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Letter to the Editor

Four-dimensional printing applications in dentistry

Dear Editor,

Three-dimensional (3D) printing technology has already provided extensive support to dentistry by providing 3D dental implants as per patient match. Thus, with the use of different designing software programs and oral scanning technologies, dentists are rapidly and accurately producing bridges, crowns, orthodontic appliances and stone models.[1]

A new technological innovation, four-dimensional (4D) printing, is providing higher capabilities to change the restorative dentistry. Nowadays, it is predicted that 4D-printed products will replace 3D-printed products. 4D printing concept was introduced in 2012 and attracted interest in processes and materials. 4D printing technology allows the printed model/product to change its shape and function, concerning time-effected external conditions such as heat, water, light and electricity. This technology provides added capability of embedded transformation in products from one shape to another.[2,3]

4D printing is a digital process that prints 3D smart materials and adds time dimension. After printing, this provides reconfiguration to a printed object.[4,5] Dentistry models are designed and printed in such a way that after printing, one shape of the model is converted into another shape with the variation of temperature. It enhanced the opportunities to create a new dental product.

Restorative dentistry is awaiting the revolution of smart material techniques. This technology seems to have the ability to print a 3D model with smart material that has excellent potential to adjust itself in any condition. A 4D-printed dental implant with smart material can be able to adjust itself to compensate the lost tooth structure and fix failed parts. In dentistry, missing tooth is the primary challenge, which can grow and change to the same shape as of the original tooth. However, commercially, this technology is not yet available.

Dentist job has become more comfortable with the 3D dental scanner, as these 3D scanners are used to scan the patient teeth, and 4D printing technologies to print these scanned data by the applications of smart dental material and smart machining technologies. The dentists are also using this digital technology for research purpose in which a prototype is created and tested for various properties.[6] It reduces the complexity and time of the production cycle.

The research in the 4D printing in dentistry will be increasing as to produce smart bridges, elaborate dental crowns, aligner, surgical templates and orthodontic braces adjusted as per requirement of the individual patient after temperature change. It brings an innovative revolution in dentistry. It will improve the quality of patient life and efficiently solve the problem in dentistry. The dentist can convert need/idea into a reality that provides a comprehensive opportunity to manufacture smart dentistry tools and devices as per the requirement of the patient.

4D printing can create dental implants with properties as good as natural teeth. Patient's denture could be redesigned to adjust with new shapes as per the eating habits and also to take care of humidity and temperature in the mouth. 4D-printed dental implants possess characteristics of dimensional changes that could help to avoid marginal leakage. Smart orthodontics implants enhance the function of ligature and wires that help teeth to move in the desired direction.[7] These implants can adjust the situation without any need for human control.

In future, 4D printing can print low-cost, smart, functional dentures using multiple biocompatible materials. It can provide a perfect solution for the production of various types of smart, customised dentistry model that can grow as patient teeth grow. Now, 4D printing can solve various problems that are the limitation of 3D printing technologies. This technology has the potential to grow as rapidly as digital dentistry.

Conflict of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cmrp.2018.12.005.

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