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RESEARCH ARTICLE

3D PRINTING: A COMFORTING PROSPECT IN PEDIATRIC DENTISTRY

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Abstract

Three-dimensional (3D) printing is a rapidly developing technology that has gained extensive acceptance and application in dentistry. It is also known as additive manufacturing (AM), rapid prototyping or layered manufacturing. The term 3D printing is generally used to describe a manufacturing approach that builds an object by laying down one layer at a time, adding multiple layers. To meet the needs and requirements for pediatric dental patients, Pediatric dentistry is advancing and shifting towards better to perform dental treatment effectively and efficiently. Among these advancements concept of 3D printing has recently emerged. This article provides an overview of 3d printing: a comforting prospect in pediatric dentistry and its application in pediatric dentistry.

Introduction:-

Dental treatment of children poses significant challenges for clinicians. An adult patient can understand the gravity of the situation and the consequences that come with it, so they work with their doctors to tackle the issues. While a child patient is emotionally immature and have lots of fear and anxiety associated with dental treatment. Hence it would not be fair to expect from them the magnitude of concern and cooperation towards dental treatment[1].

To meet the needs and requirements for pediatric dental patients, Pediatric dentistry is advancing and shifting towards better to perform dental treatment effectively and efficiently. Among these advancements concept of 3D printing has recently emerged. 3D printing is a manufacturing process in which formation of object is done by building one layer at a time. Various sectors from education to industry are covered through 3D printing. A significant application has been shown by 3D printing in clinical and laboratory techniques in many areas of dentistry[1].

3d printing can replicate human form more accurately than traditional manufacturing technique. This can provide comfort and better quality treatment and enhanced treatment procedure to dentist. Patient treatment becomes fast with grater precision. Thus looking into this newer technology, this library dissertation is focusing on various application of 3D printing in pediatric dentistry[1].

The additive manufacturing process or 3D printing process is the production of any object by adding material layer by layer. There are different additive manufacturing methods present: Stereolithography, Fused deposition modeling, Selective Laser Sintering, Poly jet printing, and Bioprinting. Fused deposition modeling is most commonly used due to its wide availability, reliable printing quality, ease of installation and use, and economic. CAD-CAM technology enables the rapid growth of 3D printing technology in the field of dentistry and medicine. Its faster manufacturing rate, painless digital data workflow, and patient friendly approach going to revolutionize modern-day dentistry.[4]

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In the field of dentistry, its applications range from prosthodontics, oral and maxillofacial surgery, and oral implantology to orthodontics, endodontics, and periodontology[3].

Discussion:-

3D printing has been used since the 1980s. In 1983 Charles Hull printed the first 3D object using the technique of stereolithography. However, modern additive manufacturing technology was introduced approximately three decades ago and its application in dentistry is recent. Additive manufacturing (AM) which involves the deposition of material in increments, is an innovation over subtractive manufacturing (SM) where an object was cut off from a block of material[2].

Charles Hull is known as the "Father of 3D Printing." Hall later in 1988 founded the company 3D Systems and introduced the first commercially available 3D printer named SLA-250.

3D printing was first applied in dentistry in the early 2000s, when the technology was first used to make dental implants and custom prosthetics. The global dental 3D printing market is expected to be worth US$3,427.1 million by the end of 2025 from US$903.0 million in 2016[15].

Table 1:- Various Technologies IN 3D Printing.

Type	Material used	Advantage	Disadvantage	Use
Stereolithography: Each time a layer of resin is polymerized, UV light is focused onto the surface of a vat filled with liquid photopolymer and the object are drawn onto the liquid surface by the beam.	A variety of resins for photopolymerization, ceramic filled resins, etc.	High accuracy Smooth surface Finish High mechanical strength	High cost of equipment Requires post-cure Only can be used in polymers	Implant guides Surgical stent
Fused Deposition Modelling: It depositions a thermoplastic polymer material layer by layer to construct an object. This substance is given by a nozzle system that is temperature-controlled, and the material's motion is computer-controlled. The thermoplastic substance is semiliquid, solidifies in 0.1 seconds, and bonds to the prior layer. The entire procedure is carried out in a chamber.	Thermoplastic polymers such as polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), polyether ether ketone (PEEK), etc.	Wide availability Reliable printing quality Ease of installation and use Economic	Can be used with thermoplastic material only Rough surface finish Lack hundred percent density	Anatomic models without complexity such as edentulous mandible
Selective Laser Sintering: A high-powered laser is aimed at a small layer of powder on a substrate using a mirror; when the beam strikes the powder, it creates a melt pool, fusing the powder particles together. The powder bed is lowered by one layer thickness after scanning each cross-section, and a new layer of material is put on top. This procedure repeats itself till the thing is finished.	Powder such as alumide, polyamide, glass-particle filled polyamide, rubber-like polyurethane, etc.	Different material variety Hundred percent density	Material and equipment are expensive	Anatomical study models Cutting and drilling guides Implant bridge frameworks Cobalt chromium RPD frameworks
Polyjet printing and Bioprinting: Micro droplets of liquid photopolymer resin are sprayed onto a build tray by material jetting 3D printers, which then polymerize the resin using UV light. It's easy to use and doesn't require a final cure.	A variety of photopolymers Cell-loaded gels and inks based on collagen, photopolymer resins, agarose, alginate, hyaluronan, chitosan, etc.	Low material cost Fast fabrication time Low toxicity Relative material variety	Lower strength of models Rough surface finish	Dental or anatomical study models Implant drill guides

Technologies Involved In 3d Printing:
The following techniques are employed for Additive manufacturing or 3D printing of various applications in dentistry:
1. Stereo lithography (SLA).
2. Fused Deposition Modelling (FDM).
3. Selective Laser Sintering
4. Photopolymer Jetting
5. Electron Beam Melting (EBM)
6. Power binder printers
7. Direct light processing[1]

Application of 3d printing:
Regaining the comfort, function, speech and esthetics is the ultimate goal of providing dental treatment to the patient. These problems result in affecting the psychology of the patients. 3D printing technology has gained acceptance and is employed for a wide range of applications in almost every field of dentistry. Application of 3D printing in various fields are;

3D printing in prosthodontics:
Custom trays can be manufactured or 3D printed from computerized scans of impressions or models. Model printing directly from intraoral scan helps quick fabrication of prosthesis. In RPD, resin framework can be tried in a patient's mouth before casting.

3D printing in implant dentistry:
The use of tooth implants has rapidly evolved and widely accepted for replacing single or multiple missing teeth in the last two decades. The use of 3D printing technology has gained popularity and acceptance in dental implantology due to the introduction of guidelines for a surgical procedure which implies the usage of surgical guides for insertion of dental implants.

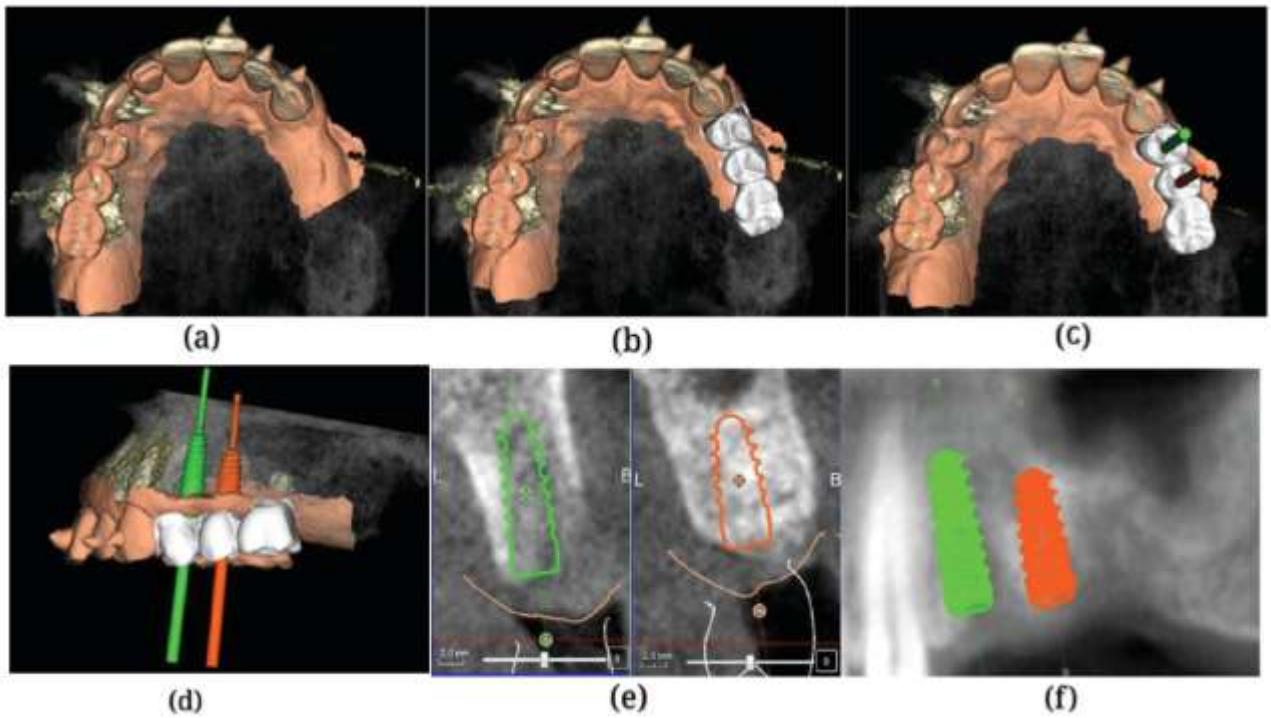

Fig 2:- Surgical and prosthetic 3D planning: a) overlapping of intraoral scan and CBCT; b) overlapping of intraoral scan and CBCT with molded provisional restorations; c) overlapping of intraoral scan and CBCT with modeled provisional restoration and implant planning (occlusal view); d) overlapping of intraoral scan and CBCT with modeled provisional restoration and implant planning (side view); e) implant planning (cross sections); f) implant planning (panorex).

3D printing in oral surgery:
The development of 3D imaging has enabled us to attain a more precise diagnosis and improved treatment planning. 3D models of detailed replicas of the skull and jaws of patients serve as anatomical models which have been beneficial in pre- surgical planning and also serve as a reference during surgery. Surgical guides, augmentation of bone defects and creating replicas of jaws that could serve as study models for students, fixation plates etc can be 3D printed and used for Oral and Maxillofacial and Orthognathic surgeries.

3D printing in endodontics:
3D printing serves as a solution for endodontic challenges; some of which include guided access with pulp canal application in auto transplantation, accurately locating the osteotomy perforation sites, pre-surgical planning, educational models and stent guides.

3D printing in orthodontics:
Indirect bracket-bonding splints, occlusal splints, aligners, etc can be 3D printed. Adjustment or customization in terms of angulation, bending, etc is possible during the manufacture of brackets. In addition to this, it is now virtually possible to present the changes that will be caused by the braces in advance.

3D printing in periodontics:
Another area of expertise in dentistry where 3D printing is employed is periodontics, where the prime focus is regenerative periodontal research. Few of the major periodontal post-operative complications include mobility, loss of attachment, furcation, painful and bleeding gums, gingivitis cellulitis and Methicillin-resistant Staphylococcus aureus (MRSA) mediated skin and soft tissue infections. It is recommended to keep the gingival margins relieved and retracted to avoid such complications. 3D printed guides are used for aesthetic gingival correction.

Application In Pediatric Dentistry:
Pediatric dentistry is a unique specialty of dentistry, where it deals with all fields of dentistry for a particular age group. Because of this reason itself, pediatric dentist is the one who should be multi skilled. A pediatric dentist should be a versatile person who have to take the role of a various specialists because they have to deal with lot of areas like behavior management, oral surgery procedures, preventive and interceptive orthodontic procedures, conservative and endodontic procedures, prosthodontic procedures etc. The patients whom they deal with are the little minds and the future of tomorrow. So at the same time pediatric dentist is a person who needs lots of skill and facing lots challenges.

Challenges Faced in Pediatric Dental Practice
1. Managing fearful and anxious child
2. Managing uncooperative child
3. Managing differently abled child
4. Delivering tedious and lengthy procedures to the child
5. Multiple dental visits which are inconvenient for children as well as their parents now a day in their busy schedule.
6. Gag reflexes during dental procedures like impression making.

Something which makes the work easier and hassle free such that reduced chairside time, reduced multiple visits, reduces gag reflexes, removes fear and anxiety and which is harmless to children have a great role in pediatric dental practice. Hence the technology of 3D printing gains attention and relevance in the field of pediatric dental practice.1

Different uses of 3d printing in pediatric dentistry:
Aesthetic restoration of fractured anterior teeth
3D printed templates are an effective, convenient, and elegant approach for direct resin composite replacement of injured anterior teeth. They aid in the accurate replication of the fractured tooth's architecture, colour, and translucency.

Reconstruction of fractured mandible
After treatment of complex mandibular fractures, contouring of bone plates is a time-consuming and labor- intensive technique. Preoperative planning for difficult mandibular fracture repair and plate contouring can be made easier

with 3-D-printed templates. 3D printers can produce customised bone tissue for patients, as well as biomimetic scaffolds for bone cell augmentation and tissue development and differentiation.

Pediatric rehabilitation

Rehabilitation should be the main focus of this century. But this rehabilitation process sometimes becomes very time-consuming, cumbersome, and physically and psychologically traumatic for a young patient, a mentally and physically disabled child, or a child with TMJ defects or orofacial deformities. It may require a multistage process and highly skilled dental technicians to produce a good maxillofacial prosthesis for orofacial defects. With the recent advancement of digital dentistry, intra-oral scanners. CAD-CAM devices, along with 3D printing technology, can directly print maxillofacial prostheses from the digital data workflow without traumatizing young patients or special children.

Fig 3:- The 3D-printed nasoalveolar molding (D-NAM) in place with the nasal stent and the horizontal taping.

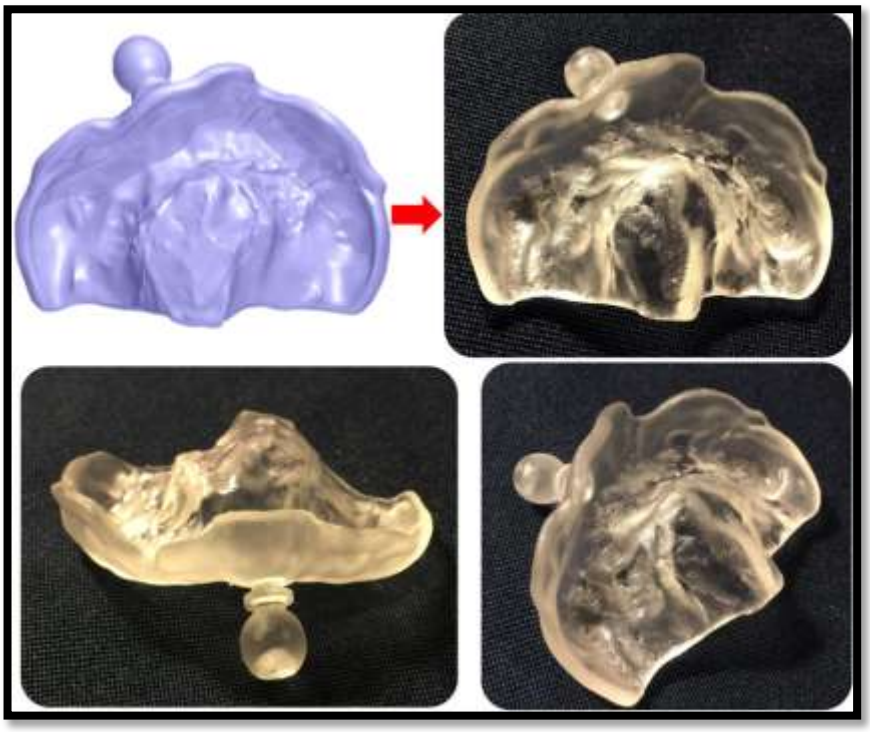

Fig 4:- The 3D-printed intraoral plate.

Orthodontics for young and adolescents

In the near future, 3D printing technology could be a revolutionary tool for patient diagnosis, treatment planning, and most importantly, patient motivation. With 3D printing technology and artificial intelligence software, it is now very much possible to virtually present facial changes to patients. The patient can see and feel the three-dimensional models of corrected arches and precise changes in their hand. Stereolithography can 3D print customized braces with specific tip and torque or individualized clear aligners for the patients.

Pediatric endodontics

Sometimes it is impossible to analyze a complex root canal system with obliterated canals and lateral canals using 2D radiographic images. When the root canal system becomes obliterated as a result of rapid dentinogenesis and dystrophic calcification, a custom-designed endodontic guide is created utilizing 3D digital planning for predictable navigation of the obliterated pulp. This reduces the risk of severe dentine destruction/root perforation by preventing iatrogenic root damage.

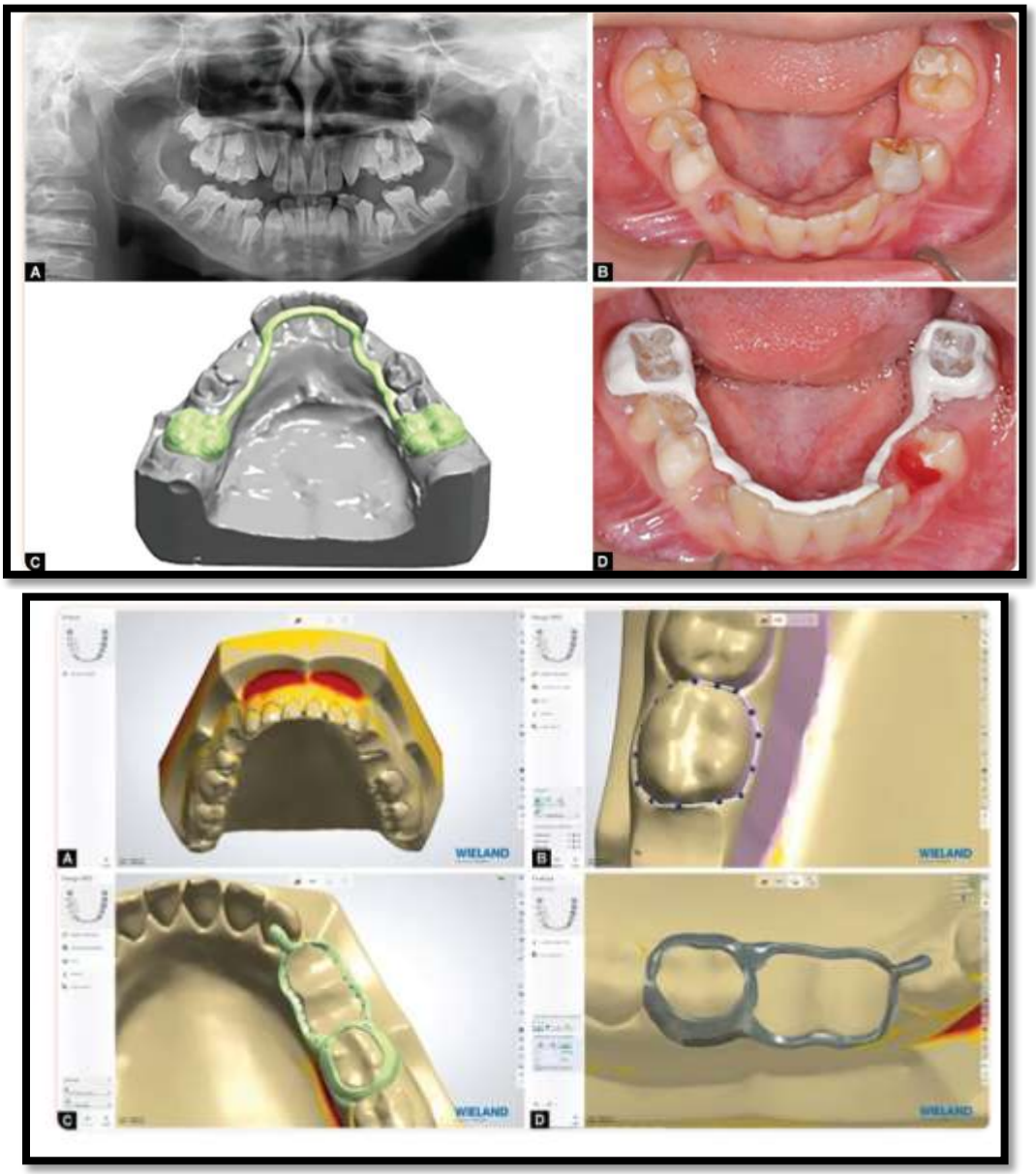

Fig 5:- Digitally made space maintainers 1ST fig. a. opg of patient b. intraoral picture c. processing d. placement in mouth of patient 2nd fig . a. digital impression b. processing in digitally. c. making d. placement of digitally making SM.

Educational approach

3D printed structures are a great way to learn about complicated anatomical structures. Students often struggle to properly examine a child patient, leading to pain, discomfort and bleeding during examination. 3D printed models stimulating teeth, periodontal and perioral structures with respective tissue characteristics are very helpful to orient students about proper examination and develop skills and proprioception required for different dental procedures. These three-dimensional anatomical structures give students a detailed and precise spatial view of the complexity of the structure and its pathology and help them plan treatment modalities with great accuracy.

Conclusion:-

3D printing, along with CAD-CAM, intra-oral scanning, and CBCT data, has the ability to revolutionize dentistry. It has the ability to generate sophisticated three- dimensional anatomical structures for educational and training purposes, as well as research and treatment planning. With the help of 3D printed models and surgical guides, complex cranio-facial surgeries have become more predictable, less invasive, and more precise. The lack of qualified operators, greater operating costs, fewer compatible materials, the need for post-processing, regular maintenance requirements, and stringent adherence to health and safety issues are all important downsides of this technology. With the advancement of this technology, within a few decades, 3D printing and digital dentistry are going to significantly change the field of dentistry.

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