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Editorial

Dental 3D and 4D Printing: Changing Paradigms

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The first computer-aided design and computer-aided manufacturing (CAD-CAM) machine was created in the 1960s for building parts of an automobile. In dentistry, CAD-CAM milling has been in use since 20 years. Still, CAD-CAM's limitations seem to be keeping the technology from becoming status quo in the general dentist's office.

CAD covers 2D drawings, 3D models of parts, assemblies and even gigantic projects. Fit and function testing is possible once we have the CAD data of whatever is being designed. A CAD model can also be considered as a virtual prototype. There are many manufacturing processes and there are many machines for each type of manufacturing process (CAM). Computers have been integrated into those machines and they are called CNC (Computer Numerically Controlled) machines. Most of these work by subtracting the material from a raw block. For example, CNC turning centers and machining centers (Milling + Drilling with Automatic Tool Changers). These CNC machines require certain computer codes for operating. These are called CAM codes or programs.

3D printing is a process of making objects by adding up material (contrary to subtraction of material as in CNC Machining). 3D printing was introduced in 1984. The technologies, such as additive manufacturing (AM) also known as rapid prototyping (RP) or three-dimensional (3D) printing, are rapidly growing and have entered the biomedical sector allowing the surgeons and researchers to utilize them in manufacturing objects [1].

3D printing has revolutionized dentistry and medicine as it could provide maximum accuracy with patient comfort and short operative time [2]. One clinical scenario in which a customized implant is a boon are craniofacial abnormalities. A diverse group of congenital defects as well as traumatic defects and tumors can be treated successfully. Additive manufacturing helps to eliminate the constraints of free form shapes and structures, making it possible to fabricate implants that conform to the physical and mechanical requirements of the region of implantation.

CAD-CAM provides the 3D printer with an STL (stereo lithography) file to use. The primary advantage with CAD-CAM is that there are hundreds of solid and surface modeling features. When compared, 3D printing works with resins and non-precious metal alloys unlike CAD-CAM which works with feldspathic porcelain blocks. Its speed is much faster than milling and its accuracy is also higher. Milling is a removal process, whereas printing is an additive process. Curves, holes, and tiny shapes are no problem for a 3D printer with the added benefit of wastage reduction. Its higher efficiency, passivity, flexibility and superior material utilization earn it its distinction [3].

However, 3D printed implants are being sparsely performed in India, given the costs associated with it as well as the market restraints. An initiative has been taken in this direction by the Central Scientific Instruments Organization (CSIO), and this technology does not remain a distant future. Other shortcomings include the occurrence of staircase effect, inconsistent reproduction and requirement of support materials. Ceramics, one of the most popular materials used in dentistry lacks the ability to be 3D printed due to the high porosity caused during fabrication [3].

4D printing is a digital process that prints 3D smart materials and adds time dimension. After printing this provides reconfiguration to a printed object [4]. Research in the 4D printing in focused to produce smart bridges, dental crowns, surgical templates, and orthodontic braces adjusted as per requirement of the individual patient after temperature change. The aim of 4D printing is to produce functional objects rather than static ones [2]. One outcome of 4D printing can be restorative materials which are capable of moving toward the peripheries thereby avoiding microleakage or overhangs at the margins. The technique would still rely on the advancing CAD-CAM technology, and in the long term, follow up appointments will decrease [2]. This manufacturing technique relies on 3D printing of several materials with enhanced digital shape-memory properties that can alter over time under different thermal/physical conditions. 4D printing relies on the sequence and path of movements, which determine the self-folding pattern [5].

The current research and future trends provide ample evidence to believe that 3D and 4D printing will be a path breaking reality soon. This presents great opportunity to the dentist to revolutionize his/her skills with technology. The perfection we strive to achieve

in our day to day practice can be within our reach as long as we keep moving along the learning curves.

Conflict of Interest

None.

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