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FORENSIC APPLICATIONS OF ORAL AND MAXILLOFACIAL RADIOLOGY

By

Dr. Megha B

Department of Oral Medicine and Radiology, Institute of Dental Sciences and Hospital

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Abstract

In the wake of natural calamities, accidents, and criminal activities, the identification of human remains becomes essential for personal, legal, and humanitarian reasons. Forensic science plays a critical role in this process, and within it, forensic odontology has emerged as a reliable tool for human identification. While traditional identification methods often rely on the preservation of soft tissues, these may be compromised in cases of decomposition, burning, or mutilation. Oral and maxillofacial radiology, however, offers a resilient and dependable alternative due to the durability of teeth and facial bones. Radiographs, which capture unique anatomical features, serve as crucial antemortem and postmortem records, assisting in the determination of age, gender, and identity. The integration of advanced imaging modalities with forensic protocols has further enhanced the accuracy and efficiency of identification. This review explores the pivotal role of radiological techniques in forensic investigations and emphasizes the need for dental professionals to be well-versed in these applications to contribute effectively to medico-legal cases.

INTRODUCTION

In spite of rapid technological advancements and modern medical breakthroughs, humanity continues to grapple with challenges such as natural disasters, pandemics, violent crimes, and mass fatalities. In these unfortunate situations, identifying the deceased becomes essential not only for humanitarian reasons but also for legal and social purposes. Forensic science has emerged as a powerful discipline in aiding human identification through a variety of methods. Among these, forensic odontology holds significant value due to the durability of dental and maxillofacial structures.

Conventional identification techniques like lip prints, bite marks, palatal rugae, and photographs primarily rely on the preservation of soft tissues. However, these methods fall short when remains are subjected to decomposition, mutilation, or incineration. Teeth and facial bones, owing to their resilience, often remain intact even under extreme conditions. Maxillofacial radiology, by capturing unique anatomical features through imaging, serves as an efficient and economical tool for postmortem identification. With the capability to compare antemortem and postmortem radiographs, and assist in constructing biological profiles, forensic maxillofacial radiology has become an indispensable resource in modern forensic investigations.

FORENSIC RADIOLOGY

Forensic radiology is a legal branch of dentistry where the radiographs is used in identification of indivisual in mass disaster and in routine has been recognized sincel long time.the identification by maxillofacial radiograph is relatively swift, easy and efficient.[1,2]

In recent days maxillofacial radiology can be utilized in two ways in foreign dentistry:

- Comparative identification-compares radiograph exposed prior to death
- Reconstructive type of identification-generates biological profile of a person whose identity remains unknown [3]

Forensic odontology has a lot of scope in human identification. Methods like rugoscopy, bite marks, palatal rugae, photographs, lip prints, etc. are used for identifying the individuals.[4]

- 1895 – Discovery of X-rays by Wilhelm Conrad Roentgen.
- 1896 – Prof. Arthur Schuster used X-rays to visualize the lead bullets in the head of a dead person.[5]
- In October 1898 issue of the American X-ray Journal, Dr. Fovau d'Courmelles wrote, "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]
- In 1921, Schuller compared the radiographs of the frontal sinuses.[7]
- In 1927, Culbert and Law described the complete radiological identification of the skull by using

*Corresponding Author: **Dr. Megha B** .

pneumatic cells of the sinuses.[7]

- In 1991, Happonen et al. recommended the use of orthopantomography in identification, which enables visualization of the jaws and related structures as a single radiograph. In the same year, Haerting et al. stated that panoramic dental radiography is the only regularly updated and"truly reliable identification card" for comparison radiography.
- Radiology was also applied in the identification of celebrities like Theodore Roosevelt and Adolph Hitler.
- Forensic radiologists had been using the traditional methods for capturing the images. With the ad vancement o f tec hnology, newer armamentarium like NOMAD (portable hand held X-ray generating device manufactured by Aribex, Charlotte, North Carolina, USA) computed tomography (CT), cone beam computed tomography (CBCT), multidetector CT (MDCT), and magnetic resonance imaging (MRI) are gradually replacing the traditional ones.

TYPES OF RADIOGRAPHS USED

CBCT

CBCT is a three dimensional imaging method , it has innumerable advantages in this field when compared to the conventional radiographic method [8].It rules out various factors which remain a obstacle in conventional radiograph, for example, superimposition, elongation , shortening of the images etc.[9]

- It had numerous advantages such as:
  - Image segmentation
  - Easy image manipulation
  - Improved imaging quality with excellent color scale and transparency
  - Information regarding volume and area
  - Angular and linear measurement

CT SCAN

CT scans are used for 3D reconstruction of dental and skeletal structures. In forensic cases
like gunshots, CT helps identify the bullet's exact location and the entry and exit wounds. In drowning cases, radiological findings such as pulmonary barotrauma and fatal gas embolism have been identified through CT imaging.

MRI

Used in conjunction with CT in virtopsy procedures, MRI helps detect head injuries, evaluate burn-related findings, and identify pathological and toxicological changes. It's particularly useful in determining cause of death due to drug overdose or drowning, and in evaluating neck findings in cases of hanging

3D RECONSTRUCTION TOOLS

Software-based tools like Autodesk 123D enable forensic experts to perform virtual facial reconstruction using skeletal remains. This technique helps in identifying individuals by comparing the reconstructed 3D image with ante-mortem photographs. Additionally, extended DNA analysis can support identity confirmation.

OPG

OPGs are commonly used for comparing ante-mortem and post-mortem radiographs for identification. They can reliably estimate the age of immature or young adults (up to 22 years) by evaluating dentition and eruption sequence.

VIRTOPSY

Virtopsy integrates multislice CT and MRI to provide a virtual alternative to traditional autopsy. It allows estimation of time of death, assessment of skull injuries, detection of toxicological substances, and visualization of burn-related changes. It can also determine age and sex based on sexually dimorphic bone measurements.

LATERAL CEPHALOGRAM

Often used in craniofacial analysis and age estimation. In forensic odontology, it can assist in identification through skeletal profiling and comparing jaw or facial bone structures in ante- and post-mortem records.[10]

RADIOLOGICAL ANATOMICAL FEATURES

FRONTAL SINUS

The frontal sinuses are typically two air-filled cavities located behind the superciliary arches within the frontal bone. A key anatomical feature is the septum, which often deviates from the midline. This deviation, along with other structural variations, makes the sinus pattern distinctive for every individual, much like fingerprints. Remarkably, even identical twins do not share the same frontal sinus morphology. [11,12]

Radiographs taken using the Caldwell view, and more recently CBCT scans, provide detailed sinus images that are useful in such analyses.[13]

Early research by Schuller (1943) and later findings by Ponde et al. confirmed this trend. Additionally, Brown reported a greater sagittal (front-to-back) dimension in males. Although some studies observed no statistically significant difference, the general consensus remains that frontal sinus size is typically greater in males. [14]

GONIAL HEIGHT, RAMUS AND BIGONIAL WIDTH

Females were found to have a significant higher value of gonial angle than their male counterpart; which was similar to the results obtained by Ghosh et al. These measurements can help estimate age and gender in forensic and clinical scenarios. [15]

Parameter	Gender Difference	Age-Related Change	Reliability
Gonial Angle	Larger in females	Increases with age	Most reliable
Ramus Height	Slightly larger in males	Decreases with age	Moderately reliable
Bigonial Width	Larger in males	Decreases with age	Less reliable than angle

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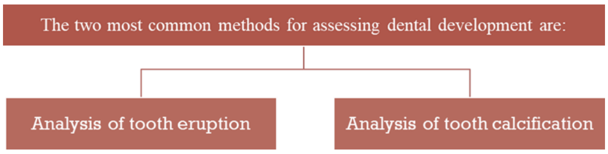
MANDIBULAR SECOND MOLAR CALICIFICATION STAGES



Among these, the analysis of tooth calcification, especially of the mandibular second molars, offers a practical advantage in clinical settings, particularly since panoramic radiographs (OPGs) are routinely advised for orthodontic patients. Utilizing these existing radiographs eliminates the need for additional radiation exposure, making it a safer diagnostic option. The present study demonstrated a strong and statistically significant correlation between the Demirjian Index (DI) stages of second molar calcification and the Cervical Vertebral Maturity Index (CVMI), thereby establishing the reliability of DI as an indicator of skeletal maturity. Hence, mandibular second molar calcification stages can serve as a dependable and non-invasive tool for assessing skeletal development in growing individuals.[16]

DENTAL IDENTIFICATION PROCEDURE

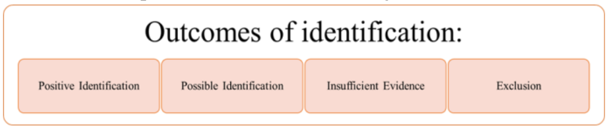
Dental identification plays a significant role in forensic investigations, particularly when a body is recovered in a severely burned or decomposed condition. Owing to their high resistance to destruction by fire, dental structures—such as natural teeth and various restorative materials—often remain intact and serve as valuable forensic evidence.[17] Identification is primarily performed through the comparison of antemortem (before death) and postmortem (after death) dental records, focusing on key features such as the number of teeth present or missing, restorations, occlusal patterns, root and crown morphology, pulp anatomy, and any prosthetic appliances. This comparison helps determine the identity of the deceased, even when other means of identification are not viable.[18]

The American Board of Forensic Odontology (1986) has standardized the process by categorizing the outcomes of such comparisons into four types: positive identification, possible identification, insufficient evidence, and exclusion, depending on the degree of similarity and availability of data.

Important Forensic Considerations [19]:

Dental Structure/Material	Approximate Resistance Temperature
Natural Teeth	Up to **1000°C**
Acrylic Restorations	**~540°C**
Gold and Amalgam	~870°C
Porcelain	~1100°C

- Teeth can withstand temperatures up to **1000°C**, making them ideal for forensic analysis.
- Dental materials have **varying resistance to heat**, which helps in identifying the type of restorations used.
- Common factors analyzed include:
  - Present/missing teeth
  - Restorations and prostheses
  - Occlusion and attrition patterns
  - Root/crown morphology
  - Pathologies or dental treatments
  - Antemortem and postmortem **radiographs** are compared to determine identity.



APPLICATION IN FORENSIC SCIENCE

HUMAN BODY IDENTIFICATION

Recently, Dental Profiling is used to recreate the victim's profile prior to death, based on the accessible clinical and radiological data.[20]

With the advent of three dimensional (3D) imaging techniques, the ante-mortem CT image can be utilized in profiling of the postmortem images, which allows accurate location and measurement of the cranio-metric points.4 Also, CBCT is currently used for post-mortem imaging and for imaging high-density metal projectiles in cases of gunshot injury in forensic odontology.[21]

AGE ESTIMATION

Estimating age is the most important prerequisite for identification of the dead. Age estimation can be done by various factors like:

- Jaw bones.
- Tooth germs.
- Process of mineralization.
- Stages of crown development, completion and their eruption into oral cavity.
- Volume of pulp chamber.
- Third molar development and eruption pattern.
- Root morphology.

Age estimation methods may be classified as:

1. Age estimation methods for the forming dentition.
2. Age estimation methods for the adult dentition.[22]

Pre-natal, neonatal and post-natal age determination is done by radiographic examination of Jaw bones pre-natally and evaluating tooth germs which are present before mineralization in intrauterine life and are visualized as radiolucent areas on radiographs prior to mineralization.[23]

SEX DETERMINATION

Teeth measurements taken from panoramic radiographs, lateral cephalometric radiographs, and postero-anterior projections have demonstrated an 80% accuracy rate in gender identification. These radiographic techniques allow for the measurement of various dental features, including the total tooth length, crown and root lengths, as well as bony ridges, crests, and processes. Additionally, they provide

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measurements of the temporal line, mastoid processes, nuchal lines, external occipital protuberance, superciliary arches, craniofacial height, mastoid height, bicondylar width, and mandibular width, all within a single frame.[24]

Occurrence of hyperostosis in post-menopausal females and decrease in size of frontal sinuses in old females, ossification points analysis such as Spheno-occipital synchondrosis and Cranial base synchondroses are useful markers to assess age on radiographs.[25]

CBCT analysis of the frontal sinus (FS), maxillary sinus (MS), and foramen magnum (FM) is considered a highly effective method for gender determination, offering precise and accurate results. It provides detailed insights into the mandible, revealing distinct dimorphic traits in its shape and size. Linear measurements of the ramus on CBCT are typically larger in males compared to females. The gonial angle, on the other hand, shows a downward and backward rotation in females, while in males, it exhibits a forward rotation. Additionally, the foramen magnum (FM) measurement on CBCT is generally larger in males.[26]

BITE MARK ANALYSIS

Growth and Progress of Forensic dentistry has propelled responsibilities and role of Maxillofacial Radiologists towards this sub speciality of Forensic Science, at a global scale.25 3D printing has a myriad of applications in forensics by means of 3D bite mark analysis, 3D skull printing which is done for comparison with dentition of the suspect and analysis of trauma respectively.[27]

GUN SHOT- CT SCAN

CBCT (Cone Beam Computed Tomography) is an effective tool in the evaluation of gunshot wounds, providing detailed images to precisely determine the bullet's location, as well as the entry and exit points of the wound. It allows for accurate visualization of the trajectory of the bullet within the body, aiding in the assessment of surrounding structures and the extent of damage [28]. This imaging technique plays a critical role in forensic investigations, helping to document and analyze gunshot injuries in detail.[29]

MASS DISASTER VICTIM IDENTIFICATION

In mass disaster incidents, portable dental X-ray units are often used on-site to create radiographs. Full mouth radiographs are typically preferred as they capture all potential fragments of dental remains, which can then be digitized for rapid comparison. Recently, 2D automated recognition technology has enabled the cross-matching of a pool of radiographs from suspected victims against post-mortem (PM) remnants, facilitating content-based retrieval of antemortem (AM) images that match post-mortem images. The use of Computer-Assisted Post- Mortem Imaging (CAMPI) has been successfully applied in many cases in the past.

Mobile CT scanners are also widely used in mass fatality disasters. These scanners are useful both inside permanent and temporary mortuaries. The high-resolution eLU-CT scanners minimize metallic artifacts caused by dental fillings, ensuring clearer images for comparison. Additionally, semi-automated image analysis software has been developed to assist in performing these comparisons.[30]

Cone Beam Computed Tomography (CBCT) allows for the reconstruction of images from a single scan, which enables operators to select slices and orientations for optimal analysis. CBCT minimizes the production of artifacts and reduces errors in victim identification, making it a reliable tool in disaster identification.

Fluoroscopy is another method used in scanning disaster victims, typically at the initial reception stage, followed by further examination using plain X-ray. MRI is also utilized, although it is dependent on the availability of fixed and mobile technology, and its use is limited by the presence of metallic materials in bodies or body parts, which can interfere with the imaging process.[31]

A more recent innovation in disaster victim identification is "Dental Biometrics," which uses dental radiographs for identifying deceased individuals. This technique extracts tooth segments using a mixture of Gaussian models, allowing for image matching, computation of image distances, and subject identification.[32]

MEDICOLEGAL CASES

Forensic radiology plays a crucial role in identifying the cause of death, whether accidental or intentional. Radiographic imaging helps determine the site and direction of impact, which is particularly significant in cases of trauma. For instance, signs of strangulation can be detected through fractures of the thyroid cartilage or hyoid bone. Additionally, metabolic disorders, infections, nutritional deficiencies, and bleeding conditions often leave characteristic changes on bones that are visible through radiographs.[33]

Radiographic techniques also aid in detecting foreign bodies, such as bullets or shrapnel, especially in scenarios involving mass disasters. Advanced imaging modalities like CT and CBCT are particularly useful for evaluating the severity and nature of skull injuries, offering detailed insights that contribute to accurate forensic interpretations.[34]

FACIAL RECONSTRUCTION

Craniofacial reconstruction (CFR) is a technique that replicates the individual facial characteristics, published using media and therefore lead to recognition identification of the unknown.[35]

3D computerized reconstruction technologies (3D-CT) integrate multiple advanced imaging modalities to enhance forensic identification. These systems offer high-resolution image generation and sophisticated reconstruction tools, enabling accurate facial approximation. MRI plays a vital role by providing precise soft- tissue depth measurements and revealing intricate structural details. Cone Beam Computed Tomography (CBCT) software supports 3D skull imaging with reduced radiation exposure, making it highly suitable for facial reconstruction tasks.

Recent advancements in maxillofacial radiology have

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introduced innovative techniques in CFR, such as **Fusion Imaging**, which overlays CT scans with 3D facial images acquired via optical methods. **Laser Scanners** offer a non-contact surface imaging option, producing full 360-degree facial data. **Digital Stereophotogrammetry**—a rapid, non-invasive imaging method—delivers life-like facial representations with accurate geometry, refined texture, and realistic color, enhancing the reliability of facial reconstruction for identification purposes.[36]

CONCLUSION

Oral and maxillofacial radiology has emerged as an indispensable tool in forensic investigations. Its ability to capture unique anatomical landmarks, dental features, and skeletal traits enables accurate human identification even in the most challenging circumstances like mass disasters, severe burns, or advanced decomposition. With advancements like CBCT, digital radiography, and 3D reconstruction technologies, the precision and efficiency of forensic identification have significantly improved. As technology continues to evolve, the integration of radiological modalities in forensic odontology will not only enhance identification accuracy but also expand the horizons of justice and humanitarian service.

REFERENCE

1. Shamim T. Forensic odontology. J Coll Physicians Surg Pakistan. 2012; 22(4): 240-5.
2. Wood RE. Forensic aspects of maxillofacial radiology. Forensic Science International. 2006,
3. Kahana T JH. Forensic Pathology Review. Forensic Radiol. 2005; 3: 43-460.
4. Kavitha B, Einstein A, Sivapathasundharam B, Saraswathi TR. Limitations in forensic odontology. J Forensic Dent Sci 2009;1:8-10.
5. Eckert WG, Garland N. The history of the forensic applications in radiology. Am J Forensic Med Pathol 1984;5:53-6.
6. 6Brogdon BG, Vogel H. Conventional radiologic identification. In: Brogdon BG, Vogel H, McDowell JD, editors. A Radiologic Atlas of Abuse, Torture, Terrorism, and Inflicted Trauma. Boca Raton, FL: CRC Press LLC; 2003. p. 255-6.
7. Carvalho SP, Alvesda Silva RH, Lopes-Junior C, Peres AS. Use of images for human identification in forensic dentistry. Radiologi Brasileira 2009;42:125-30.
8. Sushil Kumar et al. Skeletal maturation evaluation using mandibular second molar calcification stages. Angle Orthod. 2012;82:501–506.
9. Aprajita Sikka, Anjali Jain. Sex determination of mandible: a morphological and morphometric analysis. International Journal of Contemporary Medical Research. 2016;3:1869-1872.
10. Importance of dental radiography in forensic odontology : A review- Bheemavarapu Naveen Kumar Reddy, Swetha P, Ravikanth Manyam, A Naga Supriya
11. Verma. S, Mahima .V.G, Patil. K.Radiomorphometric analysis of frontal sinus for sex determination J Forensic Dent Sci. 2014;6:177–1.
12. Tang JP, Hu DY, Jiang FH, Yu XJ. Assessing forensic applications of the frontal sinus in a Chinese Han population. Forensic Sci Int. 2009;183:104.e1–3.
13. Schuller A. A note on the identification of skulls by x-ray pictures of the frontal sinuses. Med J Aust. 1943;1:554–6.
14. Camargo JR, Daruge E, Prado FB, Caria PH, Alves MC, Silva RF, et al. The frontal sinus morphology in radiographs of Brazilian subjects: Its forensic importance. Braz J Morphol Sci. 2007;24:239–43.
15. Ghosh S, Vengal M, Pai K. Remodeling of the human mandible in the gonial angle region: A panoramic, radiographic, cross-sectional study. Oral Radiology. 2009;25:2-5.
16. Sushil Kumar et al. Skeletal maturation evaluation using mandibular second molar calcification stages. Angle Orthod. 2012;82:501–506.
17. Pallagatti S, Sheikh S, Aggarwal A, Singh R, Gupta D, Kaur A. Maxillofacial Imaging; An emerging tool in Forensic Science. J Forensic Res 2011;2:134.
18. Avon SL. Forensic odontology: The roles and responsibilities of the dentist. J Can Dent Assoc 2004;70:453-8.
19. Guidelines for bite mark analysis. American Board of Forensic Odontology, Inc. J Am Dent Assoc 1986;112:383-6.
20. Sinha S, Singh C, Chandra S, Singh SK, Mehta P. Role of Maxillofacial Radiology in Expediting Forensic Odontology. International Journal of Oral Care and Research October-December 2018;6(4):89-92.
21. Senn DR, Stimson PG.Forensic Dentistry .2nd Edition. Boca Raton London. Taylor & Francis Group : CRC Press;2010 ,Chapter 2 History of Forensic Dentistry ; p 11-24, Chapter 9, Forensic Dental Identification; p 163- 186 , Chapter 10, Forensic Dental Radiography; p 187- 202, Chapter 12, Dental Identification in Mass Fatality Incidents; p 245-262
22. Whittakar DK, McDonald DG. Age determination from teeth. A color atlas of forensic dentistry. England: Wolfe Medical Publications Ltd; 1989. p. 58-66.
23. Panchbhai AS. Dental radiographic indicators, a key to age estimation. Dentomaxillofac Radiol. 2011 May;40(4):199-212. doi: 10.1259/dmfr/19478385. PMID: 21493876; PMCID: PMC3520308.
24. Capitaneanu C, Willems G, Jacobs R, Fieuws S, Thevissen P. Sex estimation based on tooth measurements using panoramic radiographs. Int J Legal Med. 2017 May;131(3):813-821. doi: 10.1007/s00414- 016-1434-0. Epub 2016 Aug 17. PMID:27534562
25. Sujatha S, Azmi RS, Devi YBK, Shwetha V and

*Corresponding Author: **Dr. Megha B** .

Kumar PT. CBCT - The Newfangled in Forensic Radiology. Journal of Dental & Oro-facial Research. Aug 2017;13(2):47- 55.-3

26. Rutty GN, Robinson CE, BouHaidar R, Jeffery AJ, Morgan B. The role of mobile computed tomography in mass fatality incidents. J Forensic Sci. 2007 No v ; 5 2 (6) : 1 3 4 3 - 9 . d o i : 1 0 . 1111 / j. 1 5 5 6 - 4029.2007.00548.x. Epub 2007 Sep 15.PMID: 17868270.
27. Shetty S. Advanced Technologies an Aid in Forensic Odontology. An Update International Journal of Advanced Research 2015: 3 (10) 1615 – 1620 (ISSN 2320-5407).
28. Sidler M, Jackowski C, Dirnhofer R, Vock P, Thali M. Use of multislice computed tomography in disaster victim identification-Advantages and limitations. Forensic Sci Int. 2007;169(2–3):118–28.
29. Garetier M, Deloire L, Dédouit F, Dumousset E, Saccardy C, Ben Salem D. Postmortem computed tomography findings in suicide victims. Diagn Interv Imaging. 2017;98(2):101–12.
30. Kumar R, Athota A, Rastogi T, Karumuri SK. Forensic radiology: An emerging tool in identification. Journal ofIndian Academy of Oral Medicine & Radiology. Jul-Sep 2015;27(3):416-22.
31. Achar MS, Shetty SR, Al-Bayati SF, Joshua A and Suneja R. Importance of radiography in forensic odontology: A brief review European Journal of Forensic Sciences. 2015;2(3):1-3. DOI: 10.5455/ejfs.183027.
32. Rutty GN, Robinson CE, BouHaidar R, Jeffery AJ, Morgan B. The role of mobile computed tomography in mass fatality incidents. J Forensic Sci. 2007 No v ; 5 2 (6) : 1 3 4 3 - 9 . d o i : 1 0 .1111 / j . 1 5 5 6 - 4029.2007.00548.x. Epub 2007 Sep 15. PMID: 17868270.
33. Pretty IA, Sweet D. A look at forensic dentistry-Part 1: The role of teeth in the determination of human identity. Br Dent J 2001;190:359-66.
34. Goren AD, Bonvento M, Biernack J, Colosi DC. The British Institute of Radiology, technical report, radiation exposure with the NOMADTM portable x-ray system. Dentomaxillofac Radiol 2008;37:109-12.
35. Chandrasekhar T and Vennila P. Role of Radiology in Forensic Dentistry. Journal of Indian Academy of Oral M e d i c i n e a n d R a d i o l o g y . J u l y - September2011;23(3):229-231.
36. Khatri M, Misra D, Rai S, Misra A. Unfolding the Mysterious Path of Forensic Facial Reconstruction: Review of Different Imaging Modalities.MAMC J Med Sci 2017;3:120-127.

*Corresponding Author: **Dr. Megha B** .