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3d Printing In Prosthodontics

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ABSTRACT : The connecting link of technologies and dentistry has often resulted in innovations in manufacture of dental restorations right from Taggart's lost wax technique to the latest CAD CAM restorations . 3d printing has revolutionized the way things are manufactured and we may not possibly imagine what future hold for us this paper will give an insight on how 3d printing works, its applications in 3D printing of dental restorations and its future directions.

KEYWORDS:3D printings,(CAD\CAM technology),ink jet printing ,additive manufacturing technology.

INTRODUCTION:

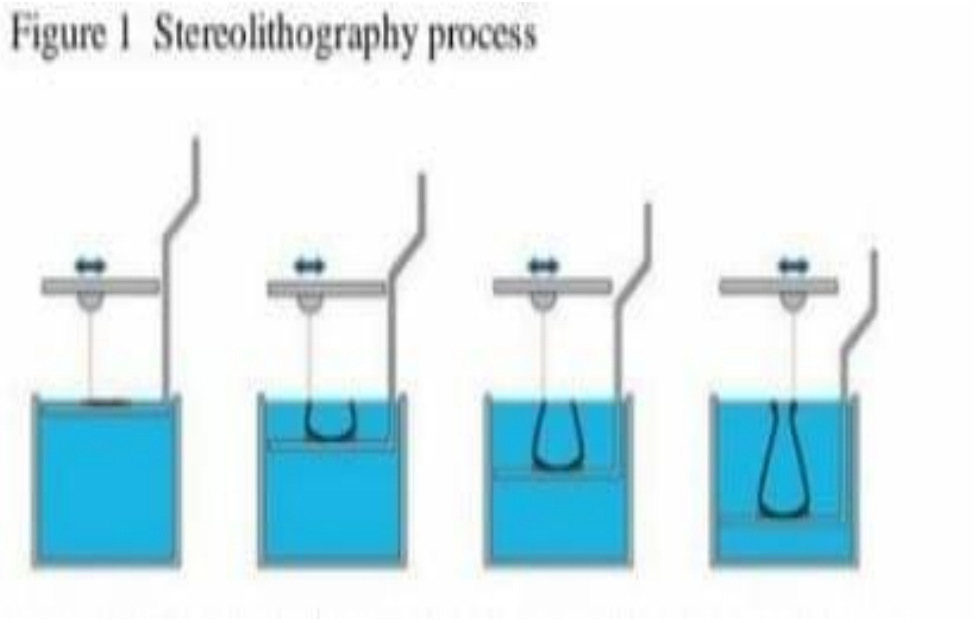
Technological developments have made significant impact and contributions to the field of dentistry. Right from the adaption of lost wax technique in jewellery fabrication in early 20th century for the fabrication of crowns and bridge to the recent influence of computer aided design and machining (CAD CAM) technology on digitisation of restorations.

Traditional fabrication of inlays, onlays and crowns uses a multistage process which involves an indirect technique of an impression followed by laboratory processing of the restoration. This procedure involves several steps which increases the possibility of errors in marginal accuracy, time consumed by the patient as well as the doctor and the treatment costs. As in many other industries, production stages are increasingly becoming automated in dental technology now en-able cost-effective production of individual pieces.[1]

CAD/CAM systems allow for production of indirect restorations in a single visit. These systems use an optical camera to take a virtual impression by creating a three dimensional image which is forwarded to a software program. This impression results in a virtual cast on which the restoration is designed. The software then controls a milling process that uses prefabricated blocks of restorative material, either reinforced composite or all ceramic material, to produce the restoration . The end results in chair side production of the restoration.[2]

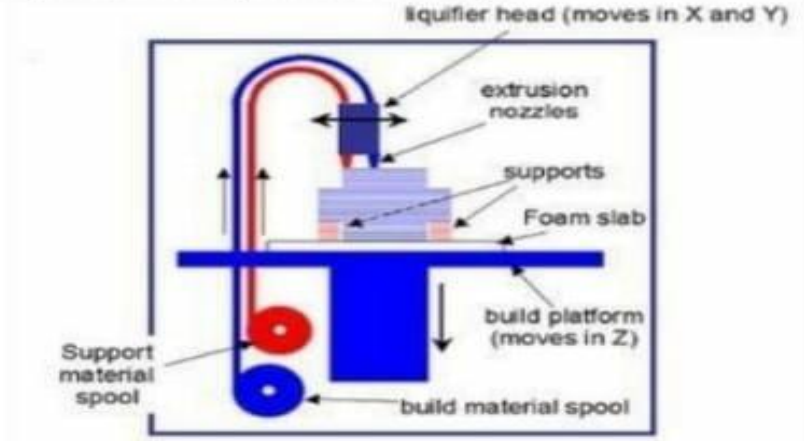
Principles of subtractive manufacturing have been majorly used by both lost wax technique and CAD CAM technology. subtractive technology is based on power driven machine tools such as saws, lathes and milling machines that are used to mechanically cut a block of material to a desired shape and geometry. This technology enable reduction of production time and ease of fabrication complex models. However, subtractive manufacturing brings with it disadvantage of increased wastage with removal of excess material and inability of mass production.

Additive Manufacturing Technology :Additive manufacturing on the other hand opens up new avenues for production of dental restorations. Additive manufacturing according to the American society for testing and materials(ASTM)is the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies. The process of additive manufacturing works on the principle of taking a 3D computer file and creating a series of cross sectional slices. Each slice is printed one on top of the other to create the 3 dimensional object with an advantage of minimal wastage .Today additive manufacturing can apply for product life cycle from prototyping to full scale manufacturing. Additive manufacturing technology has a range of applications such as stereo lithography, laser forming, selective electron beam melting and ink jet printing. Stereo lithography was introduced in 1980 by Charles Hull. It works on principle of making solid objects by successively printing thin layers of UV curable photopolymer on top of the each layer as shown in fig 1. The UV light draws the object and therefore cures it with the input as digital CAD. SLA can be used for studying preoperatively human models from CT(DICOM)data, for preparation of customised surgical implant guides and also as resin models for lost wax casting .
figure 1. Stereolithography process



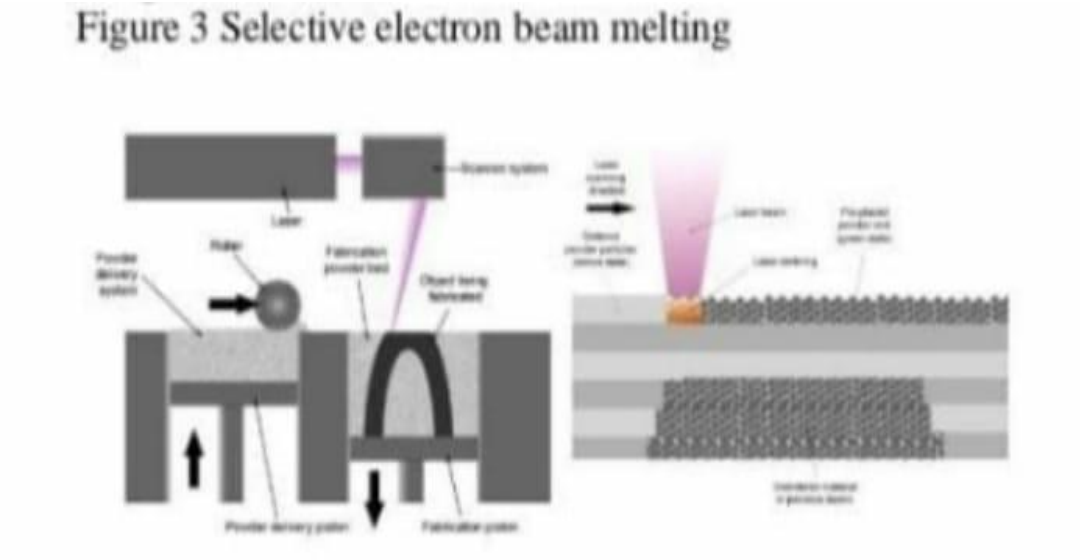
Fused deposition modelling developed by Schott crump USED mostly for modelling and prototyping applications. This technology works on the principle of extruding a thermoplastic filament material through a heated nozzle and the material hardens immediately after extrusion as shown in fig 2. Materials such as acrylonitrile butyro styrene ABS , polycarbonates and poly sulfonates are used .
fig.2.fused deposition modelling

Figure 2 Fused deposition modelling



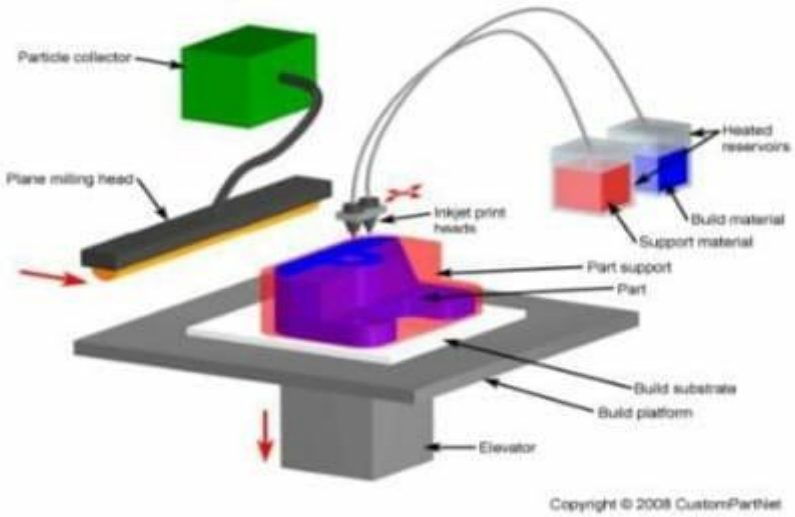
selective electron beam melting works by melting metal powder layer by layer with an electron beam in high vacuum as shown in fig.3. Used for making porous dental implants with an advantage of stress shielding & better in growth of bone ,its roughness may not suitable for crowns and bridges fabrications. Figure 3. Selective electron beam melting

Figure 3 Selective electron beam melting



In laser powder forming technology , laser beam hits the powder and creates a melt pool and the powder particles fuse together . The terminologies of selective laser sintering or selective laser melting may not be clear. Selective laser sintering works on the principle of using a digital scanner(CAD)that scans the die model with the CAD core design.
Inkjet printing ejects small ink drops of ink propelled with pressure , heat, vibration, towards a substrate as shown in fig 4. Liquid droplets change phase on deposition on substrate, dental models , surgical guides, try in veneers and mouth guard can be fabricated .The ink could be a suspension of ceramic powders that is forced to pass through the nozzle . In comparison with traditional ceramic processing methods, ceramic inkjet printing has a number of advantages. It requires minimum tooling and gives great design and fabrication flexibility. Figure 4 ink jet printing .

Figure 4 Ink jet printing



Methods: a literature search using search engines such as google scholar and pubmed with key words additive manufacturing/three dimensional printing /rapid prototyping in dentistry , specifically stereo lithography/selective laser melting/ink jet printing/fused deposition modelling in prosthodontics or dentistry was done. All articles in English inclusive of case reports, in vitro studies and systematic reviews were considered studies on stereolithography stereolithography is commonly used to make surgical guides for dental implant insertion with advantages of high mechanical strength and accuracy however, it has the flip side of being costly and requiring expensive equipment. Computer technology in guided implant surgery uses the DICOM data conversion to CAD CAM TECHNOLOGY to produce surgical guides . But there is still no strong evidence to recommend computer assisted surgeries based on safety , morbidity , efficiency or cost factors. Stereolithography has been used in the field of maxilla facial prosthodontics as obturators , surgical stents, duplications of prosthesis and burn stents .The obturator can fit exactly on the patient requiring fewer adjustments compared to the traditional impression techniques .

Studies on selective laser sintering or Melting :A number of studies on laser sintered nickel chrome and cobalt chrome copings have been published . Bond strength of the metal frame works to porcelain , their marginal and internal fit were evaluated. A permitted value of marginal gap of at least 120um is required for clinical application. A critical review showed few case reports, case series, cohort studies and few histomorphometric and mechanical studies . the quality of methodology in human interventions with laser sintered implants were medium , hence more evidence is required to prove their efficacy Studies on electron beam melting :mechanical properties, grind ability and corrosion of dental implants manufactured by electron beam melting were found to be comparable to the precious and non-precious metal alloys. Fatigue resistance was influenced by electron beam orientation and the crack propagation .this technology has found more wide application in orthopaedics and oral maxillofacial surgery as customised implants in the form of porous scaffolds .

Studies on direct ink jet Printing :In direct ceramic ink jet printing , the ceramic particle pass through the printer nozzle and droplets of ceramic ink are propelled towards the substrate where they spread on impact to produce a layer thickness less than 1 micron. Application of direct ink jet printing for yttria stabilised zirconia ceramic powders for dental

restorations was tried ceramic ink suspension were made ; characterised and specimens were fabricated and tested for fracture toughness . Use of spherical powder offers special advantage for 3D printing . They are known for producing low cohesive strength powder assemblies or powders with small internal friction for unusual good flow properties . Faceted or nisotropic powders tend to stick much more and are therefore, much more difficult to spread into thin layers. Dental ceramic powders vary from feldspathic porcelains to the doped zirconia powders . Direct ceramic ink jet printings uses ceramic powder in a carrier medium . Which is deposited through a delivery system actuated by a piezoelectric device. Successful printin depend on well dispersed suspension of affine powder. The dispersion must be stable and free from agglomerates. Sinmazisik g et sl compared the values of 6 commercial dentin porcelain powders for the purpose of studying the microstructure characterisation.
Particle analysis of the powders is necessary to determine ceramic powder particle size andparticle size and particle distribution is important to prevent agglomeration in the nozzles. Irregularparticle size with a wide particle size with a wide distributions of particles could be possibly increase the chances of agglomeration . Based on results of particle analysis of various powders , appropriate flow agents must be identified that can potentially improve the flow ability of the ceramic ink suspension. Green and sintered copings of both zirconia and alumina dental parts infiltrated with glass were successfully experimented, further studies are needed to prove their efficacy. Studies on fused deposition Modelling :Ear prosthesis have been fabricated using semi-automated technology of CAD modelling and rapid prototyping . Subtractive method of combining the mirror image of the controlateral ear with the scan of the defective side is used to print the mold models with the fused deposition modelling technique . Integrated manufacturing systems with a laser digitising scanner, rapid prototyping and a vaccum casting machine were used to fabricate a facial prosthesis .Conclusion :Developments in science and technology might look fictional but it could impedingly disrupt our future . Though the experiments are in a native phase , additive manufacturing technology has potential in terms of cost, productivity and time. Mechanical testing and evidence of its efficacy are more needed to explore for dental applications.

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