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Ultraviolet Photography: Bite Marks on Human Skin and Suggested Technique for the Exposure and Development of Reflective Ultraviolet Photography

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ABSTRACT: This project is an attempt to standardize a technique for ultraviolet (UV) photography of bite marks on human skin. It also deals with a technique for producing clinical bite marks on living human subjects and a review of the equipment, lighting source, scanning technique, filters, films, and recommended camera exposures and film development for reflective UV photographs for bite marks on human skin.

KEYWORDS: odontology, bite marks, skin, photography, ultraviolet photography

While attending the AAFS 35th Annual Meeting in Cincinnati, the authors were shown an ultraviolet (UV) photograph of a bite mark on a young girl's arm. The startling fact was that the bite had been inflicted several months before the picture was taken [*1*]. This excited us because we had recently worked on a bite mark case using conventional photographs of a bite 12 h old. There appeared to be more information and a more workable pattern on the several-month-old bite than was available on the 12-h bite. Forensic odontologists must usually document bite marks in human skin as soon as possible because the normal healing and inflammatory responses in living individuals distort and blur the bite mark image. We felt that if it was possible to document a bite mark better using UV photography, a standardized technique should be developed.

The literature has classically stated that it is impossible to induce a bite mark of sufficient intensity so that it would last long enough (several months) for the research to be accomplished [*2*].

The induction of a clinical bite mark had two main problems: (1) the victim cannot with-

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stand the pain associated with a bite of sufficient intensity, and (2) the suspect (biter) cannot generate as much pressure as if he were in combat or a life-threatening situation.

The problem of severe pain is one that is met in every dental office every day, and we felt it could be overcome through use of intravenous (IV) sedation. We felt that the problem of inadequate intensity would be overcome if the bite could be maintained for 15 s.

The authors felt the simplest solution to finding voluntary participants was to run the first tests on ourselves. Before subjecting ourselves to this experience, however, we had to develop procedures for making UV photographs of skin.

About 100 test pictures were made of multiple skin lesions: 3-month-old surgical scar, tattoos, ecchymosis (bruising), and vascular lesions (capillary hemangioma). These photographs demonstrated the surprising fact that tattoos, livor mortis, and bruises could be "photographically erased." This phenomenon is attributed to the fact that ultraviolet radiation is not reflected off the surface of the skin, but actually penetrates below the surface underneath tattoo ink and above pooled blood [*3*]. Surgical scars under UV light showed a vast increase in contrast to the degree that suture wounds could be counted (Figs. 1*a* and *b*).

The biter first underwent an oral prophylaxis and mouth rinse while the subject underwent antibiotic prophylaxis and the area to be bitten was surgically scrubbed with betadine. A local anesthesiologist[4] initiated an IV injection with 5% dextrose and administered 20 mg of diazepam (valium) and 50 mg of meperidine hydrochloride (Demerol®). The biceps and triceps areas of the left arm of one of the authors, a white adult male, were used. During the bite to the tricep area, the victim was conscious and reacted audibly. This caused the biter to relinquish his bite after 5 s. It was decided to render the victim unconscious during the second bite to the deltoid area. This time he sensed pain upon awakening and tried to remove himself from the chair. In the first bite, the biter was unprepared and in the second the victim was unprepared. For the third bite in the bicep area, both were prepared to withstand the pain and to maintain the bite. The bite was maintained for 13 s and all agreed that it was of sufficient intensity for our purposes.

The final bite area was photographed immediately using conventional color and black-and-white photography and ultraviolet reflective black-and-white photography. It was pho-

FIG. 1*a*—*Three-month-old surgery scar with ultraviolet photography.*

[4]B. Smith, M.D., anesthesiologist, private practice, Hattiesburg, MS, 1983–1984.

FIG. 1*b*—*Same scar as Fig. 1a with a 18A UV transmitting filter on the camera lens.*

tographed again in 1 h, 6 h, 12 h, 24 h, 48 h, and then once a week for the next 24 weeks. The disappearance of the bite mark and its reappearance under UV light are shown in Figs. 2 to 6.

A wide range of photographic techniques and materials were tested. The films used were Kodak Tri-X film, Kodak Panotomic-X film, Kodak Technical Pan Film, and Ilford XP1 400 film [*4*]. Light sources varied from electronic flash to photo floods to Kerr longwave length UV curing light. A wide range of shutter speeds and F stops was used.

The ultraviolet photographs exposed immediately after the bite were of higher contrast and clarity than either color or black-and-white. This maintained itself through the first 12 h. On the second day, no discernible bite mark was visible, only large areas of bruising, which the UV photographically erased. The bruising persisted for approximately twelve days. No bite marks were visible to the eye or to the UV photography. On the seventeenth day, a bite mark pattern began to reappear in the UV photographs. The intensity and clarity of the bite mark increased and peaked at sixty days and then decreased. It must be remembered that after the bruise had faded on the twelfth day no marks were visible under ordinary light.

At this time, we should review ultraviolet photography and radiation (see Fig. 7). The light visible to the human eye is composed of radiation with wavelengths 400 to 700 mm. Wavelengths of over 700 mm are called infrared while ultraviolet is in the 200 to 400 range. UV can be broken down into two classes, shortwave and longwave. Shortwave UV has wavelength of 200 to 300 mm. It is damaging to the human eye and cannot be transmitted through glass. Longwave length UV is 300 to 400 mm, can pass through glass, and is harmless to human eye [*5*]. UV light responds in the same way visible light does. As it contacts an object it can be reflected or absorbed. This property is the basis of UV reflective photography [*6*]. But UV also has another property, fluorescence. As the UV light is absorbed, it excites some materials to the point that they give off light in the visible spectrum. By filtering out the UV light, only the light from fluorescence exposes the film, and you have fluorescent photography. This paper and technique will deal with UV reflective photography only.

Of all the various methods available for the development of UV photography, we have found two simple yet effective techniques. Both utilize longwave length ultraviolet radiation (LUV) 300 to 400 mm. This radiation can be produced by two methods: first, by filtering

FIG. 2—*Prominent marks in biceps region shown immediately after bite was inflicted. Photographed using Tri-X film and a shortwave UV fluorescent light source with a 18A UV transmitting filter in front of the camera's lens.*

available light in such a way that only LUV is passed, or second, by direct production of longwave UV as an available light source. The first is accomplished by the properties of Kodak filter 18-A (see Fig. 8). It allows passage of only two bands of radiation LUV 310 to 400 and infrared 700 to 815 [7]. The second uses an ultraviolet diagnostic lamp with a Woods filter. It produces a high intensity, completely harmless radiation from 320 to 420 (Graham Field Surgical Co., Inc. New Hyde Park, NY. 11040, Model 1736 (b-1001). The camera must be placed on a tripod because of the slow shutter speed needed to expose the film properly. A modified Corker Filter Adapter makes for easy attachment of the 18-A filter. The image must be brought into focus before the filter is placed because no visible light is transmitted.

To understand the properties of the skin that make production of the image of the bite mark possible, we enlisted the aid of Dr. Ricardo Martinez, a dermatologist with extensive training in wound healing, and asked that the first bite be biopsied. At this time, Dr. Martinez demonstrated the value of a diagnostic Woods Lamp. The bite areas that were invisible under ordinary light appeared as red welts on the skin under the light of the Woods lamp. These areas could then be delineated in brackets with a felt pen so that the photographer would know what area to photograph and the surgeon the area to biopsy.[5] The biopsied

[5]R. Martinez, M.D., Ph.D., F.A.C.P., Diplomate, American Board of Dermatology, private practice, Metairie, LA, 1983–1984.

FIG. 3—*This photo of the bite mark was taken 1 h after the bite using Kodak Tri-X film exposed by electronic flash without any camera lens filter.*

material was then taken to the Department of Oral Pathology at the LSU Medical Center School of Dentistry and examined through various techniques for signs of hyperpigmentation, scarring, and collagen healing. The images seen on the UV photographs appear to represent healing collagen fibers. In other words, we are observing the healing process of the lower layers of skin in this instance.[6] In other tests, the abraded skin of Caucasians also absorbed UV radiation, while in Negroes the lack of pigmented areas (melanin) as seen in abrasions and lacerations led to a negative image of the bite mark outline.[7]

The results of our tests suggest the following technique for exposure and development of reflective ultraviolet photography on bite marks on human skin (authors note—these parameters were found best for the types of materials and techniques used by the authors, but we realize there are many other techniques for exposing and developing UV reflective photographs.[8]

1. Film	Kodak Tri-X 400 ISO
2. Developer	Diafine chemicals (will allow Tri-X to be rated at 1600 ISO)
	A. Accufine, Inc.
	1-312-321-0240

[6]Personal communications, R. E. Barsley, D.D.S., associate professor of oral diagnosis, medicine, and radiology; R. F. Carr, D.D.S., associate professor of oral pathology; W. D. Davenport, Ph.D., associate professor of oral pathology and anatomy; J. Weir, D.D.S., J. D., associate professor of oral pathology, Louisiana State University Medical Center, School of Dentistry, New Orleans, LA, 1983–1984.

[7]T. C. Krauss, personal communications, 1986.

FIG. 4—*This photo of the bite mark bruise was taken 32 h later using incandescent light and Ilford XP1 film without a camera lens filter.*

	B. Dickens Sale Co. 11341 Indian Trail Dallas, TX 75229 1-214-243-5971
3. Filter	Kodak 18-A A. 50-mm square Part Number 840-447 B. 75-mm square Part Number 840-449
4. Lens	50-mm macro no fluoride coating
5. Light source	A. Electronic flash: full power guide number of flash 80 at 100 ISO Shutter speed X-Sycn F Stops 3.5, 5.6, 8 B. Photo flood 1 BBA Bulb at 2 ft Shutter Speed 1, 2, 4 F Stop 3.5

FIG. 5—*Faint bite marks reappearing in same area shown under UV light 16 days after the bite was inflicted. This photograph was taken with Tri-X film exposed under electronic flash and with a 18A filter on the camera lens.*

6. Focus shift	Same distance as infrared but in opposite direction
7. Scanning	Woods Lamp - longwave length UV 365NU
8. Time	As early as 17 days to as late as 6 months*

*We believe there will be great variance in the duration of a detectable UV image. This is due to differences in mechanism of image, healing rate of patient, and intensity of trauma to the skin.

Discussion

We feel that bite marks in human skin can be experimentally produced to a level that permits comparison to bites delivered in combative or life-threatening situations, and that more research is needed using living subjects to explore a variety of experimental situations. An example is that during our tests the bite marks in Caucasians would frequently exhibit a central area of ecchymosis which was once though to have occurred only if the biter applied suction. On reviewing video tapes of the actual bites, no suggestions of sucking were observed.

FIG. 6a—*Absence of marking in same area photographed under ordinary electronic flash 59 days after bite mark was inflicted. Photographed with Tri-X film without a camera lens filter.*

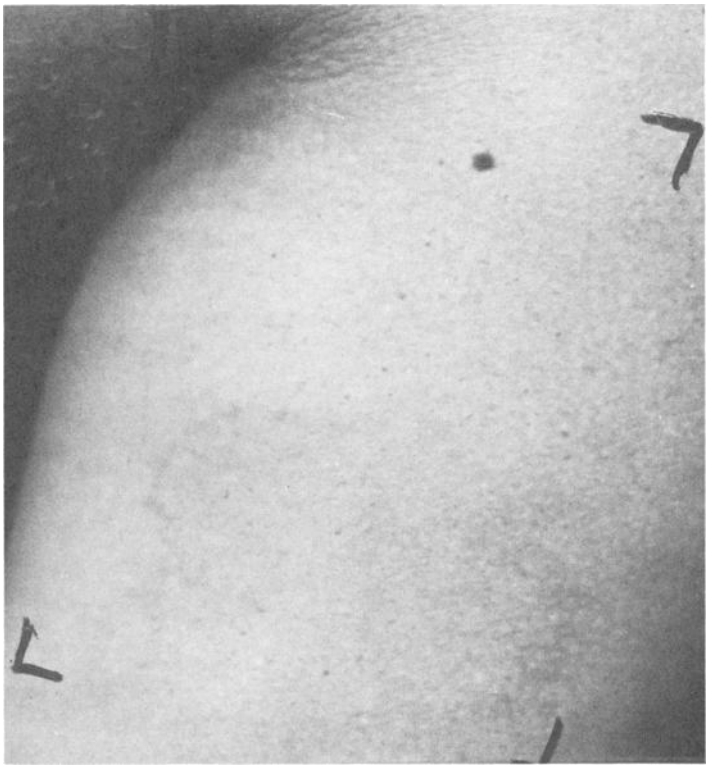

FIG. 6*b*—*Recognizable bite mark seen in same area under UV light. Photo taken with a 18A filter on the camera lens.*

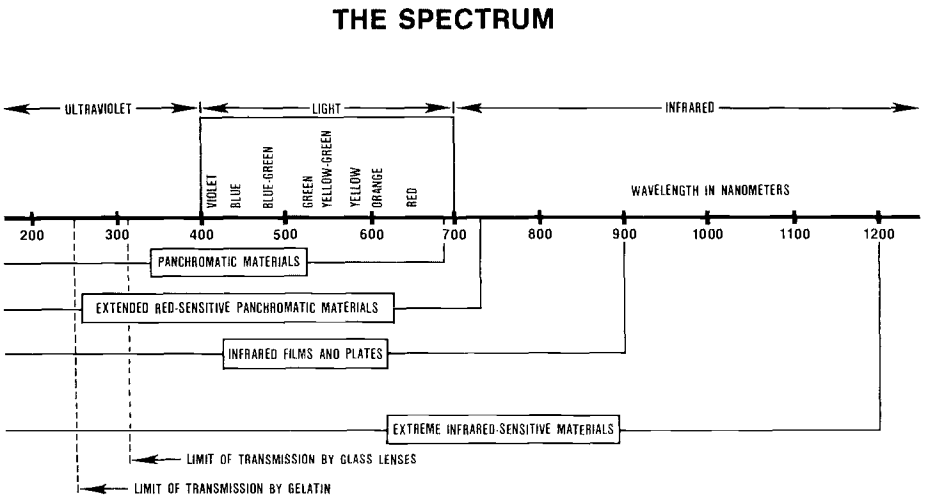

FIG. 7—*Electromagnetic spectrum and film sensitivities. From Kodak Publication M-28,* Applied Infrared Photography, *1977 ed., first 1980 printing. Copyright Eastman Kodak Company, 1980.*

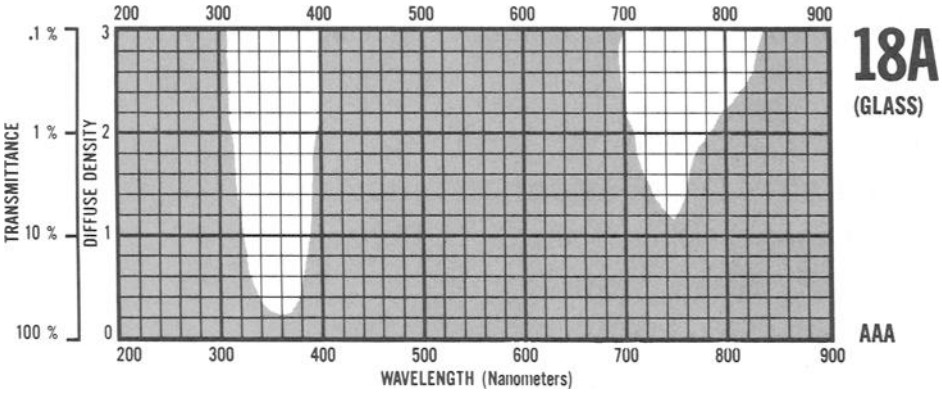

FIG. 8—*Visibly opaque glass filter. Only transmits ultraviolet radiation between about 300 and 400 nm (for example, 365-nm line of mercury spectrum) and infrared radiation. Used for ultraviolet reflection photography. Copyright Eastman Kodak Company, 1980. From Kodak Publication B-3,* Kodak Filters for Scientific and Technical Uses, Second Edition, 1981.

Conclusion

Time used to be the enemy of forensic odontologists, especially when trying to document a bite mark. It can now be used as an ally to gain higher resolution photographs immediately following and months after the bite. Hopefully this technique can be employed to salvage what was once considered unusable evidence and may be of special value when the victim of a crime bites his attacker, who may not be apprehended for several months [*8*]. We are just beginning to realize the possibilities and potentials of ultraviolet photography in this area, and more extensive research is mandatory.

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