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Visualization of old bruises in children: Use of violet light to record long-term bruises

Sohtaro Mimasaka*, Toru Oshima, Maki Ohtani

Department of Forensic Sciences, Akita University Graduate School of Medicine, Hondo 1-1-1, Akita 010-8543, Japan

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ABSTRACT

When a child consultation center evaluates abused children, evidence of the abuse must be documented. Children who have suffered physical abuse often have bruises, which cannot be confirmed by visualization when the bruise has healed. In forensics, a method to confirm an old bruise by ultraviolet radiation is possible. However, long-term ultraviolet exposure can be harmful. In this study, we observed 15 bruises on healthy volunteer children using four kinds of light sources, including ultraviolet radiation, over time. The violet light source enabled observation of a bruise for a longer time than ultraviolet radiation. Although other studies have shown that violet light is superior for enhancing bruises, this is the first report to evaluate data concerning the ability to identify bruises over time in living children. These results might help to identify evidence of past violence suffered by children.

1. Introduction

Bruises are present in 90% of physically abused children [1]. Bruises arise when blood is lost from the intravascular space into the skin and subcutaneous tissues [1]. The breakdown of hemoglobin and blood cells results in a sequence of colors, including red, purple, black, blue, yellow, green, and brown [2].

Photographs play an important role in providing evidence of abuse in injured children with suspected abuse. However, bruises in children often heal quickly, and as time passes from the injury, it is difficult to show evidence of a past bruise. Often, by the time a child consultation center evaluates an abused child, and a specialist performs an examination, the wound has healed.

In forensics, ultraviolet radiation is used conventionally to enhance injuries of the skin [3–5]. It has been reported that ultraviolet radiation can help to visualize an old bruise. In addition, reports have shown that ultraviolet radiation can estimate the shape of the object that caused the bruise [6–8]. Successful identifications of bite marks (faint, old, and difficult to recognize) have been made 6 months after injury [9]. However, long-term ultraviolet exposure is known to adversely affect the skin and eyes. West et al. reported that the biological hazard of UVA (long ultraviolet waves with wavelengths of 400 nm–320 nm) is quite small, although it can be potentially hazardous to the eyes [10]. Therefore, although ultraviolet imaging is useful for documenting injuries related to violence, using ultraviolet radiation to study normal children as a positive control is not recommended.

Therefore, in this study, we attempted to visualize old bruises using ultraviolet radiation as well as alternative light sources. This is the first report to observe old bruises over a long time period using different light sources with multiple wavelengths in healthy volunteer children.

2. Materials and methods

2.1. Light sources, camera, and filter

Illuma-Light™, a series of bright white and 470-nm blue LED lights that provide 360-degree shadow-free lighting (blue ring; Crime Sciences Inc™, Fonthill, ON, Canada) (Fig. 1), and a forensic light source, Crime-lite® 2 (ultraviolet, violet, blue; Foster Freeman, Worcestershire, UK), were used as light sources in this study. A spectrometer (BLACK-Comet C-SR-50; StellarNet, Tampa, FL, USA) was used to confirm the distribution of the accurate wavelength of the light sources. A Canon PowerShot® G12 camera was used with a Canon Zoom Lens 5× IS 6.1–30.5 mm 1:2.8–4.5, with a narrow band filter (including Illuma-Light™; Crime Sciences Inc.).

2.2. Observation and photography of the bruise

We examined 15 bruises in healthy volunteer children, who acquired the bruises in typical daily accidents (for example, having

* Corresponding author.
E-mail addresses: mimasaka@med.akita-u.ac.jp (S. Mimasaka), tooshima@med.akita-u.ac.jp (T. Oshima), mohtani@doc.med.akita-u.ac.jp (M. Ohtani).

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Fig. 1. Illuma-Light (a series of bright white and 470-nm blue LED lights that provide 360-degree shadow-free lighting: blue ring).

an accident while exercising, accidentally falling down the stairs, etc.). The mean age of the children was 11.1 ± 2.5 (range, 7–13) years.

The observation and photography of each bruise were carried out in a darkroom. The bruise was observed by two observers. At first, we confirmed the location (e.g., direction and distance from the datum-point) of the bruise and observed and photographed it under visible light. Subsequently, the bruise was illuminated with four different forensic light sources: blue ring, blue, violet, and ultraviolet. We wore yellow-filtered goggles and observed each bruise under the four different forensic light sources separately; photography was attempted with a yellow filter. The children wore protective eyeglasses during the observation and photography. The children were instructed to remain still for several seconds during the photography.

To measure chronologic changes, the observation and photography were performed daily for the first 7 days and approximately once weekly thereafter (>7 days) until the bruise could no longer be observed macroscopically. We compared the elapsed time after the injury in terms of how long we were able to observe the bruises macroscopically with each light source. All bruises were allowed to heal naturally, without treatment such as cold-packs during the healing process.

2.3. Statistics

The time during which it was possible to observe each bruise was compared using visible light and the aforementioned four light sources: blue ring, blue, violet, and ultraviolet light. The differences between the groups were compared using the Friedman test. SPBS (The Statistical Package for the Biosciences: K. Murata, E. Yano. (2002) *Medical Statistics for Evidence-Based Medicine with SPBS User's Guide*, Nankodo Publisher, Tokyo, Japan) was used for the statistical analyses.

2.4. Ethics

We obtained written informed consent from the parents of volunteer children who had bruises, and permission to conduct this study was obtained from the Akita University Graduate School of Medicine Ethics Committee.

3. Results

3.1. Distribution of wavelengths

Fig. 2 shows the distributions of wavelengths of the four kinds of forensic light sources: blue ring, blue, violet, and ultraviolet light. The peak wavelength of each light source was confirmed as follows: blue ring, 450–500 nm; blue, 420–470 nm; violet, 400–430 nm; and ultraviolet, 350–380 nm. The light quantity of the blue ring light was approximately half that of the other sources of light.

3.2. Case (bruise no. 11 in Table 1)

This is the case of a 12-year-old boy, who fell down the stairs and sustained an injury involving a bruise on his right leg (Fig. 3). The bruise appeared to have healed by one week and was not visible under visible light. However, at one week, the bruise was

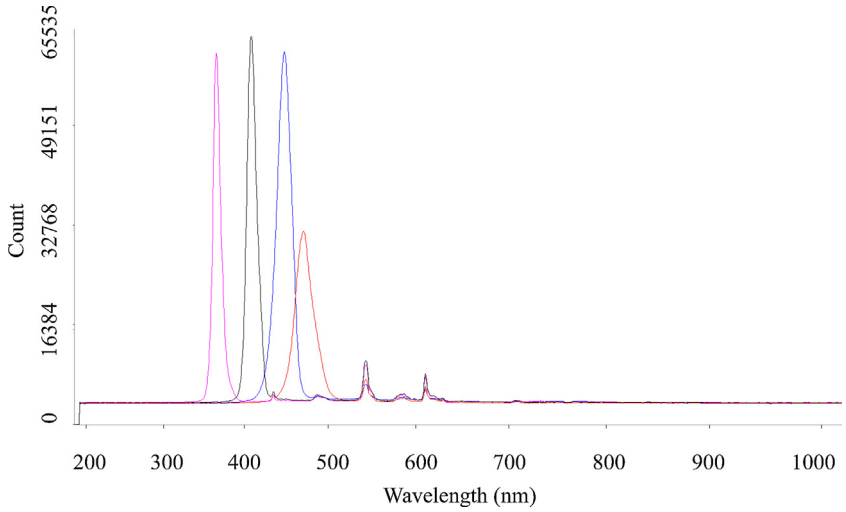

Fig. 2. Distributions of the wavelengths of four kinds of forensic light sources: blue ring (red line), blue (blue line), violet (black line), and ultraviolet (pink line) light. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)