FORENSIC ODONTOLOGY – BITE MARKS
– A REVIEW OF THE LITERATURE (PART 1)

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ABSTRACT
The fundamental principle in any forensic investigation is based on the evidence left at the scene of crime. Historically bite marks left on the skin or inanimate material have been accepted as an important persuasive evidence in the court of law. Various unquantifiable factors affect the production and the morphology of a bite lesion. Some of these factors are caused by the offender and the others by the material on which it is produced. The different classifications of the bite marks which have been detailed by various researchers are summarised in this paper. They are useful for accurate preparation of a bite mark report. In addition, an internationally recognised protocol in the proper recognition, investigation, and the interpretation of bite marks is presented.

INTRODUCTION
Forensic investigation is based on the simple axiom, “that any contact leaves a trace”. The study of marks or artefacts left at the scene of a crime has always been an important means of proving or eliminating the presence of a suspect. Bite marks left on human tissue and bitten material have become an important aspect of the scientific evidence used for the conviction of a suspect. On account of this significance, a bite injury or tooth marks has been accepted as definite reliable evidence in a criminal investigation. In support of this, Furness stated that a criminal may “lie through his teeth” but the teeth themselves cannot lie. The technique generally involves comparison of the bite mark pattern at the site of the crime with the dental alignment and characteristics of the dentition of a suspect. The use of imprints or marks made by the human dentition on skin or inanimate objects has been well accepted for identification purposes by the scientific, law enforcement and legal authorities.

Bite marks analysis requires full scientific investigation where objective principles and scientific procedures are to be followed. Bite mark evidence has led to the indictment, court trial and conviction of suspects in crimes associated with homicide, sexual assault, child abuse, and other physical alterations in many advanced countries.

BITE MARKS – BASIC CONSIDERATIONS
A suitable definition of a bite mark is a mark caused by the teeth either alone or in combination with other mouth parts. This definition merely implies that the marks may not only be made by the teeth but also with a combined sucking and tongue thrusting force (sometimes termed as sucking). To make a successful bite mark comparison, it is essential that only a short interval exists between the time of infliction and the analysis of the bite mark. Although no two mouths are identical, bite marks may on occasion appear exactly alike because the tooth characteristics have not been sufficiently evident in an impression of a bite. The human skin is a poor medium for bite mark registration. The appearance of bite marks is influenced by both the mechanism and forces which produce them and by the mechanical properties of the skin/subcutaneous tissue or other bitten material. Bite marks also differ according to the particular way the bite was made (especially its direction) and the condition of the dental arch and teeth (indicating identifiable peculiarities) of the assailant. The appearance of bite marks varies from site to site because they are modified by the mechanical properties of the tissues. The skin on the back, for example, is naturally stiffer than that of the breast. In addition to these site variations, there are directional variations at given sites due to pre-existing tension lines (elastic fibres of the dermis) in the skin, known as Langer’s lines. Flexion, extension and rotation of surface skin markings would be expected to follow the pattern of these Langer lines. Other factors that influence appearance of bite marks are curvature of the surface bitten, and dragging during the biting process. The actual biting of the victim is a dynamic process which involves complex movements of the jaws relative to each other, as well as the possible movement of the victim in defence. The geometric shape of individual imprints and shape and size of the arch are characteristics of the assailant’s dentition, provided there is no post-traumatic swelling or shrinkage of the bitten tissue or material. There will always be difficulties in the measurement and subsequent study of the marks in comparison to suspected dentitions, if any gross shrinkage or swelling has occurred. Clothing through which a bite is inflicted will tend to reduce the degree of force on the tissues and may be responsible for the absence of injuries from a particular tooth.

Bite marks usually involve the anterior dentition and may contain impressions of between
five and twelve teeth. In a case study by Levine, maxillary and mandibular teeth were clearly defined in the bite marks. According to him the maxillary teeth are used for holding and they produced only slightly diffused marks, while the mandibular teeth are used for cutting and created more clearly defined marks.

**CLASSIFICATION OF BITE MARKS**

Cameron and Sims classified types of bite marks into two groups; the agents that produce the marks and the materials or substances that exhibit the marks.

During intra-oral examination of a perpetrator, the size and mobility of the tongue and also the condition of each individual tooth, especially anteriors should be carefully observed.

Vale also reported the importance of extra-oral examination of the perpetrators to study factors that may influence biting dynamics. These include temporomandibular joint status, facial asymmetry, muscle tone and balance, maximal opening of the mouth, deviations in opening or closure and occlusal disharmonies. Facial scars or evidence of surgery should be noted. According to Cleland any non-accidental or self-inflicting wound caused by teeth simply indicates a criminal assault.

It is important to distinguish animal bites from those caused by humans. Animals reveal bites with markings, teardrops and arch shape which vary according to the species of the animals. Dog bites, perhaps the most common non-human bite, are characterised by a narrow anterior dental arch consisting of deep tooth wounds over a small area. The dog (or other carnivorous mammal) is also more apt to cause avulsion of tissue during violent biting. Feline bites are small and rounded with pointed cuspid tooth impressions, and claw scratches may be a particular feature with this species.

**MATERIALS EXHIBITING BITE MARKS**

Strom and Gustafson reported that it is often easier to analyse a bite mark in foodstuff than in human tissue. Some foods will preserve clear marks of teeth and cases have been quoted of convictions from bites in apples, chocolate, cucumber, roast pork and cheese. Bite marks have also been observed on oranges (bitten through the skin), persimmon, pear and potatoes.

Human skin would seem to be a poor material for reproducing tooth imprints, due to its elastic properties and ability to move over the supporting tissues. Moreover bite mark injury may present a diffuse bruise appearance rather than a well defined pattern. It is evident that qualitative as well as quantitative evaluation must be considered in establishing the most important concordant points between bite mark lesions and the dentition of potential suspects. Details of the marks could reveal the position of the assailant at the time of the bite and perhaps the approximate time before death the bite was inflicted. Some experts believe that evidence which involves the identification of a person by tooth marks left as bruises in flesh should never be admitted. If any victim survives long enough after being bitten or analysis is delayed, the bruise shape will spread and the characteristics become obliterated.

**AETIOLOGICAL CLASSIFICATION OF BITE MARKS**

An excellent bite mark has been described by McDonald as a recent mark, complete with tooth indentations, capable of reproduction in an impression-making medium, definite areas of contusion, and the presence of specific peculiarities in the alignment of the bite mark components. Since bite marks are frequently highly complex, it is pertinent to examine them from an aetiological view and to enquire how the changes observed in the bitten material have actually been produced. The classification of bite marks as proposed by McDonald include tooth pressure marks, tongue pressure marks and tooth scrape marks.

**TOOTH PRESSURE MARKS**

Tooth pressure marks are caused by the direct application of the incisal edges of anterior teeth or the occlusal surfaces of posterior teeth upon tissue. The exact nature of the marks produced probably depends upon several factors; the sharpness of the biting edge of teeth, the force applied, the duration of the application, and the degree of movement between tissue and teeth during the application of the force. In such marks, the incisor teeth leave pale areas representative of the main part of the incisal edge and a zone of bruising at the margins of the incisal edge. This is due to damage to blood vessels at the area of maximum stretching adjacent to the relatively static tissue actually in contact with the incisal edge of the tooth.

**TONGUE PRESSURE MARKS**

When the material bitten can be taken into the mouth adequately and is sufficiently malleable it may be pressed by the tongue against the teeth or other rigid areas of the mouth, such as the palatal rugae, and this can leave distinctive marks. In bites in flesh, this mechanism has been referred to as sucking as it involves a combination of sucking and tongue thrusting. Marks produced by tongue pressure are usually imprints of the palatal surfaces of the upper anterior teeth but marks of the lingual surface of lower incisors may also be found. A series of arcs is seen which represents the outline of the palatal surface of the upper incisor teeth. These marks are caused by bruising due to stretching of supported tissues across the gaps between teeth or at the cervical margins during which time the main mass of
the issue is held relatively steady against the tooth surface or the gingiva. It was also observed that the force of the tongue thrust could exceed the suction pressure in many of the subjects.

TOOTH SCRAPE MARKS

Tooth scrape marks usually involve the anterior teeth and may present as scratches or as areas of superficial abrasion according to the width of the teeth producing them. If such marks occur as scratches, then they may be indicative of peculiarities in the incisal edges and this is of value in identification. Bite marks may be described as penetrating or non-penetrating according to whether or not the teeth penetrate through the epidermis. Consideration of such elements of bite marks can give an indication of the probable circumstances in which the bite was made.

In another classification, which is independent of the substance bitten and the reason for the bite, Holt proposed three categories, namely, teeth marks, arch marks, and bite marks.

TEETH MARKS

In the investigation of teeth marks of human origin on a body of a person, their position will help to determine the possibility of them being self-inflicted and from the detail of the marks one can often determine if the tooth making the mark had any morphological or acquired defect which would produce a mark of significance.

ARCH MARKS

The term arch mark is taken to mean the pattern presented by the upper and/or lower teeth of the dental arch. However in a bite mark situation, it is unusual to consider any teeth further back than the first premolar to produce a mark. The inter-canine width will give some idea of the size of the mouth of the assailant and so indicate the possibility of a child bite or an adult with a small mouth. Jakobsen and Keiser-Nielsen supported the contention of Berg and Scheidt (quoted by Whitaker), that 4-5 marks of adjacent teeth must be present before a mark can be identified as a human arch mark. This seems to be a subjective rather than a precise basis for a definition.

BITE MARKS

If it is an aggressive bite, then the marks of the teeth and dental arches are usually multiple, in close proximity to each other and often with the outer layer of the skin being penetrated or even torn. If it is so called love or erotic bite, there is a combination of tongue thrust and sucking. These can cause an oval bruise mark within the arch areas as the small blood vessels in the skin are ruptured in the act. In this type of bite, it is not uncommon to see a pattern of the upper front teeth as the tongue of the biter forces the tissue of the victim on to the teeth.

Whitaker and McDonald stated that bite marks are often complex injuries and their recognition and interpretation depend upon a clear understanding of the mechanisms involved. They described bite marks as definite, amorous and aggressive.

DEFINITE BITE MARK

Each tooth can cause a mark because of direct application of pressure by its biting edges, thereby causing noticeable tissue damage. Other elements of the injury have however been caused by the sucking force.

AMOROUS BITE MARKS

Bites made in amorous circumstances tend to be made slowly with no movement between the teeth and the tissue. The marks of lower teeth are caused by gently increasing pressure into the tissues. By contrast, the marks of the upper teeth form a series of arcs where tissue was sucked into the mouth and pressed against the backs of the teeth with the tongue. The area in the centre of the bite was caused by tongue pressure pushing the tissue against the rugae of the roof of the mouth.

AGGRESSIVE BITES

These bite marks may range from moderate to very aggressive types. The wounds cannot be positively be identified as bite marks and it is practically impossible to say which tooth would have caused the elements of the bite.

Examination by Webster of the mechanism of biting and of bites produced has shown that there are three main types of bite marks in food.

Type 1

Those found in material such as chocolate, which fractures readily after a limited depth of tooth penetration. Bites of this type will record the most prominent incisal edges of the upper and lower anterior teeth, up to a depth of 1 to 2mm.

Type 2

Consist of those where a good grip of the material is obtained by the teeth and then the bitten piece is removed by fracturing it from the main material. This is typical of the bite seen in firm fruit such as apples, pears and large pieces of cheese. Both the upper and lower labial outline marks and the tooth scrape marks tend to record those elements of the teeth which are prominent anteriorly.

Type 3

Teeth bites through, or almost through, the bitten material which is typical of the bite marks found in cheese. The morphology of the bite mark exhibits extensive scrape marks and may give an indication of the relative position of the upper and
DETERMINING THE AGE OF A BITE MARK INJURY

Forensic experts often have difficulty to determine how old a human bite injury is when a victim presents for examination. This difficulty is due to the variation of the tissue involved, the depth of the bite and the type of injury which affect the normal healing process. Bacteria in the wound will also hinder normal healing by enlarging the wound and competing for the vital nutrients, such as oxygen and glucose, needed for wound healing. This causes tissue anoxia, the production of lactic acid and further breakdown of the wound.

Bite age can be approximated using histological and bio-chemical determinations. These analysis are greatly assisted by an understanding of the mechanisms of wound healing. The immediate result of bruising may not be obvious or may show merely as a red bluish. The discouloration will be more marked after the passage of time and it is therefore always advisable to re-examine the bruises 24 hours later as the initial appearance of slight swelling or tenderness which may indicate a struggle or restraint will have manifested as obvious bruises. Generally, the shape and degree of bruising is related to the causative agent and amount of violence but this relationship must be interpreted with caution since certain following factors will modify the effect.

Conditions and Types of Tissue

If the skin is loose or is with excessive subcutaneous fat, bruising will occur more easily and be more extensive. Conversely, if the skin is strongly supported by fibrous tissue then bruising will be considerably less or even absent.

Age

Infants and old people tend to bruise easily. The former do so because of looseness and delicacy of the skin and the presence of subcutaneous fat, while the latter have loss of subcutaneous fat and poorly supported blood vessels.

Sex

Women who are especially obese tend to bruise more easily than men because they have subcutaneous fat.

Texture and colour of the skin

Fair skinned persons show bruises more obviously than coloured persons.

Natural Diseases

Persons suffering from scurvy, purpura, hypertension and cardiovascular degenerative changes tend to produce more extensive extravasations of blood and, as absorption of the extravasated blood is slower, the colour changes may be delayed and histologically characteristic.

The age of a bruise can be roughly estimated from its colour immediately after infliction it will be red, turning soon to a dusky purple or black. When bruising these lesions are yellow in 7-10 days, finally disappearing in 14-15 days. These colour changes take place from the periphery, and the time period involved may vary from 1-4 weeks.

To decide whether any injury took place just before, at the time of, or just after death is a difficult matter. A true ante-mortem bruise inflicted a short time before death will usually show swelling and infiltration of the tissues with blood. It must be noted that post-mortem changes may confuse the issue but ante-mortem injuries produced several hours or days before death will show obvious macroscopic and microscopic tissue inflammatory reaction. For this reason, tissue samples showing these lesions should always be retained in a fixation solution. However, when a lesion is produced after death, bruising will be absent and tiny abrasions may take on a characteristic brown appearance. With respect to post-mortem changes, the passage of time is itself does not negate the validity of a bite mark comparison. A well preserved body without the obvious effects of post-mortem decomposition will possess minimal, if any, distortion of the bite mark in relation to the mark and time of infliction. Many defence counsels will raise the issue of post mortem shrinkage of tissue as a means of discrediting the analysis. However such changes in the preserved body are minimal and represent a lesser source of dimensional error than possible change related to distortion of the skin surface as a result of the pressure inherent to the act of biting.

Reasonable estimates of wound age can be determined from human bites, for instance, laceration wounds that have not yet re-established hemostasis would be classified as being in the early stages of inflammation and thus would be only several hours old. Erythematous lesions are also part of the inflammation stage, and, depending on the degree of erythema, could range in age from several hours to 7-10 days old. Laceration injuries without erythema would be considered in the granulation tissue formation/matrix formation and remodeling stages and would be older than 10 days.

Tissue changes from bite marks have been tested in volunteers whose skin has been submitted for histological study. The most obvious vascular damage was found in the deeper dermal regions, where the larger blood vessels are located. Even after the edematous reaction has regressed considerable number of erythrocytes remained in the dermal region, which explained the distinctive erythematous discoloration of the skin. This examination can be of great value in supplying supportive evidence in the
assessment of both time of application, extent and intensity of a bite injury. The evidence itself is not substantive but could be useful correlative data in the investigation of such cases.

CONCLUSION

The unique morphology and alignment of the teeth in the dental arch are functionally and aesthetically very important for an individual. However if they are used as weapons for an attack or when in contact with appropriate substrate, they leave impressions displaying feature that have caused them. Peculiar dental features will leave potentially discriminatory marks which become useful in the process of bite mark investigation.

The process of biting may consist of incising, sliding, shearing and even squeezing of tissues. Suffusion and contours varies with different parts of the body and likewise foodstuffs too vary in fragility and consistency. These variations can cause the bite lesion to differ from the offender’s teeth. Furthermore, bite marks inflicted on human skin are especially transient in nature and the marks produced may range from bruises to actual tearing of tissues. Many factors have been identified which affect the healing process of bite marks. The changes occurring during this process provides an indicator of the age of the injury. In deceased persons, this can further be supported by histological studies.

REFERENCES