OPEN ACCESS
Global Journal of Research in Dental Sciences
ISSN: 2583-2840 (Online)
Volume 05 | Issue 03 | May – June | 2025
Journal homepage: https://gjrpublication.com/gjrds/

Review Article

Three-Dimensional Printing in Forensic Odontology: A Transformational Tool for Identification and Analysis

*Dr. Anieta Merin Jacob[1], Dr. Chandrasekhar BS[2], Dr. Shibu P[3], Kevin Emmanuel Suresh[4], Dr. John Abraham[5], Dr. Clement Prakash[6]

[1]Assistant Professor, Department of Oral Medicine and Radiology, NSVK Sri Venkateswara Dental College and Hospital, Bangalore
[2]Professor and Head, Department of Public Health Dentistry, NSVK Sri Venkateswara Dental College and Hospital, Bangalore
[3]Associate Professor and Head, Department of Oral Medicine and Radiology, NSVK Sri Venkateswara Dental College and Hospital, Bangalore
[4]Department of Microbiology, St. John's National Academy of Health Sciences, Bangalore
[5]Assistant Professor, Department of Family Medicine, St. John's National Academy of Health Sciences, Bangalore **ORCID ID:** 0000-0002- 4850-5070
[6]Associate Professor and Head, Department of General Surgery, St. John's National Academy of Health Science, Bangalore

DOI: 10.5281/zenodo.15679963 **Submission Date:** 10 May 2025 | **Published Date:** 17 June 2025

Corresponding author:** *Dr. Anieta Merin Jacob
Assistant Professor, Department of Oral Medicine and Radiology, NSVK Sri Venkateswara Dental College and Hospital, Bangalore.
***ORCID ID:** 0000-0002-4850-5070*

Abstract

Three-dimensional (3D) printing technology has emerged as a revolutionary tool in forensic odontology, offering unprecedented precision and versatility in the identification and analysis of human remains. Traditionally reliant on dental records, radiographs, and physical impressions, forensic odontology has been significantly enhanced by the integration of 3D printing, which enables the accurate reconstruction of dental and craniofacial structures. This technology allows for the creation of detailed replicas of teeth, jaws, and bite marks, facilitating comparative analysis, court presentations, and educational demonstrations. 3D-printed models provide a non-invasive, durable, and reproducible means of preserving forensic evidence, especially in cases involving mass disasters, trauma, or decomposition. Furthermore, the ability to digitally archive and replicate evidence supports collaborative efforts among forensic experts across geographical boundaries. The integration of cone-beam computed tomography (CBCT), intraoral scanning, and CAD/CAM systems with 3D printing enhances diagnostic accuracy and speeds up the identification process. This paper explores the applications, advantages, and limitations of 3D printing in forensic odontology, highlighting its role in modern forensic investigations. As technology continues to evolve, its adoption is poised to transform the field, improving the reliability and efficiency of forensic identification and contributing significantly to the pursuit of justice.

Keywords: *3D Printing, Forensic Odontology, Cone-Beam Computed Tomography, Gender and Age Determination, Reconstruction, Forensic Medicine.*

INTRODUCTION

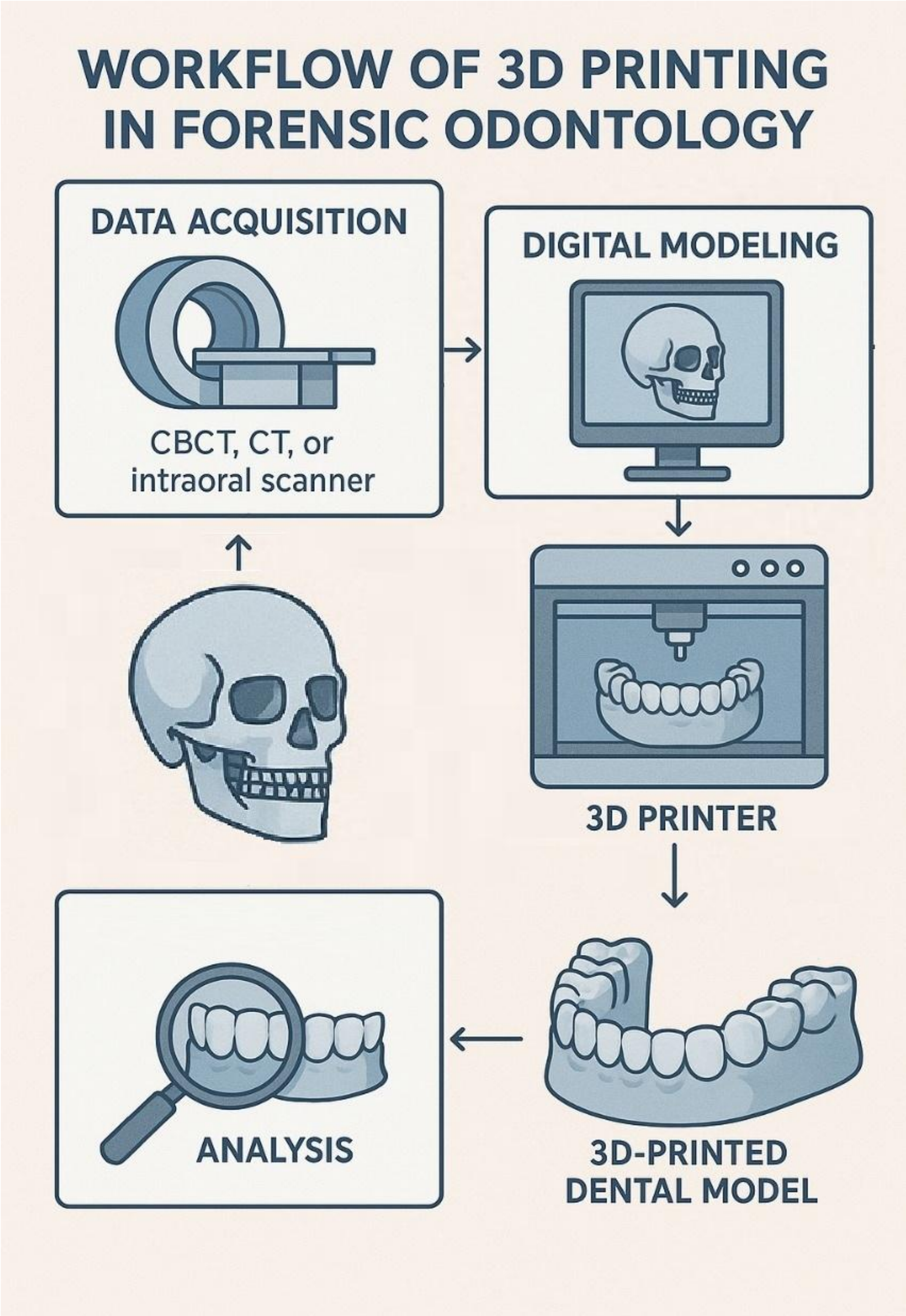
Three-dimensional (3D) printing is an approach that is used to produce a 3D object using digital model data. It involves establishing a real-world physical 3D model from a computer model where information in all three dimensions is produced. 3D printing is a technology that provides a tactile response and a substantial depth of information about the structure that is being recreated. 3-D models are printed from imaging modalities that provide information about all 3 dimensions and have sufficient contrast, such as computed tomography (CT) data, cone beam computerized tomography (CBCT) data, optical surface scan data slices, etc. Additive manufacturing process is the technique that is used because the slices are printed sequentially in layers, and these are added one layer on top of the other to create the 3D model. [1] Specialized software like computer-aided design (CAD), Lux Align, GrabCAD, etc. are used for 3D printing in dentistry. 3D printing has an accurate production of a single product at a time with complex structures in different types of materials with properties that are highly desirable in various disciplines of dentistry. This technology has got a particular resonance in the medical field, chiefly in specialties like maxillofacial surgery, radiology/imaging, and Dental anatomy. 3D printing has also been used increasingly in the field of forensic odontology. It allows better visualization, interpretation, preservation, and analysis of forensic evidence.[2] The use of 3D printing in forensic odontology includes bite mark analysis, tomographic facial reconstruction, age-gender determination, and construction of physical models. In this context, this paper highlights the benefits of 3-D printing brought about in the field of forensic odontology.

FORENSIC ODONTOLOGY

Forensic dentistry has been defined by the Federation Dentaire International (FDI) as that branch of dentistry that, in the interest of justice, deals with the proper handling and examination of dental evidence and with the proper evaluation. A significant outgrowth of forensic odontology has enabled an appropriate examination, handling, and demonstration of dental evidence in the court of law. It plays an important part in relating to the human remains of victims, not only those of crippled, mutilated, burnt, and perished but also victims of bioterrorism and mass disasters. Forensic odontologists are also called upon in cases of catastrophic events like industrial explosions, airline accidents, natural disasters, and terrorist attacks, including explosive, chemical, radiological, or nuclear disasters, for identification of the victims. The call for forensic identification arises in mass disasters to resolve criminal investigations, legal problems of settlement, inheritance, funeral rites, and grief resolution of family and friends. 3D printing can be used as demonstrative evidence in court and has a more humanitarian approach in collecting and visualizing the evidence as it is reconstructed without touching the evidence, thereby not damaging the actual evidence.

PRINCIPLES OF THREE-DIMENSIONAL PRINTING

Digital imaging and communications in medicine (DICOM) is the leading standard in the medical imaging field, where the biomedical images and image-related information can be interpreted and exchanged for reference. 3D printers do not accept DICOM images; hence, these images must be converted to standard tessellation language (STL) files, where they take in individual objects defined by surfaces that surround a region of space [3]. Additive Manufacturing File Format (AMF) is a new format that is being introduced to overcome the limitations of STL. It has the added advantage of incorporating various features in the images, such as color, surface texture, and different properties of material.[3,4] The AMF formatted data is now transferred to the AM machine for file manipulation, and the model is prepared for printing by creating slices of the image. The sliced data is now sent to the printer, where slices are printed sequentially in layers or in an additive manner; the material is laid down layer by layer. Post-processing procedures such as cleaning, finishing, polishing (sandblasting, jet-washing), and sterilization are done using various techniques. The process of 3D printing can be understood under three parts: Data acquisition, Digital Modelling and 3D printing (Fig. 1: Workflow of 3D Printing in Forensic Odontology)


WORKFLOW OF 3D PRINTING
IN FORENSIC ODONTOLOGY
DATA ACQUISITION
CBCT, CT, or
intraoral scanner
DIGITAL MODELING
3D PRINTER
3D-PRINTED
DENTAL MODEL
ANALYSIS

Workflow of 3D Printing in Forensic Odontology:

The workflow of 3D printing in forensic odontology involves a systematic process that integrates digital imaging, data processing, and physical model creation to assist in forensic analysis and identification. This multi-step process ensures precision and replicability while preserving the integrity of evidence.

1. Data Acquisition:
The first step involves obtaining detailed digital data of dental structures. This can be achieved through various imaging techniques such as cone beam computed tomography (CBCT), intraoral scanners, or traditional CT scans. These methods capture the fine details of the dental anatomy, including restorations, fractures, and root morphology, which are essential for forensic comparison.

2. Data Processing and 3D Modelling:
The imaging data is converted into a digital 3D model using specialized software (e.g., CAD or DICOM-to-STL conversion tools). During this stage, artifacts are removed, and the model is refined for accuracy. The file is usually saved in STL (stereolithography) format, which is compatible with most 3D printers.

3. 3D Printing:
Once the model is prepared, it is printed using a suitable 3D printer and material often resin or polymer based depending on the required resolution and durability. Additive manufacturing techniques like stereolithography (SLA) or fused deposition modelling (FDM) are commonly used.

4. Post-Processing:
After printing, the model undergoes cleaning, curing, and sometimes surface finishing to ensure its usability for forensic purposes.

5. Application and Analysis:
The printed models are then used for comparison in identification, trauma analysis, or courtroom presentation. Their tactile and visual clarity aids in precise, reproducible forensic assessments and facilitates better communication among forensic experts and legal professionals.

Materials used in 3D Printing: Biodegradable polymeric acid (PLA), which is a commonly used material, or similar materials such as polyvinyl chloride (PVC), nylon, acrylonitrile butadiene styrene (ABS), investment casting wax, Polypropylene, polycarbonates, and photopolymers have been used as key components of 3D printing in dentistry.[15]

Technologies used in 3D printing: The quality of the 3D-printed model depends on the technology used, where stereolithography (SLA) is one of the best choices for precision. An innovative approach to 3D printing, by using light and oxygen to continuously grow a model from a resin pool, is under development. This technology, called Continuous Liquid Interface Production (CLIP), makes way for much faster printing of 3D models. Other technologies include:

- **Fused deposition modelling (FDM)**: FDM builds models by selective deposition of melted material layer by layer in a predetermined prototype/model.
- **Selective laser sintering (SLS)**: uses a high-power laser to sinter small particles of polymer powder into a solid structure based on a 3D model
- **Stereolithography (SLA):** SLA uses light/ UV laser to solidify or cross link the resins layered on a pre-programmed design/ shape.
- **Digital light processing (DLP):** DLP uses projection light to polymerize materials to obtain pre-designed structures. Projected light source cures the entire layer at once, rather than layer by layer.
- **Powder binder printers (PBP):** An inkjet print head moves across a bed of powder, selectively depositing a liquid binding material. A thin layer of powder is spread across the completed section and the process is repeated with each layer adhering to the last.
- **Photopolymer jetting (PPJ):** PolyJet 3D printing works by jetting tiny droplets of photopolymer materials, layer by layer, onto a build platform, where they are immediately cured by UV light

3D PRINTING IN FORENSICS APPLICATIONS

1. BITE MARK AND PATTERN ANALYSIS

a) Bite Mark Analysis

MacDonald defined a bite mark as “a mark caused by the teeth either alone or in combination with other mouth parts.” Like fingerprints, the marks made by human teeth can be a tool for identification, as this is unique in every individual. Bite marks disclose individual tooth imprints. Bite marks can be obtained with tooth pressure marks, tongue pressure marks, tooth scrape marks, or a combination of these. The dynamics of biting make the analysis of bite marks and their comparison to the suspect’s teeth a highly challenging aspect of forensic dental investigation. It is important to recognize uncommon characteristics of the bite mark, such as the presence or absence of a particular tooth, its dimension, rotation, fracture, diastema, and other unusual features of the teeth, as these can aid in implicating a suspect. Digital scanning can be performed with the bite mark at the crime scene, and the entire bite mark can be recreated by developing overlays with suitable material, using 3D printing. This scan is then compared with a suspect’s dentition cast. The scans themselves can be used for digital comparison of the suspect's teeth using various software. Hence, 3D scanning helps to preserve the information obtained and can be used as secure evidence in the court of law.[3,6,7]

b) Analysis of lip print pattern (cheiloscopy), palatal rugae pattern (palatoscopy), and tongue print pattern (lingual print).
Cheiloscopy, palatoscopy, and lingual print analysis are emerging biometric tools in forensic identification due to their uniqueness and permanence. Lip prints (cheiloscopy) assist in identifying individuals based on groove patterns, while palatal rugae (palatoscopy) and tongue prints offer stable anatomical markers resistant to trauma and decomposition. The integration of three-dimensional (3-D) printing with these techniques enables accurate replication of oral structures for comparison, preservation, and courtroom presentation. 3-D models enhance visualization, improve training, and facilitate interdisciplinary collaboration. This transformative technology elevates traditional pattern analysis into a digitized, reproducible, and legally admissible format, significantly advancing forensic odontology's role in human identification.

c) Fingerprint analysis: Fingerprint analysis using 3D printing, where replica prints are produced, has been researched recently. 3D printing helps to replicate the 3-dimensional curvature features of fingerprints. However, printing a latent fingermark that is obtained from a surface would be conceivably more difficult due to the difficulty in adequately capturing the mark, given that the mark is only perceivably present in two dimensions [8,9].

d) **Tool marks in crime scenes:** Tool marks can be documented from the crime scenes either for a forced entry into the house or where it was used to attack the victim's causing injury. Using 3D printing, the tool marks can be recreated to identify the tool, the type of mark it makes (impressed mark, crushed mark, or scrape mark), and the type of injury it causes, and this model can be used as a source of evidence.

2. FORENSIC FACIAL RECONSTRUCTION
It is a method by which a deceased individual's face is reconstructed from the skull by making use of tissue depth markers and other anatomical landmarks. Conventionally, a 2-dimensional and 3-dimensional reconstruction using different methods such as the Anthropometrical American method, Anatomical method, and British method is followed, which then got replaced with computerized 3D facial reconstruction using different software with haptic feedback systems. [10] In 3D printing, the model of the skull in the form of STL (stereolithography) with minimum slice thickness, produced from the CT scan, is used. Appropriate material like acrylonitrile butadiene styrene (ABS) filament is used, and the layers are additively laid down to produce anatomically accurate models. Hence, 3D printing coupled with CT scans allows facial reconstruction that can be reproduced multiple times and can be preserved for forensic investigations and in intelligence gathering.[11,2]

3. BALLISTIC RECONSTRUCTION
Fired bullets or evidence from firearms can leave microscopic marks on the bullet and the cartridge, which can be considered as ballistic fingerprints in forensics. These can be compared with the victims of deformation as well. 3D printing helps to reconstruct the bullet trajectories, i.e., the path of a bullet from or through an object, as well as the trajectory of the bullet within a human body. This helps the forensic expert to identify the type of firearm as well as the nature of the injury the jury caused, which can be used as an alternative source for visualization of crime scenes.

4. FORENSIC MEDICINE
3D printing in forensic medicine has helped to find out the internal pathology with the aid of different imaging modalities such as CT angiography, MRI, surface scanning, etc. Rather than understanding the disease mechanism, models produced in such a way have added advantages, as they can be used for medical education and aid in improving the skills of pathologists and surgeons. 3D-printed models help to find out the causes of death of the victim in forensic cases where a demonstration of the internal pathology may serve as evidence in courtroom demonstrations.

5. FORENSIC ODONTOLOGY
a) Dental Age Estimation
An important aspect of forensic odontology is the age determination of an individual based on a sequence of dentition eruption status. The number and sequence of the teeth erupted can equitably determine the age of an individual. Radiographic methods can further show in detail the different stages of mineralization and help in a more accurate estimation of age[14]. Models produced by 3D printing from existing scans help in the calculation of a person's dental age. Also, 3D models can be used for average grading of attrition (Li and Ji method), where the age range of the patient can be approximated. Age estimation with printed models removes the need for direct examination in the oral cavity as well as eliminating other difficulties such as improper visualization and access secondary to rigor mortis[3].

b) Gender Determination
By considering dimensions of teeth, the sex of an individual can be determined. Tooth size, root length and crown diameter, canine dimorphism, inter-canine and intermolar distance, and arch length assessment are the parameters used for gender determination. 3D-printed models produced by scanning and additive layout have decreased chances of

variation with the original teeth morphology. This dimensional accuracy of 3D printed models is best made use of gender determination. No significant difference in the various parameters of tooth models and 3D-printed models was found in studies. Hence, an accurate printed model could improve the accuracy of sex determination procedures and population identification.[3,13]

c) Human Identification
Forensic odontology plays an important role in the identification of victims in mass disasters, i.e., earthquakes, tsunamis, aviation accidents, crime investigations, and identification of decomposed and disfigured bodies. Teeth withstand degradation from extreme conditions even after the death of an individual and hence enable analysis of ante mortem and postmortem dental variables. Dental remains, as teeth are superior material in living and non-living populations for anthropological, genetic, odontological, and forensic investigations. Being the hardest, most rigid, and chemically the most stable tissue in the body, they are selectively preserved and lapidified, thereby used as the best records for evolutionary change. Their resistance to combustion and bacterial disintegration makes them indispensable in forensic identification. A 3D-printed model obtained from postmortem computed tomography helps to reduce the difficulties found in traditional autopsies and for the better identification of the deceased. A very minimal or null dimensional change is reported between the tooth and the 3D-printed models, hence making it a valuable tool for human identification and record referral.

d) Disaster Victim Identification
Disaster victim identification (DVI) is used in scenarios where there is a mass fatality incident with the deceased body being burned or utterly destroyed. The uniqueness of concordant postmortem and antemortem dental records provides proof to identify the person. [12] If the ante-mortem dental records are not available for comparison, then a forensic anthropologist or odontologist can give clues regarding the age, race, and sex of the deceased from the dental evidence recovered from the scene[14]. 3D-printed models from the scans of the victims help with personal identification, and they help in better handling of the charred remains. Once obtained, the scan can be preserved, and multiple models can be produced from the data available without the tedious handling of the remains every single time.

e) Documentation
The use of unique features and morphological variations of the teeth in personal identification is well accepted in forensic examinations and in the court of law. The transfer and presentation of human remains and evidence to the court must be done strictly in legal context with utmost care, as it has legal and ethical protocols associated with their handling and storage. In such cases, realistic 3D replicas of human remains can be produced using 3D printing technology and can ultimately serve to convey important details to the court and jury without offending anybody or causing bias.[2]

Table 2: Advantages and Disadvantages of 3D Printing in Forensic Odontology

Advantages	Disadvantages
High accuracy in replicating dental structures	High initial cost of equipment and materials
Enhance visualization for forensic analysis and courtroom presentation	Requires technical expertise and training
Preserves fragile or decomposed remains safely	Time-consuming processing and post-production steps
Allows digital storage and reprinting of models	Risk of data loss or corruption during digital conversion
Enables interdisciplinary collaboration	Limited accessibility in low-resource or remote areas
Ideal for education and training without ethical concerns	Output quality depends on printer type and material
Assists in accurate trauma and facial reconstruction	Legal acceptance may vary across jurisdictions
Minimizes repeated handling of original remains	Errors possible if imaging data is incomplete or improperly captured

Future of 3-D Printing in Forensic Odontology
3-D printing is revolutionizing forensic odontology by enhancing the precision, documentation, and presentation of dental evidence. One major advancement is the replication of dental structures, allowing for exact reproductions of teeth and jaws for comparison in bite mark analysis and identification of human remains[17]. This enhances reliability in court, where physical models are more persuasive than photographs or reports.

Digital imaging techniques like CBCT (cone beam computed tomography) and intraoral scanning are increasingly paired with 3-D printing to reconstruct high-resolution, patient-specific dental structures[18]. This allows forensic odontologists to assess trauma, pathology, and age estimation with increased accuracy[19].

Furthermore, 3-D printing is being used to preserve fragile evidence, especially in mass disaster or decomposition scenarios where handling the original specimen may be risky[20]. Printed models are durable, reproducible, and can be shared among investigators across geographies[21].

Educational applications are also growing. Dental schools and forensic training programs use 3-D printed models to simulate cases, enhancing skill development and standardizing instruction[22]. As artificial intelligence integrates with digital Dentistry, automated data processing, and model generation are expected to become more mainstream[23].

In the future, bioprinting though currently in experimental stages may permit reconstruction of soft tissues, opening new frontiers in facial reconstruction for forensic purposes[24]. Meanwhile, ongoing improvements in material science promise more accurate reproduction of dental tissues, reducing error margins in forensic analysis[25].

1. Integration with Advanced Imaging Technologies

- The combination of 3-D printing with technologies such as cone beam computed tomography (CBCT) and intraoral scanners will improve the accuracy of dental models.
- Real-time scanning and printing could facilitate faster identification during mass disasters.

2. Custom Materials Mimicking Dental Tissues

- Development of biocompatible and tissue-mimicking printing materials to replicate the hardness and texture of teeth and gums for more realistic bite mark and dental impression analysis.

3. Automation and AI Integration

- Artificial intelligence could assist in automating the comparison of 3-D printed dental models with databases for rapid identification.
- AI-powered software can enhance bite mark pattern recognition and reduce human error.

4. Portable 3-D Printing Devices

- Portable, compact 3-D printers may be used directly at crime scenes or disaster sites to produce immediate dental replicas.

5. Enhanced Digital Record Keeping

- Creation of digital dental archives that can be used to print models on demand worldwide, facilitating international forensic collaboration.

6. Use in Mass Disaster Victim Identification (DVI)

- 3-D printing will play a pivotal role in reconstructing and identifying remains when bodies are severely damaged.

7. Legal and Ethical Framework Development

- As 3-D printed evidence becomes more prevalent, standards and regulations will be refined to ensure the accuracy and admissibility of 3-D printed forensic evidence.

CONCLUSION

Three-dimensional (3D) printing has emerged as a transformative tool in forensic odontology, revolutionizing the processes of identification and analysis. By enabling the accurate reproduction of dental structures, 3D printing enhances the reliability of comparative analysis in both living and deceased individuals. It allows for the preservation and duplication of fragile or decomposed remains, providing critical evidence in complex forensic investigations. Moreover, 3D models can be used effectively in courtrooms, offering visual and tactile representations that support expert testimony and improve juror understanding.

Beyond identification, 3D printing facilitates interdisciplinary collaboration, allowing forensic odontologists, pathologists, and law enforcement personnel to interact with tangible models. This technology has also proven invaluable in educational settings, offering students and trainees realistic practice materials without ethical concerns tied to human remains. Additionally, its application in reconstructive facial modelling and trauma analysis further broadens its scope in the forensic field.

Despite some limitations, such as cost and the need for technical expertise, ongoing advancements in 3D printing materials and techniques promise to overcome these challenges. As technology becomes more accessible and precise, 3D printing is poised to become a standard tool in forensic odontology, significantly improving the speed, accuracy, and effectiveness of forensic investigations.

Authors Contribution Statement:

All authors have made a substantial, direct, and intellectual contribution to the work and approved it for publication. Dr. Anieta Merin Jacob contributed to the main writings, diagrammatic conceptualization, and overall supervision, including appropriate cross-references. Dr. Chandrasekhar BS, Dr. Shibu P, Kevin Emmanuel Suresh, Dr. John Abraham, and Dr. Clement Prakash played a key role in peer reviewing and editing the final manuscript.

Conflict of Interest: Conflict of interest declared none.

Funding: None

REFERENCES

1. A. Dawood, B. Marti Marti, V. Sauret-Jackson and A. Darwood, 3D Printing in dentistry, ©British Dental Journal 2015; 219: 521-529. DOI: 10.1038/sj.bdj.2015.914
2. G. Jani, A. Johnson, J. Marques et al. Three-dimensional(3D) printing in forensic science–An emerging technology in India, Annals of 3D Printed Medicine, March 2021.
3. Chaudhary RK, Doggalli N, Chandrakant HV, Patil K. Current and evolving applications of three-dimensional printing in forensic odontology: A review. Int J Forensic Odontol 2018;3:59-65.
4. Mitsouras D, Liacouras P, Imanzadeh A, Giannopoulos AA, Cai T, Kumamaru KK, et al. Medical 3D printing for the radiologist. Radiographics 2015;35:1965-88.
5. Hiller J, Lipson H. STL 2.0: A Proposal for a Universal Multi Material Additive Manufacturing File Format. Proceedings of the Solid Freeform Fabrication Symposium 2009. Austin, Texas; 2009. p. 266-78.
6. Anoop K. Vermaa, Sachil Kumarb et al Review Article Identification of a person with the help of bite mark analysis., Journal of oral biology and craniofacial research 3 (2017).
7. Anupama M, Singh BA, Khurana BS, Kaur SJ. Role of bitemark analysis identification of a person. Glob J Med Public Health 2012; 1:56-9.
8. Forensic uses of 3D Printing E. Liscio Forensic magazine 2013
9. Rachael M. Carew ,1,2 M.Sc.; and David Errickson,3 Ph.D. An Overview of 3D Printing in Forensic Science: The Tangible Third-Dimension J Forensic Sci, 2020 doi: 10.1111/1556-4029.
10. Sonia G, Vineetha G et al Forensic facial reconstruction: The final Frontier JClin Diag Res2015 Sep 9(9): ZE26-ZE28
11. Nicoleta-Violeta Stanciu1*, Razvan-Tudor Rosculet1, Catalin Fetecau1, Costel Tapu Forensic Facial Reconstruction Using 3D Printing, Mater. Plast., 57 (4), 2020, 248-257, https://doi.org/10.37358/MP.20.4.5424
12. B.Kolude , BF. Adeyemi et al The role of forensic dentist in mass disaster Ann Ib postgrad Med 2010n Dec 8(2):111-117
13. Chalishazar Monali, Panja Pritam et al. Gender Determination: A View of Forensic Odontologist Indian Journal of Forensic Medicine and Pathology Volume 4, Number 4, Oct - Dec 2011
14. Kewal Krishan*, Tanuj Kanchan and Arun K. Garg3Dental Evidence in Forensic Identification – An Overview, Methodology and Present Status, The Open Dentistry Journal, 2015, 9, 250-256
15. Adam Nulty Aliterature of Review of Current 3D Printing Materials in Dentistry. International Dentistry-African Edition Vol 12, April/May 2022.
16. Sunali K, Prita D. Exploring the 3rd Dimension: Application of 3D Printing In Forensic Odontology. J Forensic Sci & Criminal Inves.2017; 3(3): 555616. DOI: 10.19080/JFSCI.2017.03.555616.
17. Verma A, Mahajan A, Srivastava R. Application of 3D printing in forensic odontology. J Forensic Dent Sci. 2019;11(1):3–9.
18. Colaco M, et al. The role of CBCT and 3D printing in forensic dental identification. J Forensic Sci Med. 2018;4(2):96–101.
19. Da Silva RF, Sales MAO, Cavalcanti MGP. 3D imaging in age estimation and identification. Forensic Sci Int. 2017;278:269.e1–269.e7.
20. De Angelis D, et al. Three-dimensional printing and forensic anthropology: preservation and analysis. Forensic Sci Int. 2018; 289:203–12.
21. James H, Nordgaard A. Sharing 3D forensic data across jurisdictions. J Forensic Sci. 2020;65(6):2001–7.
22. Limdiwala PG, Shah JS. Applications of 3D printing in forensic odontology education. Indian J Dent Res. 2020;31(4):617–20.
23. Acharya AB, et al. Future directions in forensic odontology: AI and digital workflows. Aust J Forensic Sci. 2021;53(1):17–24.
24. Turner K, et al. Bioprinting applications in forensic sciences: A future perspective. Biomed Tech. 2022;67(5):471–9.
25. Rajkumari N, et al. Advancements in 3D printing materials for forensic dental models. J Indian Acad Forensic Med. 2021;43(1):45–9.

CITATION
Anieta M. J., Chandrasekhar BS, Shibu P, Kevin E.S., John A., & Clement P. (2025). Three-Dimensional Printing in Forensic Odontology: A Transformational Tool for Identification and Analysis. In Global Journal of Research in Dental Sciences (Vol. 5, Number 3, pp. 63–70).
https://doi.org/10.5281/zenodo.15679963