Extended Abstract
Journal of Dental Research and Practice
2020
Vol. 2, Iss. 2

Recent Advancement of Photographic Printing Techniques in Forensic Dentistry

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Forensic Dentistry is a significant part of the forensic sciences and has been an integral part of criminal investigation. Presenting physical models of evidence in court is a recognized practice, however often a number of legal and ethical concerns prevent the investigators from presenting any physical evidence that is of human origins in the court. This causes the judicial systems to rely merely on photographs of these evidences which cannot always provide the accurate amount of information that a three dimensional structure does. The use of 3D digitizing systems such as laser scanners, structured light scanners, photogrammetric, etc. has revolutionized the field of forensic sciences. It allows presentation of three dimensional models of any evidence of human origin without creating bias in the court. The application of these technologies also allows prompt collection of data with minimal degradation and reduction in human errors. Another important application of 3D printing is to impart education in the field of forensics. 3D printing in forensic sciences includes facial reconstruction, identification of pattern of fracture Thus these 3D digitizing technologies can be wisely adapted to advance forensic sciences.

Forensic odontology is proper handling, examination, and evaluation of dental evidence, which will be presented in the interest of justice. The evidence that may be derived from the teeth, the age (in children) and identification of the person to whom the teeth may belong. Knowledge of forensic dentist requires encompassing of number of disciplines, since the dental records obtained can identify an individual or afford the information needed by the authorities to establish identification of the case (1).

Keiser-Neilson defined forensic dentistry as “that branch of forensic dentistry that in the interest of justice deals with the proper handling and examination of dental evidence and the proper evaluation and presentation of dental findings (2)”.

This article will give you a collective review on the evolution, various methods and applications of forensic odontology, which plays a major role in keeping the dental records accurately, and providing required information, which will help the legal authorities to recognize negligence, malpractice, fraud or abuse and identification of unknown individuals.

Forensic dentistry (odontology) deals with the examination, handling and presentation of dental evidence for the legal system. In the UK this work mainly involves criminal cases but in many other countries its remit also extends to civil litigation. There are four main aspects to forensic dentistry: single body identification, Disaster Victim Identification (DVI), age estimation and bite mark identification and analysis. This article provides a brief introduction to the topics and discusses potential future developments that aim to reduce the subjectivity in the analysis process and simplify presentation of evidence to non-dental parties.

3D printing generally describes a manufacturing process that creates an object by building one layer at a time adding multiple layers which results in the formation of an object.3D printing can be precisely described as Additive manufacturing or Rapid prototyping.3D Printing is emerging as a promising technology over a wide variety of fields including aerospace, defence, art, design, architecture, engineering, medicine, dentistry by allowing the individuals to personalise designs and fabricating. There has been a revolutionary growth of 3D printing in medicine and dentistry with the help of CAD CAM technology. 3D printing promises to improve patient care

and enhance the relative contribution to that care by radiologist if implemented correctly.3D printing can deliver customised medicine based on the anatomic data radiologists acquire and interpret everyday. 3D printing has been useful to create more naturalistic models in the medical field for educational, training and research purposes, treatment and surgical planning. In dental field it has been used in various treatment modalities. This article reviews the recent advances in the applications of 3D printing in dentistry. History of 3d printing A 3Dimensional object was printed for the first time by Charles Hull in the year 1983.Hull invented 3D printing which he named "stereolithography". Stereolithography interprets the data in a CAD file by using the file in STL format. Apart from shape the instructions may also include information on colour, texture and thickness of the object to be printed. Hull later founded the company 3D Systems which introduced the first commercially available 3D printer named SLA-250 in 1988. 3D PRINTING TECHNOLOGY In medical and dentistry field the volumetric data is readily accessible using CT and CBCT data, and also using intraoral or laboratory optical surface scan data. Advancement in the computer technology and the software applications has contributed a lot to 3D printing (1).3D printing process begins by designing a virtual image of the object to be constructed, then converts the information into a digital file.3D modelling program provides the virtual design for the printer to follow. This requires CAD software which enables to create objects from scratch.

Stereo lithography, photopolymer jetting and digital light processing use light cure resin. Stereo lithography uses a vat of light-cured photopolymer resin and a light-sensitive laser to build successive layers. In photopolymer jetting, an ink type print-head jets light-sensitive polymer onto a platform incrementally building layers. Digital light processing builds the object upside down using liquid resin and light source on an elevating platform. These processes are expensive, have limited shelf life and cannot be heat sterilized.

Powder binder is a process that uses water from an inkjet printer head projected onto a powder bed to construct the object. Although this technique is cost-effective, it falls short on the resolution output, easiness to operate and heat sterilization.

Technologies like selective laser sintering and electronic beam melting sinter powder in a heated chamber to a point below its melting point, after which a scanning laser builds the object. Selective laser sintering can be used to print objects from polymers and metals. This is expensive due to its high capex and maintenance costs. It also poses a health risk due to dust inhalation or accidental explosion.

In fused deposition modeling, small beads of thermoplastic material are released from a nozzle to construct the model. The 3D printers adopting this technique find the highest penetration at the domestic level; often nicknamed 'home-printers'.

Advantages: Conventional standalone subtractive manufacturing techniques such as milling create high wastage by their very nature. This can be minimized by utilizing these techniques in adjunction with additive manufacturing. Among all the available digital processing methodologies used for this purpose, 3DP is clearly the winner. Its higher efficiency, passivity, flexibility and superior material utilization earn it its distinction.

Disadvantages: The benefits from high material utilization might in some cases diminish when contrasted with the drawbacks due to its extended postprocessing duration. Other shortcomings include its high cost, the occurrence of staircase effect (created by layered deposition), inconsistent reproduction and requirement of support materials (that is difficult to remove postprocessing). Ceramics, one of the most popular materials used in dentistry lacks the abili-

ty to be 3D printed due to the high porosity caused during fabrication.

Forensic odontology is primarily concerned with the use of teeth and oral structures for identification in a legal context. Various forensic odontology techniques help in the identification of the human remains in incidents such as terrorists' attacks, airplane, train and road accidents, fires, mass murders, and natural disasters such as tsunamis, earth quakes and floods, etc. (Disaster Victim Identification-DVI). Dental structures are the hardest and well protected structures in the body. These structures resist decomposition and high temperatures and are among the last ones to disintegrate after death. The principal basis of the dental identification lies in the fact that no two oral cavities are alike and the teeth are unique to an individual. The dental evidence of the deceased recovered from the scene of crime/occurrence is compared with the ante-mortem records for identification. Dental features such as tooth morphology, variations in shape and size, restorations, pathologies, missing tooth, wear patterns, crowding of the teeth, colour and position of the tooth, rotations and other peculiar dental anomalies give every individual a unique identity. In absence of ante-mortem dental records for comparison, the teeth can help in the determination of age, sex, race/ethnicity, habits, occupations, etc. which can give further clues regarding the identity of the individuals. This piece of writing gives an overview of dental evidence, its use in forensic identification and its limitations.