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Research Article

Detecting Latent Saliva Stains on a Pistol Grip Using the Blue Laser (447 nm): A Comparative Study of Two Field Methods

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Abstract

Rapid detecting, visualizing, and photographing latent saliva stains in the field remain as a challenge to the forensic science community. A more challenging situation is such an attempt on black color surfaces because traditional methods, e.g., blue lights and U.V. lights are usually unable to produce strong light for a better contrast. Under a quasi-experimental study, this paper reports detection and visualization of latent saliva stains on a pistol grip using three different light sources of blue light (450 nm), a U.V. light (365 nm) and a blue laser (447 nm) for a comparative purpose. The preliminary results indicate that the laser method is much superior to the blue and the U.V. lights since the laser possesses three unique technological strengths: a compact diode pump solid-state laser (447 nm wavelength), a 1 nm color-purity bandwidth, and a special yellow filter/goggle. Essentially, the laser device can detect and produce an excellent image of the latent saliva stain on the pistol grip almost simultaneously. The forensic value of the study lies in the fact that once saliva stains are located on a surface, a swab for a DNA test can follow immediately. To date, this new method may represent a new field-based approach to detect latent saliva stains at crime scenes. Finally, this work may progress toward the ultimate goal of rapidly detecting latent biological evidence (e.g., sweat residues) that would otherwise remain undetected using traditional development methods.

Introduction

Biological fluid stains recovered at crime scenes are among the most important types of evidence to forensic investigations. Saliva stains on different surfaces render valuable forensic possibility for a DNA analysis to identify a suspect or victim as well as exonerate an innocent individual, which is a very crucial step in a wide range of forensic investigations. Saliva is one of the vital biological fluids that are secreted from humans, which can be deposited on a specific surface by many criminal acts, such as biting, sucking, licking, kissing, and possibly through other behaviors [1]. As routine tasks at crime scenes and in the labs, quick detection and visualization of saliva stains constitute daily forensic science casework because detected saliva can be used as a potential source of DNA identification. Depending on the type of surface, however, it is still very difficult to detect saliva on black color surfaces, namely, television remote controls, cell-phones, and pistol grips because these black surfaces absorb more lights, reducing a contrast on the background for visualization and photographing, also known as the background rejection effect. Further, dried saliva stains are invisible to the human eye, which adds to more difficulty of recognizing and detecting dried saliva on latent biological evidence [2]. While saliva stains containing the DNA on black color surfaces are more difficult to detect than similar stains on glass bottles, plastic cups, or door handles, these unique objects (T.V. remote controls, cell-phones, and pistol grips) are commonly encountered at crime scenes. In reality, some of the objects on which saliva is deposited (e.g., gun grips) cannot be submitted for direct swab and extraction procedures without initial detection [3]. Therefore, a novel and improved detection and visualization method is much needed and demanded to identify invisible dry saliva stains on these surfaces. In fact, if the detection is initiated improperly, other methods of extracting DNA are then flawed, erroneously identifying the wrong suspect and possibly including the innocent [4]. To date, various methods for detecting dried saliva stains have been tried out, e.g., chemicals [5], fluorescence spectroscopy [6], lasers [7], but each method has its strengths and limitations. This paper reports the preliminary findings of detecting, visualizing, and photographing dry saliva stains on a black color surface of a pistol grip using a blue light, a U.V. light, and a new laser device for a comparative purpose.

A surface containing possible biological stains usually absorbs, reflects, or transmits light that is shed on it. If the light is absorbed by the biological material, the light unusually then re-emitted at a different wavelength (called a Stokes shift), also known as fluorescence. Typically, when a biological stain fluoresces, the light is re-emitted at a lower energy state with a longer wavelength.

The wavelength of visible light runs from 400 nm to 700 nm, of which the blue light (430 nm~490 nm) is often employed to detect latent biological stains (e.g., blood) with limited success. As one of the multiple light sources, the blue light can re-emits fluorescence from the detected biological

stains under the orange spectrum for detection and visualization. In other words, the faint fluorescence from the biological stains can be observed only if the blue light is being blocked out by an orange filter or goggle. Thus, the blue light is always used as the first attempt at crime scenes mainly due to its non-destructive quality that would cause damage or harm to the evidence.

A U.V. light or ultraviolet light has also been commonly used to detect biological stains (semen, blood, and saliva) both in the field and in the laboratory. A U.V. light is electromagnetic radiation with two subcategories: short U.V. wavelength (190 nm~290 nm) and long U.V. wavelength (290 nm~400 nm). As a traditional method, the U.V. wavelength (365~395 nm) radiation is commonly used in the forensic investigation because it can cause many substances to glow or fluoresce to detect latent fingerprints due to its UV radiation from its interactions with organic molecules contained in latent fingerprints.

The detection or location of latent biological stains, namely saliva, however, faces three challenges. While certain biological stains, such as semen and vaginal fluids, usually fluoresce themselves automatically, latent saliva does not glow significantly for a detection or visualization. Certain objects with a black color surface, e.g., a pistol grip, absorb much of the light, hindering detection. Finally, saliva stains evaporate much faster than semen and vaginal fluids, requiring a rapid field detection method rather than the common protocol of taking the evidence back to the lab for detection. Therefore, an effective, portable, and real-time device is needed for quicker field applications.

While the blue and the U.V. lights are the current methods, laser technology is a new technology. Laser technology refers to a special device that can emit light through a process via the simulated emission of electromagnetic radiation (a short term for "light amplification by simulated emission of radiation. The laser light has three features: the spatial coherence for a concentrated spot via a light beam; the temporal coherence that allows the beam to focus on a very narrow spectrum. A combination of both features can generate a very strong and single color light to emit a sharp contrast between a substance and the substrate. Among its many applications, the laser has been used to detect latent fingerprints, and latent saliva stains on paper towels and bitten apples.

Materials and Quasi-Experimental Design

The study compares three different light sources to see which one is the most effective light in detecting latent saliva stains on a piece of the pistol grip with a focus on the new laser device. A preliminary investigation is reported under a controlled-setting (quasi-experimental design) using three different light sources: a blue light (450 nm), a U.V. light (365 nm), and a blue laser (447 nm). The manufacturer's information for the laser device is provided in the Acknowledgement section (also see Figure 1).

With a purposive sampling method, the author's prior knowledge and experience could contribute to selecting a proper and targeted sample, in this case, the pistol grip, which is common evidence found in a shooting related crime. A quasi-experimental design is an empirical method estimating the causal impact of treatment or intervention on its targeted samples. The design consists of three main components. First, a quasi-experimental research does not use random assignments to treatment or control. Instead, a quasi-experimental design typically allows the researcher to control the treatment condition and use some criterion for practical purposes. Second, the researcher can have more control or manipulation to the treatment condition due to limitations of time and resources [8]. Finally, there are several types of quasi-experimental designs, each with different strengths, weaknesses, and applications [9]. The quasi-experimental design allows the researcher to maximize the crime scene scenario with a certain level of control for this study. A pistol grip was chosen because it is a common type of evidence in a shooting related crime. Thus, if latent saliva stains were detected at the scene, the evidence could be swabbed for a DNA analysis. To simulate a real scenario of a crime scene, a volunteer was asked to deposit his saliva onto the pistol grip three separate times without telling the author of the exact location(s), which in principle is similar to the so-called black box study.

Quasi-experimental 1 using the blue light (450 nm)

The volunteer was first asked to deposit his saliva onto the pistol grip in any act he preferred. The volunteer, however, was told to exercise a similar act for the following two depositions. After the deposition, he tossed the pistol grip onto a carpeted floor. After one hour of waiting, the author came into the room, picked up the pistol grip with a pair of latex gloves, and placed it on a piece of white paper with a scene marker and a ruler. A pair of cotton gloves was not used because it might absorb any saliva residues on the pistol grip. For a comparative purpose, the pistol grip was photographed first using a regular digital camera under the normal lighting in the room before the application of the three different light sources (three treatments). Notably, no saliva stains were visible at this time (Figure 2). Then a blue light (450 nm) was employed to detect any latent saliva stain on the pistol grip and no visible saliva stains were observable at this time (Figure 3).

Quasi-experimental 2 using the U.V. light (365 nm)

The volunteer repeated the same procedure after wiping off his first saliva deposit on the pistol grip. The author repeated the same steps to detect any latent possible saliva stains on the pistol grip using the U.V. light (365 nm). Almost immediately, a noticeable saliva stain was observed on the upper portion of the pistol grip in a dark room setting. The quality of the fluorescent image should be ranked as a mid-level image for its outline of the shape and a few concentration spots (Figure 4).

Quasi-experimental 3 using the laser blue (447 nm)

The volunteer repeated the same procedure after wiping off his second saliva deposit from the pistol grip. The author repeated the same steps to detect any latent possible saliva stains on the pistol grip using the laser light (447 nm, blue). Almost immediately, a very clear saliva stain was observed on the upper portion of the pistol grip (the other side). The quality of the fluorescent image should be ranked as an excellent image for its outline of the shape, a few concentration spots, and nearly 50% of latent saliva residues, which allows for a more accurate swabbing for a later DNS analysis (Figure 5).

Figure 1: The portable laser device (447 nm, blue) was employed in the quasi-expermental study.
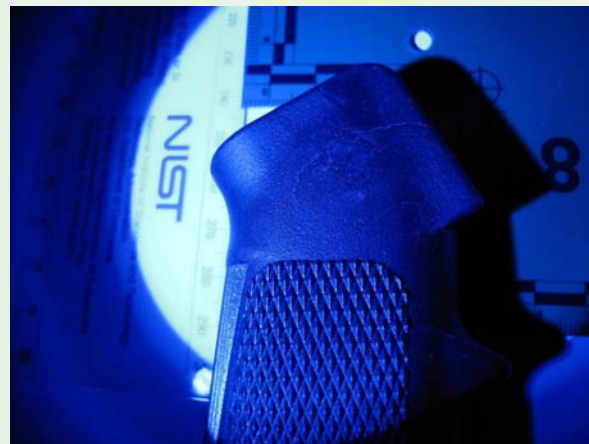

Figure 4: The same pistol grip was photographed by the U.V light under 365 nm. A fluorescent image (a mid-level of quality) of a dry saliva stain was visible.

Results

After one hour of waiting after each detection (the treatment), the author first photographed the pistol grip with a regular digital camera, but no saliva stains could be seen on the surfaces (Figure 2). Then the author employed the blue light (450 nm) and did not detect any latent saliva stains either (Figure 3). Next, the U.V. light was used to detect the dry saliva stain and a clear and noticeable saliva stain was present (Figure 4). Finally, when the laser light scanned the pistol grip, an excellent fluorescent image of a dry saliva stain was immediately observed with a clear contour and a concertation area under the yellow filter/goggles (Figure 5). This area should be the target for a DNA swab. From this preliminary study, three levels of image quality of the latent dry saliva stains were detected, visualized and photographed by three different light sources on the pistol grip-a black surface object that usually renders little contract under the traditional lighting methods. The scenario of a possible crime scene under the quasi-experimental design consists of three different light sources or three different treatments: a blue light (450 nm), a U.V.

Figure 2: A pistol grip was photographed by a regular digital camera under a normal lighting. No dry saliva stain was visible to the naked eye.
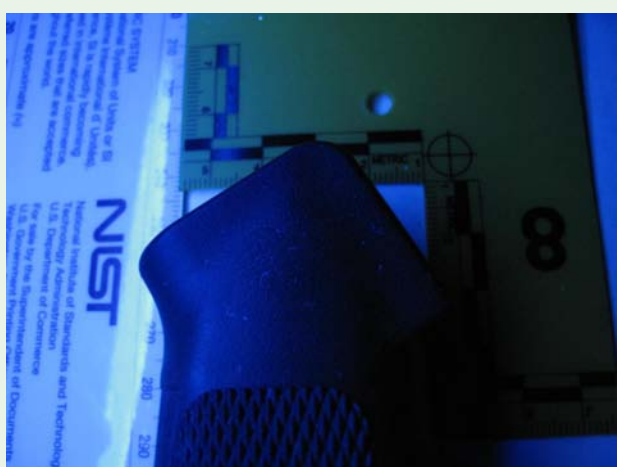

Figure 3: The same pistol grip was photographed by the LED blue light under 450 nm. No fluorescent image of dry saliva stain was visible.
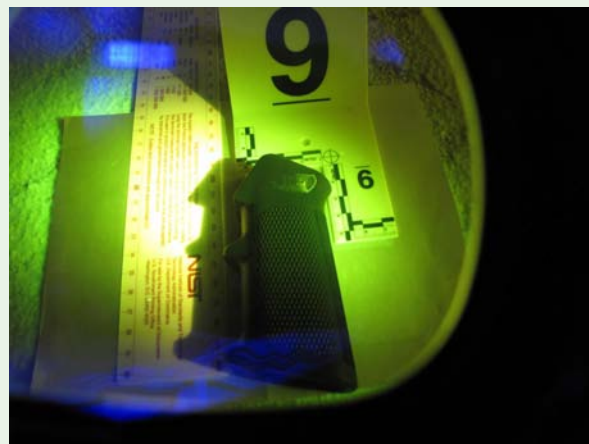

Figure 5: The same pistol grip (on the other side) was photographed by the laser device under 447 nm and a yellow goggle. A fluorescent image (a high-level quality) of a large dry saliva stain was visible now.

Table 1: A comparison of detecting latent saliva stains on a pistol grip using three different light sources.

Types of Object	Types of Surfaces	Types of Forces	Types of Acts	Wavelength	Goggle/Filter Used	Image Results
Pistol Grip	Black Plastic	Normal	Licking and Smearing	Blue Light 450 nm	No	No
Pistol Grip	Black Plastic	Normal	Licking and Smearing	U.V. Light 365 nm	No	Clear
Pistol Grip	Black Plastic	Natural	Licking and Smearing	Laser Light 447 nm	Yellow	Excellent

light (365 nm), and a laser light (447 nm, blue). The table 1 below summarizes the comparison results of the dry saliva stains on the three different light sources examined in the study.

In other words, an excellent image of a dry saliva stain was successfully detected, visualized, and photographed on the pistol grip using the laser device at 447 nm wavelength (Figure 5).

Discussions

The preliminary purpose of this project was to compare the three different light sources in detecting latent saliva stains on a black surface (a pistol grip) with a purposive sampling. The three image results indicate that the blue laser device (447 nm) is the most effective light source for detecting and visualizing latent dry saliva stains deposited on the black surface of a pistol grip. Several features of the laser device are worth mentioning. First, the device weighs only 3.5 kg with a dimension of 225 mm/9″ (length), 105 mm/4.2″(width), and 165 mm/6.6″ (height). Either AC or an inserted DC battery (1.5 kg) can operate the device. The battery can last 4~6 hours for interrupted or continuous operations for an output power of 8- watts and can be rechargeable for 4 hours for another full use. Second, in this investigation, the laser beam was emitted at the 447 nm wavelength with the color purity level of 1 nm to minimize all light divergence. As a result, the presence of human latent dry saliva stains was detected, visualized, and photographed by observing the fluorescent images. Third, the laser beam can produce a maximum illumination of a circular area (D=50 centimeters) with no speckles on the target area. The fiber delivery cable can be used in different flexible positions depending on the height of potential target areas. Finally, the filter/goggle is required for viewing and photographing, which is made to block certain wavelength due to its OD value (>7) and renders the human eyes to see with a regular digital camera for photographing under the yellow filter/goggles.

While the image quality of the latent dry saliva stains in this study tends to be a promising future for forensic examinations at the scene or in the lab, many new questions remain for further studies. First, more comparative studies are needed for latent dry saliva detection on other difficult surfaces, such as leather (belt and shoes), polyester fabric (bras and underwear), and even human skin (kissing areas and bite-marks). Second, this study is limited to detecting dry saliva deposition within a one-hour timeframe only; thus, future studies should be extended for longer deposition hours. Third, to explore the utility of the laser technique, future locations should be moved from the indoor setting as used in this study to outdoor settings. Next, the laser method works on latent dry saliva stains, but may be applicable to other latent biological evidence, such as sweat and semen [10].

Finally, to be more practical, a similar project may be conducted on latent sweaty fingerprints on a human neck in a strangulation case.

Conclusion

Several advantages of this blue laser device can be summarized directly from the quasi-experimental project. First, the laser device has a light weight with a rechargeable battery and thus qualifies for a portable usage in the field as well as lab applications. Second, while a U.V. light must require a dark setting to see an image, this laser device can generate a very strong blue laser beam and excite human dry saliva stains to be fluorescent for visualization and photographing during the daytime. Next, the photographing is also easy to operate with a regular digital camera and regular yellow filter/goggles. In fact, the goggles provided can be used as a filter as well because both can effectively block the laser light source, isolate the excited fluorescence, and in some cases reduce the exhibited fluorescence from the surfaces. Fourth, the laser detection is a real-time device with a direct and simultaneous viewing result under a yellow filter or goggles. Finally, the laser detection is non-destructive by nature (including DNA in saliva) and should be used as a first attempt in detecting latent saliva stains at crime scenes. All of these observations from the quasi-experimental project render the laser device a practical instrument for crime scene processing and identification in the field as well as in the lab. In sum, such a device can reduce the time required to process a crime scene by providing a rapid and real-time detection, visualization, and photographing of latent saliva stains to forensic investigators.

Acknowledgement

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