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Dental Pulp Stem Cell: A Promising Tool in Forensic Odontology

Shah Nida[1], Sonali Kadam[2], Shweta Vilvadrinath[3], Anusree J[4]

[1]Postgraduate student, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai

[2]Associate Professor and Professor (Academic), Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai

[3]Assistant Professor, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai

[4]Post graduate student, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai

ABSTRACT-

Forensic odontology, also known as forensic dentistry, is a specialized field within dentistry that deals with the application of dental science in medico-legal investigations, identifying accidental human remains during mass disasters, identifying victims from the site of crime scene. Most of human body parts perish after death, but tooth is one such organ which is incredibly resilient, preserving DNA well even in extreme conditions that may destroy other human body parts. Therefore, they serve as an excellent source of genetic material for identifying individuals in forensic cases. Stem cells, with their ability to develop into different cell types, have various applications in forensic investigations, including identification, reconstruction, and age estimation. Dental pulp stem cells (DPSCs) and stem cells from human exfoliated deciduous teeth (SHED) are particularly valuable in forensic identification. Amongst other methods used in Forensic odontology the use of DPSCs gives us significant results and aid in an accurate finding. The article intends to discuss the basis of DPSCs, its sources and methods of isolation, applications, accuracy of DPSCs through case study and its limitations.

Keywords: Forensic Odontology; Forensic Dentistry; Stem Cells; Dental Pulp Stem Cells

Introduction

Ambiguity and uncertainty pertaining to several tools of forensic odontology such as cheiloscopy, rugae patterns, bite mark analysis, dental records, photographs, radiographs etc. can lead to difficulties owing to their lack of confirmatory nature. There is a need for more certain and confirmed results and hence Dental Pulp Stem Cells (DPSC) have emerged as a promising tool in forensic odontology. The application of stem cells in forensic dentistry offers several benefits for both identification as well as for investigative purposes. This article elucidates the role of stem cells in advancing forensic dentistry thus showcasing the impact of stem cell technology in this field.

What is stem cell?

Stem cells are primitive cells found in all multi-cellular organisms that are characterized by self-renewal and the capacity to differentiate into any mature cell type.[1]

Based on the origin adult stem cells can be classified in to two types: germline and somatic stem cells. Variety of somatic stem cells have been discovered in different parts in the human body like mesenchymal stem cells (MSCs) are found in the stroma of adult bone marrow which can differentiate in to osteoblast, adipocytes in response to appropriate signal.

Noteworthiness of the dental pulp and dental pulp stem cells

Human tooth consists of hard and soft tissues. Enamel, dentin and cementum are the hard tissues. Dental pulp has rich innervation, vascular connective tissue and periodontal ligament (PDL) which attaches the tooth to the bony socket are the soft tissues present in the tooth. Dental pulp is a soft tissue that is encased within a hard mineralized tissue that protects and preserves it. Human teeth can withstand the temperature of 1600o C and extreme environmental conditions.[2] This persistence of dental tissue makes it useful in various applications in forensic dentistry. Also, the rich cellularity and vascularity makes the dental pulp a reservoir of Dental Pulp Stem Cells (DPSC) which has the lifelong ability to regenerate and differentiate into odontoblasts,

Address for Correspondence:
Dr. Shah Nida
Post graduate student
Room no. 23, Department of Oral Medicine and Radiology, Government Dental College and Hospital Mumbai, Pd'mello Road,
Mumbai 400001.
Email : snida214@gmail.com

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neural progenitors, osteoblasts, chondrocytes, and adipocytes.[3]

Different sources of stem cells in orofacial region:

Apart from Dental Pulp Stem Cells (DPSC), we have other sources of stem cells in the orofacial region such as Stem Cells From Human Exfoliated Deciduous Teeth (SHED), Periodontal Ligament Stem Cells (PDLSC), Dental Follicle Stem Cells (DFSC), Stem Cells from Apical Papilla (SCAP), Epithelial Stem Cells (EpSC), Induced Pluripotent Stem Cells (IPSC), Oral Epithelial Stem Cells (OESCs), Immature Dental Pulp Stem Cells (IDPS), Gingiva derived MSCs (GMSCs), Tooth Germ Progenitor Cells (TGPCs), Salivary gland stem cells (SGSCs) and Periosteum derived Stem Cells (PSCs), Bone Marrow Stem Cells (BMSC).

Methods of isolation and storage of dental pulp stem cells:

Methods of isolation: Table no. 1 and 2 shows various methods of isolation and approaches used for stem cell storage respectively.[4]

Methods of isolation(a) Size-sieved isolationEnzymatic digestion of whole dental pulp tissue in solution of 3% collagenase Type I for 1 h at 37°C is done followed by the process of filtering, seeding, culture and amplification.(b) Stem cell colony cultivationEnzymatic digestion of the dental pulp tissue is done to prepare single cell suspension cells followed by colony formation and amplification.(c) Magnetic activated cell sorting (MACS)Immune-magnetic method used for separation of stem cell populations based on their surface antigens (CD271, STRO-1, CD34, CD45, and c-Kit).(d) Fluorescence activated cell sorting (FACS)Isolation of stem cells from cell suspension based on cell size and fluorescence.Table no. 1. Name of various methods of isolation of DPSCs and its procedure.

Approaches used for stem cell storage(a) Cryopreservation Liquid nitrogen vapour is used to preserve cells at a temperature of <−150°C.(b) Magnetic freezing. It works on principle of applying a weak magnetic field to water or cell tissue which will lower the freezing point of that body by up to 6–7°C.Table no. 2. Methods of stem cell storage and its procedure.

DPSCs maintain their stem cell properties even after cryopreservation as reported by Zhang et al.[4]

Table 1: Name of various methods of isolation of DPSCs and its procedure

Methods of isolation	
(a) Size-sieved isolation	Enzymatic digestion of whole dental pulp tissue in solution of 3% collagenase Type I for 1 h at 37 °C is done followed by the process of filtering, seeding, culture and amplification.
(b) Stem cell colony cultivation	Enzymatic digestion of the dental pulp tissue is done to prepare single cell suspension cells followed by colony formation and amplification.
(c) Magnetic activated cell sorting (MACS)	Immune-magnetic method used for separation of stem cell populations based on their surface antigens (CD271, STRO-1, CD34, CD45, and c-Kit)
(d) Fluorescence activated cell sorting (FACS)	Isolation of stem cells from cell suspension based on cell size and fluorescence.

Table 2: Methods of stem cell storage and its procedure

Approaches used for stem cell storage	
(a) Cryopreservation	Liquid nitrogen vapour is used to preserve cells at a temperature of <−150°C.
(b) Magnetic freezing	It works on principle of applying a weak magnetic field to water or cell tissue which will lower the freezing point of that body by up to 6–7°C.

Applications of stem cell in forensic odontology:

1. **Regeneration and Repair of Dental Tissues**

   Stem cells have the capacity to regenerate and repair dental tissues, which is useful in reconstructive forensic cases where teeth have been damaged or are missing. They can aid in the identification process by reconstructing dental features which are unique to individuals.[5] Methods such as cell homing, transplantation, explant outgrowth and enzymatic digestion can be used to regenerate tissues using DPSC.[6]

2. **Age Estimation**

   DPSCs are valuable in forensic investigations due to their regenerative properties and ability to provide high-quality DNA. Changes in the cellular and molecular composition of DPSCs can be indicative of age, making them useful for age estimation in forensic cases.[7] Age estimation has applications both in postmortem identification as well as in living individuals where chronological age is under dispute. The dental pulp can be considered a tissue, in which biological age approximates chronological age.[8] As age progresses cell density of dental pulp cells of crown and

root region changes, fibroblasts of the older age group appeared to be flattened and spindle shaped when compared with the fibroblasts of the younger age group.

3. **Sex Determination**

Dental stem cells can be used to identify the sex of an individual. Amelogenin gene, located on the X and Y chromosomes, is used in forensic science for determination of sex. Differences in the length of the amelogenin gene on the X and Y chromosomes helps in this through polymerase chain reaction analysis.[9] DPSC is a good source for extraction of DNA. Restriction fragment length polymorphism, polymerase chain reaction (PCR), and microarrays are various methods to analyze DNA.[10] Barr bodies are strongly stained chromatin material present in nucleus of female somatic cells and F bodies are available in Y chromosome which can be used in sex determination. The accuracy of DPSCs in sex determination is as high as 99%.[11]

4. **Disaster Victim Identification**

In mass disasters, dental pulp stem cells can be used to rapidly extract DNA which will help in victim identification and even in cases where other tissues are compromised. [12]

DNA in dental pulp remains stable for long periods, even in harsh conditions like extreme temperatures or post-mortem changes. This stability is significant in disaster victim identification where body remains may be exposed to severe environmental conditions.[13]

5. **Criminal Identification**

The dental pulp is a good source of genomic DNA. Extraction of genomic DNA and amplification of dental pulp stem cells through Polymerase chain reaction technique leads to a positive identification of the human in question.[14]

6. **Blood Group Determination**

Blood group antigens are preserved for over 2 years after the death of an individual and can be retrieved from the dental pulp. ABO genotyping using dental pulp can be used to identify blood group of an individual by 'absorption elution technique'.[15]

7. **Post Mortem Interval Estimation**

The correct estimation of post mortem interval (PMI) can be crucial aspect on the success of a forensic investigation. Researchers used diverse method to estimate PMI, considering physical changes that occur after death using DPSCs.[16]

Discussion

In 2000, Gronthos et al. isolated the first MSC like cells from the human dental pulp.[17] Studies in the stem cells of dental pulp showed that it has a has a high potential for proliferation in turn promotes auto renewal.[18]

The pilot study conducted by Ilenia Bianchi et al "Dental DNA as an Indicator of Post-Mortem Interval (PMI): A Pilot Research" explores the feasibility of using Next-Generation Sequencing (NGS) to analyze genetic mutations in dental pulp DNA post-mortem samples. By examining mutations in a 56-gene panel, they aimed to correlate these changes with the time since death. The findings suggest that there are specific genetic mutations in dental pulp DNA can indicate PMI, thus providing a potential tool for forensic investigations.[19]

A study conducted in the year 2010 by Nayar et al determined gender by pulp tissue using fluorescent Y body test and reported 100% specificity.[20] A study conducted by Saxena et al. proved the sensitivity of blood group determination using dental pulp by the absorption-elution technique to be 80% accurate.[21]

Gawande et al in a study showed that postmortem DP shows well-preserved histological appearance for up to 72 hours in contrast with destruction and degeneration seen in other body tissues as early as 24 hours, making it a viable candidate for soft-tissue age estimation. Vavpotic et al have demonstrated that odontoblast numbers can be used to estimate time of death for about 5 days postmortem, further signifying the role of DP in forensic odontology. Another application of DP in forensics has been described by Sandoval et al who validated that the Barr body test can be applied to DP fibroblasts of human remains exposed to extreme conditions of pH, humidity and salinity for gender identification with 98.9% accuracy.[22] Daud et al. in their study used the histological method for age determination and found that cell density of dental pulp cells of crown and root region changes with age.[23] Sweet and Sweet in 1995 presented a case of human remains identification using a preserved unerupted third molar which enabled 1.35 µg DNA extraction from the dental pulp.[24]

A study conducted in the year 2011 by Nalini A to emphasize the sensitivity and specificity of dental pulp in identifying the ABO Blood group, Rhesus factor and also to emphasize the role of dental pulp in forensic odontology to identify the

deceased individual. 60 individuals were studies out of which 57 showed positive results wherein blood group identification from the capillary blood and the dental pulp extract was compared. The study concluded and highlighted the high potential of dental pulp in the identification of blood group and hence serve a great tool of identification in forensic identification.[25]

Limitations:

Despite the potential, stem cells in the field of forensic odontology also face some limitations. Usage of stem cells in the field of forensic can also raise legal as well as ethical concerns regarding the consent and privacy. There is a need to adapt to the ever-advancing techniques for the evaluation of these stem cells without which the results will fall short of its accuracies.

Conclusion:

The potential of dental stem cells in forensic odontology is significant although it is accompanied by few limitations. Their applications in forensic dentistry include aiding in the regeneration and repair of dental tissues, age estimation, sex determination, and disaster victim identification through DNA analysis and criminal identification. But, challenges such as ethical and legal concerns, the need for advanced technology limits their use. Despite these limitations, ongoing research, like studies on the expression of mesenchymal stem cell markers and genetic mutations in dental pulp DNA, all these endeavors have the potential to advance the field, thus pointing towards more accurate and reliable forensic tools in the future.

Conflicts of interest:

None.

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The Little Baby Canal: A Case Report of a New Unreported Variant of an Inferior Alveolar Nerve Canal as Observed on Cone Beam Computed Tomography Scan.

Dr. Shah Nida[1], Dr. Sonali Kadam[2], Dr. Easwaran Ramaswami[3], Dr. Vijayalaxmi Nimma[4], Dr. Shweta Vilvadrinath[5]

[1]B.D.S. (Second year Post graduate student) Designation: Postgraduate student Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[2]M.D.S. Associate Professor and Professor (Academic) Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[3]M.D.S. Professor & Head of the Department Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[4]M.D.S. Associate Professor Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[5]B.D.S. (Third year Post graduate student) Postgraduate Student Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai

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ABSTRACT

A population shows uniformity in patterns mostly but at times we come across findings that are exceptional and characteristic to that particular case which is quite nearly impossible to discover unless a radiograph is made. Radiographs are made each day for various purposes, what are the chances we come across an 'unusual, rare and interesting' finding? In this case report we present an unreported and new variation of accessory branch of an inferior alveolar nerve canal that was discovered incidentally on a Cone Beam Computed Tomography scan which proved instrumental in designing and executing a careful and proper treatment plan without causing any damage to the canal thereby avoiding any associated post operative complications. This case report emphasizes on the importance of interpreting the entire radiograph carefully as a whole and not just focus on the limited area of chief complaint which further helped in architecting a successful treatment.

Keywords: Mandibular Canal, Incidental Findings, Cone-Beam Computed Tomography, Mandibular Nerve, Radiography

INTRODUCTION

Radiographic incidental findings are occult abnormalities and maybe discovered only when a radiograph is made pertaining to patient's chief complaint. Every clinical case differs from another and must be treated so. 'Expect the unexpected' should always be in the back of one's mind while dealing with a patient even if everything seems to be normal. Variations in a population and deviations from normal uniform patterns exist. It might go unnoticed and ignored if careful observation is not done. Addressing variations of normal entity is significant for future prospects of diagnosis and treatment plans. Inferior alveolar nerve canal houses inferior alveolar nerve and vessels running a course through mandibular ramus and body supplying the teeth and adjacent soft tissue structures. Dry skulls have been put to use to study the variations in the course of inferior alveolar nerve canal [1]. The reporting of morphological variations in the course and configuration such as bifid and trifid inferior alveolar nerve canal has been done using various imaging modalities [2]. It is very important to know the actual anatomy and configuration of the canal before performing procedures such as transalveolar extractions of impacted mandibular molar, osteotomy, dental implant placement, reduction and fixation of mandibular fractures, sagittal split ramus osteotomy etc. Also, the course and configuration of inferior alveolar nerve canal is instrumental in effective administration of local anesthesia without any intra operative and post operative complication. It is difficult to determine the course and configuration of the canal in a two-dimensional radiograph. Hence, CBCT scan is an excellent choice to study the inferior alveolar nerve canal and its branches [3]. It is imperative for the oral radiologists to evaluate complete radiograph and report the findings which can further enable clinicians in planning an effective treatment.

Case Description And Results

A 21-year-old female patient was referred from the Department of Oral and Maxillofacial surgery to the Department of Oral Medicine and Radiology with a requisition form for performing CBCT scan for a horizontally impacted mandibular right third molar to assess the anatomy and position of the tooth in relation to the inferior alveolar nerve

canal with the purpose of extracting the tooth. A two-dimensional orthopantomogram was performed prior to a three-dimensional CBCT scan which revealed a close approximation of the inferior alveolar nerve canal to the horizontally impacted mandibular right molar. In order to study the course and configuration of the canal in detail in all the three plains a CBCT scan of voxel size 400 micrometer, 90 kV, 10.0 mA was performed on Planmeca Promax 3D Mid CBCT machine using Planmeca Romexis 3.2.0 R software. A careful examination of the scan revealed a horizontally impacted mandibular right third molar in close approximation to the inferior alveolar nerve canal. Apart from this, the scan surprisingly revealed an accessory canal arising from the superior surface of the main canal in an upward and forward direction exiting from the buccal cortical plate. The accessory canal was in a very close approximation to the mesial root in the middle third region without any bony separation in between (figure. 1).

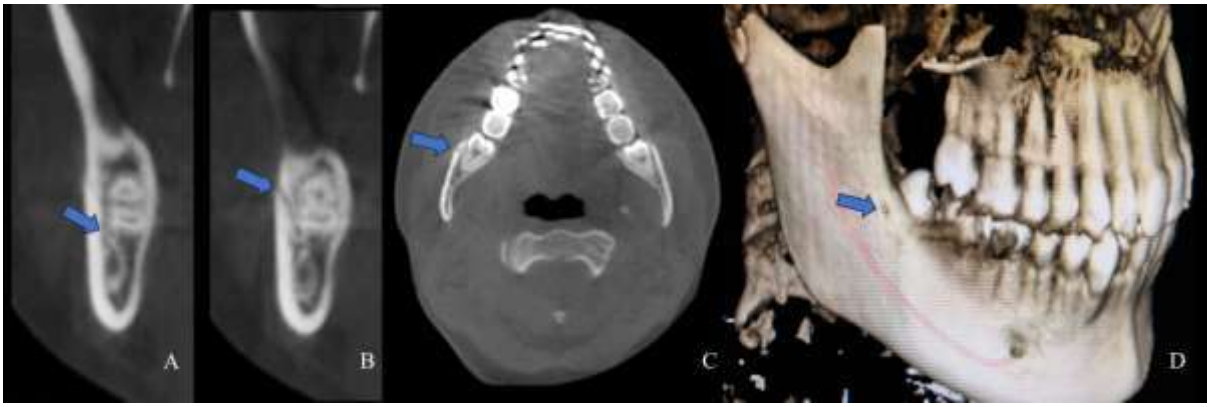

Figure. 1 (A) An accessory canal arising from the superior surface of the main inferior alveolar nerve canal in close proximity with impacted mandibular right third molar in a sagittal section of a CBCT scan (indicated by a blue arrow). (B) An accessory canal arising from the superior surface of the main inferior alveolar nerve canal in an upward and forward direction exiting from the buccal cortical plate below the alveolar crest and in close relation to the impacted mandibular right third molar in a sagittal section of a CBCT scan (indicated by a blue arrow). (C) The opening of an accessory canal in the buccal cortical plate in close proximity with impacted mandibular right third molar in an axial section of a CBCT scan (indicated by a blue arrow). (D) A 3D reconstructed image showing opening of an accessory canal in the buccal cortical plate below the alveolar crest in close proximity with impacted mandibular right third molar (indicated by a blue arrow).

A complete detailed report of the findings was prepared, and the oral and maxillofacial surgeon was well informed beforehand about the variation of an accessory canal. After learning the proper anatomy and position of the tooth, the course and configuration of the inferior alveolar nerve canal, and the relation of an accessory nerve to the main canal as well as the tooth a careful execution of treatment was made. Buccal guttering of bone to elevate the tooth for extraction and administration of long buccal nerve block that would predispose to the risk of injuring the accessory nerve due to its location on the buccal cortical plate and hence was taken care of. Administration of local anesthesia in adequate amount and proper site of approximately 1 cm above the occlusal plane to anesthetize the main as well as an accessory canal, and extraction of tooth without damaging the main or accessory canal was performed. The patient was recalled. There was an uneventful healing of the extraction socket and there was no post operative complaint or any associated symptoms of complications such as paresthesia, numbness or tingling sensation reported.

DISCUSSION

In the prenatal development the mandible develops from intramembranous ossification. The development of the inferior alveolar nerve canal takes place simultaneously. The four branches of the inferior alveolar nerve canal normally present are incisive branch, mental branch, mylohyoid branch and dental branch. The intramembranous ossification takes place from anterior to posterior direction i.e from the site of division of the incisive and mental branch to the mandibular canal. As the development progresses a bony canal is formed around these branches of the nerve, and they are then fused together. Any disturbance in the development of the canal would lead to the failure in fusion of these branches to the main canal would result is an accessory canal [4].

In 1967, Schejtman et al demonstrated the presence of accessory mandibular canals (retro molar canals) in 13 of 18 specimens of human cadaver [5]. According to the study done by Castro MA et al in year 2015, the prevalence of mandibular canal branching varied from 0% to 38.75% when a two-dimensional imaging modality was used while it ranged from 15.6% to 65% when a three-dimensional imaging modality was used [6]. According to the study conducted by M Naitoh et al in the year 2009, presence of buccal foramen in the mandibular body was present in 44% of 84 patients using CBCT images. Also, a buccal foramen showing continuity with the mandibular canal was observed in 7.1% of patients [7].

Classifications of bifid mandibular canal proposed by Langlais et al and Naitoh et al (Table. 1) [8,9].

(Table no. 1) Classifications of bifid mandibular canal proposed by Langlais et al and Naitoh et al.

Author	Types	Description
Langlais et al (1985)	Type 1	A unilateral or bilateral bifurcation that extends to the third molar region or surrounding area from a single mandibular foramen.
	Type 2	A unilateral or bilateral bifurcation that extends along the main canal and then merges in the mandibular ramus or body.
	Type 3	A combination of type 1 and 2.
	Type 4	A bifid mandibular canal that originates from two distinct mandibular apertures and then merges into a single, broad mandibular canal.
Naitoh et al (2009)	Forward canal	The branch arising from the superior wall of the main canal.
	Buccolingual canal	The branch arising from the buccal or the lingual wall of the main canal.
	Dental canal	The end of the bifurcated canal reached the root apex of the molars.
	Retromolar canal	The branch arising from the main canal, opening at the retromolar foramen

The prevalence of mandibular canal branching is 65%. The frequency of forward canal is 55.3%, buccolingual canal is 1.8 %, dental canal 7% and retromolar canal 29.8% [10].

In our case the accessory ‘baby canal’ closely resembles the categories in above given classification but does not exactly fit it and hence is a new variant which as not been reported previously.

The clinical implication of this case is that we might lack the achievement of profound anesthesia and successful pain control if we lack the knowledge of anatomical variations [11]. Alternate techniques to achieve anesthesia of the inferior alveolar nerve may include delivery of the adequate anesthetic solution at a higher anatomical level in order to sufficiently anesthetize all branches of the mandibular nerve, including any additional inferior alveolar branches that may be present [12]. Also, if the inferior alveolar nerve canal and its accessory branch is damaged the patient might experience paresthesia, hypo/anesthesia, and dysesthesia in the area supplied by it [13]. Buccal nerve block is commonly administered during surgical extractions [14]. The presence of accessory nerve in our case is in close proximity with the site of injection for administering the local anesthesia for buccal nerve block and would predispose to the risk of injury to the accessory nerve branch and hence must be taken care of.

CONCLUSIONS

‘Away from the normal’ is least expected but that shouldn’t limit us to rule out the possibility of its presence. A proper know-how of the anatomy and its variations that is best achieved using a three-dimensional imaging modality such as CBCT which allows us to view structures in all three planes must be studied thoroughly and not just focus to the limited area. An appropriate detailed reporting by the oral radiologist helps the clinicians to make them aware about the unknown variations and help them to adapt techniques that would make their treatments successful without any complications. Also, it would add on to the plethora of knowledge and research for future prospects.

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Herpes Zoster Revisited: A Case Series on the Awakening of Varicella-Zoster Virus

Dr. Suraj Bhoye[1], Dr. Siddhi Rane[2], Dr. Sonali Kadam[3], Dr. Easwaran Ramaswami[4], Dr. Vijayalaxmi Nimma[5], Dr. Anusree J[6], Dr. Lucky Tiwari[7]

[1]B.D.S. (Second year Post graduate student) Designation: Postgraduate student Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[2]B.D.S. (Second year Post graduate student) Designation: Postgraduate student Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[3]M.D.S. Associate Professor and Professor (Academic) Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[4]M.D.S. Professor & Head of the Department Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[5]M.D.S. Associate Professor Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[6]B.D.S. (Second year Post graduate student) Postgraduate Student Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[7]B.D.S. (First year Post graduate student) Postgraduate Student Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai

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ABSTRACT

Herpes zoster — often known as shingles — is much more than just a painful rash. It is the dramatic reawakening of the varicella-zoster virus (VZV), which can lie dormant for decades after an initial chickenpox infection. This viral comeback strikes unexpectedly, unleashing a spectrum of clinical presentations that range from classic dermatomal eruptions to rare, atypical, and sometimes severe complications. While traditionally associated with older adults and immunocompromised patients, herpes zoster continues to surprise clinicians with its diverse manifestations and unpredictable course. Factors that increase the risk of reactivation include advancing age, physical injuries such as those caused by dental procedures, psychological stress, malignancies, and conditions that compromise immunity, including organ transplantation, pregnancy, and HIV infection. Beyond the immediate discomfort, it carries the heavy burden of postherpetic neuralgia and other debilitating sequelae that challenge both diagnosis and treatment. In an era of antiviral therapies and vaccines, herpes zoster remains a formidable opponent. Through this case series, we dive deep into the many faces of herpes zoster, unmasking unusual presentations, clinical puzzles, and management challenges that enrich our understanding and inspire improved care.

Keywords: Ophthalmic, dermatomal, postherpetic neuralgia, Varicella Zoster, Herpes Zoster, shingles, Ramsay hunt syndrome.

INTRODUCTION

Varicella-zoster virus (VZV), a DNA virus from the Alphaherpesvirinae subfamily, is widely prevalent and typically remains dormant within the body. However, it can be reactivated as herpes zoster due to triggers such as physical trauma, specific medications, other infections, or psychological stress. Herpes zoster, also known as shingles, is a vesicular skin eruption that typically results from the reactivation of the dormant varicella-zoster virus (VZV), which remains in the dorsal root ganglia following an initial chickenpox infection. It most often affects the thoracic or cranial dermatomes. The estimated lifetime risk of developing shingles is between 10% and 20%, with the likelihood increasing by approximately 50% in individuals over the age of 80[1].

Herpes zoster presents as painful vesicular eruptions on inflamed skin, typically limited to one or two adjacent dermatomes. In about 75% of cases, pain precedes the rash, which progresses to pustules and crusts. Reactivation of latent VZV causes the condition. Despite antiviral therapy, it may lead to ophthalmic, vascular, visceral, and neurological complications [2].

Primary complication of herpes zoster is postherpetic neuralgia—persistent pain lasting more than 90 days after the rash begins—which affects approximately 20% of individuals with the condition [2]. Despite the presence of antiviral treatments and preventive vaccines, herpes zoster remains a considerable global healthcare burden, primarily due to its

high occurrence in older adults and the persistent pain linked to its complications. Reports have documented bone and dental issues, including devitalized teeth, spontaneous tooth loss, and necrosis of the maxilla or mandible. When herpes zoster involves the oral and maxillofacial region, it can be difficult to diagnose and should be considered as a differential diagnosis in cases of atypical odontalgia [3]. In this case series, we present three cases in which patients diagnosed with herpes zoster, highlighting the diversity of clinical manifestations, diagnostic challenges, therapeutic approaches, and outcomes. Our objective is to contribute to a better understanding of the disease spectrum and to support clinicians in optimizing management strategies tailored to individual patient profiles.

Case report 1- A 78-year-old female patient presented to the department with complaints of pain and a burning sensation accompanied by fluid-filled lesions localized to the right midfacial region, persisting for the past 5 days. The initial symptoms included tingling and a burning sensation, which were soon followed by the development of several fluid-filled vesicular lesions. The patient denied any recent illness, trauma, or dental procedures. Her past medical history was unremarkable.

Extraoral examination revealed a unilateral cluster of vesicular lesions on a reddened base, located on the right cheek, lower eyelid, nasolabial fold, and the lateral aspect of the nose, without crossing the midline of the face (Fig. 1-A). The patient experienced significant tenderness, heightened sensitivity (hyperesthesia), and pain from normally non-painful stimuli (allodynia) in the affected dermatome. Mild enlargement of the right submandibular lymph nodes was also noted.

Intraoral examination revealed multiple vesicles and shallow ulcers confined to the right side of the hard palate and upper alveolar mucosa (Fig. 1-B). The lesions appeared erythematous and tender, with no evidence of secondary infection. Based on these findings, a clinical diagnosis of herpes zoster involving the maxillary branch of the trigeminal nerve, with both cutaneous and oral manifestations, was established.

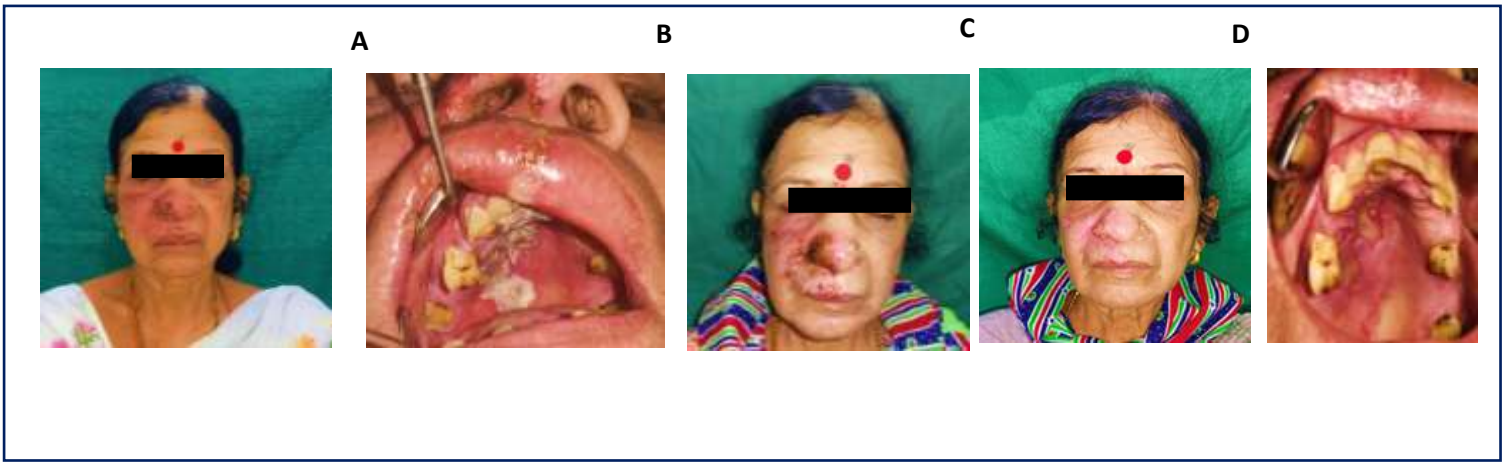

Figure. 1 (A) vesicles involving the entire right side of the face. (B) intraoral ruptured vesicle involving the right palatal mucosa. (c) one-week follow-up- crusting of vesicular lesion noted over right side of face. (D), (E) third week follow-up both the skin and oral lesions had significantly healed.

The patient was prescribed oral Acyclovir at a dose of 800 mg, to be taken five times daily for 7 days. Pain management included carbamazepine 200 mg prescribed twice a day. For topical relief, Calamine lotion was applied to the facial lesions, and Acyvir gel 5% was recommended for intraoral application five times daily. To help prevent postherpetic neuralgia, Rejunuron 500 mcg capsules were also prescribed. The patient was advised to maintain good oral hygiene and avoid dietary irritants such as spicy food.

At the one-week follow-up, the vesicular lesions had crusted, and there was a significant reduction in facial and oral pain (Fig. 1-C). By the third week, both the cutaneous and oral lesions had significantly healed, although the patient continued to experience mild residual neuropathic pain (Fig. 1-D & E). Carbamazepine was maintained and gradually tapered, while Rejunuron 500 mcg capsules were continued. At the six-week follow-up, the patient was symptom-free, with no evidence of postherpetic neuralgia.

Case report 2 -A 62-year-old male visited the department complaining of pain in the lower right molar region. He initially believed it to be a dental issue—possibly a cavity or gum infection—and requested a routine dental check-up. However, what appeared to be a standard dental visit quickly took an unexpected turn. The patient also reported a burning sensation on the right side of his face, along with tingling and pain radiating along his lower jaw and chin (Fig.

1-A). Upon further inquiry, he stated that these symptoms had begun about four days earlier and were followed by the appearance of fluid-filled lesions on his chin and lower lip.

Intraoral examination revealed multiple shallow ulcers and ruptured vesicles on the right buccal mucosa and gingiva, accompanied by erythema and swelling (Fig. 1-B). The patient denied any history of trauma, recent dental procedures, fever, or systemic illness. His past medical history was unremarkable.

A B C D

Figure. 2 (A) vesicles involving the entire right side of the face. (B) intraoral ruptured vesicle involving the right Buccal mucosa. (c) one- week follow-up- crusting of vesicular lesion noted over right side of face. (D), (E) third week follow-up both the skin and oral
lesions had fully healed.

Herpes zoster involving the mandibular (V3) division of the trigeminal nerve was diagnosed based on the characteristic clinical signs.

The patient was promptly initiated on oral acyclovir 800 mg, five times a day for 7 days. Analgesics (paracetamol and ibuprofen) were prescribed for pain management, and Carbamazepine 200 mg twice a day was added to address the neuropathic pain. For the intraoral ulcers, a topical Acyvir gel 5% was recommended for intraoral application five times daily. The patient was counselled to maintain good oral hygiene, avoid spicy or hard foods, and report any worsening symptoms.

At the one-week follow-up, the facial vesicles had crusted, and the intraoral lesions showed significant healing. (fig.1-C). Pain had reduced substantially, and the patient had resumed eating soft foods. By the third week, both cutaneous and oral lesions had resolved completely. (fig.1-D&E). Only mild residual tingling remained, which gradually improved. Carbamazepine was tapered over the next over the next two weeks. At the six-week review, the patient was entirely asymptomatic with no evidence of postherpetic neuralgia. Two weeks. At the six-week review, the patient was entirely asymptomatic with no evidence of postherpetic neuralgia.

Case report 3- A 65-year-old male presented to the department with complaints of severe pain, a burning sensation, and fluid-filled lesions localized to the right lower jaw, chin, and lower lip. The condition had begun five days earlier with a burning and tingling sensation in the right ear, which rapidly progressed to the development of vesicular eruptions. The patient denied any recent trauma, fever, systemic illness, or dental procedures. His medical history was unremarkable.

Extraoral examination revealed multiple grouped vesicles on an erythematous base involving the right pinna and external auditory canal (Fig. 1-A), as well as vesicular eruptions extending across the right side of the face and lower lip region (Fig. 1-B). Intraoral examination showed multiple ruptured vesicles and shallow ulcers on the right buccal mucosa and gingiva, accompanied by erythema and oedema, with the lesions confined to the mandibular division of the trigeminal nerve. No crossing of the midline was observed.

Further intraoral evaluation revealed several vesiculoulcerative lesions on the right side of the soft palate and tongue. These lesions were painful and erythematous, significantly impairing the patient's ability to speak and eat. The patient also reported an altered sense of taste, noting that food tasted noticeably blander on the right side of the tongue.

A clinical diagnosis of herpes zoster involving the mandibular branch of the trigeminal nerve was established. The patient was started on oral acyclovir (800 mg, five times daily for 7 days), along with carbamazepine 200 mg twice daily for pain management. Topical calamine lotion was prescribed for extraoral application, and Acyvir 5% gel was recommended for intraoral use five times daily.

At the one-week follow-up, the vesicular lesions had begun to crust, and the patient reported a partial reduction in pain. However, he began experiencing new symptoms, including right-sided facial weakness, difficulty in closing the right eye, and a diminished sense of taste on the right side of the tongue. Based on these findings, a diagnosis of Ramsay Hunt Syndrome (herpes zoster oticus) was made.

The patient was continued on oral acyclovir (800 mg, five times daily), and analgesics (paracetamol and ibuprofen) were prescribed for general pain relief. Carbamazepine 200 mg twice daily was maintained to manage neuropathic pain. Lubricant eye drops (Eyemist) and an eye patch were provided to protect the cornea. A topical anaesthetic mouth rinse was advised for oral pain relief, and dietary recommendations included soft, bland foods. The patient was also referred to neurology and otolaryngology departments for multidisciplinary management.

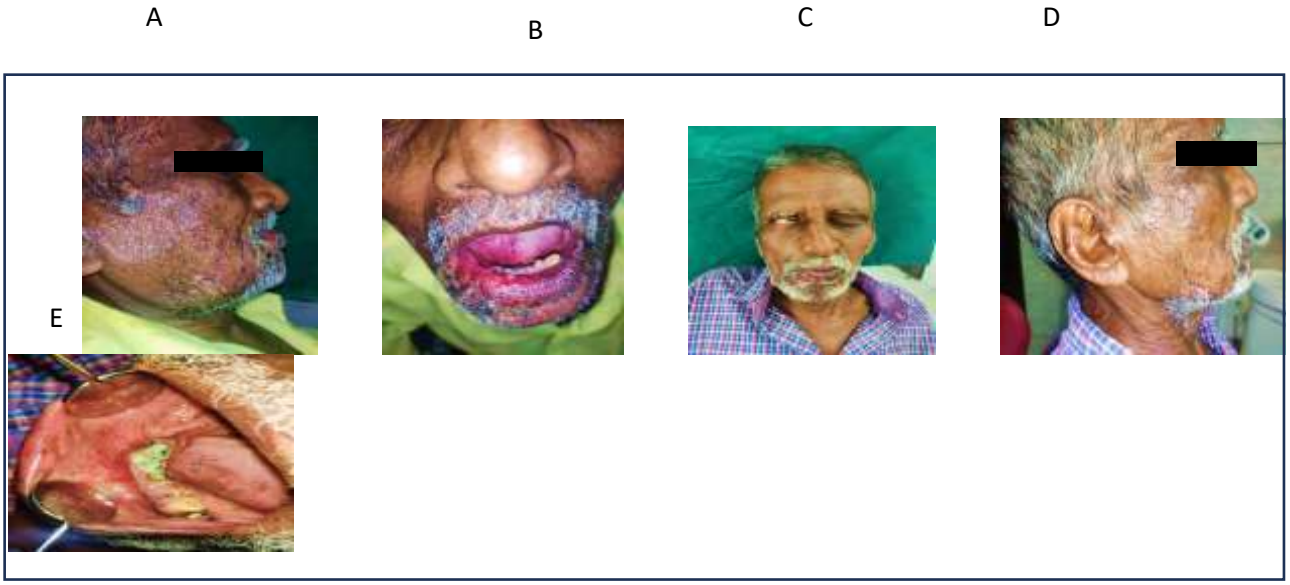

Figure.3(A) multiple grouped vesicles with an erythematous base were present on and around the right pinna and the external auditory canal (B) vesicles involving the entire right side of the face (C) right eyebrow was drooping, the nasolabial fold was flattened, and the right oral commissure sagged, classic signs of lower motor neuron facial nerve paralysis).(D) (E) third week follow-up both the skin and oral lesion had fully healed.

At the second follow-up visit (week two), the facial vesicles had crusted, and the oral lesions were healing (Fig. 1-D & E). Pain levels had significantly decreased, and the patient was able to eat and speak with less discomfort. Facial nerve function showed slight improvement, although mild residual facial weakness persisted. By the third-week follow-up, further improvement in facial nerve function was noted—he was able to smile and close his right eye with effort. The intraoral lesions had completely resolved, and taste sensation was gradually returning. At the six-week review, the patient demonstrated near-complete recovery of facial movements, no longer experienced oral discomfort, and had stable hearing.

DISCUSSION

Herpes zoster, commonly called shingles, gets its name from the Latin word cingulum, meaning 'girdle,' reflecting the typical presentation of a unilateral rash that often encircles the waist or torso like a belt. The term 'zoster' is derived from classical Greek, where it referred to a warrior's belt used to secure armor [4].

VZV reactivation can happen spontaneously or when the immune system is weakened. Factors that increase the risk include aging, physical trauma such as dental treatments, psychological stress, cancer, radiation therapy, and conditions that suppress immunity like organ transplantation, steroid use, and HIV infection. The infection typically affects individuals over 45 years of age, with the highest incidence occurring between 68 and 90 years [5]. In our cases, the patients were elderly, ranging in age from 60 to 80 years.

Herpes zoster advances through three distinct stages: prodromal, active, and chronic. It typically begins with the prodromal phase, which is characterized by mild to moderate burning, tingling, or occasional numbness in the skin of a specific dermatome, often accompanied by fever, headache, and general malaise. These symptoms were also noted in our cases. The chronic stage is defined by a pain syndrome known as postherpetic neuralgia (PHN) [6]. Postherpetic neuralgia (PHN) is characterized by pain that persists beyond the healing of the active skin lesions. While it is often defined as pain lasting between 1 to 3 months after the rash has resolved, it can sometimes continue for years or even decades.

Approximately 48 to 72 hours after the onset of prodromal symptoms, a unilateral erythematous maculopapular rash develops along the affected dermatome, which subsequently progresses to vesicular lesions, indicating the active stage [4]. The ophthalmic division of the trigeminal nerve is the most commonly affected, with the maxillary and mandibular divisions being less frequently involved. Case 1 involved the maxillary division, while Cases 2 and 3 showed involvement of the mandibular division. Herpes zoster, especially when affecting the trigeminal nerve during tooth development, has been associated with dental abnormalities and significant scarring of the facial skin. Additionally, cases of pulpal necrosis and internal root resorption have been reported. Schwartz and Kvoring documented 10 instances of herpes zoster with postherpetic complications, including jaw osteonecrosis, tooth loss, severe periodontitis, and skin scarring [7].

Trigeminals nerve consists of three branches: ophthalmic, maxillary, and mandibular. In cases of ophthalmic herpes zoster, the eye is affected in approximately two-thirds of patients, particularly when vesicles appear on the side of the nose—a sign of nasociliary nerve involvement known as Hutchinson's sign. This sign is a strong indicator of potential ocular inflammation and corneal nerve damage. Additionally, if the ciliary ganglia are involved, it may result in the development of an Argyll Robertson pupil [8].

In case number 3, involvement of the facial nerve (seventh cranial nerve) was observed. Pressure on its motor fibres can lead to the development of facial paralysis. When both the facial and vestibulocochlear nerves are affected, it results in the classic presentation of Ramsay Hunt syndrome, characterized by herpes zoster lesions on the external ear or tympanic membrane, facial paralysis on the same side, and auditory disturbances. Compression of the vestibulocochlear nerve can lead to symptoms such as sensorineural hearing loss, tinnitus, vertigo, and dizziness. If the nervus intermedius or its geniculate ganglion is involved, it can impair taste perception on the anterior two-thirds of the tongue and affect tear production [6]. In the case no 3 patient was struggled to close his right eye and showed impaired puffing of the cheeks and smiling with facial weakness and alteration of taste sensation gave the classic sign of Ramsay Hunt Syndrome.

Secondary bacterial infections are a frequent complication of herpes zoster. In recent years, infections caused by group A β-haemolytic streptococci, such as cellulitis and necrotizing fasciitis, have increasingly been observed in conjunction with varicella. Additional complications may include skin scarring, keratitis, retinal necrosis leading to blindness, keratouveitis, cranial and peripheral nerve palsies, cerebral ataxia, and pneumonia, some of which can be fatal. Herpes zoster has also been associated with dental complications such as periapical lesions, root resorption, tooth loss, and alveolar osteonecrosis [5].

Antiviral therapy should ideally begin within 72 hours of the appearance of skin lesions, as viral replication typically declines after this period. Effective antiviral agents include guanosine analogues such as acyclovir (800 mg, five times daily for 7–10 days), famciclovir (500 mg, three times daily for 7 days), and valacyclovir (1000 mg, three times daily for 7 days). Valacyclovir, a prodrug of acyclovir, achieves serum concentrations 3–5 times higher than oral acyclovir. These medications are initially phosphorylated by viral thymidine kinase, followed by additional phosphorylation by host cell kinases, ultimately inhibiting viral DNA polymerase activity [5].

The use of corticosteroids in the management of herpes zoster remains a subject of debate. While concerns exist regarding potential suppression of the immune response—making them unsuitable for immunocompromised individuals—when used alongside acyclovir, corticosteroids have shown modest yet meaningful improvements in skin lesion healing and relief of acute pain. However, research has not established any impact of corticosteroids on reducing the risk or duration of postherpetic neuralgia (PHN). It is important to note that corticosteroids should not be used as a standalone treatment without concurrent antiviral therapy [10].

Symptomatic management includes maintaining clean and dry skin lesions, applying sterile non-adherent dressings to protect the affected areas, and using topical agents such as calamine lotion. Additional supportive measures like sympathetic nerve blocks, analgesics, antidepressants, and anticonvulsants can also be beneficial. These approaches, as recommended in all cases, contributed to an accelerated recovery [10]. Recent advancements in the pharmacological management of herpes zoster (HZ) have introduced several promising agents currently under investigation. These include CMX001 (hexadecyloxypropyl-cidofovir), a lipid-conjugated form of cidofovir with improved oral bioavailability; Valomaciclovir (H2G), a nucleoside analogue demonstrating enhanced antiviral activity; ASP2151, a helicase-primase inhibitor that targets viral DNA replication; and FV-100, a bicyclic nucleoside analogue showing

potential for reducing the incidence and severity of postherpetic neuralgia. Emerging literature supports the efficacy of these agents in preclinical and early clinical trials, highlighting their potential to improve outcomes in herpes zoster management. [5].

CONCLUSION

Herpes Zoster is more than just a viral reactivation—it's a masquerader that can strike with alarming precision, especially when it involves the trigeminal nerve's maxillary and mandibular branches or manifests as Ramsay Hunt Syndrome. When the face becomes its canvas, the disease paints a vivid picture of pain, paralysis, and mucocutaneous eruptions that require prompt clinical evaluation. This case underscores a critical lesson: what starts as a tingling sensation or subtle vesicle may signal a deeper neurological storm. Delay in diagnosis risks not just discomfort, but enduring complications like post-herpetic neuralgia and permanent facial nerve damage. This case series highlights the vital need for early recognition and interdisciplinary collaboration, particularly among dental, medical, and otolaryngological teams. Timely antiviral and supportive therapies not only reduce morbidity but may be the difference between complete recovery and chronic, life-altering neuralgia or facial dysfunction.

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Case Report

Role of Oral Physician in Diagnosis of Hyperparathyroidism

Vijayalaxmi Nimma[1]*, Om Kharat[2], Easwaran Ramaswami[3] and Sonali Kadam[4]

[1]Associate Professor (Academic), Department of Oral Medicine Diagnosis and Radiology, Government Dental College and Hospital, Mumbai, India

[2]Consultant Oral Physician & Maxilllo-facial radiologist, Chh. Sambhaji Nagar, Maharashtra, India

[3]Professor and Head, Department of Oral Medicine Diagnosis and Radiology, Government Dental College and Hospital, Mumbai, India

[4]Associate Professor, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, India

***Corresponding Author:** Vijayalaxmi Nimma, Associate Professor (Academic), Department of Oral Medicine Diagnosis and Radiology, Government Dental College and Hospital, Mumbai, India.

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Abstract

Oral physician has an important role in diagnosing patients with systemic diseases which can save the patient's life, one such systemic disease which is diagnosed on incidental findings of oral manifestations is hyperparathyroidism. Parathyroid hormone plays an important role in the metabolism of calcium and phosphorus; influencing the mineralization of bone and teeth. Parathyroid disorder may lead to hyper or hypo secretion of hormone, which results in various oral manifestations. Common oral manifestations in patients with hyperparathyroidism (HPT) are brown tumor, loss of bone density, soft tissue calcification, and dental abnormalities. Dental management of patients with HPT involves a higher risk of bone fracture, whereas in hypo parathyroidism the caries control is the main concern. It is the important that the dentist be aware of the risks and difficulties that may arise during the dental management of these patients.

Earlier the diagnosis better is the treatment. As rightly said mouth is mirror of the body many diseases are diagnosed with oral and maxillofacial manifestations which can be the initial or the only signs of the disease. Thus, emphasizing the role of oral physician in diagnosis and further management of the patient.

Keywords: Hyperparathyroidism; Oral Physician; Oral Manifestations

Introduction

Parathyroid consists of four small glands (3 mm wide × 6 mm long × 2 mm thick), with dark brown in color, which are paired and located behind the thyroid gland in the neck. Parathyroid glands produce and release parathyroid hormone (PTH), which is involved in regulating the metabolism of calcium and phosphorus [1]. So, it plays an important role in tooth and bone mineralization, increases the bone resorption, stimulates formation of active metabolite of Vitamin D in the kidneys, which promotes the intestinal absorption of calcium and decreases renal reabsorption of phosphate. Normal serum PTH is about 10- 65 ng/L [2].

Management of medically compromised patients is challenging, which requires early diagnosis and prompt treatment [2].

The present case report is of a hyperparathyroid patient whose condition was diagnosed based on the oral manifestation of the disease alone. [2].

Case Report

A 18 years old male patient reported to the department of Oral Medicine and Radiology, with chief complaint of pain and swelling in the mandibular right posterior teeth region. Patient visited a local dentist for the complaint and for which an intra oral periapical radiograph (IOPAR) was made and a diagnosis of periapical infection made in the mandibular right first molar. There was a past dental history of restoration with the same tooth. Though he did not have any known significant medical history, the patient he complained of tiredness, lethargy. Occasional bone pain and mild state of confusion. Family and habit history were not contributory.

Physical examination shows normal vital signs. General physical examination showed no significant findings. Mild tenderness was palpable over the right mandibular body region.

Upon intra-oral examination (Figure 1) a restoration was noted in the mandibular right first molar, with a slight tender swelling in the buccal vestibule. IOPAR showed a radiopaque restoration in the crown of the tooth with discontinuity of the lamina dura and a diffuse periapical radiolucency in the second premolar and molar region. (Figure 2). The surrounding bone also showed areas of altered trabeculae. The lamina dura of the adjacent second molar was also indistinct. The orthopantomogram (OPG) showed (Figure 3) generalized loss of lamina dura in all the teeth. The inferior cortex of the mandible was thin on both the sides. There was generalized rarefaction of bone with irregular radiolucent lesion in the mandibular right quadrant in the periapical region of the mandibular right second premolar till the second molar. The outlines of the inferior alveolar nerve canal were not traceable clearly. There was no significant root resorption noted. The mandibular left first molar was missing and the third molars in all four quadrants were in their normal stages of development. The hand- wrist radiograph was taken which showed signs of subperiosteal erosion (Figure 4). Cone-beam computed tomography (CBCT) examination (Figure 5) showed, generalized altered bony trabeculae with ground glass appearance, bi- cortical expansion of the mandible. Focal lytic area was seen in the mandibular right body.

Figure 1: Intra oral photograph.

Figure 2: Intra oral periapical radiograph showing deep restoration with periapical rarefaction.

Figure 3: Orthopantomograph findings.

Figure 4: Hand wrist radiograph showing sub periosteal erosions.

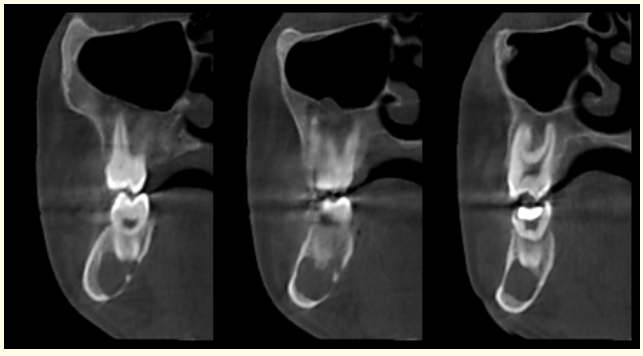

Figure 5: Advanced imaging by CBCT appreciating the changes.

The lamina dura around all the teeth were not traceable.

Thus, considering the radiographic findings of generalized rarefaction of bone with loss of lamina dura and focal lytic areas in the mandible, a diagnosis of hyperparathyroidism was made with a differential Diagnosis of Fibrous Dysplasia, Paget's disease and biochemical investigations were carried out for confirmation of the same.

Table 1 shows the reports of the investigations and were indicated a hyperparathyroidism status. There was a marked increase of parathormone level (277.1 pg/ml), a normal calcium level and alkaline phosphatase (Table 1-3) Provisional diagnosis was confirmed as hyperparathyroidism. Thus, the diagnosis of hyperparathyroidism was confirmed.

Test	Patients value	Normal Values	Interpretation
Serum Calcium	10.6	8.-11 mg/dl	Normal
Alkaline phosphates	155	53-155 IU/L	Borderline
Parathormone	277.1	14-72 pg/mL	Increased

Table 1: Parathyroid Function Test report.

	Calcium	Phosphate	Alkaline phosphate	Urea
Primary without bone lesion With bony lesion	Increased Increased	Decreased Decreased/Normal	Normal Increased	Normal Normal/Increased
Secondary Hyperparathyroidism Due to Renal failure Due to Malabsosorption	Normal/Decreased Normal/Decreased	Normal /Increased Decreased	Normal/Increased Increased	Increased Normal
Tertiary hyperparathyroidism with bone lesion without bone lesion	Increased Increased	Normal/Decreased Decreased	Increased Normal	Normal/Increased Normal/Increased

Table 2: Showing biochemical changes in different types of hyperparathyroidism.

Discussion

Hyperparathyroidism (HPT) was first described by von Recklinghausen in 1891, who reported patients with a condition called osteitis fibrosis cystica [4]. It affects 0.05-0.1% of general population. The prevalence is 1 in 400 female and 1 in 1000 male [2] usually affecting middle aged person [5]. The term hyperparathyroidism was coined by Henry Dixon and colleagues [6]. It was realized that HPT has an effect on multiple system of the body such as renal system, skeletal system, early effect on bone such as subperiosteal erosions and loss of lamina dura [7]. Diagnosis is usually made by increased levels of Serum parathyroid hormone (normal range 14-72pg/ml), Alkaline phosphatase (normal range 53-155 IU/L) and normal levels of calcium (normal range 8-11mg/dl) [3].

Parathyroid hormone plays a crucial role in maintaining bone health and calcium and phosphate metabolism. The primary function of the parathormone is to maintain serum calcium levels in the body. Primary hyperparathyroidism is a condition when an underlying neoplasm such as a parathyroid adenoma result in increased production of parathormone. Parathormone in turn mobilizes calcium from the bone into the blood resulting in altered bony architecture. Secondary hyperparathyroidism is a sequela of conditions such as chronic renal failure or severe prolonged Vitamin D deficiency. Kidneys play an important role in the production of 1, 25 dihydroxy cholecalciferol which is the physiologically active form of Vitamin D that aids in the absorption of calcium from the intestine. Thus, chronic kidney disease or severe vitamin D deficiency which causes reduced serum calcium levels, stimulates excessive production of parathormone resulting in secondary hyperparathyroidism. [10]

Tertiary hyperparathyroidism is a condition that occurs when an excess of parathormone is secreted by parathyroid glands, usually after longstanding secondary hyperparathyroidism.[11]

Increased osteolytic activity due to high levels of parathormone results into formation of osteolytic lesions in the jaw bones. These are giant cell tumors which are known as brown tumor (osteitis fibrosa cystica) due to the brown color of the cross section of the cut surgical specimen due to high hemosiderin content. [12] These are rare tumors that appear in the late stage of the disease affecting women more often than men. [13] Though brown tumor are solitary, Chirihan Ayadi et al have reported a case of multiple brown tumors. [13]

Jackson and Frame in 1972 have described a tetrad of findings in hyperparathyroidism which include 'bones, stones, abdominal groans, psychic moans with muscle overtones. Bone pain may be caused due to the changes described above. Prolonged hypercalcemia may lead formation of nephrolithiasis (renal stones) which have been reported by PV Wanzari eat al [14] While symptoms of vomiting, peptic ulcers lead to abdominal pain, CNS manifestations cause mood changes and psychic disturbances. Hypercalcemia also leads to muscular pain and discomfort. In the present case also, the patient complained of lethargy, bone pain and mild state of confusion. The bony changes are more likely to occur in the mandible (40.8%) than the maxilla (29.4%). In many cases (29.8%) there may be involvement of both the jaws. [15]

Other findings reported in patients with hyperparathyroidism include anorexia, bloating, constipation, weight loss, pruritus, polyuria, nocturia, polydipsia. [16] Subperiosteal bone resorption is a striking feature of this disease and commonly seen in the middle phalanx, distal radius, humerus, and clavicle.[16] Similar resorption of the middle phalanx was noted in the present case as well.

The oral physician plays important role in the detection of HPT [3]. Occasionally, the first sign of the disease may be a cyst in the jaw. The disease should be considered by the dentist whenever single or multiple radiolucency's are observed on radiographs of the jaw. It is important for an oral physician to be aware of the various oral and extra oral findings so that the disorder can be diagnosed correctly followed by a precise and prompt treatment. There is higher risk of bone fracture, before providing endodontic treatment [9].

Conclusion

This case report emphasizes the role of oral manifestation in the diagnosis of systemic diseases. The role of an oral physician and radiologist in identifying these changes will help in early diagnosis and timely management of these conditions.

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Case Report

Knife or light? A case report of recurrent telangiectatic granuloma

Nida Shah[1]*, Sonali Kadam[1], J Anusree[1], Shubhangi Patil[2]

[1]Dept. of Oral Medicine and Radiology, Government Dental College & Hospital, Mumbai, Maharashtra, India
[2]Dept. of Oral and Maxillofacial Pathology and Microbiology, Government Dental College & Hospital, Mumbai, Maharashtra, India

Abstract

This paper intends to highlight the importance of LASERS (Light Amplification by Stimulated Emission of Radiation) in the treatment of recurrent telangiectatic granuloma.

A Diode soft tissue cutting LASER of 810 nm wavelength, 1.8 W, contact LASER was used in continuous mode to excise recurrent telangiectatic granuloma. The lesion was successfully excised with no recurrence and postoperative complications thereafter.

Telangiectatic granuloma has a tendency to bleed profusely due to its rich vascular supply, with scalpel surgery handling of the tissue becomes cumbersome and there is an increased chance of leaving behind a tissue remnant leading to recurrence of the lesion if not excised or curetted completely. On the other hand, LASER has an advantage of much lesser intra operative bleeding making the procedure easier which enables to excise and curette the tissue completely and hence no recurrence. It does not need administration of local anaesthesia and application of sutures thus avoiding the use of needles. It is a painless, fearless and bloodless procedure. Hence, although scalpel (knife) can be used to excise the lesion, LASER (light) has many more advantages that makes it a preferred choice for the treatment.

Keywords: Pyogenic granuloma; Telangiectatic granuloma; Recurrent, Diode LASER; LASER.

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1. Introduction

Telangiectatic granuloma which is traditionally called as ‘pyogenic granuloma’ is a benign vascular tumorlike growth noted on skin and oral mucosa. The most common site of occurrence is the gingiva (75%) followed by lips, tongue, buccal mucosa and occasionally on other areas. The term ‘pyogenic granuloma’ is a Latin term which means producing or generating pus by an infectious agent is considered a misnomer. ‘Telangiectatic granuloma’ is a Greek term which means dilated capillary vessels is considered a more appropriate term.[1] The etiology of the lesion is usually considered as some form of trauma to the tissues which paves a pathway for the invasion of nonspecific types of microorganisms. The tissues respond in a characteristic manner to these organisms of low virulence by the overzealous proliferation of a vascular type of connective tissue. The lesion appears as a reddish blue smooth or lobulated growth the surface of which maybe ulcerated. The growth maybe sessile or pedunculated involving most commonly the facial aspect of maxillary anterior gingiva including the interdental gingiva.[2] The size of the lesion may grow upto a considerable size which becomes a matter of concern due to its resemblance to a cancerous growth or some vascular malformation and it becomes necessary to excise a lesion and do a histopathology for the same. The lesion may get traumatized posing a difficulty in eating and talking and it also affects the aesthetics of the patient. Moreover, the patient gets anxious about it being a cancerous growth and hence it is necessary to treat it and reassure the patient. The recurrence rate of telangiectatic granuloma is 16%.[3] Surgical scalpel excision and curettage is the conventional method of approaching the lesion. Other methods of treatment used are electrocautery, chemical cautery with silver nitrate without excision, cryotherapy, LASER excision using diode LASER, carbon dioxide LASER, Nd:YAG LASER, medical management including topical imiquimod cream, alitretinoin

*Corresponding author: Nida Shah
Email: snida214@gmail.com

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gel, timolol, propranolol and intralesional therapy with corticosteroids and sclerosants such as ethanolamine oleate, sodium tetradecyl sulfate, polidocanol, and bleomycin.[4] In this case report we will look into a successfully treated case of recurrent telangiectatic granuloma with diode laser. It was previously excised surgically using a scalpel which failed and the lesion recurred. This case report highlights the importance of taking appropriate measure to treat telangiectatic granuloma using diode LASER which alleviates the problems and complications associated with traditional methods.

2. Case Report

A 30 years old female patient reported to the department of Oral Medicine and Radiology with the chief complain of painless tumor like growth in the gums of the upper front teeth region of the jaw.

The history of present illness revealed that the patient was apparently alright two months back when the patient experienced small growth in the gingiva in the upper front region of the jaw which increased gradually. The patient then underwent scalpel surgical excision of the lesion past one month after which the lesion recurred within 15 days. The lesion was smaller in size and grew larger gradually. There was associated bleeding on brushing or slightest provocation of the growth. There was no relevant medical history as given by the patient. Past dental history was the scalpel surgical excision of the gingival growth. No habit history was given by the patient. No history of pregnancy or administration of oral contraceptives, hormonal pills was given.

On careful clinical examination a small, reddish pink, firm, lobulated, pedunculated gingival growth was seen in between maxillary right and left central incisor involving the interdental gingiva. The growth measured 1 cm x 1cm approximately. The surface of the growth was smooth and ulcerated in some region. The adjacent areas of the teeth and gingiva showed plaque retention. Bleeding on provocation was noted. **(Figure 1)**

Figure 1: A small, discrete, reddish pink, firm, lobulated, pedunculated gingival growth in between maxillary right and left central incisor involving the interdental gingiva measuring 1cm x 1cm approximately.

Based on the clinical findings a provisional diagnosis of pyogenic granuloma was given. Differential diagnosis included peripheral giant cell granuloma, inflammatory gingival enlargement, haemangioma, vascular malformation. Chairside investigation of diascopy test and palpation of the lesion for bruit helped us rule out the possibility of vascular malformation.

A radiograph of the maxillary right and left central incisor was made using intra oral periapical technique to rule out any severe bony changes which is usually associated with peripheral giant cell granuloma. A mild bone loss in the interdental crestal region was noted between maxillary right and left central incisor and radiographic inference of mild periodontal bone loss was given. **(Figure 2)**

Figure 2: Radiograph of maxillary right and left central incisors showing mild interdental bone loss in the crestal region.

A LASER excision of the lesion was proposed as a treatment plan. The patient was explained about the lesion and its treatment procedure in detail. Investigations such as complete blood count, bleeding time and clotting time was advised and the patient was appointed for the LASER excision procedure.

Localized scaling in the maxillary anterior region was performed a week before the LASER excision to eliminate the local irritant. The patient reported with the investigations of complete blood count, bleeding time and clotting time all of which was within normal physiological limits. Informed consent of the patient and the accompanying relative was taken. The procedure was explained in detail to the patient. The patient was conscious and well oriented with time, place and person.

The lesion was excised in to using a soft tissue cutting diode LASER of 810 nm wavelength and 1.8 W power. The tip of the LASER was kept in contact of the mass and was used intermittently in swaying motion. The LASER was used in a continuous mode. The interdental region and the margin

of the lesion was curetted carefully. Suturing was not required as the wound created was small and there was very less and controlled intra operative bleeding. The postoperative wound was allowed to heal by secondary intention. The tissue specimen was kept in 10% formalin solution and then sent for histopathological evaluation to the Department of Oral and maxillofacial microbiology and pathology. **(Figure 3a,b)**

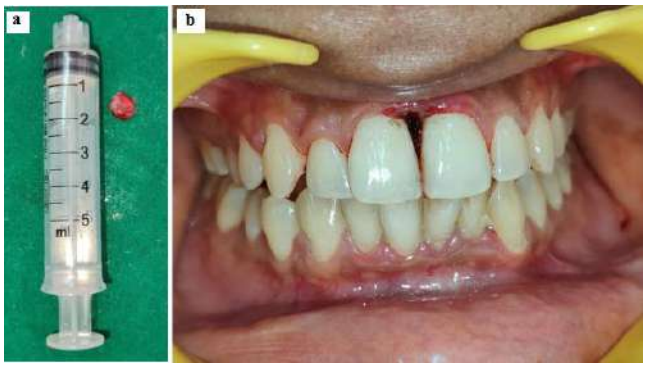

Figure 3: Excised specimen and postoperative clinical picture after LASER excision of the lesion.

After the completion of the procedure the patient was kept under observation for an hour. The patient was given postoperative instructions to maintain oral hygiene and rinse the oral cavity using chlorhexidine 0.2% mouthwash thrice a day, apply choline salicylate (8.7%) and lidocaine 2% gel on the site of operation thrice a day for three days, and take Tab. Diclofenac sodium 50 mg stat. There was no immediate postoperative complication reported.

The patient was recalled after three days for the follow up and the monitoring the healing of the lesion. The healing followed a normal course, with fibrin formation at the site. **(Figure 4)**

Figure 4: Clinical picture on the third day of follow up.

The patient reported after a month with complete healing of the lesion and no recurrence of the growth was noted. Reformation of interdental papilla was noted. The patient was advised to undergo complete oral prophylaxis and maintenance of oral hygiene. The patient reported after two months with no recurrence, complete healing and maintained oral hygiene. **(Figure 5,6)**

Figure 5: Clinical picture after one month of follow up.

Figure 6: Clinical picture after two months of follow up.

Histopathological report showed haematoxylin and eosin-stained section under scanner view showed parakeratinized stratified squamous epithelium of varying thickness. Connective tissue stroma is fibrocellular with dense bundles of collagen fibres arranged haphazardly interspersed with spindle and plump shaped fibroblast. Diffuse, dense, chronic inflammatory infiltrate are also noted. Numerous dilated endothelial lined blood vessels engorged with red blood cells are noted. Areas of haemorrhage and hemosiderin pigment is also noted. Areas of degeneration and necrosis also noted. Overall features suggested the lesion as 'telangiectatic granuloma'. **(Figure 7)**

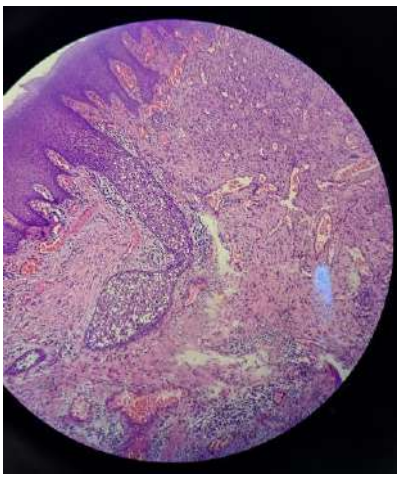

Figure 7: 4x view H & E-stained section under scanner view showing parakeratinized epithelium, fibrocellular connective tissue stroma, chronic inflammatory infiltrate and endothelial lined blood vessels engorged with red blood cells.

3. Discussion

According to the WHO classification of 2015, telangiectatic granuloma is a vascular entity that is included in the gingival disorders and edentulous alveolar ridges subgroup.[5] Pyogenic granuloma is a common benign mucocutaneous lesion. It was first described by Poncet and Dor in 1897. The term pyogenic granuloma is now considered a misnomer as it

does not produce pus.[6] In literature various names have been given to this lesion; botryomycosis hominis, botryomycoma, telangiectatic granuloma, benign pedunculated granuloma, pseudobotryomycosis, fibroangioma, Croker and Hartzell disease, septic granuloma, hemangiomatous granuloma, lobular capillary hemangioma, eruption capillary hemangioma.[7-9] Due to the histopathological appearance of capillaries engorged with red blood cells which literally means 'telangiectasia' as seen in our case, it would be more appropriate to call the lesion as 'telangiectatic granuloma'.

Clinically telangiectatic granuloma appears as a dull reddish pink or blue, sessile, or pedunculated smooth surfaced nodule that may easily bleed, crust, or ulcerate. Lesions may grow rapidly, reach its maximum size, and remain static.[10] The most common site affected is gingiva as seen in the present case, which accounts for 75% of all cases. Poor oral hygiene and presence of local irritational factors acts a precipitating factor predisposing to the inflammation. The lip, tongue, and buccal mucosa are the next most common sites. Minor trauma or chronic irritation to the tissue is found as a precipitating factor in majority of the cases.[11] Other factors which contribute to the etiopathogenesis are; viral oncogenes, hormonal influences, microscopic arteriovenous malformation along with inclusion bodies and gene depression in fibroblasts.[12]

Telangiectatic granuloma may appear at any age, 60% cases are observed between the ages of 10 and 40. Peak incidence is seen during the third decade of life. Female predilection is twice as that in male, as seen in this case. It is more common in children and young adults.[13] Endothelial cells are able to proliferate under inflammatory stimuli by increased secretion of angiogenetic growth factors such as VEGF (vascular endothelial growth factor) and basic fibroblast growth factor. Female sex hormones such as oestrogen and progesterone may stimulate the secretion of these factors from activated monocytes/macrophages that protects from apoptosis and leads to the development telangiectatic granuloma by vascular proliferation. The incidence of telangiectatic granuloma is a common finding in pregnant women in the first trimester, also called as 'pregnancy tumor' or 'granuloma gravidarum'.[14] Hence, it is very important to take careful history of pregnancy or administration of any hormonal pills or oral contraceptive agents.

Differential diagnosis includes haemangioma, peripheral giant cell granuloma, peripheral ossifying fibroma and metastatic carcinoma, and amelanotic melanoma.[15]

Surgical scalpel excision and curettage is the conventional method of approaching the lesion. Other methods of treatment used are electrocautery, chemical cautery with silver nitrate without excision, cryotherapy, LASER excision using diode LASER, carbon dioxide LASER, Nd:YAG LASER, medical management including topical imiquimod cream, alitretinoin gel, timolol, propranolol and intralesional therapy with corticosteroids and sclerosants such as ethanolamine oleate, sodium tetradecyl sulfate, polidocanol, and bleomycin.[16]

The principle behind working of LASER is selective photo thermolysis. The light energy absorbed by the tissues is converted into the heat energy. The heat energy diffuses through the tissues causing mechanical injury to the blood vessels due to photocoagulation. The Diode LASER works on "hot-tip" effect. Accumulation of heat at the fibre tip results into thick layer of coagulation on treated surface area.[17]

4. Conclusion

The mainstay of the treatment of telangiectatic granuloma is that the lesion has to be completely excised and curetted leaving no amount of remnant tissue behind which would then tend to recur later. It can be achieved by both scalpel surgical excision (knife) and LASER excision (light) effectively. LASER excision however, has got an added advantage of relatively bloodless surgery and ease of handling the tissue as telangiectatic granuloma is a highly vascular lesion that bleeds easily on slightest provocation. It is a painless procedure which does not need an administration of local anaesthesia thereby warding off the fear of needle prick in patients. Postoperative healing is excellent which does not necessitate the use of sutures. Also, there is minimal swelling, scarring and coagulation, reduction in surgical time and less or no postsurgical pain and complications in healing making it a better choice of treatment.

5. Ethics Approval

No ethical approval is required as this is not a research involving humans or animals.

6. Consent to Participate

Written informed consent was obtained from the concerned patient and relative.

7. Consent to Publish

The authors affirm that participants provided informed consent for publication of the images in figures 1-7 and the clinical details.

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9. Conflict of Interest

None.

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Self - Healing Traumatic Bone Cyst of the Mandible: A Case Report

Dr. Anusree J[1], Dr. Easwaran Ramaswami[2], Dr. Sonali Kadam[3], Dr. Vijayalaxmi Nimma[4], Dr. Siddhi Rane[5], Dr. Suraj Bhoye[6]

[1]B.D.S. (Second year Post graduate student), Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai.
[2]M.D.S. Professor & Head of the Department, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai
[3]M.D.S. Associate Professor and Professor (Academic), Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[4]M.D.S. Assistant Professor and Associate Professor (Academic), Department of Oral Medicine and Radiology Government Dental College and Hospital, Mumbai
[5,6]B.D.S. (Second year Post graduate student), Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai.

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ABSTRACT

Traumatic bone cyst (TBC) is a rare jaw lesion, most often detected incidentally on radiographic examination. Its etiopathogenesis remains uncertain, although trauma is considered a possible factor. This report describes a 24-year-old male patient with a history of trauma, in whom a traumatic bone cyst was incidentally identified during radiographic evaluation. A conservative approach with periodic monitoring was adopted. Follow-up imaging after one year showed marked reduction in lesion size with progressive bone healing. This case emphasizes the potential for spontaneous resolution in asymptomatic traumatic bone cysts and highlights the importance of regular follow-up before considering surgical intervention.

Keywords: Intraosseous pseudocyst; Simple bone cyst; Traumatic bone cyst; Trauma–haemorrhage theory.

INTRODUCTION

Traumatic bone cyst (TBC) was initially described by Lucas and Blumin in 1929.[1] It is classified as an intraosseous pseudocyst. They are asymptomatic and are usually seen during routine radiographical examination.[2]

Traumatic bone cysts have been reported in the literature under a variety of names: solitary bone cyst, haemorrhagic bone cyst, extravasation cyst and simple bone cyst. The multitude of names applied to this lesion implies the lack of understanding of the true aetiology and pathogenesis.[3]

Although the exact etiopathogenesis of the lesion remains uncertain, though it is often associated with trauma.[4]
This report describes a 24-year-old male with a history of trauma resulted in tooth cusp fracture, where a traumatic bone cyst was incidentally detected on radiographic examination.

Case Report
A 24-year-old male patient reported to the department with the chief complaint of a broken tooth in the lower left back tooth region. The history of present illness revealed that he had fallen from his two-wheeler 3 months back while riding it on a gravel road, and during the fall, some gravel entered his mouth, which he accidentally bit on. No other significant injury was reported by the patient in the maxillofacial region.

The patient had no relevant past medical or dental history. Extraoral examination revealed no significant findings. Intraoral examination showed fractured lingual cusps of the mandibular left second molar, and tenderness was elicited on percussion in relation to the mandibular left second molar. Based on these findings, a provisional diagnosis of mesiolingual cusp fracture with periapical pathology in relation to the mandibular left second molar was made.

An intraoral periapical radiograph was advised as it is the basic investigation of choice to examine the periapical aspect of the tooth, which revealed apical periodontitis in relation to the mandibular left second molar. An orthopantomogram

(OPG) was also advised to assess any possible fractures, considering the patient's history of trauma, although no significant findings related to maxillofacial trauma was noted on clinical examination.

The OPG revealed a well-defined radiolucency in the mandibular left posterior tooth region, extending mediolaterally from the distal aspect of the mandibular left first premolar to the mesial aspect of the mandibular left second molar, and superoinferiorly from the periapical aspect of the mandibular left second premolar, first molar to the inferior border of the mandible. The internal structure appeared radiolucent, with the periphery showing ill-defined corticated areas. The lesion appeared to extend between the interradicular areas of these teeth. In addition, a mesiodens was also noted in the OPG **(Figure 1)**.

Figure 1: Orthopantomogram showing well defined radiolucent area in the mandibular left premolar- molar region.

Based on these findings, in addition to the fractured cusp with apical periodontitis in relation to the mandibular left second molar, the OPG also revealed a cystic lesion in the mandibular left posterior tooth region, most probably a traumatic bone cyst, considering the history of trauma.

Odontogenic Keratocyst (OKC) was considered as another radiographic differential diagnosis, as there was no significant expansion of cortical plates clinically and the radiolucency was growing between the roots. However, the margins are not well scalloped, no displacement teeth, no resorption of the roots and no displacement of the inferior alveolar nerve canal seen, so OKC was considered less likely.

Another differential diagnosis of radicular cyst is also less likely as the epicentre of the radiolucency is placed anterior to the fractured tooth. Another possibility was the initial stages of periapical cemento-osseous dysplasia, but this was considered unlikely, as such lesions are less common in the mandibular posterior region and usually appear smaller than the radiolucent area observed in this OPG. Thus, a radiographic diagnosis of traumatic bone cyst was made.

Cone beam computed tomography advised for the patient which revealed a well-defined hypodense area in the left posterior mandible measuring about 10 mm x 15.5 mm x 28.3 mm in the anteroposterior, superoinferior and mediolateral dimension. The periphery of the lesion well defined in most areas and ill-defined in some areas with no effect on the adjacent structures **(Figure 2)**.

Endodontic treatment was performed on the fractured mandibular left second molar, while no treatment was advised for the traumatic bone cyst. The patient was kept under regular follow-up.

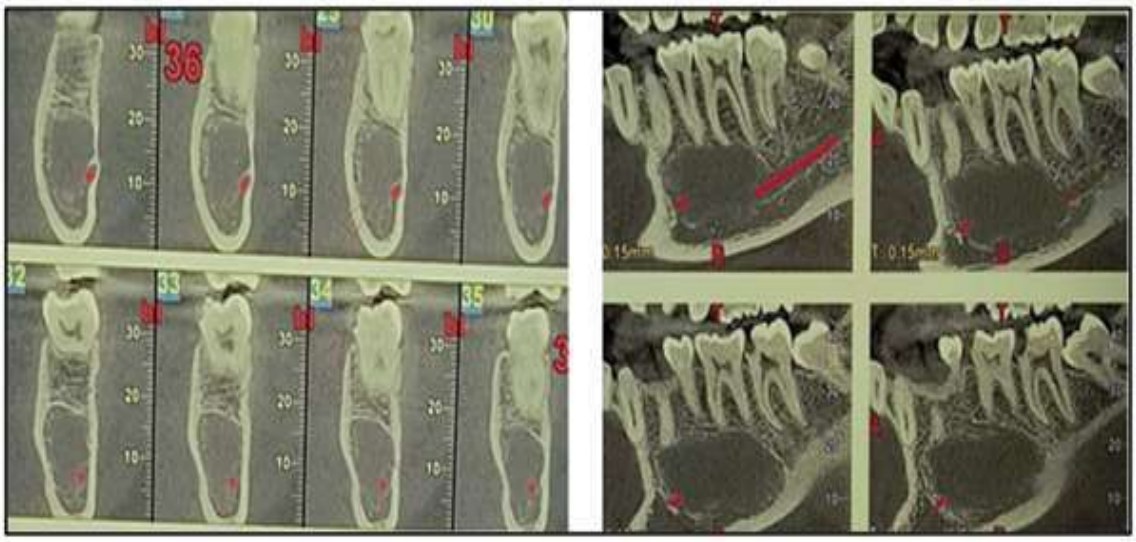

Figure 2: Cone Beam Computed Tomography showing a hypodense area without any buccal or lingual cortical layer perforation or root invasion.

A follow-up OPG taken after 6 months showed evidence of healing of the traumatic bone cyst lesion. A subsequent OPG taken after 1 year demonstrated significant reduction in the size of the cystic lesion, along with further healing **(Figure 3)**. The patient is currently under periodic follow-up.

Figure 3: Follow – up orthopantomogram after one year showing significant reduction in the size of the cystic lesion.

DISCUSSION

Traumatic bone cysts are relatively rare lesions. The pathogenesis of TBC is believed to involve multiple factors. [5] The etiopathogenesis of simple bone cysts (SBC) has not been clearly established to date. Harnet et al. summarized three main hypotheses: (1) abnormal bone development, (2) cystic change secondary to tumor degeneration, and (3) the trauma–haemorrhage theory. Among these, the trauma–haemorrhage theory is the most widely recognized. It proposes that trauma within the bone marrow results in intramedullary bleeding and hematoma formation. The resulting increase in pressure may obstruct venous drainage, leading to fluid accumulation. Enzymatic activity within this exudate further enhances bone resorption, ultimately causing aseptic necrosis of the marrow. This explanation also accounts for the

higher frequency of SBC in the mandible compared to the maxilla. The maxillary alveolar bone has a thinner cortex, richer vascularity, and a greater number of nutrient foramina, allowing better microcirculation and repair. In contrast, the mandible has a denser, thicker cortex and reduced regenerative potential. [6] Despite the wide acceptance of the trauma–haemorrhage theory, definitive evidence linking trauma as the sole causative factor is lacking.[7,8]

Most unicameral bone cysts occur in the mandible, particularly in the posterior region and ramus. Occurrence in the maxilla is uncommon. Typically, these lesions develop between tooth roots, present with a scalloped margin, and rarely cause displacement or resorption of adjacent teeth. [9]

Several studies have reported that fibro-osseous lesions—such as fibrous dysplasia, cemento-osseous dysplasia and ossifying fibroma may be associated with cyst-like lesions lacking an epithelial lining, such as simple bone cysts.[10]

Management of idiopathic bone cavities remains debatable and varies case by case.[11] Some reports indicate that TBCs may resolve spontaneously without intervention.[12] However, in larger or symptomatic lesions—especially those demonstrating progressive changes in size, border definition, or cortical integrity—surgical treatment is considered the most reliable approach. Therapeutic procedures include exploration, curettage, fenestration, or cavity packing to stimulate bone healing. Among these, surgical exploration combined with curettage is strongly recommended, as it not only confirms the diagnosis but also promotes bleeding within the cavity, encouraging bone regeneration through mesenchymal cell differentiation. [13]

The present report suggests that a conservative approach may be considered in asymptomatic traumatic bone cysts with no significant cortical expansion. This case further illustrates the potential of traumatic bone cysts to undergo resolution over time, as demonstrated in the case reported here.

CONCLUSION

Traumatic bone cysts are uncommon, benign intraosseous lesions with uncertain pathogenesis. While surgical exploration remains the standard approach in many cases, this report highlights that a conservative “wait-and-watch” strategy may be considered for asymptomatic lesions without cortical expansion. Regular follow-up is essential, as these lesions may demonstrate progressive healing over time, as seen in the present case.

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DENTIST'S DILEMMA ON MR SAFETY OF DENTAL MATERIALS

Dentistry

Dr. Vijayalaxmi Nimma Associate Professor (Academic) Department Of Oral Medicine Diagnosis And Radiology Government Dental College And Hospital, Mumbai, PD'Mello Road, St.George Hospital Campus, Near Chatrapati Shivaji Terminus, Mumbai, Maharashtra, India, 400001

Dr. Easwaran Ramaswami Professor And Head Department Of Oral Medicine Diagnosis And Radiology Government Dental College And Hospital, Mumbai, PD'Mello Road, St.George Hospital Campus, Near Chatrapati Shivaji Terminus, Mumbai, Maharashtra, India, 400001

Dr. Nitika Aggarwal Post Graduate Student Department Of Oral Medicine Diagnosis And Radiology Government Dental College And Hospital, Mumbai, PD'Mello Road, St.George Hospital Campus, Near Chatrapati Shivaji Terminus, Mumbai, Maharashtra, India, 400001

ABSTRACT

Magnetic Resonance imaging (MRI) is non-invasive and non-ionizing imaging modality providing highly sensitive and specific soft tissue contrast. It can be used to assess intracranial and extra cranial lesions particularly those involving the soft tissues. MRI has the shortcoming of being prone to magnetic susceptibility difference artefacts, caused by the presence of metallic materials such as dental restorative materials, implants and orthodontic appliances. All substances when placed in a magnetic field are magnetized to a degree which varies according to their magnetic susceptibility. The presence of dental materials in patients' body during MRI is a contentious issue which has no uniform standing. There is difference of opinion among radiologists, some proceed without removal and some insists removing of dental materials like prosthesis and appliances prior to MRI. However, the literature exhibits conflicting results regarding the severity of undesirable effects triggered by different dental materials. For the obvious advantages that MRI offers the probabilities of patient undergoing MRI for various diseases and lesions of head and neck region are higher. This has led to the question of whether the dental materials in the craniofacial region are acceptable or need to be removed during the imaging procedure of MRI. This review will brief you regarding the MR imaging and its effects on various dental materials, dental materials compatibility and recommendations to dentist to inculcate practice of using MR Safety documentation.

KEYWORDS

Magnetic resonance imaging (MRI), dental materials, MR safety, artifacts in MR Image.

INTRODUCTION:

Advanced imaging modalities have definitely increased the horizons of health care practices, Magnetic Resonance Imaging (MRI) is one such imaging modality which is a non-invasive imaging technique widely used for evaluating various medical and dental conditions without involving ionizing radiation. In dentistry, MRI finds major applications in examining soft tissue lesions, salivary gland pathologies, and internal derangements of the temporomandibular joint(TMJ), benefiting from its exceptional soft tissue contrast resolution.[1] Researchers have noted MRI's superiority in detecting tumor staging, odontogenic cysts, and perineural spread compared to computed tomography (CT).[2] Despite its benefits, MRI is contraindicated in with ferromagnetic medical devices or dental materials in their bodies, as these can interact detrimentally with the MRI's magnetic field. Such interactions may result in undesirable effects like artifact production, radiofrequency (RF)-induced heating, and magnetically induced displacement of objects. Among dental materials, metallic dental devices like orthodontic brackets, metal crowns, and dental implants have been found to cause artifacts in oral and maxillofacial MRI, potentially complicating diagnostic interpretations.[3]

Magnetic Force And Types Of MRI:[1]

It is measured in tesla (T). MRI uses 1.0-1.5 T, more powerful MR scanner uses 3.0 T. Compared to earth's magnetic force (50 μT); it is 10,000 times more powerful.

Based On The Magnetic Field Strength: Low-field MRI scanners (0.23 T-0.3 T): They are typically identified as open MRI scanners, have decreased image quality and require a longer scan time compared to high-field MRI scanners.

High-field MRI Scanners (1.5 T to 3.0 T): These are typically identified as closed MRI scanners. A 1.5 T MRI scanner provides great image quality, fast scan times, and the ability to evaluate how certain structures in the body function. The 3.0 T MRI scanner is great for visualizing very fine detail, such the vessels of the brain or heart.

Ultra-high Field MRI Scanners (7.0 T to 10 T): It is not widely available and is typically used for research.

Implications Of Dental Materials On MRI

Dental materials have important implications on the use of MRI as a diagnostic imaging Modality which can be categorized into

a) Radio Frequency-driven Heating:

Dental treatments use metals for manufacturing crowns, orthodontic wires, implants, restorations etc., which are affected by radiofrequency driven heating, further resulting in its displacement or damage to its mechanics or damage to underling mucosa. The first potential method of displacement of the crown is that radiofrequency energy is absorbed, resulting in heating, compromising the adhesion of the crown to the tooth structure. Increases of less than 1^0C, remain well below natural variations induced while eating and drinking, and similar results have been confirmed for other intraoral and intracranial medical devices made of steel. There is estimated risk of injury from radiofrequency heating of metallic dental devices during 3.0T MRI. Relatively minor RF heating ($< 2^0$ C) of the dental castings in the normal mode should not pose a risk to patients, however orthodontic appliances may exhibit RF heating above the industrial standard; therefore, the wire should be removed from the bracket or a spacer should be given between the appliance and the oral mucosa during MRI.[4]

b) Magnetically Induced Displacement Forces

Other issue is with the crowns or the fixed prosthodontic crowns, causes of fixed prosthodontic retention loss include adhesive or cohesive failure of cement, excessive crown taper, short clinical crown length or recurrent caries. These factors may contribute but would be significantly coincidental given the timing of retention failure with the diagnostic scan. The strength of the magnetic field can have a "projectile effect" by pulling ferromagnetic materials. Due to this strong magnetic field stringent safety mechanisms are practiced.[5] Metal objects are removed by the patient prior and any medical implantable devices must to be checked for their compatibility with magnetic resonance. There is a relevant risk in the presence of inadequate bonding to the teeth. Thus, it is mandatory to check bond strength prior to a MRI examination. However, the 60N that is required to loosen a sufficiently strong bond is not even achieved by 3 Tesla.[6] The translational attraction and torque from magnetic field interactions may cause the movement or dislodgement of a ferromagnetic restorations, implant, fixed prosthodontic dentures resulting in possible injury to the patient. The translational attraction is dependent on the strength of the static magnetic field, the spatial gradient

magnetic field and the object's mass, shape and magnetic susceptibility. [4]Though the retentive force of the dental luting cement is reportedly 48-150N, which is sufficiently strong, the fixation of ferromagnetic devices to the dental prosthesis or abutment teeth should be checked before and after the MRI because of the possibility of cement degradation. The ferromagnetic components of the patient's crown may have created enough displacing forces to overcome the already compromised retentive force of the luting cement on the crown. It is recommended that ferromagnetic containing dental prosthesis are checked for retention prior to and after the MRI scan.[7]

c) Image Artefact

An 'artefact' may be defined as a distortion of signal intensity or void that does not have any anatomic basis in the plane being imaged. The size and shape of the artefact depends on the magnetic properties of the metal object examined, on its size and shape, space orientation and the homogeneity of the alloy.[8] Dental restorations usually contain precious metals such as gold (Au), silver (Ag), platinum (Pt) and non-precious alloys like chromium (Cr), cobalt (Co), molybdenum (Mo), nickel (Ni) and other metals like titanium (Ti) and titanium alloys. Many of these materials can influence the MR image quality and may cause artefacts to various degrees. [9]This clearly impedes identification of anatomical areas and the detection of pathology, ultimately hindering accurate medical diagnosis. Magnetic susceptibility artefacts in MRI typically involve image degradation of signal distortion occurring in tissues adjacent to the interfering compounds. These compounds become magnetized when placed in a large superconducting magnet, creating their own magnetic fields, and largely alter the precession frequencies of protons in adjacent tissues. The shape of the metal may alter the size and configuration of the metallic artefact on MR images, even if the volume and weight are the same.[5]

Common Materials Used In Dentistry:

Dental materials classified based on magnetic susceptibility as Ferromagnetic: These are those types of materials which are strongly attracted to a magnet. Their permeability is very high in the range of hundreds and thousands. Examples include chromium oxide,cobalt, ferrite (iron), cadolinium, nickel, rare earth magnet, magnetite, yttrium, etc. Paramagnetic: These are those materials which are not very strongly attracted to the magnet. They are slightly magnetized when placed in a strong magnetic field and act in the direction of the magnetic field. Their relative permeability is slightly more than one. Examples of such materials are magnesium, tin, platinum, lithium, tantalum, aluminum, molybdenum, etc. and Diamagnetic: These are those materials which are repelled by a magnet. They are slightly magnetized when placed in a strong magnetic field and act in the direction opposite to that of the magnetic field. Their permeability is slightly less than one. Examples are wood, zinc, copper, bismuth, silver, gold, etc., are diamagnetic materials. [10]

Compatibility Of Dental Materials:

Schenck Categorized The Dental Materials Into Three Groups According To The Magnetic Susceptibility Difference:[11]

Compatible Material: Create no detectable distortion in MRI image e.g. Resin-based root canal sealer, glass ionomer cement, gutta-percha, zirconium dioxide and some composites.

Compatible I Material: Noticeable distortions created in MRI image and acceptance depends on the application e.g. some composites, amalgam, gold alloy, gold-ceramic crowns, titanium alloy, Ni-Ti orthodontic wires.

Non-compatible: Strong image distortions produced in MRI image e.g. Stainless steel orthodontic appliances (wires and brackets), Co-Cr alloys and porcelain fused to metal alloys.

Recommendations For Dentist:

With the increasing use of MRI technology, dentists should be aware that dental materials affect MR images and MR technology affects dental materials. The two internationally recognized definitions for classifying MRI interactions with medical devices: "MRI safe" meant that the device does not trigger any significant effects on surrounding tissue when exposed to magnetic forces. This definition thus focused on patient safety, and the synonym "first-order MRI compatibility" was introduced by Schenck.[11] "MRI compatible" (or "second-order MRI compatibility") meant that a device, in addition to being MRI safe, would not generate any clinically relevant imaging artifacts.[5] However, these definitions were modified by the American Society for Testing and Materials (ASTM) in 2005. Since then, the term "MRI compatibility" has been formally abandoned. The new system defines three classes of risk: "MRI safe" means that a device poses no risk whatsoever to patients, medical staff, or any other individuals present within the controlled area while an MRI scan is being prepared or executed Conversely, "MRI unsafe" devices are expected to carry such a risk. A third class called "MR conditional" indicates that a device requires specific conditions to be safe, which are subject to mandatory labelling.[5]

For dental materials, there are currently no similar statements. Most manufacturers, when asked, recommend indiscriminately that appliances be removed prior to MR, although differentiation would be useful to eliminate the expense and discomfort of removing and reinserting fixed appliances.[12]

Guidelines To Prevent These Interactions

- Knowledge about the interaction of dental materials and MRI is essential for dentists and radiologists. MRI centers can be notified whether the restoration/appliance is MR friendly or not.
- Materials for prosthetic restoration should be selected based not only on their biological compatibility and functional and esthetic qualities, but also on whether they generate artifacts in MRI and MR safety. Prefer nonmetals like all ceramic restorations over metal ceramic. Even in metal ceramic it is better to choose a noble metal alloy.[13,14]
- Removable appliances/prosthesis are not a problem, since patient can remove it.[13]
- **Dental Amalgam-** Compatible due to the presence of non-ferromagnetic metal silver. [15]
- **Composite:** Compatible or Compatible I because of the addition of iron oxide pigments by some manufacturers. It is advisable to use compatible composite materials in the tooth of interest or its neighbours or antagonists for high-resolution dental MRI applications, such as diagnosis of caries or MRI-based dental impressions as the smallest distortion is critical and can result in wrong measurements.[16]
- **Glass Ionomer Cement-** Compatible with no influence on dental MRI.[16]
- **Dental Implants:** The interaction with MRI may result in heating & mechanical movement which are negligible but artefacts will be produced. patient with dental implant can undergo MR imaging safely.[13]
- **Osseous Fixation Plates:** Titanium plates and screws are frequently used in trauma and reconstructive surgeries of fractured maxillofacial skeleton to achieve osteosynthesis. All Titanium plates induce significant MRI artefacts which depend on the implant or plate size, configuration, magnetic field strength, MRI protocol and sequence parameters.[13]
- Fixed orthodontic treatment commonly involves the use of Ni-Ti and stainless steel arch wires with stainless steel brackets. The ferromagnetic metals nickel and chromium present in austenitic stainless steel cause large artefacts which makes MRI image analysis impossible. Magnetic field interaction results in Average deflection angle of 13° for brackets, 62° for NiTi wire and 71° for stainless steel wire were recorded by Gorgulu et al. which indicates removal of orthodontic wires before imaging. Orthodontic brackets do not pose any danger to the patient.[17]
- Treat all material as MR unsafe, if the dentist is not sure about the type of prosthesis/appliance. It is advisable to remove the prosthesis/appliances prior to MRI.

CONCLUSION:

Dental practice is having a paradigm shift, opening up new horizons which include treatments with materials which can influence the MR imaging. Knowledge of these materials and MR safety can reduce the unnecessary work up and difficulties the patient can face. Also avoid the life threatening incidences which can be just done by removal of these material sources from oral cavity. A small step towards adopting a change in the practice of incorporating use of mention or certification regarding the MR safety of materials can solve this dilemma efficiently.

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REVIEW ARTICLE

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Reframing Harm: Ethical Gaps in Trauma Informed Dental Care in India

Arya Sabnis[1*], Sonali Kadam[2], Shweta Vilvadrinath[3], Anusree J.[1], Divya Tripathi[1]

[1]Postgraduate Student, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, St. George's Hospital campus, Mumbai, India

[2]Associate Professor and Professor (Academic) , Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, St. George's Hospital campus, Mumbai, India.

[3]Assistant Professor, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, India.

Abstract

Domestic violence (DV) significantly impacts one's oral and maxillofacial health, with patients experiencing it often presenting to dental settings with unexplained trauma and a confusing history. Most common clinical manifestations of the same may include visible bruises, lacerations, tooth fractures and even temporomandibular joint disorders. Injuries of the oro-facial regions may be the first visible signs and, ironically, the hidden indicators of abuse, thereby putting dental surgeons at the forefront in suspected DV cases. The Dental Council of India emphasises patient confidentiality in the information entrusted by the patient unless the laws of the state require a revelation for medicolegal cases. There is a lack of a specific code of conduct concerning known or suspected DV cases. There are a few law enforcement helplines available for reporting such cases, like the Domestic Violence Helpline (1091) and the National Commission for Women (NCW) Helpline. However, when compared with the mandatory reporting laws in countries like the U.S. and Australia, Indian protocols remain vague and optional. There is a significant knowledge gap among the Indian dental professionals regarding how to properly identify DV while diagnosing a patient, documentation of cases and reporting procedures worsened by insufficient training and the dentist's agitation concerning legal implications. This article highlights the urgent need for incorporating structured information and awareness programs in dental curricula and continuing dental education. In conclusion, reinforcing dentists with knowledge and clear reporting channels is critical for timely intervention, ensuring that neither ethical compliance nor victim protection is compromised through the process

Keywords: Review, domestic violence, dental trauma, Maxillofacial injuries, oral health, oral injuries.

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Introduction

The pervasiveness of domestic violence can be assessed from the fact that it has been reported in different cultures and societies all over the world. Today, there is growing awareness that domestic violence is a serious issue in developing countries as well. The prevalence of domestic violence in India ranges from 6 per cent to 60 per cent, with significant variations among different states.[1]

Despite the range of abuse that may include people of all ages, genders or socio-economic status, it is the most common cause of non-fatal injury in women, who suffer, blame themselves and are unable to report it. Most of them simply accept it as their fate and continue to live with it.[2]

Dental professionals are in a unique position to identify cases of such abuse owing to their signs being most commonly visible in the head and neck region. Studies have demonstrated that the common site of injuries in domestic violence cases is the head and neck, accounting for 38.7%.[3] Domestic violence also significantly impairs the temporomandibular joint and the muscles associated with it. Even after all possible interventions, suicide and death rates among these cases are high due to a deteriorated quality of life, be it physically, aesthetically, or mentally.[4]

Corresponding Author: Arya Sabnis, Postgraduate Student, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, St. George's Hospital campus, Mumbai, India, e-mail: aryasabnis.18@gmail.com

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However, the dental professionals are not well-trained to identify such victims, and if identified, they lack the appropriate resources to manage them. This article explores the current dental scenario, especially the lack of protocol in the clinic and discusses details on how the dental professional should respond.

Signs of Domestic Abuse

Dental professionals play a crucial role in identifying potential abuse because domestic violence is often associated with the head and neck region. All the signs stated below may show overlapping features of general trauma, but these are some

features hidden in plain sight, so one ought to have awareness of how to differentiate between them. They tend to be as follows-

- Visible bruises over the malar region and surrounding eyes, especially the shape and size of the bruising indicative of a fingerprint pattern.
- Skin discolouration or scars, which may be present because of healed burns or lacerations, one should also look out for bite marks.
- Teeth may show discolouration, mobility, fractures involving enamel, dentin and root. There can be forced avulsion of the tooth out of the alveolar bone socket.[5]
- Fractures of the jaw and facial bones and malunion of previously fractured bones as incidental findings because of inadequate or no treatment.
- The temporomandibular joint is most prone to functional disturbances in the head and neck region. The patient will present with symptomatic features, which can be due to repetitive trauma and stress or anxiety-related habits like bruxism.
- Unexplained soft tissue lacerations, traumatic ulcerations or petechial haemorrhages involving the gingiva, tongue, soft palate, buccal mucosa or lips.

In our clinical experience, we have seen cases that raise suspicion while correlating the history and clinical findings. Such an example was a patient with a unilateral mandibular angle fracture who claimed to have fallen from the stairs; however, she had no other bruises or injuries indicative of the same. In a study done by Hansa Kundu et al, the relation of individual psychological, physical and sexual domestic violence was assessed with the oral health status of those with domestic violence. A significant correlation was found between psychological domestic violence and Periodontal status, and physical domestic violence with tooth fracture.[6]

How should a Dental Professional Respond?

It is a dilemma on behalf of the dentist to decide how to respond in such situations, taking into consideration the ethical responsibility along with maintaining patient confidentiality. The maximum cases we go through in India in this setting are due to Intimate partner violence.[7] The patient will have the fear of a negative impact of their confessions in such settings on their personal life and its repercussions in their social life as well. Detecting risk factors specific to rural regions, including alcoholism, poor literacy rates, and even having a girl child, should be considered.[8] Following points can be taken into consideration pertaining to the same.

- Firstly, to note any irregularities in the history given by the patient and/or the accompanying person, including time, place and order of events
- To make a safe environment for the patient that will minimise the triggers, if there are any.Ensure obtaining explicit consent of the patient before and during any procedures, may it be examination or treatment.
- Communicating using clear and simple terms without confusing the patient or using any violent language to avoid further hesitation in the conversation flow.
- Reassurance for treatment protocols and to manage general anxiety by preventing retraumatization by being mindful about the use of tone, touch and instruments.
- Recognising the psychological aspect behind the trauma, which may manifest as severe anxiety, emotions, and avoidance behaviour.
- To establish a feeling of trust and support by giving the patient choice and control during the dental procedures.
- Making proper referrals by incorporating mental health professionals at any point of the treatment, if and when required.
- To keep proper records of known domestic violence cases for further legal applications.

Discussion

The Protection of Women from Domestic Violence Act, 2005, provides for more effective protection of the rights of women guaranteed under the Constitution who are victims of violence of any kind occurring within the family and for matters connected therewith or incidental thereto. Under section 10 (1) of this act, a service provider, which includes medical professionals, can record a domestic violence incident if the aggrieved person so desires; get the aggrieved person medically examined; and ensure that the aggrieved person gets shelter in a shelter home, if she so requires [9]

However, this Act does not necessitate the need to report such a crime.

The POCSO Act, on the other hand, under section 19, necessitates the need to report such an offence to the special juvenile police unit or the local police [10]

As a medical professional, it becomes necessary to uphold the dignity of the medical code of ethics and maintain patient confidentiality. This often leads us to a dilemma where the choice between reporting such crimes and maintaining confidentiality is a tough one. According to the Indian Medical Council Regulations, 2002, section 7.14, the medical practitioner shall not disclose the secrets of the patient that have been learnt in the exercise of his/ her profession except-

- In a court of law under the orders of a presiding judge
- In a situation where there is a serious and identified risk to a person.
- Notifiable diseases.

The Dental Council of India doesn't explicitly discuss domestic violence, but it follows principles similar to the MCI code of ethics.

Conclusion

The overall prevalence of oral and maxillofacial injury and Traumatic dental injury in DV victims is 29% and 4%, respectively. Women present higher rates of OFMI (41%) and TDI (6%).[11] In India, trauma-informed care is a newly understood and not yet completely established concept. The major knowledge gap present in such scenarios is due to the lack of awareness and professional training.[12] Another

significant issue pertains to the stigma in Indian culture when it comes to understanding and treating mental health issues. This proves as an additionWal barrier for the patient to disclose their trauma in an already depressed state.

A proper interdisciplinary approach between the dental, mental health and legal professionals can nullify these problems. Additional achievable modalities include integration of training concerning psychological management in continuing education programmes or even dental curricula. This is where one can say that the horizons of dentistry are not just concerned with treating fractured bones or replacing missing teeth, but are way beyond that.

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ROLE OF FRACTAL ANALYSIS IN FORENSIC ODONTOLOGY

Oral Medicine & Radiology

Dr. Surabhi Srivastava*	MDS, (Assistant Professor)Department of Oral medicine Diagnosis and Radiology, Nair Hospital Dental college, Mumbai. *Corresponding Author
Dr. Easwaran Ramaswami	MDS, Professor and Head of Department of Oral Medicine Diagnosis and Radiology, Government Dental College And Hospital, Mumbai.
Dr. Vijayalaxmi Nimma	MDS, (Associate Professor-Academic), Department of Oral Medicine Diagnosis and Radiology, Government Dental College and Hospital, Mumbai.
Dr. Amit Ramchandani	MDS, Assistant Professor, Department of Oral Medicine Diagnosis and Radiology, Government Dental College and Hospital, Mumbai.
Dr. Nitika Aggarwal	BDS, Third year postgraduate student, Department of Oral Medicine Diagnosis and Radiology, Government Dental College and Hospital, Mumbai.

ABSTRACT

Introduction- Age and gender determination becomes the first priority in the process of identification of a person by a forensic investigator in the case of mishaps, chemical and nuclear bomb explosions, natural disasters, crime investigations, and ethnic studies. Fractal analysis has been used in various bone and mucosal lesions but it is seldom used in gender determination and age estimation. **Aims And Objectives-** To assess the role of fractal analysis to evaluate age and gender in digital panoramic radiograph. **Material And Method-** A retrospective radiographic study was planned for fractal analysis, for evaluation of age and gender. This study included a total of 100 panoramic radiographs retrieved from archives of Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, which were taken for various dental procedures using Planmeca ProMax orthopantogram unit. Images with any pathology, fractures, and artifacts pertaining to the region of interest were excluded. For all analysis, the examiner was blinded to the individual's sex and chronological age. A trained calibrated examiner measured the fractal dimension (FD) of the mandibular condyle and mandibular angle. Linear regression and multiple logistic discriminant analysis were carried out to explore the accuracy of Fractal analysis. The fractal analysis was carried out using the box-counting method with the help of Image J software. Linear measurement of gonial angle and condylar height were also measured on digital orthopantogram. **Results-**The result of the study showed mean D value(value obtained by fractal box counting method) at angle of mandible 1.42 for male and 1.39 for female. D value at condyle showed 1.44 for male and 1.43 for female. The linear measurement mean value for height of condyle was 20.86 mm for male and 20.31mm for female. The mean value for gonial angle for male was 243.65 degree and for female it was 236.02 degree. The data showed statistically significant difference for the values between the groups ($p < 0.01$) for gonial angle with higher values in Male and $p < 0.05$ for height of condyle. **Conclusion-** Our study is one of the few studies which tried exploring fractal analysis in forensic odontology. We found that age and gender determination was promising but it was not evident statistically.

KEYWORDS

Forensic odontology, Fractal analysis , Age and Gender evaluation

INTRODUCTION

Forensic odontology can be defined 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 in the interest of the justice.[1] Sex and age determination is a subdivision of forensic odontology, and it is important especially when information relating to the deceased is not available. Age estimation is of wider importance in forensic medicine, not only for the purpose of identifying deceased victims, but also in connection with crimes and accidents. Age and gender determination becomes the first priority in the process of identification of a person by a forensic investigator in the case of mishaps, bomb explosions, natural disasters, crime investigations, and ethnic studies. Various methods are employed to determine age and gender in forensics such as cheiloscopy, human bites, rugoscopy, and the application of biomolecular methods for analyzing DNA from dental pulp tissue[2,3] and many more are yet in the process of establishment in determination of age and gender.

Digital radiography because of its obvious advantage offers its usefulness in forensics as well. Age estimation in adults is challenging as there are few methods which have been used for the same. In adults, human identification relies on alterations in dental, bone, and oral structures. [4] In this context, digital image processing allows the assessment of morphologic features of the trabecular bone pattern with minimally-invasive techniques, such as fractal analysis (FA) .[5]The word fractal originates from the word “fractus” meaning “broken” or “fractured” .[6]This mathematical method was first described in 1897 and has since improved to encompass irregular and complex body regions.[7] Fractal geometry is a quantitative approach to characterize complex self-similar shapes using the fractal dimension (FD).[6] Fractal dimensions (FD) are metrics useful in characterizing the geometry of sets too irregular to be described in more classical ways that nevertheless exhibit sufficient fractal regularity [7],with $D = \log n / \log \varepsilon$, where N is the total of parts and ε is the specified scale.[8]Fractal analysis has been used in in various bone and soft tissue lesions but it is seldom used in gender determination and age estimation. So, an attempt is made to evaluate the role of fractal analysis in forensic odontology.

AIMS AND OBJECTIVES-

To assess the role of fractal analysis of mandibular morphometric measurements using a panoramic radiograph in age and gender determination.

MATERIAL AND METHOD-

A retrospective radiographic study was done for fractal analysis, for age and gender determination . This study included a total of 100 panoramic radiographs retrieved from archives of Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, which were taken for various dental procedures using Planmeca ProMax orthopantogram unit. For all analysis, the examiners ,blinded to the individuals, sex and chronological age. A trained calibrated examiner measured the fractal dimension (FD) of the mandibular condyle and mandibular angle. The principle investigator also measured linear digital parameter of gonial angle and condylar height. Linear regression and multiple logistic discriminant analysis was carried out to explore the accuracy of Fractal analysis. The investigator carried out fractal analysis using the box-counting method [1] with the help of ImageJ software.

Inclusion Criteria-

- Panoramic image of patients more than 15 years of age as most of the skeletal development completes by 15 years.
- Panoramic image of either gender.

Exclusion Criteria-

- Images with any pathology, fractures, and artifacts pertaining to the region of interest.
- Poor quality panoramic images.

METHOD-

For digital image processing, two Region of interest measuring 64 x 64 pixels were selected within the trabecular bone (Kato et al, 2019). ROI1 and ROI2 were specified-mandibular angle and condyle, respectively (Figure 1).The fractal analysis was carried out using the box-counting method (White & Rudolph, 1999). For the measurement of fractal dimension (FD), the examiner performed the following steps: (A) selection of ROIs (64x64 pixels) (B) duplication of ROIs (C) use of Gaussian or gray filter (sigma: 35 pixels) (D) subtraction of blurred image from original (E) addition of greyscale value of 128 (F) binary image (G) erosion of image(H) dilation of image (I) inversion of image and (J) skeletonization of image to assess FD using fractal box-counting method dividing image into box sizes of 2, 3, 4, 6, 8, 12, 16, 32 and 64 pixels.(Figure 2).

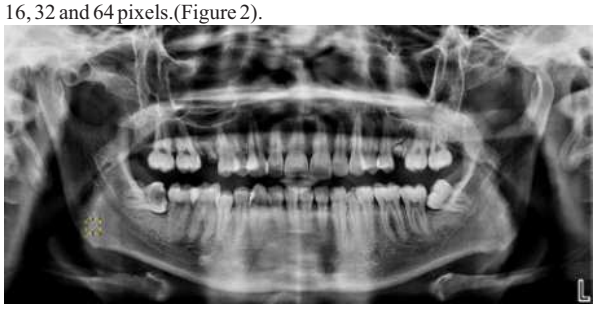

Figure 1- Region Of Interest For Fractal Analysis-angle Of Mandible

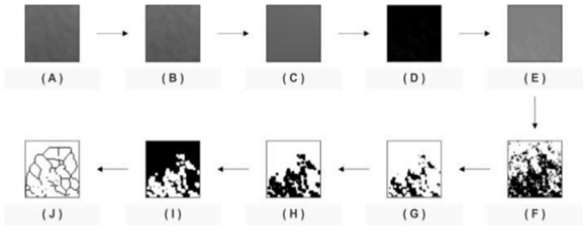

Figure 2- Step Wise Sequence Showing Fractal Box Counting Method

Conventionally, linear measurement of the digital radiograph was done for evaluation of age and gender. As this method showed a promising result, in our study we have tried to compare the conventional method with the fractal box counting method. For this purpose, linear parameter measurement of condylar height and gonial age was measured using measurement tool in the romexis software. For angle of mandible, the angle was obtained by drawing a tangent to the lower border of mandible and a tangent to the distal border of the ramus and condyle.The condylar height was measured as the distance from the line drawn on the superior portion of the condyle to the line drawn on the most inferior portion of the sigmoid notch (Figure 3).

Figure 3- Linear Measurement On Orthopantogram

For age estimation, the association between Fractal dimension and linear measurements and age was investigated using linear regression. Based on the results, a formula was devised for testing accuracy by assessing differences between predicted and actual age. Multiple logistic discriminant analysis was employed for sex estimation.

For analysis, the sample was expressed as frequencies, percentages, mean, and median and depicted using box plots by sex. The investigator employed Student's t-test and the Mann-Whitney U-test for FD values for sex.

RESULTS-

In the present study, the sample comprised of 51 females and 49 males, respectively. Intergroup comparison of variables between gender was done which showed mean FD values 1.42 for male and 1.39 for female for mandibular angle and 1.44 for male and 1.43 for female at mandibular condyle, respectively. The mean value for height of condyle was 20.86 mm for male and 20.31mm for female, respectively. The mean value for gonial angle for male was 243.65 degree and for female it was 236.02 degree, respectively. The data showed statistically highly significant difference for the values between the groups ($p<0.01$) for gonial angle with higher values in Male and $p<0.05$ for height of condyle with higher values in Male. There was a statistically non significant difference seen for the values between the groups ($p>0.05$) for D value (angle of mandible) and D value (condyle). Table 1 shows the data.

Table 1- Inter Group Comparison Of Variables Between Gender

D value (angle of mandible)	M	49	1.4202 0	.090015	.012859	965.000	-1.962	0.050#
	F	51	1.3941 2	.084642	.011852			
D value (condyle)	M	49	1.4400 2	.047832	.006833	1140.00 0	-0.755	0.450#
	F	51	1.4318 8	.051230	.007174			
height of condyle	M	49	20.865	2.5348	.3621	955.500	-2.030	0.042*
	F	51	20.311	2.6092	.3654			
gonial angle	M	49	243.65 1	8.3611	1.1944	597.500	-4.498	0.000**
	F	51	236.00 2	8.1146	1.1363			

Multiple regression analysis was done to derive a formula for age estimation. Since only gonial angle had a p value which was statistically significant (table no. 2), a formula was derived as , Age = -4.991 + .124 x gonial angle. The respective derived formula was applied to the study sample size and comparison was done for actual and predicted age which showed a statistically ,non significant difference for the values between the actual vs predicted age ($p>0.05$). Table no. 3 provides the data.

Table 2- Coefficients For Regression Analysis

Model	Unstandardized Coefficients		Standardized Coefficients		95.0% Confidence Interval for B	
	B	Std. Error	Beta	p value	Upper Bound	Upper Bound
(Constant)	-12.026	19.619	-.613	.541	-50.974	26.923
D value (angle of mandible)	1.482	6.071	.244	.808	-10.571	13.535
D value (condyle)	4.087	10.690	.382	.703	-17.135	25.309
height of condyle	-.011	.203	-.052	.959	-.413	.392
gonial angle	.121	.056	2.142	.035	.009	.233

a. Dependent Variable: Age

Age = -4.991 + .124 x gonial angle

Table 3- Comparison Of Actual Vs Predicted Age

		N	Mean	Std. Deviation	Std. Error Mean	T value	p value of t test
Age	Actual	100	24.72	5.063	.506	.037	.970#
	PA	100	24.70	1.151	.115		

DISCUSSION

As literature is sparse in role of fractal analysis in forensic odontology for age and gender determination. In our study we have pioneered using this simple, mathematical calculations in evaluation of age and gender. Therefore, our study tries to present the role of fractal analysis for age and gender estimation using digital orthopantogram radiographs.

In the present study, the mean linear measurement value for height of condyle was 20.86 mm for male and 20.31mm for female, respectively.

The mean value of gonial angle for male was 243.65 degree and for female it was 236.02 degree, respectively. The values showed statistically significant data which showed higher value in male for condylar height and gonial angle which was in agreement with the study done by Ashima Bali Behl et al[9] in which 400 orthopantograms were studied (200 male and 200 female) of north Indian population between 10 and 40 years of age. Linear measurement of ramus breadth(1.74±0.26), condylar (3.01±0.31) and coronoid ramus height (2.93±0.41) for males were higher than the females, which was 1.67±0.35 for ramus, 2.79±0.32 for condylar height and 2.73±0.36 for coronoid height ,respectively. Female have higher gonial angle (120.45±8.33) as compared to males (117.87±9.04) and the angle decreases with age which was contrary to the present study. Most probably due to more number of sample size.

In the present study, statistical significant correlation was present between age and gonial angle which was contrary to the study done by Noha Saleh Abu-Taleb et al[10] in which they studied a total number of 191 panoramic images (105 males and 86 females).No statistically significant correlation between age and gonial angle was found. Males showed statistically significant higher mean linear ramus measurements (8.3±0.8)) and lower mean gonial angle (122.2 ±4.8)) values than females in which the mean ramus measurement was 7.2 ±0.7 and gonial angle was 125.1 ± 4.3 .Condylar height (8.4 ± 0.8) and coronoid height (7.8 ± 0.7) were the most significant predictors for sex and age respectively.

In the present study, the value was statistically significant for condylar height for male as compared to female which is similar to the study done by Aditi Ramesh et al[11] in which 150 digital panoramic radiograph were assessed. The values of condylar height for male was 59.03 height of and 54.15 for female, the data showed statistically significant higher mean value for male than female for condylar and coronoid height. The present study was in agreement with Saini et al. [12] study on mandibles of Northern Indian population (92 males, 24 females, mean age 37.4 years) who found that all the ramus metric parameters were higher in males than females (coronoid height: 61.68 ± 5.45) and 54.89 ± 3.54, projective height: 53.89 ± 6.93 and 47.45 ± 4.63, condylar height: 60.67 ± 5.32 and 54.46 ± 4.97, maximum breadth: 42.81 ± 3.59 and 40.34 ± 3.76 and minimum breadth: 31.29 ± 2.99 and 29.65 ± 1.96 in males and females respectively) and showed significant sexual dimorphism. Similarly, Indira et al. [13] found that all linear ramus dimensions measured on orthopantomographs (50 males, 50 females aging 20-50 years) were significantly higher for Bangalore males compared to females (coronoid height: 119.70 ± 10.87 mm and 111.15 ± 9.51, projective ramus height: 129.05 ± 9.51 and 120.82 ± 7.85, condylar height: 131.30 ± 9.26) and 123.27 ± 7.36), maximum breadth: 74.20 ± 6.34 and 68.98 ± 5.75 and minimum breadth: 51.35 ± 4.43, 46.96 ± 3.83 in males and females respectively).

In the present study, the mean fractal value for male was greater than female which was 1.44 and 1.43 in the condylar region for male and female ,respectively. At the mandibular angle region the mean value were 1.42 for male and 1.39 for female, respectively which was similar to the study done by Fabrício dos et al[14] in which 120 lateral cephalogram were studied and fractal analysis using box count method was done in Brazilian population at mandibular ramus and mandibular angle. The mean age group was 38.5 years. The average FD values was higher for males (1.50) than females (1.48). The FA was more accurate for identifying males than females in the mandibular ramus and mandibular angle for which the mean value was 1.49±0.10 for mandibular ramus and 1.48±0.09 for mandibular angle, respectively. However, the data in the present study was found to be statistically non significant which can be due to differences in type of radiograph taken for study, region of interest selected for fractal analysis and variation in the population subtype. Although, the FD value was statistically non significant still the use of fractal analysis in orthopantogram radiographs constitute a low-cost, non-destructive minimally-invasive technique for human identification services which needs to be assessed more for further accurate results.

CONCLUSION

Thus it can be concluded from this study that FA values of the mandibular condyle and mandibular angle are slightly higher in males. The linear measurements of the height of condyle and gonial angle are significantly higher in males and are reliable in gender identification. Using regression analysis, the following formula was derived for estimation of age using gonial angle. Age = -4.991 + 0.124 x gonial angle. In the present study, Linear measurement were found to be more accurate and relevant in evaluation of age and gender than the fractal analysis. The results showed that the mean FA value in the mandibular condyle and mandibular angle provided acceptable sexual differences.

Conflict Of Interest
None Reported.

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NARRATIVE REVIEW

Imaging to Evidence: An Introduction to Forensic Radiology - Part I

Siddhi Rane[1*], Vijayalaxmi Nimma[2], Sonali Kadam[2], Easwaran Ramaswami[3], Anusree J[1], Suraj Bhoye[1]

[1]Postgraduate Student, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, Maharashtra, India.

[2]Associate Professor (Academic), Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, Maharashtra, India.

[4]Professor and Head, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, Maharashtra, India.

Abstract

Forensic radiology communicates through images in ways that words often cannot, particularly within the field of oral and maxillofacial sciences. The unique patterns of dentition and the resilience of skeletal structures provide reliable evidence in medico-legal investigations. Radiographic techniques such as cone beam computed tomography, panoramic radiography, and cephalometric analysis play a vital role in human identification, age estimation, bite mark assessment, trauma evaluation, and disaster victim identification. With the advancement of three-dimensional reconstruction, digital imaging, and artificial intelligence, forensic radiology now offers an unprecedented level of precision, enabling accurate and rapid comparison with antemortem records. Part I of this review article highlights the critical intersection of advanced dental imaging and legal justice, underscoring the role of oral and maxillofacial radiologists as both scientific experts and interpreters of hidden narratives within human remains. The details of the imaging techniques used and their interpretation are intended to be covered in the part II of the review.

Keywords: Forensic radiology, Maxillofacial imaging, Human identification, Legal justice.

Introduction

Forensic radiology is a specialized branch of medical imaging that applies radiological techniques to law enforcement, medico-legal investigations, and the administration of justice. It involves the acquisition, interpretation, and preservation of imaging data to aid in human identification, age and sex estimation, trauma evaluation, and determination of cause of death. Within this domain, oral and maxillofacial radiology holds a pivotal role, as the craniofacial complex contains highly individualistic and resilient anatomical features that can withstand extreme environmental conditions such as decomposition, burning, and submersion.[1]

Dental and maxillofacial structures including teeth, restorations, bone trabeculation patterns, and sinus morphology are unique to each individual and remain stable over time, making them valuable for comparative identification in both single-case investigations and mass disaster victim identification scenarios.[2]

Forensic maxillofacial radiography has become a standard practice in many dental and medical facilities, playing an important role in assisting forensic odontologists with dental identification. This process can be broadly divided into two categories. *Comparative identification* involves establishing a definitive match by comparing the dental features of the deceased with their available dental records. *Reconstructive identification*, also known as dental profiling, focuses on deducing characteristics such as ethnicity, gender, age, and even occupation of the individual when direct records are unavailable.[3]

The integration of three-dimensional reconstruction and artificial intelligence has further strengthened the reliability of forensic evaluations by enabling automated matching, virtual autopsy, and predictive modelling for age estimation.[4] This review provides a comprehensive overview of the applications, advantages, limitations, and future prospects of forensic radiology in the oral and maxillofacial region, highlighting its indispensable role in bridging the gap between dental science and legal justice.

History of Forensic Radiology

- 1895 – Wilhelm Conrad Roentgen's groundbreaking discovery of X-rays revolutionized medical imaging.

Author for Correspondence:
Siddhi Rane, Postgraduate Student, Department of Oral Medicine and Radiology, Government Dental College and Hospital, Mumbai, Maharashtra, India. Email id- ranesiddhi944@gmail.com

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- 1896 – Prof. Arthur Schuster made history by using X-rays to locate lead bullets in the head of a deceased individual.[5]
- 1898 – In the *American X-Ray Journal* (October issue), Dr. Fovau d'Courmelles remarked, *"Knowing the existence of a fracture in a person who has been burned or mutilated beyond recognition, we can hope to identify him by the X-ray."*[6]
- 1921 – Schuller introduced the idea of using frontal sinus radiographs for identification.[7]
- 1927 – Culbert and Law demonstrated complete skull identification by analysing the pneumatic cells of the sinuses.[7]
- 1990-Kultman reported 100% success in comparison of antemortem and postmortem radiographs of the frontal sinuses.[8]
- 1991 – Happonen and colleagues advocated for orthopantomography, allowing the jaws and related structures to be visualized in a single panoramic view. That same year, Haerting et al. described panoramic dental radiography as the only regularly updated and "truly reliable identification card" for comparative purposes.

Radiographic Fingerprints in Forensic Dentistry

In forensic radiology, the process of identification relies on precise imaging techniques performed by skilled professionals with specialized expertise in biology and dental anatomy. These techniques are crucial for achieving accurate human identification.[9]

A primary approach involves the comparison of antemortem and postmortem radiographs. Distinct anatomical and dental characteristics—such as the shape and length of teeth and roots, the presence of supernumerary or missing teeth, patterns of attrition and abrasion, coronal fractures, periodontal bone loss, pathological bone changes, diastemas, carious lesions, endodontic treatments, interradicular or intracoronal posts, dental implants, extraction sockets, and prosthetic restorations—serve as reliable markers for comparison.[10]

Traditionally, two-dimensional radiographs, such as frontal sinus views and bite-wing films, served as dependable tools for dental identification. With technological advancements, digital imaging methods such as radiovisiography have transformed the process by enabling precise evaluation of tooth roots and surrounding structures. These high-resolution images allow accurate comparison of antemortem and postmortem records, thereby enhancing both the speed and reliability of forensic analysis.[11]

In modern forensic odontology, dental profiling has emerged as a valuable tool for reconstructing a victim's identity prior to death, drawing on available clinical and radiological evidence. The advent of three-dimensional imaging has further revolutionized this process—antemortem computed tomography scans can now be matched with postmortem data to accurately locate and measure craniofacial landmarks. In addition, cone beam computed tomography plays a vital role in postmortem imaging, providing exceptional detail in identifying high-density metallic fragments, such as those resulting from gunshot injuries, thereby enhancing both accuracy and investigative value.[12]

From Film to Pixels: The Revolution of Radiography

Digital Radiography in Mass Disaster Forensics

- Rapid Identification – Accelerates comparison of antemortem and postmortem dental records.
- Onsite Imaging – Portable X-ray units enable imaging directly at disaster sites.
- Protection of Fragile Remains – Reduces the risk of damage during transport.
- Real-Time Data Sharing – Secure satellite transfer allows immediate communication with command centers.
- Lossless Data Preservation – Digital copies can be stored indefinitely without quality degradation.
- Enhanced Efficiency – Provides faster turnaround, improved productivity, and greater flexibility.

Recent Advances

Computed Tomography (CT) is widely used in forensic maxillofacial investigations due to its ability to reconstruct teeth in three dimensions, locate bullets, and determine entry and exit wounds. It is also valuable for detecting barotrauma and gas embolism in drowning cases, as well as for identifying broken blade fragments in stabbing incidents. The technique offers precise assessment of bone width and high image detail. However, it is not yet fully developed for complete virtual three-dimensional modelling, has limited application in cases of self-poisoning, and cannot accurately correlate wound size with the weapon if the weapon has been removed.[13,14] Cone Beam Computed Tomography (CBCT) plays a significant role in forensic applications, particularly in estimating the biological age of infants through detailed analysis of tooth development. It is also applied in superimposing skull images to aid in the identification of missing persons and in reconstructing skulls by comparing antemortem and postmortem records. This technique provides high precision in evaluating individual teeth, panoramic images, and skull volumes. However, its accuracy can be affected by the presence of metal artifacts, which may compromise image quality.[15]

Virtual three-dimensional facial reconstruction is a forensic technique that employs specialized software to recreate a person's face from their skull, enabling comparison between antemortem and postmortem records. In addition to visual identification, this method can be supplemented with DNA testing for confirmation. It is particularly valuable in mass disaster scenarios where conventional identification methods are challenging. However, its effectiveness depends on the

availability of an intact and supportive skeletal structure to ensure reliable reconstruction.[16]

Virtual Autopsy Innovations in Forensic Maxillofacial Imaging

Virtopsy is a modern, non-invasive alternative to traditional autopsy that combines advanced imaging with three-dimensional body surface scanning for detailed forensic analysis. Using computed tomography (CT) and magnetic resonance imaging (MRI), it reconstructs three-dimensional anatomy, enabling assessment even in decomposed or severely damaged remains. MRI provides high-resolution soft-tissue imaging, while contrast-enhanced MRI can reveal injuries in living victims of abuse. Magnetic resonance spectroscopy assists in estimating time of death by analysing tissue metabolites, and magnetic resonance microscopy captures fine soft-tissue details. In addition, microtomography is useful in identifying weapon characteristics and injury patterns.[17,18]

Virtopsy offers several advantages: it enables detailed three-dimensional analysis, allows digital storage for repeated review, assists in weapon matching, and provides precise assessment of fractures and pathologies. Despite its accuracy and minimal infection risk, the method also has limitations. It is costly, prone to artifact-related interpretation errors, unable to capture fine surface details or skin changes, and lacks the tactile feedback provided by conventional manual examinations.

Advantages of Forensics Radiology

Radiographs provide a fast, simple, and non-invasive method for obtaining crucial information from both the living and the deceased. They are cost-effective when compared with DNA analysis and hold strong credibility as admissible evidence in courts of law, making them a trusted and valuable tool in forensic investigations.[19]

limitations of Forensic Radiology

Postmortem intraoral radiography presents significant challenges, particularly when rigor mortis restricts mouth opening, making film placement and retention difficult. In situations where only a tooth fragment or a section of the jaw requires imaging, achieving accurate radiographic orientation becomes even more complex. Radiographs are also vulnerable to mishandling and require a high level of technical expertise to produce error-free images. Any imaging errors may mimic foreign objects or pathologies, potentially misleading investigators and complicating forensic analysis.

Future Scope of Forensics Radiology

The future of forensic radiology in oral and maxillofacial sciences is poised for rapid advancement with the integration of artificial intelligence, machine learning, and three-dimensional imaging technologie s. AI-driven image analysis will enable faster and more accurate identification, age estimation, and trauma interpretation, even in degraded remains. Portable digital radiography and mobile cone beam computed tomography units will make on-site forensic imaging more accessible, particularly in mass disaster situations. Advancements in magnetic resonance imaging and micro-computed tomography will enhance both soft- and hard-tissue visualization without the need for invasive procedures. The development of global forensic radiology databases and standardized protocols will further improve antemortem and postmortem comparisons across borders. Virtual autopsy methods, combined with robotic-assisted imaging, are expected to reduce reliance on traditional invasive autopsies, ensuring both preservation of evidence and dignity of the deceased. These innovations promise to make forensic oral and maxillofacial radiology an even more precise, reliable, and indispensable tool in medico-legal investigations. Further details of the radiographic techniques and their interpretation will be discussed in Part II of this review.

Conclusion

- Forensic radiology in oral and maxillofacial sciences serves as a bridge between technology, medicine, and justice by transforming hidden details into reliable evidence.
- Its non-invasive ability to capture, preserve, and analyse anatomical structures makes it an indispensable tool for both the living and the deceased.
- The permanence of digital imaging ensures that evidence can be revisited and reinterpreted as technology advances.
- Despite challenges in technique and logistics, the future appears promising with artificial intelligence, immersive three-dimensional imaging, and virtual autopsy expanding its applications.
- These innovations will not only strengthen medico-legal investigations but also redefine the ways in which truth is uncovered and preserved.

Conflicts of Interest

None.

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ORIGINAL ARTICLE

Development and Validation of a Novel Device for Three-Dimensional Bite-Mark Analysis: An *In-vitro* Study

Sanpreet Singh Sachdev[1], Tabita Joy[2*], Manisha Ahire Sardar[3], Sonali Kadam[3], Sarang Sonawane[4], Jyotsna Batra Sachdev[5]

[1]Assistant Professor, Department of Oral Pathology and Microbiology, Bharati Vidyapeeth (Deemed to be) Dental College and Hospital, Pune, India.
[2]Professor and HOD, Department of Oral Pathology and Microbiology, Government Dental College and Hospital, Mumbai, India.
[3]Associate Professor, Department of Oral Pathology and Microbiology, Government Dental College and Hospital, Mumbai, India.
[4]Assistant Professor, Department of Oral Pathology and Microbiology, MGV KBH Dental College and Hospital, Nashik, Mumbai, India.
[5]Postgraduate Student, Department of Pediatric Dentistry, YMT Dental college and Hospital, Navi Mumbai, India.

Abstract

Background: Bite mark analysis is a pivotal tool in forensic odontology, founded on the uniqueness of dental configurations. However, traditional photographic methods are increasingly criticized for subjectivity, distortion, and inter-observer variability, challenging their forensic credibility. Recent technological advancements have emphasized the need for standardized, three-dimensional approaches to improve the reliability of bite mark evidence.

Aim: The present study aimed to develop and validate a novel three-dimensional bite mark analysis device and compare its diagnostic accuracy, reliability, and efficiency against conventional photographic methods.

Materials and Methods: An in-vitro study was conducted using 60 bite mark specimens created on dental impression materials. Measurements were independently performed by two blinded forensic dental examiners using both the novel device and the photographic method. The novel device employed a vertical screw mechanism with an optical rotary encoder and dual-direction Persistence of Vision sensors to capture x, y, and z coordinates. Measurement accuracy, time taken, inter-observer reliability, sensitivity, specificity, and diagnostic performance were assessed and statistically analyzed.

Results: The novel device achieved significantly higher measurement accuracy (92.3%) compared to the photographic method (76.4%) ($p < 0.001$). The mean analysis time was reduced by nearly half with the novel device (6.8 minutes vs. 12.4 minutes, $p < 0.001$). Inter-observer reliability was greater with the device (kappa = 0.82) compared to photography (kappa = 0.65). Sensitivity, specificity, and area under curve values were also superior for the novel device.

Conclusion: The novel bite mark analysis device demonstrated superior precision, efficiency, and reproducibility over conventional methods, offering a promising tool for enhancing the scientific and legal admissibility of bite mark evidence.

Keywords: Bite mark analysis; Forensic odontology; Measurement accuracy; Three-dimensional imaging

Introduction

Bite mark analysis has long served as a crucial tool in forensic odontology, founded on the premise that no two oral configurations are identical. Defined as "a mark caused by the teeth either alone or in combination with other mouth parts," bite marks offer potentially valuable evidence in criminal investigations when properly documented and interpreted.[1]

Author for Correspondence:
Tabita Joy, Professor and HOD, Department of Oral Pathology and Microbiology, Government Dental College and Hospital, Mumbai, India. Email id- dr.tabitajoy@gmail.com

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However, the reliability and admissibility of bite mark evidence have come under increasing scrutiny in recent years. Concerns regarding subjectivity, distortion from skin elasticity, and the lack of standardized analytical protocols have cast doubt on the forensic robustness of traditional methodologies, especially photographic analysis.[2,3]

Photographic documentation of bite marks has been a cornerstone of forensic evidence collection, relying heavily on correct angulation, scale placement, lighting conditions, and operator expertise.[4] Despite the use of standardized tools such as the ABFO No. 2 scale and advanced digital imaging, this method is not without its limitations. Issues such as distortion due to skin curvature, tissue elasticity, and variations in photographic conditions can lead to inaccuracies in measurements. Moreover, the process can be time-consuming, technically demanding, and prone to inter-observer variability.[4,5]

The growing skepticism surrounding bite mark evidence has catalyzed the need for more objective, standardized, and reproducible methods of analysis. In response, efforts have been made to incorporate digital technologies into forensic odontology. Recent innovations have explored three-dimensional (3D) scanning, coordinate mapping, and sensor-based measurement systems to enhance accuracy, reduce observer bias, and enable better documentation of bite mark depth, angulation, and orientation.[6,7]

The present study introduces and validates a novel device specifically developed for three-dimensional bite mark analysis. This device utilizes an integrated system comprising a vertical screw with an optical rotary encoder and a dual-direction Persistence of Vision (POV) sensor to capture precise spatial dimensions of bite marks. By directly measuring x, y, and z coordinates along with depth, this technology aims to minimize distortion and inter-observer discrepancy while enhancing the diagnostic utility of bite mark evidence. This study evaluates the reliability, efficiency, and diagnostic accuracy of the new device in comparison to conventional photographic methods, with the goal of bridging the gap between forensic accuracy and accessibility.

Materials and Methods

Study Design

The present in-vitro study was designed to evaluate the validity, reliability, and operational efficiency of a newly developed three-dimensional bite mark analysis device. The study aimed to compare the performance of this novel device with that of conventional two-dimensional photographic bite mark analysis in terms of measurement accuracy, time efficiency, inter-observer agreement, and diagnostic performance.

Sample Size and Specimen Preparation

A total of 60 bite mark specimens were created using dental casts and prosthesis for the study. Dental impression materials, including putty, alginate, and modelling wax, were used to simulate bite mark substrates. These materials were selected to represent varying consistencies and responses to bite pressure, closely mimicking soft tissue in forensic contexts.

Standardized bite marks were created on these substrates using pre-fabricated dental casts with known measurements. The original dimensions of the biting surfaces (including depth, mesiodistal width, and inter-canine distance) were pre-recorded using a high-precision Vernier caliper by an independent investigator. These reference measurements served as the gold standard for evaluating the accuracy of both test methods.

A line was marked on the cast upto the desired depth of the bite mark. The material on which the bite mark was to be registered was then inverted on the cast upto the marked line and kept in position for five seconds to ensure that the static bite mark was adequately recorded. In this manner, the cast application pressure and contact time were standardized to avoid variability in bite depth or spread.

Investigators and Blinding

Two trained and calibrated forensic dental examiners participated in the study to perform the bite mark analysis using both the novel device and the photographic method. The investigators were blinded to the reference measurements obtained by Vernier calipers to eliminate bias. Each examiner independently performed and recorded measurements to allow assessment of inter-observer reliability.

The Novel Bite-Mark Analysis Device

The custom-designed bite mark analysis device (Figure 1) incorporated the following components:

Vertical Screw Mechanism with Optical Rotary Encoder

This component was used to assess the vertical depth (z-axis) of the bite mark. The encoder measured the degree of rotation of the screw, and as the screw pitch was known, the vertical displacement could be accurately calculated. This provided a precise means to quantify the depth of depressions or indentations caused by the bite.

Dual-Directional Persistence of Vision (POV) Sensor

Two POV sensors were aligned perpendicularly to each other to assess the horizontal (x and y axes) positioning of various bite mark elements. These sensors emitted electromagnetic waves and measured their interaction with reflective reference markers on the specimen surface to directly calculate horizontal distances, curvature, and orientation of the dental arch impressions. This allowed three-dimensional spatial mapping of bite mark parameters.

All measurements were taken with the specimen stabilized on a mounting platform to prevent any movement or tilt that could alter dimensional accuracy. Figure 2 summatively depicts various stages of simulation and analysis of bite marks using the novel device.

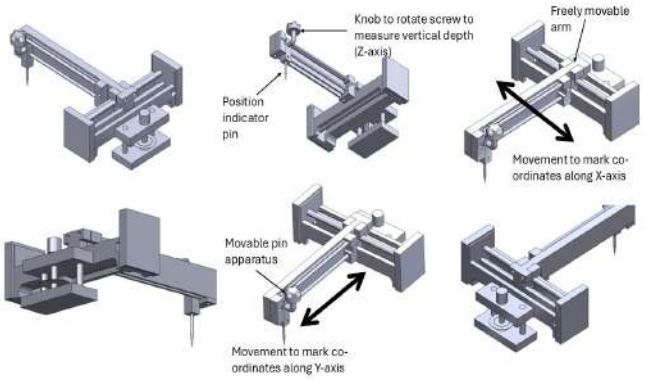

Figure 1: Schematic Diagrams of the novel bite mark device

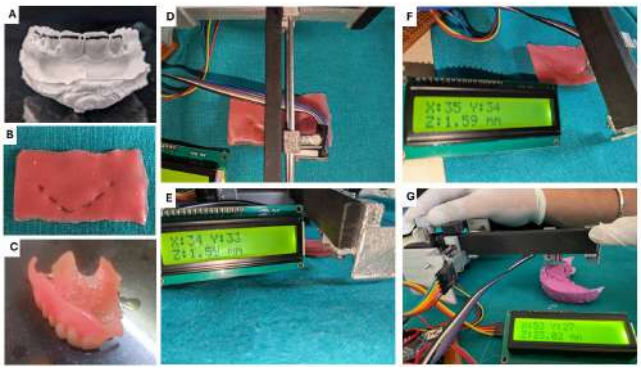

Figure 2 : A) Marking of the desired depth on the cast; B) Obtained bite mark on modelling wax; C) Sample removable prosthesis used to simulate a bite mark; D), E) and F) Positioning of the indicator pin on the desired position to measure the co-ordinates; G) Measuring co-ordinates on a putty impression

Conventional Photographic Method

For comparison, each specimen was also analyzed using standard 1:1 bite mark photography. Controlled lighting was used to minimize shadowing and glare. Instead of the standard ABFO No. 2 scale, a calibrated setup using graph paper with printed millimeter rulers and coin markers was used as a measurement reference, due to equipment constraints. The photographic images were then uploaded and analyzed using digital image processing software (Adobe Photoshop CS3) according to standard norms.[4,6]

Study Procedure

The sample bite marks were prepared as described in the above sections. Each examiner independently measured dimensions (depth, inter-canine distance, incisal width, and curvature) on each specimen using both methods. The time required to complete bite mark analysis using both the novel device and the photographic method was recorded using a digital stopwatch. All values were compared with the reference dimensions previously recorded using Vernier calipers. Both primary and secondary outcome parameters, as described below, were recorded systematically for each specimen and examiner. The workflow of bitemark analysis of the samples in the present study is depicted in Figure 3.

Figure 3: Workflow of bite mark analysis in the present study

Outcome Measures

Primary Outcomes

- Accuracy of Measurements: Accuracy was determined by comparing each method's measurements to the gold standard values obtained by Vernier calipers.
- Total Time Required: The time taken by each examiner to complete the analysis was documented for both methods.
- Inter-Observer Reliability: Measured using Cohen's kappa statistic and standard deviation of recorded values for each method.

Secondary Outcomes

- Sensitivity and Specificity: Ability of each method to correctly identify and replicate known dimensions.
- Positive and Negative Predictive Values: Assessed based on correct versus incorrect identification of reference points.
- Procedure-Specific Observations: Technical ease, portability, and subjective examiner feedback were also recorded.

Statistical Analysis

The collected data were compiled and subjected to descriptive and inferential statistical analysis. Mean values and standard deviations were calculated for measurement accuracy and analysis time. Paired t-tests or Wilcoxon signed-rank tests (depending on data normality) were used to compare the two methods. Cohen's kappa was applied to evaluate inter-examiner agreement. Receiver Operating Characteristic (ROC) curve analysis was conducted to compare the diagnostic performance of the two methods, with area under the curve (AUC) values interpreted to assess overall accuracy. A p-value less than 0.05 was considered statistically significant. All statistical analyses were performed using SPSS software version v23 (IBM Corp., Armonk, NY, USA).

Results

Accuracy of Measurements

The novel bite-mark analysis device demonstrated significantly higher accuracy in comparison to the conventional photographic method. Measurements obtained using the device showed a mean accuracy of 92.3%, closely aligning with the gold standard values previously recorded using a Vernier caliper (Figure 4). In contrast, the photographic method produced a lower mean accuracy of 76.4%. The difference between the two methods was statistically highly significant ($p < 0.001$) (Table 1). The enhanced accuracy of the novel device is attributed to its ability to measure three-dimensional coordinates (x, y, and z axes) directly from the specimen, thereby reducing errors caused by perspective distortion, angulation, and depth estimation inherent to two -dimensional photography.

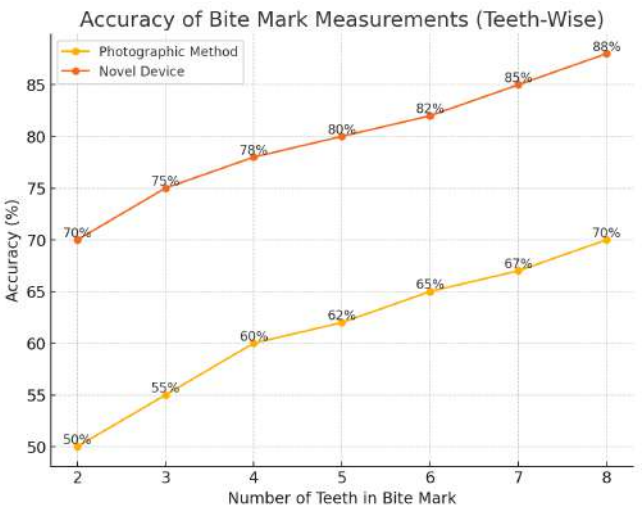

Figure 4 : Accuracy of both methods corresponding to the number of teeth included in the bite mark analysis

Time Required for Analysis

A comparative assessment of the time taken to perform bite-mark analysis revealed a substantial reduction when using the novel device. The average time required to complete one analysis was 6.8 ± 1.5 minutes with the novel device, compared to 12.4 ± 2.1 minutes for the photographic method (Table 2). This difference was found to be statistically significant ($p < 0.001$). The reduced time can be attributed to the device's integrated digital sensors and real-time measurement capabilities, which eliminate the need for additional post-capture processing and calibration steps that are typical of photographic analysis.

Inter-Examiner Reliability

Inter-observer consistency between the two examiners was assessed using standard deviation and Cohen's kappa statistic. The novel device demonstrated superior inter-examiner reliability with a standard deviation of 1.1 and a kappa value of 0.82, indicating substantial agreement. In contrast, the photographic method showed a higher variability, with a standard deviation of 2.3 and a kappa value of 0.65, signifying only moderate agreement (Table 3). These findings underscore the objectivity and reproducibility of the novel device, which reduces examiner-dependent variability.

Table 1 : Comparison of the Accuracy of Bite Mark Measurements

Method	*Mean accuracy (%)*	*Standard deviation*	*p-value*
Novel Device	92.3	±1.1	< 0.001
Photographic Method	76.4	±2.3	

Table 2: Time Required for Bite Mark Analysis

Method	*Mean time (minutes)*	*Standard deviation*	*p-value*
Novel Device	6.8	±1.5	< 0.001
Photographic Method	12.4	±2.1	

Table 3 : Inter-Observer Reliability

Method	*Standard deviation*	*Cohen's kappa*	*Interpretation*
Novel device	±1.1	0.82	Substantial agreement
Photographic method	±2.3	0.65	Moderate agreement

Diagnostic Performance

The diagnostic capability of both techniques was evaluated through sensitivity, specificity, and predictive value calculations. The photographic method showed a sensitivity of 60% and specificity of 75%, with a positive predictive value (PPV) of 65% and a negative predictive value (NPV) of 70%. In contrast, the novel device achieved a sensitivity of 85%, specificity of 90%, PPV of 88%, and NPV of 92% (Table 4). These results reflect the superior diagnostic precision of the novel device in correctly identifying and replicating bite mark dimensions with minimal error.

Receiver Operating Characteristic Curve Analysis

ROC curve analysis was conducted to further assess the discriminative power of both techniques. The Area Under the Curve (AUC) for the novel device was 0.92, indicating excellent diagnostic accuracy. The photographic method showed a lower AUC of 0.78, suggesting moderate performance (Table 5). These results confirm the superior capability of the novel device to distinguish between accurate and inaccurate measurements, reinforcing its forensic applicability.

Success Rate and Procedural Observations

The overall success rate for complete and accurate bite mark analysis was 96.7% with the novel device and 78.3% with the photographic method (Table 6). Investigator feedback noted that although the novel device required initial training and familiarization, it was easier to use and produced more reliable results once calibrated. Additionally, the device reduced dependency on external variables such as lighting conditions, image scaling, and operator skill. One observed limitation was its inapplicability in cases involving actively bleeding tissue

Table 4: Diagnostic Performance of the Two Methods

Parameter	Novel Device (%)	Photographic method (%)
Sensitivity	85	60
Specificity	90	75
Positive predictive value	88	65
Negative predictive value	92	70

Table 5: Receiver operating characteristic curve analysis

Method	*Area under curve (AUC)*	*Interpretation*
Novel device	0.92	Excellent accuracy
Photographic method	0.78	Moderate accuracy

Table 6 : Success rate of bite mark analysis

Method	*Total successful analyses (n=60)*	*Success rate (%)*
Novel Device	58/60	96.7
Photographic Method	47/60	78.3

or mobile anatomical areas, which may restrict its use in live forensic examinations. Despite this, the device proved feasible and effective for in-vitro analysis and controlled post-mortem forensic applications.

Discussion

The present study was conducted to evaluate the diagnostic utility, precision, and operational efficiency of a newly developed three-dimensional bite mark analysis device and compare its performance with the conventional photographic method. The findings of this study demonstrate a clear superiority of the novel device across multiple parameters, including measurement accuracy, inter-observer reliability, diagnostic sensitivity and specificity, as well as overall time efficiency. These results highlight the potential of the device to address several long-standing challenges associated with traditional bite mark analysis techniques in forensic odontology.

One of the key outcomes of this study was the significant improvement in the accuracy of measurements using the novel device. With a mean accuracy of 92.3%, the device closely replicated reference values recorded by Vernier calipers, unlike the photographic method, which showed a lower accuracy of 76.4%. This difference can be primarily attributed to the device's ability to measure not just the horizontal (x and y) dimensions, but also the depth (z-axis), which is typically neglected or estimated in conventional 2D photographic analysis.[8] Previous literature has noted that distortion introduced by angulation, tissue curvature, or photographic artifacts can compromise measurement accuracy and reproducibility when using 2D photographs, even when standardized scales such as ABFO No. 2 are used.[9] The novel device eliminates these variables by allowing real-time direct contact measurements, thereby offering an objective and distortion-free analysis.

Time efficiency is another important factor in forensic workflows, particularly in scenarios involving multiple specimens or urgent investigations.[10] The bite marks undergo distortion whether on human tissues or simulated on materials, and therefore, warrant rapid investigation.[11] In this study, the novel device significantly reduced the average analysis time from 12.4 minutes (photographic method) to just 6.8 minutes. The streamlined workflow, integration of electronic measurement sensors, and reduced need for post-processing contributed to this efficiency. This time advantage becomes especially relevant in mass disaster scenarios or legal investigations requiring rapid evidence analysis. In the context of efficiency, the novel device lagged behind the conventional photographic method.

Inter-observer agreement is critical in forensic methodologies, including bite mark analysis, to ensure that evidence interpretation does not vary significantly between examiners.[12] The findings of this study showed that the novel device had a higher inter-examiner reliability, with a Cohen's kappa of 0.82 compared to 0.65 for the photographic method. The reduced variability in measurements obtained using the device suggests that it minimizes examiner subjectivity. This contrasts with the photographic method, where variations in angle of capture, lighting, scaling, and landmark identification can contribute to inconsistent results between investigators.[13] This improvement is particularly important in legal settings, where the admissibility and credibility of forensic evidence often hinge on reproducibility and examiner consensus.

The diagnostic sensitivity and specificity of the novel device were also notably higher than those of the photographic method. With a sensitivity of 85% and specificity of 90%, the novel device demonstrated an enhanced ability to correctly identify true positive and true negative measurements. This has practical implications for forensic bite mark comparisons, especially in criminal investigations where misidentification can have serious legal consequences. The higher area under the ROC curve (AUC = 0.92) further validates the diagnostic robustness of the novel device, highlighting its discriminatory power in distinguishing between correct and erroneous measurements. In contrast, the photographic method demonstrated only moderate performance with an AUC of 0.78.

The success rate of the analysis was also higher for the novel device, with 96.7% of cases successfully analyzed, compared to 78.3% for the photographic technique. The device was found to be technically user-friendly after initial training and did not rely on sophisticated software or expensive image-processing tools. Investigators reported that the novel device simplified the process by directly collecting dimensional data through physical interaction with the specimen, thereby bypassing several intermediate steps involved in photographic analysis, such as image calibration, landmark annotation, and digital measurement.[4,14] Moreover, the device showed high adaptability to various substrate materials including wax, alginate, and putty, reinforcing its versatility in different forensic contexts.

Despite these promising outcomes, the study does recognize certain limitations associated with the device. Firstly, its use is currently limited to dry or non-bleeding

specimens, making it less applicable in real-time clinical or fresh post-traumatic forensic scenarios where tissue fluids are present. Secondly, while the device is relatively more efficient than traditional methods, it still involves hardware components that require stabilization, calibration, and operator familiarization. Although its cost is comparable to a few high-quality ABFO scales, the need for training may initially limit its adoption in less-equipped forensic settings.

Nevertheless, the development of this novel bite mark analysis device represents a significant step forward in improving the scientific rigor of bite mark evidence, a domain that has historically faced criticism for lack of reliability and objectivity. Several authors, including Souviron and Haller, have emphasized the need to differentiate between bite mark analysis and bite mark identification, cautioning against overreliance on subjective interpretations.[3] Similarly, the Innocence Project and other advocacy groups have raised concerns about wrongful convictions linked to poorly supported bite mark evidence.[15] In this context, a device that introduces quantitative, reproducible, and three-dimensional data holds the potential to bridge the gap between forensic utility and evidentiary credibility.

Looking ahead, the future scope of this device is considerable. Further validation studies involving dynamic tissue models, animal bites, and in vivo simulation could broaden its applicability. Integration of automated software with coordinate mapping and artificial intelligence-based recognition may also enhance its functionality for bite mark comparison and suspect profiling. Additionally, the current prototype can be miniaturized and adapted for portable field use in disaster victim identification and other field forensic applications. Continued development and refinement, including the incorporation of Acharya and Taylor's conclusive scale,[16] may enable the device to contribute toward more standardized, scientific, and legally defensible bite mark analysis protocols.

Conclusion

The novel bite mark analysis device developed in this study demonstrated superior performance over the conventional photographic method in terms of measurement accuracy, time efficiency, inter-observer reliability, and diagnostic sensitivity and specificity. By enabling three-dimensional assessment of bite marks and minimizing examiner-dependent variability, the device addresses many of the longstanding limitations associated with traditional 2D analysis techniques. Although certain practical constraints exist, such as limited use in bleeding or dynamic tissue environments, the device offers a reliable and reproducible approach for forensic bite mark evaluation. With further validation in clinical and field settings, this innovation holds strong potential to enhance the scientific credibility and legal admissibility of bite mark evidence in forensic odontology.

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