TECHNICAL NOTE

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Use of an Acrylonitrile-Butadiene-Styrene (ABS) Plastic Ring as a Matrix in the Recovery of Bite Mark Evidence

REFERENCE: Sweet, D. J. and Bastien, R. B., **"Use of an Acrylonitrile-Butadiene-Styrene (ABS) Plastic Ring as a Matrix in the Recovery of Bite Mark Evidence,"** *Journal of Forensic Sciences*, JFSCA, Vol. 36, No. 5, Sept. 1991, pp. 1565–1571.

ABSTRACT: Valuable forensic information can be obtained from analysis of human bite mark injuries after careful retrieval of such evidence from living or deceased victims. It is difficult, however, to maintain the anatomical configuration of the skin, especially where body contours complicate the recovery process.

Transillumination of the injury pattern in the skin after removal and preservation of the tissue from a deceased victim can provide significant information in the investigation process. A dimensionally stable matrix is required to support the skin's anatomical configuration during and after its removal. The authors have developed a unique and convenient method of heating and contouring a ring of acrylonitrile-butadiene-styrene (ABS) plastic using table salt over a heat source. When this ring is applied to the deceased victim's skin, and a backing material is added for support, removal of the skin and the bite mark can be accomplished more predictably while maintaining the anatomical contour.

It is important to record bite marks accurately as soon after discovery as possible; the authors believe that this technique will significantly aid recovery of such evidence either at the crime scene or in the laboratory. A method of inscribing appropriate anatomical markers and case numbers on the rings is also described.

KEYWORDS: odontology, bite marks, transillumination, dental impression technique, criminal investigations, plastics in medicine, forensic dentistry

Bite mark evidence can be obtained from both living and deceased victims by using impression techniques to record the surface topography of the area of skin affected by the injury. Dental impression materials and other molding compounds have been used

This paper was presented by Dr. Sweet at the 42nd Annual Meeting of the American Academy of Forensic Sciences, Cincinnati, OH, 19–24 Feb. 1990. Received for publication 5 Oct. 1990; revised manuscript received 19 Feb. 1991; accepted for publication 25 Feb. 1991.

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extensively for this purpose [*1–4*]. When the victim is deceased, it may also be possible to remove the skin for a more detailed investigation of the deeper layers of the injury pattern. Previous authors have described transillumination techniques used to study the pattern and severity of subcutaneous hemorrhage in a bite mark injury [*5,6*]. This may allow the forensic scientist to reach conclusions on the approximate time of the bite and may provide additional information concerning characteristics of the perpetrator's dentition. If a suspect has been apprehended and a cast of his teeth has been made available, comparative metric analysis and pattern association studies can be undertaken in an attempt to implicate or exonerate him [*7,8*].

If an impression of the tissue surface is to be taken on a living victim, the odontologist will require a rigid matrix to support the impression material. Similarly, when the skin is to be removed from a deceased victim, a rigid supporting matrix is required to maintain the anatomical contour of the surface. Many techniques for preserving the skin in its original anatomical configuration and for reducing distortion of the injury pattern during skin removal have been described and utilized with varying success [*9*]. This paper suggests an inexpensive and convenient method of adapting a ring of plastic to the victim's body to produce a dimensionally stable matrix. In addition, these rings can provide markers to record the anatomical orientation of the injury. Transillumination of the bite mark and the associated bruise pattern can be undertaken after removal and preservation of the skin. The authors suggest that numerous photographs of the skin surface and the technique of skin removal and preservation be used as a record of the procedures followed and, subsequently, to assist during analysis of the evidence.

Methods and Materials

Many chemically different types of plastic pipe are currently used in residential and commercial construction. One example is a black plastic pipe used for water and sewage lines. This plastic is an amorphous material composed of acrylonitrile, butadiene, and styrene (ABS) and trace amounts of other additives. The pipe is widely available in local hardware and plumbing retail stores in a variety of sizes ranging from 5 to 15 cm (2 to 6 in.) in diameter and from 2.5 to 3.7 m (8 to 12 ft) in length.

Plastic rings were made using a band saw to cut a 10-mm (⅜-in.)-wide slice from the end of a length of ABS pipe. Medium grit sandpaper on a rotary sander was used to smooth the cut edges of the ring. A reference number was assigned to each ring in order to maintain evidence continuity and to identify the rings used in specific cases. A machinist's die punch was used to stamp this case reference number on the upper and lower surfaces of each ring (Fig. 1).

Anatomical reference points were also stamped onto each side of the ring. These demarcations were used to position the ring on the victim's body so that later, when the skin was removed, the anatomical orientation of the tissue was not lost. The authors use the Arabic numbers 1 and 2 to indicate the superior and medial directions, respectively. Since these locations were stamped corresponding to the same position on the upper and lower surfaces of the ring, a ring could be used on either the right or left side of the victim by simply selecting the appropriate surface of the ring in which the locators correctly identified the superior and medial directions (Fig. 2).

To minimize distortion, it was necessary to adapt the shape of the plastic ring to the contour of the skin surface. Heating the rings to change their shape can be a challenging problem. The glass transition temperature (T_g)—the temperature at which the greatest increase in flexibility occurs—for the ABS plastic that is available in Vancouver, British Columbia, Canada, is 106.2°C (223.2°F). The T_g for ABS plastic may vary regionally, since other manufacturers use alternative types and amounts of fillers and additives during

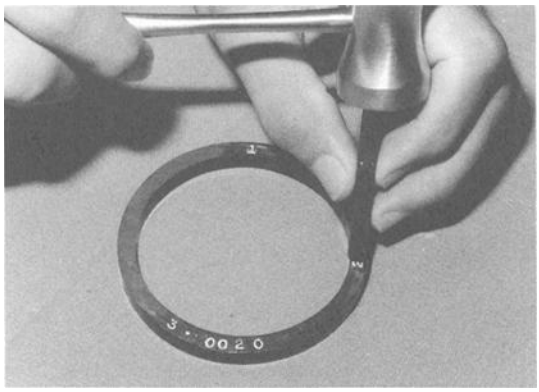

FIG. 1—*A machinist's die punch used to stamp a unique case reference number (3-0020) and anatomical location markers (1 and 2) on each side of the ABS ring.*

the production of the plastic. Since T_g is greater than the boiling point of water, a hot water bath cannot be used as a heat source. An open flame generates enough heat to soften the ring; however, once the plastic is heated sufficiently to become flexible, it is too hot to manipulate by hand. Opticians use a technique to heat and recontour the plastic frames of eyeglasses using a sand or salt bath. The specific heat of sand or salt allows easy manipulation of the plastic by hand. This technique can be adapted to heat and reshape ABS plastic matrix rings.

Approximately 300 g of iodized table salt was placed in a shallow metal container to produce a layer 2.5 cm deep. This was heated slowly using an electric hot plate. The authors used a Fisher Scientific Thermix stirring hot plate, Model 310T (Fisher Scientific, Ottawa, Ontario, Canada). The rheostat on the hot plate was set to "3" which corresponds to a temperature of 107 ± 4°C. A thermometer was used to monitor the temperature of the salt in the container as it was heated. In the authors' experience with this technique,

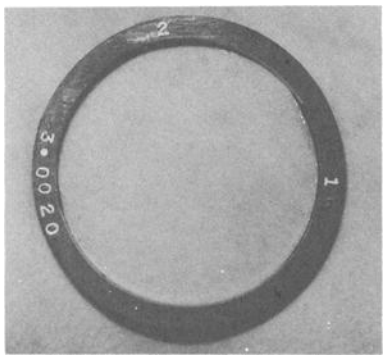

FIG. 2—*By stamping the anatomical location markers on each side of the ABS ring so that each marker refers to the same point on the circumference, a ring can be used on either the right or left side of the body. When stamping these markers, select one point at the top (for example, North) and another at 90° to the first (for example, East). Now turn the ring over and stamp the same location markers on the other side so that they identify the same points on the ring (for example, North and West on this side of the ring).*

the best results occur when the salt bath reaches a temperature in the range of 104 to 110°C (220 to 230°F).

Since we anticipated that traces of saliva would be left on the skin during biting, the first step was to swab the area in an attempt to recover a sample of the perpetrator's saliva. Approximately 85% of the population secrete ABH blood group substances in their saliva, and it is possible to determine the blood type from this serological information. The surface of the bite mark was swabbed, taking care to avoid areas contaminated with the victim's blood. Another swab of a region of the body that had not been bitten provided a control for comparison [*10*].

The surface of the skin surrounding the bite mark could then be cleaned and dried. Body hair present in the area where the ring came in contact with the skin was removed by shaving the site with a razor or scalpel blade.

When the bath reached the correct temperature, the plastic matrix ring was placed deep in the salt so that it was completely covered. It was necessary to leave it covered, depending upon the diameter of the ring, for from 4 to 6 min. Following this, the ring could be removed and easily bent and shaped to fit the skin surface. It was necessary, when fine-tuning the contact of the ring with the tissue surface, to reheat the ring and alter its shape. This was easily accomplished by reheating either the entire ring or only the area to be reshaped. Each time the ring was reapplied to the skin surface, care was taken to orient the superior and medial demarcations correctly.

Tight contact of the bottom surface of the ring with the skin surface is extremely important. It is this surface of the matrix ring that maintains the contour in its correct anatomical configuration when the skin is removed. It is sometimes difficult to visualize this surface of the ring while it is in contact with the skin. A simple test of the contact between the ring and the skin is to estimate the angle formed between the inner and outer walls of the ring and the skin surface. Both the inner and outer walls should meet the skin at 90° around the entire circumference of the ring (Fig. 3). If this occurs, it follows that the bottom surface of the ring will lie flat on the skin, and once the skin is removed, the ring will maintain the body contour. If the walls do not meet the skin at 90°, the ring should be heated again and reshaped.

After the ring was positioned so that it completely encircled the bite mark and was contoured to the exact shape of the body, it was fixed to the skin with both an adhesive and sutures. Maximum effectiveness of the adhesive is assured if close contact between the bottom surface of the ring and the skin is achieved, as previously described. Liberal amounts of a cyanoacrylate glue, such as Superglue gel (Via-Chem Inc., Montreal, Quebec, Canada) have been found to work well in this application since this glue is convenient to use and sets quickly with adequate bonding strength. Sutures in a "figure eight" configuration were placed at 4 to 5-cm (1½ to 2-in.) intervals around the circumference of the ring for added stability.

A dental impression material such as COE-flex Rubber Base medium-body material (Coe Laboratories, Inc., Chicago, Illinois) is recommended as a backing material to support the skin and to maintain the contour during removal. The impression material adheres adequately to the ring without the need for tray adhesive. This makes removal of the backing material after tissue removal and fixation much easier. This single layer of backing material is the only support required unless the investigator wishes to obtain an impression of the skin surface as well as remove the skin for transillumination.

In cases where lacerations and indentations from the perpetrator's teeth are identified in the bite mark and impressions of these are needed for comparative analysis, the backing material can be saved as an accurate impression of the surface details. A cast of the skin surface can be made. Additional rigid support for the backing (impression) material, such as orthopedic mesh [*3*] or acrylic tray material [*11*], must be provided in these cases so that the backing material will remain dimensionally stable during and after tissue

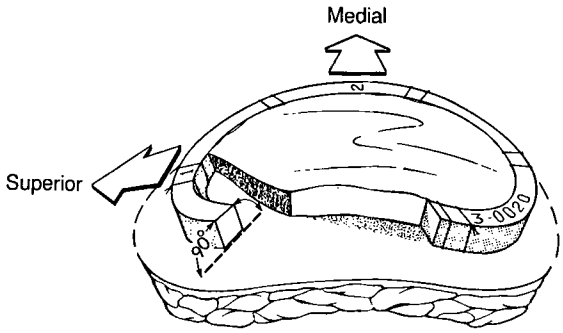

FIG. 3—*An artist's conception of a contoured ABS ring which has been glued and sutured to the skin. A layer of backing material has been applied to the skin surface within the ring matrix. Note that the inner and outer walls of the ring meet the skin at 90°. This will insure maximum contact between the bottom surface of the ring and the skin. When the skin is removed for further analysis, the anatomical markers record the superior and medial directions.*

fixation. When using an 8-cm (3-in.)-diameter ring, one layer of orthopedic mesh bandage, such as Hexcelite NS (Kirschner Medical Products, Baltimore, Maryland), placed between successive layers of impression material is adequate for this purpose (Fig. 4). Even more support may be needed in cases where larger rings, such as ones 10 cm (4 in.) in diameter or larger, are chosen. In these cases, two layers of Hexcelite NS or a layer of thermoplastic custom dental tray material, such as Easy Tray (Oral Dynamics, Seattle, Washington) are recommended.

Using this technique, the skin was removed by making an incision at a distance of 1.0 to 1.5 cm (½ in.) from the outside of the plastic ring and through the full thickness of the dermis to the adipose tissue. The tissue was then elevated and dissected *en bloc* from the underlying connective tissue. It was immediately placed in a 10% Formol saline fixative solution for 10 h. After this, the tissue held its original shape and the backing material could be removed. The ring remained glued and sutured to the skin to support the edges of the specimen. If the backing material was to be used as an impression of the bite mark, it was poured in dental stone at this time.

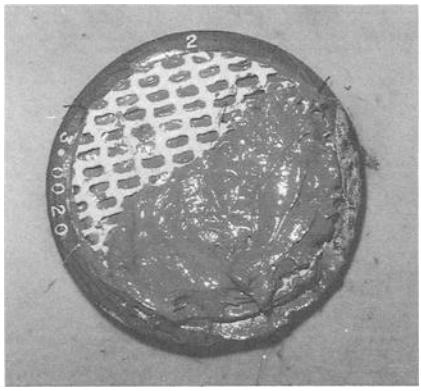

FIG. 4—*A layer of dental impression material has been added as a backing within the diameter of the ring, and one layer of orthopedic mesh has been fitted as a rigid support for the impression material. Another layer of impression material is added to lock the mesh in place. (For illustrative purposes here, one half of the orthopedic mesh has been left uncovered.)*

Photographs of the bite mark were repeated with flash and oblique lighting and under transillumination conditions immediately after tissue fixation. Additional forensic information could be obtained subsequent to transillumination of the evidence. The forensic pathologist can obtain a sample of the tissue for histopathological approximation of the age of the injury.

The specimen was then placed in Kaiserling's fixing fluid No. 1 for stabilization and storage up to 6 months. If longer storage was required, the specimen was transferred to Pulvertaft-Kaiserling mounting fluid (without sodium hydrosulfite) [*12*].

Discussion

Rings with an 8-cm (3-in.) diameter are used most commonly, since this size adequately encircles most bite mark injuries. The 10-cm (4-in.)-diameter rings are usually adequate for larger pattern injuries. Rings larger than these are difficult to handle and require a much larger quantity of backing material, which gives rise to problems in mixing and correctly placing the material. The authors have found that a number of rings of different sizes, each with unique reference numbers, can be made up in advance and kept in the odontology kit. When the need arises, the appropriate ring size can be selected and the reference number recorded in the investigation notes for that case.

Some distortion of the skin from pushing the suture needle through the tissue is a common problem. Depending upon the location of the bite mark and, therefore, the type of skin encountered, much pressure may be needed to penetrate the tissue with the suture needle. This pressure, and the subsequent movement of the skin during suturing, can lead to separation of the ring from the skin surface. One method of correcting this problem is to use a cutting type of suture needle. This will reduce the excessive pressure near the bite mark since this type of needle penetrates the skin more easily. Another method of reducing excessive pressure is to pass the needle from the inside of the ring to the outside. The suture needle should be inserted into the skin at a position inside the ring as near as possible to the inner wall. It can then be pushed through the tissue below the ring so that it exits the skin on the outside as near as possible to the outer wall. The suture is then tied over the top side of the ring.

This tissue recovery technique has been found to be very useful in a variety of circumstances. To date, it has been used to recover many pattern injuries from a variety of locations, such as the breast, scalp, upper arm, and abdomen. The technique is convenient and easy to use and can be adapted to most contoured body surfaces, either at the crime scene or in the laboratory.

Acknowledgments

The authors gratefully acknowledge the cooperation and assistance of Dr. J. A. J. Ferris and Dr. L. H. Gray, forensic pathologists; Dr. L. S. Cheevers, forensic odontologist; and T. E. Newell, coroner's technician, in the development and testing of this technique. A sincere thank you is also extended to the technicians at the Vancouver General Hospital, Department of Pathology, for their participation in the development of this technique.

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