# Forensic odontology and rapid prototyping: Adding 3 rd dimension for investigation

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REVIEW ARTICLE

# Forensic odontology and rapid prototyping: Adding 3rd dimension for investigation

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**Abstract**

Forensic odontology has evolved in multiple aspects ranging from anthropology, personal identification, crime scene investigations, mass disaster evaluation etc. Radiographs and photographs are helpful in various studies/investigations related to forensic Dental Science. Forensic Odontologist's report has been accepted in court of law to solve many medicolegal cases. Forensic radiology is particularly important in skeletal survey, antemortem and post-mortem imaging. In recent times Rapid Prototyping (3D Printing) has taken over the previous digital techniques in various fields of Medicine and Dentistry. In Forensic Odontology, 3D printing can become one of the important tools in investigation and also can overcome various shortcomings of many pervious imaging techniques.

**Key words**

Forensic Odontology; Forensic Radiology; Rapid Prototyping; 3D Printing; Radiographs

## Introduction

Use of dental evidence in court of law has been ever since a case solved at Scotland in 1814.[1] Since then the role of Forensic Odontology has evolved and crossed various milestones in recognizing the identity of a person through uniqueness of oral structures and determining probable age of an individual utilizing hard tissues of the oral cavity. This is usually accomplished by simple old dental records, soft tissue patterns and by using radiographs.

Forensic Radiology has evolved from plain film radiography to digital radiographs, Cone Beam Computed Tomography (CBCT) being the most recent. When dental identification becomes an issue, usually high resolution radiographs such as Computed Tomography (CT) is used in various parts of world as a part of post-mortem identification.[2] In recent times rapid prototyping has taken over the previous digital techniques in various fields of Medicine and Dentistry.

Rapid prototyping in other words called as 3D printing involves complex technology. But, lack of trained professionals has restricted its use presently in crime investigation. Research related to 3D printing usage in Forensic Odontology is gaining its importance in present years. Rapid Prototyping allows for the creation of full-scale models which will depict exact anatomy, hence will be of very good use in Forensic Medicine and Forensic Odontology.[3-6] This paper briefly reviews various aspects of 3D printing and its possible role in Forensic Odontology which can be accepted as evidence in court of law.

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## History

Brain behind this Rapid Prototyping is Mr. Chuck Hull who is considered as the Father of 3D printing. He developed 1st 3D printer in the year 1984. Since then there has been significant growth in the field of 3D printing. Traditionally this was used in the field of engineering, later its use was in many areas such as defence, medical and dental science[6-8]

## Technology

3D models are created based on the digital images. Different imaging modalities can be used to obtain the raw image like CT, CBCT and Magnetic Resonance Imaging (MRI). Digital Imaging and Communications in Medicine (DICOM) radiographic images are exported to Standard Triangular Language (STL) format for its use in rapid prototyping. 3D digitizing systems uses different scanners such as laser scanners, structured light scanners, photogrammetry, and similar technologies. Materials like ceramics, certain powders, liquid resins, metals, and various others are used to create layer by layer model for generating 3 dimensional objects utilizing the 2 dimensional image data.[5,8-13]

## Types

Basically 3 methods of rapid prototyping techniques are present, namely liquid-based, solid-based and powder-based. Stereolithography (SLA) is liquid –based prototyping, Fused Deposition Modeling (FDM) and Laminated Object Manufacturing (LOM) are solid-based prototyping. Selective Laser Sintering (SLS) and Direct Metal Laser Sintering (DMLS) are Powder-Based rapid prototyping methods.[10,13,14]

### Applications of Rapid prototyping in forensic odontology

In Forensic Odontology, 3D printing can be used in various areas like bite marks analysis, recording, documenting &

analysing lip prints, analysing palatal rugae pattern, facial reconstructions, post mortem recreation of the skull and other bones, for identification of pattern of fracture, identification and reconstruction of weapons used during crime, etc.[15-20]

## Discussion

Photographs and radiographs may not serve as appropriate data or information in certain situations, especially during evaluation of human remains. Presently the court of law relies on photographs and radiographs of human remains as it is difficult to transport the evidence from the investigation site.[21] But, these images may serve to develop 3D replica of the specimen, which will be more appropriate method of investigation and presenting evidence. As 3D model easily demonstrates the various anatomic abnormalities, jury members can understand the evidence better as compared to cross-sectional imaging. Facial reconstruction by 3D printing has solved a case in Florida.[22] In a case of blunt force head injury, 3D printing has been successfully used for weapon identification and construction.[23] Researchers have told facial reconstruction by 3D printing is effective for fracture analysis.[24] Bite mark analysis is done by various methods and more recently the digital analysis of the same has gained its popularity. Rapid prototyping can be useful in analysis of same by creating the 3D replica of bite mark and comparing it with the suspect.[17] In fingerprint analysis 3D printing is being used and in similar ways it can be utilized for lip print analysis and for study of palatal rugae pattern.[25] In forensic odontology gender determination is usually done using dental models. Measurements of inter-canine distances, intermolar distances, arch size/length and tooth sizes are used. The dental models created using 3D printing has shown to be accurate for measurements.[26,27] Using 3D printing, a new X-Ray equipment has been designed by researches to overcome the difficulty of aligning the equipment with the area of interest in forensic dental studies. However, still further studies are required for obtaining accurate dental X-Ray machine for forensic use.[28]

## Conclusion

Forensic medicine experts, forensic odontologists, forensic pathologists and anthropologists use photograph and radiograph images for solving mysteries. Addition of rapid prototyping will add the 3rd dimension to their investigation and help in solving the cases more accurately. More research studies are required in forensic odontology section for use of 3D printing, so it can be accepted in court of law.

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