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Applications Of 3D Printing Technology in Orthodontics: Carving a Way into Future

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Abstract

3D printing is a technology that creates physical objects from digital models by adding layers of material. It has numerous applications in Orthodontics - the branch of dentistry that deals with correcting the alignment of teeth and jaws. 3D printing can be used to make accurate and customized models, fixed as well as removable appliances, guides and mini-implants for orthodontic treatment. This article reviews the current state of the art, the advantages, and the challenges of 3D printing in orthodontics. It also discusses the future prospects and the potential impact of 3D printing on orthodontic practice and the patient's experience. The article concludes that 3D printing is a promising and innovative technology that can improve the quality, efficiency, and outcomes of orthodontic treatment, as well as reduce the costs and can affect the environmental impact of orthodontic practice. However, further research and development are needed to overcome the limitations and optimize the performance of 3D printing in orthodontics.

Keywords: 3D printing technology; Orthodontics; CAD-CAM; Three- dimensional; Dentistry

Abbreviations: 3D: Three- Dimensional; STL: Stereolithography; TMD: Temporomandibular joint Dysfunction; CBCT: Cone-Beam Computed Tomography; RPE: Rapid Palatal Expanders; CAD-CAM: Computer-Aided Design and Computer- Aided Manufacturing; TPA: Trans Palatal Arch; PNAM: Pre-surgical Naso-Alveolar Molding; LED: Light-Emitting Diode; OSA- Obstructive Sleep Apnea; MAD: Mandibular Advancement Device; SEMG: surface Electromyography; TMM: Tracking Mandibular Motion; 4D- Fourth dimension; AI: Artificial Intelligence; IDB: Indirect Bonding; TAD: Temporary Anchorage Device.

Introduction

It is 2024 and we are living through the "Digital Era", which has expanded the horizons and opened the doors for new opportunities making our day to day lives and professions quite comfortably fast paced and hassle-free. Digital Fabrication Technology, also referred to as 3D printing or Additive Manufacturing, creates physical objects from a geometrical representation by successive addition of materials, is a fast-emerging technology [1]. Three-dimensional (3D) printing is also known and referred to as Desktop Manufacturing and Rapid Prototyping. Each of these layers can be observed as a thin sliced horizontal cross-section of the eventual object. Digital manufacturing process consists of digitizing a 3D model, by scanning a real patient or designed in a computer software; either using the direct method, where the oral cavity is scanned, or by indirect method, where an impression or a model is scanned. The data obtained by the scanners is converted into an STL (stereolithography) format compatible with the computer software [2]. (Figure 1). In the process of Evolution, Charles "Chuck" Hull is one of the most eminent pioneers in the field of 3D printing. He is known as "father of 3D printing" who reshaped the print industry forever. He created the first 3D printed material ever. STL (Stereolithography) file format, the digital slicing and infill strategies, have become an integral part and he co-founded 3D Systems [3]. Creekmore and Kunik, et al. in 1993 came up with the fabrication of 3D-printed brackets and Salmi et al. [4] described the possibility of a rapid tooling method to produce custom-made, removable regulatory splints, called aligners; followed using 3D printing in the manufacturing of splints for a patient with temporomandibular joint dysfunction (TMD) disorders and many more had contributed in 2013 [4].

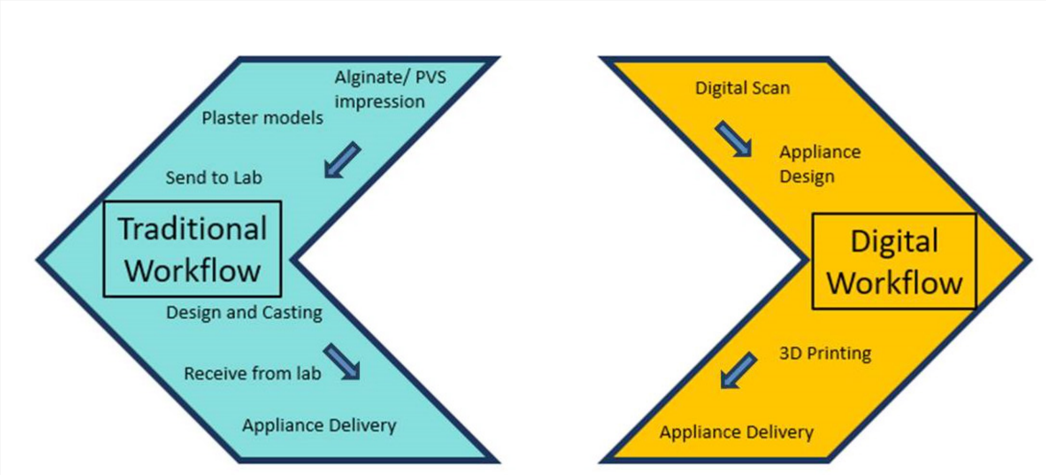

Figure 1: Traditional versus Digital workflow in the orthodontic office.

3D printing: applications in medicine and dentistry

The most cited application of 3D printing in medicine is fabrication of different surgical stents used in surgery. It has been facilitating diagnostic processes and used to fabricate customized implants of organs and recreation of damaged or removed anatomic structures or tissues. The 3D printing technology aids in pharmaceuticals manufacturing and cell-tissue Bio-printing can be done as well. Applications of 3D printing in dentistry reported in the literature includes- manufacturing of surgical guides for implant positioning, fabricating customized dental implants from titanium alloys and zirconium with additive technologies, 3D printing with biomaterials for regenerative periodontal surgery. In prosthodontics, customized impression trays, metal frameworks for removable dentures, fixed metal copings, mockups, and resin patterns for metal castings are now being printed .3D printed crowns and implants are recent and way faster as well as accurate means of rehabilitation; and one of the most common applications of 3D printing in dentistry [5].

3D Printing in Orthodontics: The Present

Orthodontics is rapidly embracing new materials and advanced technologies, making the fully equipped 3D orthodontic office a reality. With involvement of recent developments and introduction of intraoral and facial scanners, digital radiology, cone-beam computed tomography (CBCT), and additive manufacturing; the efficiency, accuracy, consistency, and predictability of the treatment outcomes has been enhanced by multiple folds [6,7].

3D printed appliances available for orthodontic practice:

Orthodontic Models

Diagnostic measurements performed on digital models represent high validity, reliability, and reproducibility, and thus may be regarded as an equal alternative to conventional plaster models. Rapid prototyping technology allows attainment of many identical copies of a digital model without any risk of distortion or deformation, available at any time. Printed models can be used for diagnosis and treatment planning, as well as to manufacture removable orthodontic appliances, expansion appliances, indirect bonding trays, or thermoformable orthodontic aligners and retainers [8].

Removable Orthodontic Appliances

The nomenclature covers a wide array of appliances including simplest appliances like Hawley, numerous functional appliances like activator, Twinblock etc. and complex sleep apnea appliances to name a few. First trials to manufacture removable acrylic orthodontic appliances using Computer-Aided Design (CAD) and 3D printing were made and presented by Sassani et al. [9] The authors reported the application of half automated technique to manufacture acrylic base plates of removable appliances. Al Mortadi et al. [10] Described a procedure of **Andresen** activator and sleep apnea appliance fabrication using CAD and additive manufacturing technology. The next development in the field was Hawley retainer manufacturing using intraoral scans obtained with TRIOS™ (3Shape, Copenhagen, Denmark), eliminating the need of conventional impression taking and pouring plaster models[10].

Pre-Surgical Nasoalveolar Moulding

The development of digital technologies has also affected the treatment protocol in patients with cleft lip and palate. These developments, aimed at reducing the risk of material aspiration, by using a scanner, seem to allow the clinician to produce appliances with less labor in a shorter time. Shen et al. designed orthopedic devices in accordance with Grayson and Cutting's treatment protocol using CAD software from scanning models obtained from patients with alginate impressions [11]. These special plates were designed to close the gap between the alveolar bones by 1 mm per week and were manufactured using maxillary models printed from 3D printers. The results of the study were comparable to the

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results provided with traditional PNAM treatment, while the number of visits to the clinic and device adaptation time decreased. Grill et al. investigated PNAM devices using CAD/Computer-Aided Manufacturing (CAM) technology and devices that combine 3D printers with semi-automatic intraoral molding design (Rapid-PNAM). This new system, called Rapid-PNAM, automatically identifies the alveolar ridges with a graphical user interface and designs plates according to the growth data of healthy newborns, allowing plates to be produced in minutes [12].

Occlusal Splints

Occlusal splints are contemporarily used for treatment of patients presenting with temporomandibular disorders (TMD) and/or asymmetries. Lauren and McIntyre were the first authors to describe digital workflow in occlusal splints manufacturing. They suggested digital protocol applied subtractive technology of splint fabrication, which was machined down from acrylic material block [13]. On the other hand, there is still a need for further clinical and scientific examination of 3D printed occlusal splints concerning clinical use.

Surgical Templates for Orthodontic Miniscrews and Miniplates Placement

Wang et al. described a technique of orthodontic miniscrew placement using a 3D printed surgical template. The superimposed CBCT and dentition scan data were imported into CAD software to design virtual surgical template [14]. Hourfar et al. introduced a method of customized adaptation and placement of orthodontic miniplates using CAD and additive manufacturing technology by utilizing CBCT based printed model as a template for 3D model. Miniplate final Positions were established and fixed with screws that served as a guide to fabricate a jig to transfer the plate to the patient's mouth [15].

Anchorage Reinforcement Devices and Space Maintainers

A division of Orthodontics in children that intercepts the malocclusion before it is well established is called INTERCEPTIVE ORTHODONTICS. These appliances mentioned below are also used for anchorage reinforcement quite frequently and efficiently.

a) Trans palatal arch is 3D printed through metal printing and the bonding site is designed on the molars not completely circular, but only confined to palatal surface.

b) Hybrid Nance appliance: Nance appliance again serving both purposes, can be 3D printed through metal printing.

c) Lingual arch: Lingual arch fabrication with bands designed to be printed through 3D metal printing (fully or partial) around the molars with a connector along the lingual surface of the teeth [16].

Expansion Appliances

Rapid Palatal Expanders (RPEs) can be designed in various ways; single or connected bands, bands with arms, or, in the case of a face mask, arms with hooks that can extend anteriorly for attaching elastics to the face mask [16,17].

Variations and modifications of expansion appliances and distalizers:

i) **3D printed Hyrax-Hayrake-Blue-grass combination Appliance:** This is an amalgamation of three separate appliances: a hyrax, a split hayrake for habit-breaking, and a movable bluegrass bead for tongue-training [16].

ii) **3D printed Hyrax – Halterman:** a combination of a Hyrax and a Halterman to perform simultaneous maxillary expansion and distalization of the molars [16].

iii) **Miniscrew-supported Hyrax-distalizer with facemask hooks:** This complex appliance epitomizes the advantages of 3D metal printing. It is a miniscrew-supported hyrax with facemask hooks that also distalized an ectopic molar [16].

Fixed Orthodontic Appliances

Customized, patient-specific orthodontic brackets are the next step in treatment efficiency. LightForce Orthodontics was the first company to 3D print customized brackets. Brackets of various materials from metal to Polycrystallines alumina ceramic are 3D printed into twin brackets with idealized geometries, allowing for highly efficient tooth movement. Self-ligating and lingual brackets are customized, too. In addition, Indirect bonding trays (IDB) are fabricated and used to ensure accurate bracket placement. Along with traditional bonding techniques, unconventional indirect bonding has been made easy through 3D printed trays that are customized according to the patient specific needs [18,19].

Mandibular Positioning Devices

Herbst with brackets: Anterior mandibular repositioning devices (Fixed functional appliance) like Herbst are also 3D printed through metal printing. Firstly CAD-CAM software is used to design and produce the model for the same. Then the appliance is 3D printed [16].

Clear Aligners

By using CAD software, the orthodontist can digitally move the teeth to the final desired position and then create a set of multiple aligners. Direct-printed aligners appear to have multiple advantages. One of the first materials that were used for direct-printed aligners or splints was Dental LT resin. Furthermore, its geometric stability at high temperatures and its shape memory properties provides advantages for clinical application [16].

Retainers

There are various types of retainers used in orthodontic practice, but Clear/ Essix/ thermoformed retainers are the currently trending and can be made with highest accuracy and ease using 3D printing.

Fixed lingual bonded retainers are being 3D printed, too, which again provides unmatchable precision and effortless customization [20].

Recent Advances of 3D Printing in Orthodontics

Just a few years ago, the benefits of additive manufacturing remained speculative and were a point of debate whether there was a financial or technological case to convert from traditional, high-volume processes to additive processes. Desktop manufacturing has found its stride, and now being an eminent pillar in the manufacturing renaissance, the future of 3D printing is bright. The most recent advances are as follows:

Compliance Monitoring

Micro-electronic sensors for monitoring compliance have been successfully embedded in functional appliances, appliances for sleep disorders, facemasks, active removable appliances and long-term removable retainer wear are recommended post-orthodontic treatment helps monitoring the same. Wearable technologies for continuous, unobtrusive, and objective monitoring of compliance, sleep disorders and jaw function and parafunction can be evaluated with these futuristic 3D printed appliances. Wearable devices that are lightweight and unobtrusive are essential for Tracking Mandibular Motion TMM in naturalistic settings and used along with microsensors to check the compliance in OSA subjects [21]. 3D printed orthodontic brackets with LED lights and batteries for enhanced bone regeneration are in a very naïve stage of research and development as reported and might take some time to become a part of clinical orthodontic practice after enough evidence-based research and trials. [22]. Moreover, the stimulations and predictions with software can help the dentists to have more accurate and futuristic appliances. This is merely the peak of the iceberg and not an extensive range of action of what one can 3D print in the dental industry, or what is coming. There is a plethora of options for 3D printed appliances like surgical devices, night guards, and more.

Navigation From Present to Future in 3D Printing

Here are six predictions about the near future of additive manufacturing.

i) 3D printing will be on a scale larger, faster & a lot cheaper.

ii) Additive manufacturing will become a resilient part of product supply chain that will aid in future advances.

iii) Working together will be important.

iv) There will be ways to provide improved quality and cybersecurity assurance.

v) 3D printing will bring about a boost in the economy.

vi) Additive manufacturing will be acing sustainability and taking it forward.

Now, with the future overlooking us the concept and ideology of Artificial Intelligence there is an arena of possibilities that could enhance the working model of the dental clinic as well as reduce the manpower and increase the efficiency of the sector. Effective device encapsulation (including supporting electronic interfaces and power supply), and the use of biocompatible materials to eliminate risks associated with salivary contact, especially the leaching of chemicals into surrounding areas, is essential to protect the functionality of electronic devices [23]. The future of 3D printing is as positive, vibrant and effective as its present and more. All the fields have their adaptation to this technology and attend to improve their input and output with the same, so has Orthodontics. (4D Facial Dynamics) are commercially available to provide a quantifiable understanding of soft tissue mobility, true anatomical motion, and facial expression. The human face can make unique micro-expressions which can be of very low intensity and last less than 0.04 seconds. Therefore, the dynamic systems continuously track frame by frame the facial surface movements to achieve accuracy in understanding the tracking motions. Assessment of facial animation could be an essential part for orthodontic diagnosis and craniofacial abnormality, virtual surgical planning, and treatment outcomes. 4D printing uses 3D printers to create live three-dimensional objects without wires or circuits. It does so by using intelligent materials, which can be programmed to change shape, colour or size when they receive an external stimulus. Such is the case with hydrogel resins, active polymers or even live tissues. 4D printing makes it possible for an object, for example, to bend, repair, assemble or even disintegrate itself. It acquires a new shape or functionality on its own by reacting with the environment [24].

Discussion

With tremendous progress, personalized or customized treatment has started to gain ground with the inclusion of digital technology in the health care field. New diagnostic tools and machines, software, capturing devices, artificial intelligence, decoding of genes, new materials and medicines, and 3D printing have helped the initialization of concepts where the individual patient is at the core of the treatment. It appears that, soon and with the use of AI, prediction of growth will help design treatments that will have a more positive effect on the final treatment outcome. In dentistry, and especially in orthodontics, polymers are used to manufacture occlusal splints, IDB trays, orthodontic models, customized brackets, and printed aligners. Polymers are most often not used as functioning appliances due to their low hardness and modulus of elasticity. Despite these shortcomings they are still suitable for

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manufacturing the appliances through 3D printing [25].

Conventional Treatment options provide some leeway of adjustments and amendments, but it is questionable to do so with 3D printed appliances, because of the materials used for models and appliance preparation. So, it might be accurate most of the time, but what about the time when it is not? As the scopes and horizons have expanded, still treatments have not been simultaneously directed to the specific problems and characteristics of the patient to equal extent, but rather have been applied in a one-treatment-fits-all concept. Nevertheless, printed appliances are a good alternative to traditional devices in cases where they can be used without creating problems like excess wastage of materials and storage space. As with 3D printing, one can get the advantage of accurate reproduction of details as well as expedited production. However, as knowledge and techniques advance, the dependency on technology becomes immense. 3D printing allows for the design and print of more complex designs than traditional manufacturing processes. While 3D Printing can create items in a selection of plastics and metals the available selection of raw materials is not exhaustive. This is since not all metals or plastics can be temperature controlled enough to allow 3D printing. In addition, many of these printable materials cannot be recycled and very few are food safe [26,27].

3D printers are becoming more and more accessible with more local service providers offering outsourcing services for manufacturing work. This saves time and doesn't require expensive transport costs compared to more traditional manufacturing processes. However, this points out another drawback of 3D technology which is the potential reduction in human labour since most of the production is automated and done by printers. However, many third world countries rely on low skill jobs to keep their economies running, and this technology could put these manufacturing jobs at risk by cutting out the need for production abroad [28]. To further name a few 3D printing technological demerits: great loss of material during milling, limited thickness of the restoration, lack of precision in the level of detail due to the size of the milling bur, and the high cost of acquisition and maintenance of the equipment. The toxic emissions of the Volatile organic compounds from using the plastics and polymers causes harm to the environment and to the health. Also causing more energy consumption leading to additional pollution of the environment. It is important to remember that we must think about why we are doing something rather than simply doing something because we can. This does not mean that just because we can do something using technology, we have to do it. The justification for whether we must use digital technology and customized appliances comes from the question: is this going to benefit the patients and their treatment as well as the orthodontist?

Conclusion

The orthodontic array is broad: ranging from printing study models to brackets & retainers, aligners, appliances for PNAM, surgical guides and splints, simulated jaws and models, functional appliances and transverse correctors- expanders, sagittal correctors - distalizers, 3D printed screws- TADS, to customization in every aspect. Thus, almost every aspect of orthodontic practice has already been capped into the panorama of 3D printing and the few remaining are on their way. 3D printing technology has and will continue to revolutionize the patient and doctor experience, leading to a new era of digital treatment planning, customization, and efficiency. Recycling efficiently while also being environmentally friendly is a major challenge with these approaches. The development of biodegradable polymer or catalysts/solvents that can promote the degradation of 3D-printed dental products would become an absolute need for in the years to come. Thus, 3D printing signifies the establishment of a new digital advent era and makes an establishment of digital workflow contributing to the technologic era further leading to and making a way for the 4^{th} dimension while keeping optimistic approach towards the impaired aspects and utmost utilization of this multidimensional boon.

References

1. Shahrubudin N, Lee TC, Ramlan R (2019) An Overview on 3D Printing Technology. Technological, Materials Applications 35: 1286-1296.
2. Mahamood S, Abdul Khader M, Ali H (2016) Applications of 3-D Printing in Orthodontics: A Review. International Journal of Scientific Study 3(11): 267-270.
3. National Center for Biotechnology Information (2023) PubChem Patent Summary for US-6027324-A, Apparatus for production of three-dimensional objects by stereolithography.
4. Salmi M, Tuomi J, Sirkkanen R, Ingman T, Mäkitie A (2012) Rapid tooling method for soft customized removable oral appliances. Open Dent J 6: 85-89.
5. Tsolakis IA, Gizani S, Tsolakis AI, Panayi N (2022) Three-Dimensional-Printed Customized Orthodontic and Pedodontic Appliances: A Critical Review of a New Era for Treatment. Children (Basel, Switzerland) 9(8): 1-14.
6. Salmi M, Paloheimo KS, Tuomi J, Ingman T, Mäkitie A (2013) A digital process for additive manufacturing of occlusal splints: a clinical pilot study. J R Soc Interface 10(84): 1-6.
7. Tartaglia GM, Mapelli A, Maspero C, Santaniello T, Serafin M, et al. (2021) Direct 3D Printing of Clear Orthodontic Aligners: Current State and Future Possibilities. Materials (Basel) 14(7): 1-11.
8. Kim SY, Shin YS, Jung HD, Hwang CJ, Baik HS, et al. (2018) Precision and trueness of dental models manufactured with different 3-dimensional printing techniques. Am J Orthod Dentofacial Orthop 153(1): 144-153.
9. Sassani F, Roberts S (1996) Computer-assisted fabrication of orthodontic appliances. Comput Ind 29(3):179-195.
10. Al Mortadi N, Jones Q, Eggbeer D, Lewis J, Williams RJ (2015) Fabrication of a resin appliance with alloy components using digital technology without an analog impression. Am J Orthod Dentofacial Orthop 148(5): 862-867.
11. Shen C, Yao CA, Magee Ward, Chai G, Zhang Y (2015) Presurgical nasoalveolar molding for cleft lip and palate: the application of digitally designed molds. Plast Reconstr Surg 135(6): 1007e-1015e.
12. Grill FD, Ritschl LM, Bauer FX, Rau A, Gau D, et al. (2018) A semi-automated virtual workflow solution for the design and production of

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intraoral molding plates using additive manufacturing: the first clinical results of a pilot-study. Sci Rep 8(1): 1-8.

13. Lauren M, McIntyre F (2008) A new computer-assisted method for design and fabrication of occlusal splints. Am J Orthod Dentofacial Orthop 133(4): 130-135.
14. Wang YT, Yu, JH, Lo, LJ, Hsu, PH, Lin CL (2017) Developing customized dental miniscrew surgical template from thermoplastic polymer material using image superimposition, CAD system and 3D printing. Biomed Res Int 2017: 1906197.
15. Hourfar J, Kanavakis G, Goellner P, Ludwig B (2014) Fully customized placement of orthodontic miniplates: a novel clinical technique. Head Face Med 10: 14.
16. Graf S, Tarraf N, Kravitz, N (2021) Three-Dimensional Metal Printed Orthodontic Laboratory Appliances. Semin Orthod 27(10): 1053.
17. Graf S (2017) Direct Printed Metal Devices - The Next Level of Computer-aided Design and Computer-aided Manufacturing Applications in Orthodontic Care. APOS Trends Orthod 7: 253-259.
18. Fiorillo G, Campobasso A, Caldara G, Battista G, Lo Muzio E, et al. (2023) Accuracy of 3-dimensional-printed customized transfer tray using a flash-free adhesive system in digital indirect bonding: An in vivo study. Am J Orthod Dentofacial Orthop 164(4): 505-515.
19. Brown MW, Koroluk L, Ko CC, Zhang K, Chen M, et al. (2015) Effectiveness and efficiency of a CAD/CAM orthodontic bracket system. Am J Orthod Dentofacial Orthop 148(6): 1067-1074.
20. Cole D, Bencharit S, Carrico CK, Arias A, Tüfekçi E (2019) Evaluation of fit for 3D-printed retainers compared with thermoform retainers. Am J Orthod Dentofacial Orthop 155(4): 592-599.
21. Prasad S, Arunachalam S, Boillat T, Ghoneima A, Gandedkar N, et al. (2023) Wearable Orofacial Technology and Orthodontics. Dentistry J 11(1): 24.
22. 3D Printed braces with LED lights and Micro Batteries save time and money. https://all3dp.com/3d-printed-braces-led-lights-batteries-every-tooth-save-time-money/ (Last accessed on 21st December 2023).
23. Chýlek R, Libor K, Jiří Pospíšil, Šnajdárek L (2021) Parameters Influencing the Emission of Ultrafine Particles during 3D Printing. Int J Environ Research and Public Health 18(21): 11670.
24. Dynamic Surface Motion Caption (4D). http://www.3dmd.com/4d/ (Last accessed on 21st December 2023).
25. Ergül T, Güleç A, Göymen M (2023) The Use of 3D Printers in Orthodontics - A Narrative Review. Turk J Orthod 36(2): 134-142.
26. Jeon H, Park J, Kim S, Park K, Yoon C (2020) Effect of nozzle temperature on the emission rate of ultrafine particles during 3D printing. Indoor Air 30(2): 306-314.
27. Karwasz A, Osinski F (2020) Literature Review on Emissions from Additive Manufacturing Fdm Method and Their Impact on Human Health. Manage Production Engineer Rev 11: 65-73.
28. Khosravani M, Reinicke T (2020) On the environmental impacts of 3D printing technology. Applied Materials Today 20: 100689.

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