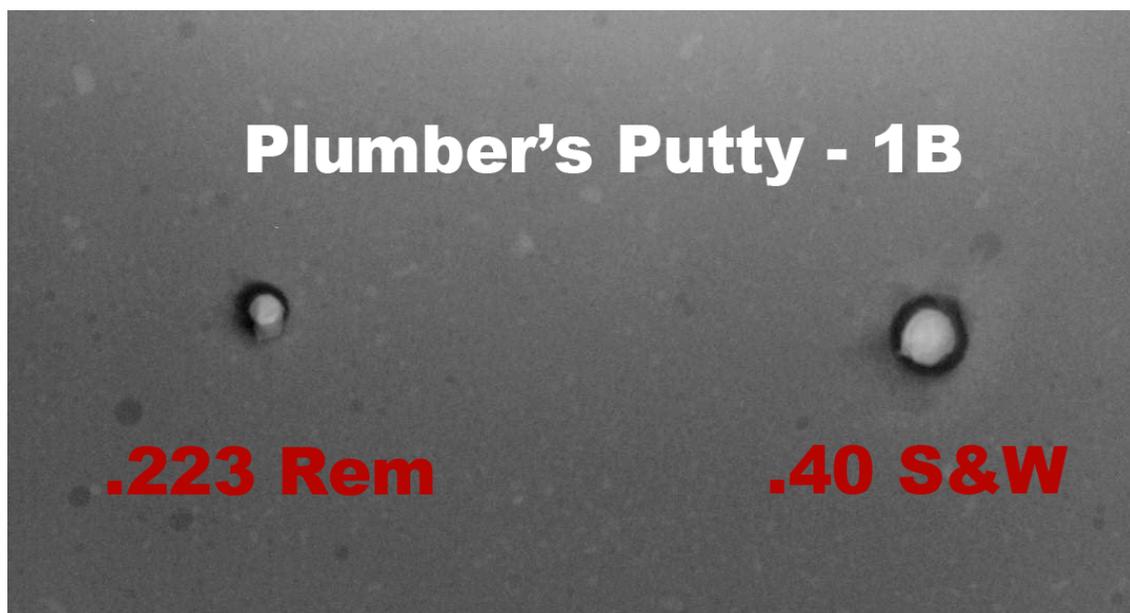
During this process, putty was extruded through the back of the hole and a ragged cylinder of putty hung from the back of the hole (figure 6). These fell off when the wall was moved for x-ray, but may still be present on an actual wall repaired in this fashion.

All the quadrants were x-rayed as before using the Logos Digital Imaging System. When analyzed, it was found that the bullet holes were clearly visible regardless of the filler material used (figures 7-9). During the first round of x-rays, it was noticed that the bullet holes had a dark ring around their periphery. Dark portions of the x-ray depict areas where more x-rays are able to reach and expose the film. Therefore, the dark rings around the bullet defects indicated areas of lower density that permitted the passage of more x-rays than the surrounding drywall or the filler material. This same dark ring was observed in the x-ray images of the patched bullet holes in the second round of tests. A close examination of the rear of the drywall revealed an explanation. The bullets created a cone-shaped defect with the larger diameter of the cone on the exit side of the drywall. When patched from the entrance side, the filler material did not fill the greater diameter on the exit side of the defect that left an air gap (figure



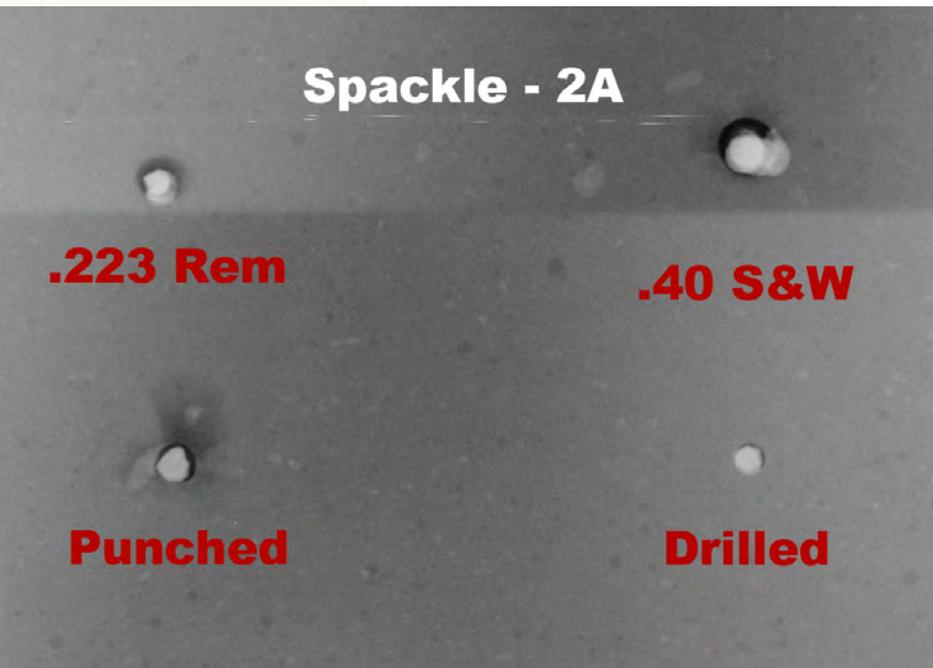
10). This air gap was the cause of the dark ring visible around the defects on the x-ray images. The x-ray image of the drilled hole showed only a thin, faint, partial ring that was clearly distinguishable from the bullet holes, likely because the hole had a uniform diameter and was more efficiently filled. The punched holes did have partial rings, but they were less distinct than the bullet holes. Though other mechanisms could result in cone-shaped defects that could also

▲ Figure 7: X-ray image of bullet holes in grid 1A, test wall 2, which were patched with caulking.



◀ Figure 8: X-ray image of bullet holes in grid 1B, test wall 2, which were patched with plumber's putty.





▲ **Figure 9:** X-ray image of bullet holes in grid 2A, test wall 2, which were patched with spackle.

▶ **Figure 10:** The cone-shaped defect on the exit side of the drywall and the air gap between the borders of the crater and the patching material.

have this appearance when patched and x-rayed, this ring was a consistently distinctive feature of the patched bullet holes. The boldness of the dark ring did vary among the patched bullet holes, but the dark ring was visible regardless of the filler material used. It is also noteworthy that the dark ring was visible regardless of the filler application technique. These techniques included application with a putty knife, hand application, and injection with a caulking gun. Each author independently used the putty knife application and the hand application.

When x-raying the low angle impacts in quadrant 2B, the authors were interested in determining if the bullet path through the 2x4 board would be visible. It was found that the bullet path was faintly visible (figure 11) and it appeared to show an upward deflection. A trajectory rod was used to demonstrate this deflection, which was measured as a 12° upward deflection and a 20° lateral deflection (figure 12).

Discussion

Any efforts to repair or conceal bullet impact evidence can seriously hinder crime scene reconstructions. Such is the case with patched bullet holes. Absent this evidence,

examiners may be unable to determine such things as trajectory, direction of travel, bullet orientation upon impact, and of course the recovery of the projectile and associated trace evidence. The portable x-ray devices routinely used by bomb squads and FBI Special Agent Bomb Technicians throughout the United States are a resource investigators should consider when faced with a need to detect the presence of patched bullet holes. All FBI-certified bomb squads are required to be equipped with a digital x-ray system, the two common commercial options being devices made by Logos and ScanX. Though not tested, the ScanX device is a comparable technology to the Logos device and is expected to produce the same results. One of the great advantages of using these devices is that they can reveal bullet defects in a non-destructive manner.

The authors are unaware of any published studies examining the detection of patched bullet holes. The fact that these incidents are rarely reported in the literature suggests further testing of feasible detection methods should be undertaken to better define “best practice” procedures. The authors are aware of an unpublished report regarding the use of a hand-



held thermal camera to detect patched bullet holes [4]. No images of this analysis were available to the authors prior to publication. The authors encourage other examiners to test additional conditions and devices in the detection of patched bullet holes so that we may broaden our understanding of these methods.



▲ **Figure 11: X-ray image of acutely impacting bullet hole in drywall and 2x4 board. An upward deflection is evident from the perforation of the board (front view).**

Bullet deflection during perforation is always a concern when conducting a trajectory analysis. Though not a focus of this study, the bullet deflection through the pine 2x4 board does highlight this issue. However, the alignment of the perforation through the drywall and the entrance impact in the board does result in an accurate extrapolation of the pre-impact trajectory of the bullet. Further probing of the board revealed the deflected bullet path that was far out of alignment with the original trajectory.

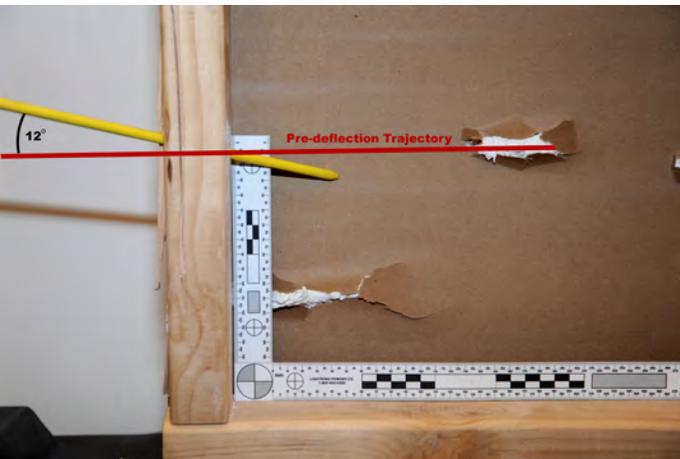
irregular impact. Presented with such evidence of an unstable bullet, any downrange impacts should be considered unreliable for determining pre-impact trajectory.

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◀ **Figure 12: Probe (yellow) showing the deflected path of the bullet through the board and the pre-deflection trajectory shown in red (back view).**

Of greater concern would be a scenario where a larger section of the drywall surrounding the initial bullet impact is removed and patched. Examiners would be wise to exercise greater caution in drawing a conclusion about the original bullet path in such a situation. However, there is another important indicator that can aid the examiner. The condition of the next available impact should be carefully documented and considered. Impacts that are irregular would indicate that the bullet had lost some of its stability while perforating the missing target. In the case of the test wall in this study, a close examination of the entrance into the board did reveal just such an



