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A Novel 3D Printed Teeth with Retentive Modification in Complete Denture Fabrication

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A B S T R A C T

INTRODUCTION: The most popular material for making complete dentures is Polymethylmethacrylate (PMMA), which 3D-printed novel retentive teeth include mechanical retentive properties that improve denture tooth attachment. In conventional PMMA artificial teeth rely on chemical bonding to keep attached to denture bases.

METHODS: This article elaborates on the laboratory procedures to fabricate a complete denture using 3D-printed teeth with retentive features, including bars, tunnels, pin holes for mechanical retention, and increased surface area for material flow.

RESULT: The 3D-printed teeth's retentive characteristic enhances retention. As the intaglio surface of the denture is trimmed, the material flows through the bars, tunnels, and pinholes and is visible. Consequently, it considerably increases the artificial tooth's resistance to fracturing.

CONCLUSION: Artificial tooth fracture is one of the issues with complete dentures. Traditional prefabricated teeth lack mechanical retention characteristics. By including mechanically retentive features like bars, tunnels, and pinholes into the artificial teeth, 3D-printed teeth could represent a revolutionary concept in the construction of dentures. Further clinical studies and patient compliance must be assessed in order to determine whether this significantly increases the artificial tooth's fracture resistance.

CLINICAL SIGNIFICANCE: Compared to conventional artificial teeth that are prefabricated, the new 3D-printed teeth would have superior retentive properties, which resist artificial tooth fracture. It is also simpler to construct 3D-printed teeth alone without the need to fabricate a 3D-milled complete denture.

Keywords:3D printed denture teeth, Mechanical retention, Laboratory procedure, PMMA, Complete denture

1. INTRODUCTION:

Polymethylmethacrylate (PMMA) is a popular and commonly used material for the manufacturing of denture bases and artificial teeth. Because of its ideal physical qualities and good aesthetics, as well as its comparatively low cytotoxicity and higher biocompatibility when compared to alternative plastic denture bases, it is expected to achieve clinical success in tissue-supported denture bases.[1][2][3][4]. A closed flask compression molding technique with heat activation in a water bath for resin polymerization is a long-established technique of denture manufacturing for acrylic resin. A 3D-printed artificial tooth with a novel retentive feature approach has been made to introduce mechanical bonding between the 3D-printed teeth and PMMA denture base by incorporating tunnels and bars. The bars have undercuts. This approach not only introduces mechanical retention but also increases the strength of the chemical bond by increasing the surface area of contact.

2. ARMAMENTARIUM:

The following instruments and materials are used for the fabrication of complete denture

- Maxillary trial denture with 3D-printed artificial teeth
- Mandibular trail denture with 3D-printed artificial teeth

- Dental flask
- Syringe
- Porcelain Jar
- Heat-cure acrylic resin
- Type II stone plaster
- Type III Dental stone
- Gas torch
- Vaseline
- Separating medium
- spatula
- Rubber bowl
- Plaster knife
- Brush

3.COMPOSITION OF HEAT-CURED ACRYLIC RESIN:

3.1 Powder:

- Polymethylmethacrylate powder
- Benzoyl peroxide – initiator
- Dibutyl phthalate- plasticizer
- Titanium and zinc oxide opacifiers
- Pigments or dyes

3.2 Liquid:

- Methyl methaacrylate monomer
- Ethylene glycol dimethacrylate cross-linking agent
- Hydroquinone-inhibitor [5]

4. STEPS IN THE FABRICATION OF COMPLETE DENTURE WITH 3D PRINTED TEETH:

Step 1: The 3D printed teeth were made with 3 Shape CAD/CAM software. The initial design was made and then transferred to the CAD software, and the 3D teeth were milled with a CAM machine in an A2 shade PMMA block into a size of 13,14 in the anterior and 35 on the posteriors. The innovative retentive tunnel holes and bar undercut elements were included in a set of 28 denture

teeth, and then PMMA was used to 3D print this set of denture teeth. *(Figure 1a,1b)*

Figure 1a

Figure 1b

Step 2: Then the model cast is taken to make a complete denture base and occlusal rim using baseplate wax, and then the cast is articulated in the mean value articulator.

Step 3: The 3D-printed teeth are set on the occlusal rim. The carver is used to carve gingival margins and root eminence, and smoothing of the gingival contours with a gas torch and polishing with a bristle brush was done

Step 4: Dearticulation of the upper and lower trail dentures from the articulator. The cast that is removed is lubricated with Vaseline before flasking.

Step 5: An articulated 3D-printed teeth set needs to be flasked for this appropriate selection of dental flask is done. By placing a trail denture into it, the height of the cast with artificial teeth in the flask is maintained for proper flasking.

Step 6: Type II dental plaster is mixed with the right proportion and poured into the base lower half of the flask, then the cast is placed and positioned in the center of the base of the flask, and the removal of excess plaster is done. *(Figure 2)*

Figure 2

Step 7: The smoothing of the dental plaster area is done with sandpaper, and then the top of the flask is checked. The incisal edges and occlusal surfaces are within the top half of the flask. The separating medium is then applied all over the dental plaster region, avoiding the wax surface and denture teeth. The second pour over the top of the flask is done by the appropriate mixing of dental stone and Type II dental plaster. *(Figure 3)*

Figure 3

Step 8: The flask closed and clamped then it was Dewaxed in a hot water bath at higher temperature of about 100̊ C for 5 minutes to eliminate the wax. After 5 minutes the flask is taken from the hot water bath and then the body and the base are separated very carefully. *(Figure 4*

Figure 4

Step 9: Excess wax that is present in the interlocking structures of the 3D-printed teeth is removed with a disposable syringe filled with hot water and sprayed over the tunnel holes and bar areas where there is residual wax. (Figure 5)

Figure 5

Step 10: Separating medium is then applied to the Dewaxed mould space before the packing of heat-cured resin into the surfaces using a paint brush applied in a uniform motion in layers. *(Figure 6,7)*

Figure 6

Figure 7

Step 11: The powder and liquid of heat cure acrylic resin are appropriately mixed in proportions in a clean porcelain jar with a stainless steel spatula and should be packed into the flask in dough consistency the flask is kept in a hydraulic bench press and pressed and excess heat cure resin is removed. *(Figure-8,9)*

Figure 8

Figure 9

Step 12: After Excess resin is removed, the flask is clamped till the metallic rims of the lower and upper rims are in contact and the flask is kept for bench press for 30 mins before heat curing.

Step 13: The flask is removed from the bench press and placed in clamps. *(Figure 10)* The short-term curing cycle is to maintain the temperature of the bath initially for 1 hr. 30mins at 165̊ F and 30mins at boil. Then it is left for bench cooling for one hour.

Figure 10

Step 14: Now the flask is De-Flasked and the denture is cleaned by removal of residual dental stone, trimmed and polished *maxillary and mandibular complete denture using 3D printed teeth (Figure-11)* Uniform thickness should be maintained.

Figure 11

DISCUSSION:

The conventional complete denture is more commonly constructed for the elderly group of the population. Teeth debonding from dentures can be aggravating for both patients and dentists. The topic of bonding acrylic teeth to denture base resin has been studied and is still being studied. The use of more suitable denture base resin and acrylic tooth combinations may reduce the number of prosthesis fractures and repairs. The contamination of the tooth surfaces, which prevents a strong bond from being created, was thought to be one of the most likely explanations for the failure of the link between the acrylic teeth and the denture base. [6][7][8]

Contaminants are essentially residues of wax absorbed from the tooth surfaces during acrylic processing or spacer material left at the base of the teeth during the acrylic packing stage. It has been estimated that 22–30% of denture repairs concern tooth debonding, typically in the anterior portion of the denture [4][6] The surface of the artificial teeth is altered for micromechanical retention, chemical co-polymerization, and the management of the polymerization shrinkage of polymers. Sandblasting with 250 m Al2O3 particles was combined with grinding, and it was discovered that this combination can offer much stronger bond strength due to increased surface area and mechanical interlocking. Denture teeth often bind better with heat-cured acrylic resins than with self-curing acrylic resins. It has been stated that heat-cured acrylic resins polymerize more completely than self-curing acrylic resins [9].

Through recent advancements in digital workflow, denture bases, and artificial teeth are printed separately, and then they are bonded with the use of bonding agents, surface conditioning, and auto polymerization PMMA. Despite the increased popularity of CAD-milled and 3D-printed materials, heat-polymerized denture base resins continue to produce the strongest bond strength and fracture toughness. Though the conventional PMMA material has better properties, the fracture and bonding of the artificial teeth occur as there are no mechanical retentive features built into the design of commercially available artificial tooth sets made from PMMA and porcelain [10].

Denture failure, however, can frequently be brought on by the debonding of the denture teeth from the denture base. It has been estimated that debonding of denture teeth accounts for around 30% of all denture repairs [4] [6]. Heat-polymerized denture bases provide the greatest bond strength between denture bases and teeth [11]. Thus, 3D printing artificial teeth with CAD/CAM using PMMA material, followed by the incorporation of mechanical properties by using interlocking tunnel holes in anterior teeth and bar undercuts in posterior teeth, will improve not only the chemical bonding but also the increased surface area and aid in mechanical retention of the tooth [12][13].

It is feasible to fabricate complete dentures using a combination of conventional processing techniques and 3D-printed technology due to the lower cost and technical sensitivity, which can improve the efficiency of complete denture prosthesis [14]. Nowadays, 3D-printed complete dentures are used for interim and immediate dentures as well as in the fabrication of custom trays and record bases. A well-designed clinical study is needed to prove the advantages of this technology [15].

CONCLUSION:

3D-printed teeth with retentive features have the benefit of greater tooth retention. The tunnel holes and bar undercuts in the novel 3D-printed teeth allow more material to flow into them, improving tooth retention. Current development and innovation in dentistry have successfully led to the fabrication of complete dentures and removable dentures using CAD/CAM technology. For the patient's comfort and a better understanding, further clinical research must be conducted.

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CONFLICT OF INTEREST:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCE:

1. Next In Denture History – A Novel Retentive Feature In Artificial Denture Teeth. An Observational Study M Vijay Anand, Swapnaneel Pradhan, Ponsekar Abraham A, Eswaran MA, Arjun SL, Karthikeyan D, S Hariprasad Thai Moogambigai Dental College and Hospital, Dr. MGR Educational and Research Institute
2. Viegas M M, Bhat V S, Shetty S K, Effect of mechanical and chemical surface treatment on bond strength of acrylic denture teeth to heat cure acrylic resin-an invitro study. IP Ann Prosthodont Restor Dent 2021;7(3):161 168
3. Phoenix RD. Denture base materials. Dent Clin North Am. 1996 Jan;40(1):113-20. PMID: 8635617.
4. Clancy JM, Boyer DB. Comparative bond strengths of light-cured, heat-cured and autopolymerizing denture resins to denture teeth. J Prosthet Dent1989;61:457–62.
5. Nejatian T., Pezeshki S., Yaqin Syed A.U. Acrylic denture base materials. In: Khurshid Z., Najeeb S., Zafar M.S., Sefat F., editors. 5 Advanced Dental Biomaterials. Woodhead Publishing; Cambridge, UK: 2019. Pp. 79–104
6. Huggett R, John G, Jagger RG, Bates JF. Strength of the acrylic denture base tooth bond. Br Dent J 1982;153:187–90.
7. Patil, S. B., B. H. Naveen, and N. P. Patil. "Bonding acrylic teeth to acrylic resin denture bases: a review." *Gerodontology* 23.3 (2006): 131-139.
8. Tzanakakis, E.-G.; Pandoleon, P.; Sarafianou, A.; Kontonasaki, E. Adhesion of Conventional, 3D-Printed and Milled Artificial Teeth to Resin Substrates for Complete Dentures: A Narrative Review. *Polymers* **2023**, *15*, 2488. https://doi.org/10.3390/polym15112488
9. Schoonover, I.C.; Fischer, T.E.; Serio, A.F.; Sweeney, W.T. Bonding of plastic teeth to heatcured denture base resins. *J. Am. Dent. Assoc.* **1952**, *44*, 285–287
10. Darbar, U.R.; Huggett, R.; Harrison, A. Denture fracture—A survey. *Br. Dent. J.* **1994**, *176*, 342–345.
11. Chung, K.H.; Chung, C.Y.; Chung, C.Y.; Chan, D.C.N. Effect of pre-processing surface treatments of acrylic teeth on bonding to the denture base. *J. Oral Rehabil.* **2008**, *35*, 268– 275.
12. Kane, B.; Shah, K.C. In Vitro Analysis of Shear Stress: CAD Milled vs Printed Denture Base Resins with Bonded Denture Tooth. *J. Prosthodont.* **2023**, *32*, 29–37.
13. Choi, J.J.E.; Uy, C.E.; Plaksina, P.; Ramani, R.S.; Ganjigatti, R.; Waddell, J.N. Bond Strength of Denture Teeth to Heat-Cured, CAD/CAM and 3D Printed Denture Acrylics. *J. Prosthodont.* **2020**, *29*, 415–421.
14. Accuracy of tooth positioning in 3D-printing aided manufactured complete dentures: An in vitro study Author links open overlay panelKehui Deng a, Hu Chen a, Wei Wei b, Xinyu Wang c, Yuchun Sun https://doi.org/10.1016/j.jdent.2023.104459

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