Review Article

Emerging Trends in Dentistry: Forensic Dental Photography

Vinayak Kumar Mantu[1], Ruchi Mitra[2]

[1]Senior Lecturer, Department of Oral and Maxillofacial Pathology, Vananchal Dental College, Garhwa, Jharkhand, India, [2]Senior Resident, Department of Dentistry, Rajendra Institute of Medical Sciences, Ranchi, Jharkhand, India

ABSTRACT

The survivability of teeth in catastrophic conditions is the feature that makes forensic odontology a definite entity. Photography is one of the most important tools used in the practice of forensic dentistry. Forensic photographs are used for measurement or analysis, to accompany forensic reports, articles or research papers. Accurate photographic documentation of a crime scene is a crucial component of any venture into evidence collection, especially when it applies to recording bite marks inflicted on humans during crimes of violence. The results of forensic photography yields good evidence in bringing with it a sense of accomplishment and satisfaction that the forensic dentist has made a significant contribution to the case. Developing the skills necessary to competently document these injuries with visible and nonvisible light is one of the great challenges in forensic dentistry**.** The aim of the present review is to highlight the concepts and techniques that are vital to the successful outcome of any investigation containing dental evidence, including cases involving violent crimes, identification of human remains and mass disaster scenarios.

Keywords: Crimes, Dentistry, Forensic, Odontology, Photography

Corresponding Author: Dr. Vinayak Kumar, Department of Oral and Maxillofacial Pathology, Vananchal Dental College and Hospital, Farathiya, Garhwa - 822 114, Jharkhand, India. E-mail: drvinayakkm@gmail.com

INTRODUCTION

Human dentition of an adult consists of 32 teeth, of which some may be missing or malformed or showing manifestations of various environmental events like use of drugs or malnutrition. The distinctive pattern of each individual's dentition is also due to the wide variety of manipulations being done to the teeth like restoration. With such an extreme array of differences, it is extremely rare to have two similar dentitions.[1]

Keiser-Nielsen (1970) have defined forensic odontology as, "a branch of dentistry, which deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings.[2] Photography is an important tool of forensic dentistry and the demands on the photographer may be great, especially when the bite mark is the sole evidence tying a suspect to the crime.[3]

Hence, the present review is a footstep to enlighten about the literature available on forensic photography and its applications in the field of dentistry.

HISTORY

Although the field of forensic odontology appears to be a new one, it is probably as old as mankind itself as inscribed in the Bible. The Bible says, Adam was convinced by Eve to put a "bite mark" in an apple. Apart from this, there are other major landmarks, which have resulted in the evolution of this field. The use of dentition in identification of a person for the first time, dates back to 49 A.D when Agrippina, wife of Claudius-Roman emperor, identified the body of her rival Lollia Paulisa by the peculiar features present in her teeth, after getting her beheaded. Later in 66 A.D Nero's mistress Sabina got recognized by characteristic black anterior tooth.[4]

The first case of identification of a person by his dentition, in India was probably in 1199 A.D, when Rahtor Raja of Conouj, Jei Chandra was recognized by his false anterior teeth, after he was beaten and killed in a battle. This has been documented in Elphinstone's "History of India."[4]

The earliest case of bite mark analysis was the Salem Witch trial of 1692, culminating in the conviction of Rev. George Boroughs.

Dr. Oscar Amoedo, who was Professor at a dental school in Paris, is considered as "Father of Forensic Odontology." He presented a paper entitled "The role of dentists in identification of victims of the catastrophe of the Bazaar de la Charite, Paris, 4th May 1897," at the International Medical Congress of Moscow. He later included many of the concepts of dental identification use in the above disaster in his book "L'Art Dentaire en medicine Lagale" published in 1898. This was the first book on forensic odontology. He also suggested the need for international system of uniform charting and a mutual understanding of the nomenclatures. Forensic photography can be used as an inexpensive and non-destructive tool to analyze these artifacts more efficiently.[5]

PROPERTIES OF ILLUMINATION

The process of photographically recording images on film, videotape, or magnetic media occurs through the capture of electromagnetic radiation (light) of specific wavelengths. However, it is also possible to record images specifically illuminated in the shorter ultraviolet range (210-400 nm) and longer infrared range (750-900 nm).

If existing light is being used to capture an image, the shutter speed selected must always be greater than 1/lenses focal length. This rule ensures that blur is not introduced into the image through camera shake. As the aperture size decreases, depth of field increases. While there are reasons for desiring shallow depth of field, for the most part, the majority of forensic applications require significant depth of field. The value that correlates to the size of the opening is known as the *f* # or *f*-stop and is representing by the equation:

$$f\# = \frac{\text{Focal length of the lens}}{\text{Diameter of the lens opening}}$$

This equation demonstrates that the *f*-stop is inversely proportional to the diameter of the lens opening and is related to the focal length.[6]

Success in photographing healing bruises over time will depend on several variables, namely:

- Composition of the injured skin
- Thickness of the skin
- Wavelength and intensity of light used to photograph the damaged area
- The equipment used
- The type of film used depending upon the specific injury.

It may be necessary to photographically capture the injuries digitally or with film, in color and black and white using visible light, as well as nonvisible light. The injury may also vary in appearance in the photographs of each of these incident light sources and over time if photographed serially.[7]

The location and type of skin injured has profound effects on the ability to photograph the injuries. For example, thick skin of the palm of the hand is usually much easier to photograph immediately after an injury than after it has partially healed. The thick, keratinized covering of the palm of the hand often exceeds the ability of most light energy to penetrate enough to record the sub epithelial injuries. Such cases require fluorescent photography due to the highly fluorescent nature of thick skin. This is directly related to the ability of the specific wavelength light energy to react with the skin to a sufficient depth to record the injury.[6,7]

TYPES OF PHOTOGRAPHY

For preserving the detail of the injury with photographs it may involve a combination of color and black-and-white visible light photographs as well as the use of the nonvisible ultraviolet and infrared photographs. A standard technique is needed that includes capturing orientation photographs showing where the injury occurred on the body.[8]

VISIBLE LIGHT PHOTOGRAPHY

It is the most common types of modern photography using visible light. Manufacturers of film-based and digital photographic equipment develop and market equipment and supplies that are specifically designed to have an optimal performance in the 400-760 nm range of the electromagnetic spectrum. The object to be photographed is viewed through the lens and the camera automatically adjusts the focus and exposure variables before image capture. Most 35 mm cameras have serious size limitations when it comes to recording life-size images. This limitation comes from the restricted emulsion area exposed on the film (24 mm × 35 mm rectangle) or the small surface area used in the digital capture device. Since there are very few objects that will fit into the small area, considerable enlargement of the photographs may be necessary to see the injuries life size.[8]

FILM-BASED PHOTOGRAPHY

Film-based photography is designed photographic films that record light wavelengths from 250 to 700 nm. Special infrared films are available that can record photographs

captured in light from 250 to 900 nm. The film must be sensitive to the wavelength of light being used to photograph the injury or no image will appear when the film is developed. There are many quality photographic negative films manufactured, in both color and black and white. Films come with a rating, referred to as the ASA/ISO number, which serves as an indicator of the amount of light energy necessary to properly expose the film. The higher the ASA/ISO number, the faster the film; in other words, less light is needed to expose an image. Films with high speed ratings (ASA 1600 or 3200) require very little light energy to expose. The higher the ASA/ISO number, the lower the grain density on the film where the image is recorded, which translates into less versatility during enlarging. Large-grain fast films tend to produce prints that appear to lose focal sharpness and detail as they are enlarged toward their normal limits, i.e., life size or 1:1. While the photographer has great latitude in film speed selection, films of ISO 100 are usually adequate for injury documentation with adequate light.[3,8]

DIGITAL PHOTOGRAPHY

The modern era of photography is being redefined as the digital era. While film-based cameras are still around, most forensic photography is done with digital cameras. Manufacturers have created a wide range of digital cameras that vary in both capabilities and cost. Generally there are two green pixels for every red or blue pixel in an arrangement known as the Bayer pattern image. Other manufacturers have developed other image capture technologies, including the Foveon layered model and the six-sided pixel technology. The density of the pixels on the sensor and the firmware driving the electronics in the camera determine the quality of the image as more pixels there are, the sharper the image becomes. For bite mark photography, the larger the image file size, the less pixilation (blurring) when enlarging to life-size proportions.[9]

Digital cameras can save the images in a number of file formats, each of which has advantages and disadvantages. The two most common file formats are JPEG and RAW. The differences between these two formats is that the JPEG file format is a compressed image of the RAW image data the sensor captured when the photograph was taken, which yields a smaller file. The RAW data file is quite large compared to the JPEG but still contains all the image data and detail, allowing more versatility when working with the image. While most digital cameras are automatic point and shoot, there are still some settings that must be applied before taking the photographs. One of the most significant would be setting the ISO for the environment where the photographs will be taken. Other settings would include the file format that will Unlike photographic film, which has to be processed before the images can be printed on paper, digital images can be immediately viewed, evaluated, and if necessary, retaken. Once again, the standard technique should be utilized. The risk of the loss of the data or the integrity of the data of the digital images requires the digital photographer to take additional steps to protect the data. The most common task is making duplicate backups frequently. This can involve writing the files to external removable hard drives, as part of the standard technique; The digital photographer must include routines for multiple frequent backups of the data files.[7,9]

Alternate Light Imaging and Fluorescent Imaging Techniques

The field of forensic investigation has seen a tremendous growth in the utilization of alternate light imaging for both locating and photographing latent evidence. Finger prints, serological fluids left behind at a crime scene (blood, semen, saliva), types of ink used to counterfeit or falsify documents and bruises or other pattern injuries left on human skin sustained during violent crimes can not only be more easily detected, but also transformed into exciting and important exhibits with the utilization of fluorescence.[10,11]

The technique of photographing evidence with alternate light is called fluorescent photography.

Since the fluorescent light is always less bright than the incident light, one must observe the fluorescence of an object with the use fluorescent photography is best accomplished successfully in complete darkness, where all other sources of light are eliminated. Several variables can influence the photographic protocol and parameters of exposure.

Darkly pigmented skin will require longer exposure times than lighter skin because more light is absorbed by the melanin pigmentation of the darker skin. Persons, who bruise easily, such as the elderly, will produce injuries that may require shorter exposure times due to the thinness of the skin, but one can also expect longer exposures when greater hemorrhaging occurs beneath the skin since the blood absorbs light.[12]

Nonvisible Light Photography

The photographic requirements for recording injuries using nonvisible light become somewhat more complex. The appearance of the injury using nonvisible light illumination cannot be seen by the naked eye. Therefore, special techniques must be employed to record the injury. They are placed between the injury and the film or digital sensor, usually on the front of the lens of the camera. The filters allow only the selected wavelengths of light to pass to the film or digital sensor.

The light source must emit the appropriate wavelength and be strong enough to expose the light image. For digital nonvisible light photography, the photographer must ensure that the digital sensor is capable of recording the wavelengths of nonvisible light being used. Most commercially available digital cameras are designed to block the nonvisible ends of the spectrum.[12]

Reflective Long-Wave Ultraviolet Photography

Ultraviolet photography is used by forensic odontologist for two reasons: The first is to visualize surface detail of the injury. Reflective ultraviolet photography helps to enhance surface detail. The second reason is to attempt to record an injury after a period of time of healing when it is no longer visible to the unaided human eye. The UV-exposed film or digital CCD records the unseen surface damage contained in the affected area of the injured skin, which later becomes visible to the human eye on the photographic image, assuming proper UV photographic techniques were used as images were acquired.[13]

Infrared Photography

Just as in reflective UV photography, infrared photography also requires special techniques. The infrared band of light is at the opposite end of the light spectrum from the ultraviolet band, with ultraviolet light being about one-half of the wavelengths of infrared light. Because infrared is longer in wavelength transmission, it penetrates up to 3 mm below the surface of the skin.[14]

The majority of biological infrared images are formed from details not on the outside of the subject. This feature accounts for the misty appearance of many infrared reflection records. Successful infrared photography is a trial-and-error process, particularly when dealing with injury patterns. The advantage of digital photography is that the image can be either previewed before or immediately seen after exposure.[14,15]

Applications and Uses of Photography in Forensic Odontology

Body identification guidelines according to American Board of Forensic Odontology: Postmortem dental examination should be conducted under the proper authority and under the direction of the Coroner.

Photography

Photographic documentation of dental evidence provides objective data that is more graphic than written charts. The photographs should be labeled clearly with the case number and date.

Recommended equipment for photography include single lens reflex 35 mm camera, electronic flash (preferably point flash or ring light system), cheek retractors, intraoral front surface mirrors. Film used might be color or black and white. Sometimes polaroid films may be of help in special circumstances. Full face (lips restricted), close up view of anterior teeth, lateral view of teeth is slightly open position and in occlusion, occlusal views and other special views may be required for complete documentation.[15]

Uses of forensic photography

- Age estimation
- Sex determination
- Bite marks
- Mass disaster identification
- Other methods of dental identification (includes dental radiographs, serological parameter, dental tissue identification)[16]

CONCLUSION

The concept of accurate forensic photography has established itself as a crucial part of the forensic investigation as a means of documenting evidence. Historically, photography has been the most significant method of preserving the physical evidence of patterned injuries in the skin. Photographs have an extraordinary ability to convince. The forensic odontologist must have broad background knowledge of general dentistry, encompassing all dental specialties since the scope of forensic medicine is very broad and challenging, dental surgeons trained in forensic odontology can make unique contributions in the administration of justice, which is the keynote of democracy. They provide to the court, information pertaining to the integrity of the photographs, both in terms of evidence continuity and explanation and control of image distortion.

Forensic photographs are used for measurement or analysis, to accompany forensic reports, articles or research papers.

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