RESEARCH PAPER

Evaluation of Candida albicans Colonization on Heat-Cured, Polyamide, and 3D-Printed Denture Base Materials

Farid Abdel-Karim Hamam, Ahmed Ragab Elbauomy, Esmail Ahmed Abdel-Gawwad, Sayed Abdalla Mohamed, Wesam E Badr

Lecturer, Removable Prosthodontics Department, Faculty of Dental Medicine, Boys, Al-Azhar University.

Received: 08th July, 2026; Revised: 07th August, 2026; Accepted: 11th August, 2026; Available Online: 14th August, 2026

ABSTRACT

Objective: This study aimed to evaluate Candida albicans colonization on different denture base materials (3D-printed, heat-cured acrylic, and polyamide resins).

Materials and Methods: Twelve patients with maxillary Kennedy Class III partially edentulous arches and completely dentate mandibles were selected from the outpatient clinic of the Removable Prosthodontics Department, Faculty of Dental Medicine for Boys, Al-Azhar University, Cairo. A cross-over study design was utilized, wherein each patient received three different removable partial dentures (RPDs) to wear for three months each, separated by a one-month washout period. The denture base materials tested were: heat-cured acrylic resin (Group I), polyamide resin (Group II), and 3D-printed resin (Group III). To evaluate fungal colonization, swabs were collected in the morning between 10:00 AM and 12:00 PM, ensuring the patients had worn the dentures for several hours prior to sampling.

Results: The results demonstrated significant differences in the susceptibility of these materials to fungal colonization over time. Heat-cured acrylic resin exhibited the lowest fungal count, while the nylon (polyamide) resin exhibited the highest.

Conclusions: Heat-cured acrylic denture bases are significantly less susceptible to Candida albicans colonization compared to nylon and 3D-printed alternatives.

Keywords: 3D Printing; Candida albicans; Crossover Trial; Denture Stomatitis; Polyamide; Polymethyl Methacrylate.

How to cite this article: Hamam F.A, Elbauomy A.R, Abdel-Gawwad E.A, Mohamed S.A, Badr W.E, Evaluation of Candida albicans Colonization on Heat-Cured, Polyamide, and 3D-Printed Denture Base Materials. 2026;16(78s): 336-341; DOI: 10.25258/ijddt.16.78s.40

Source of support: None

Conflict of interest: None

INTRODUCTION

Removable partial dentures (RPDs) serve as a practical and cost-effective treatment modality for partially edentulous patients. Traditionally, denture bases have been fabricated using polymethyl methacrylate (PMMA), a material that has been the clinical standard since 1937 [1, 2]. PMMA remains widely used due to its acceptable esthetics, ease of manipulation, and cost-effectiveness. However, despite improvements in its physical properties over the years, conventional heat-cured PMMA exhibits inherent clinical drawbacks. These include volumetric polymerization shrinkage, residual monomer leaching, and a high susceptibility to microbial adhesion, particularly Candida albicans [3]. Furthermore, conventional fabrication requires multiple clinical visits and relies heavily on trained laboratory technicians, a resource that is currently facing severe shortages [4].

To overcome the limitations of conventional compression molding, computer-aided design and computer-aided manufacturing (CAD/CAM) technologies have gained significant traction in prosthodontics [5]. Several authors have emphasized the value of digital workflows, utilizing rapid prototyping or additive manufacturing (3D printing) to fabricate denture bases [6]. Consequently, the effective and widespread adoption of CAD/CAM systems has streamlined the fabrication process, with studies showing that digital complete and partial dentures can reduce the required number of clinical appointments from five visits to as few as two [7, 8].

In addition to 3D-printed resins, thermoplastic nylon has emerged as a popular alternative denture base material. Nylon is a polyamide resin synthesized via the polycondensation of dibasic acids and diamines. It possesses excellent physical strength, chemical resistance, and thermal stability. Due to its inherent flexibility, nylon is primarily utilized for flexible, tissue-supported RPDs [9].

Regardless of the material used, denture base resins exhibit varying degrees of surface roughness, which directly influences microbial colonization. Similar to natural dentition, dentures are highly susceptible to plaque, calculus, and biofilm accumulation. Inadequate daily removal of this biofilm often leads to denture stomatitis, a multifactorial condition characterized by localized erythema of the denture-bearing mucosa [10].

The primary etiology of denture stomatitis is oral candidiasis, an opportunistic infection caused by the overgrowth of Candida species. Candida albicans, Candida glabrata, and Candida tropicalis account for over 80% of clinical isolates, with C. albicans being the most prevalent, particularly among older adults and denture wearers. While maintaining a meticulous oral hygiene regimen can prevent candidiasis in many cases, the incidence of infection remains heavily influenced by patient age, specific systemic

**Author for Correspondence: Farid Abdel-Karim Hamam*

risk factors, and the surface properties of the prosthesis itself [11,12].

Given the diverse characteristics of modern denture bases, this study was conducted to evaluate Candida albicans colonization on three different denture base materials: heat-cured acrylic resin, nylon resin, and 3D-printed resin. The null hypothesis states that there is no significant difference in C. albicans overgrowth among the different denture base materials.

MATERIALS AND METHODS:

Study Design and Population

A longitudinal, cross-over controlled clinical trial was conducted to evaluate Candida albicans colonization on different partial denture base materials. The study population comprised patients selected from the outpatient clinic of the Removable Prosthodontics Department, Faculty of Dental Medicine for Boys, Al-Azhar University, Cairo.

Sample Grouping

Based on a previous study [13], twelve patients with maxillary Kennedy Class III partially edentulous arches and fully dentate opposing mandibles were enrolled. Employing a crossover design, each participant received three different types of removable partial dentures (RPDs). Each RPD was worn for a period of three months, separated by a one-month washout period. The RPDs were categorized according to the denture base material used:

Group I: Heat-cured acrylic resin

Group II: Nylon (polyamide) resin

Group III: 3D-printed resin

Eligibility Criteria

Inclusion criteria: Systemically healthy patients aged 40 to 60 years, maintaining good oral hygiene, and presenting with an Angle Class I maxillomandibular relationship with sufficient inter-arch space.

Exclusion criteria: Patients with systemic diseases affecting immunity, active smokers, and individuals with parafunctional habits (e.g., bruxism or clenching).

Clinical Procedures (All Groups)

Prior to prosthodontic treatment, all patients underwent a diagnostic digital panoramic radiograph of the abutment teeth. Oral hygiene was optimized through scaling, root planing, oral hygiene instructions, and the conservative restoration of any carious teeth. Preliminary impressions were made using irreversible hydrocolloid and poured in dental stone to obtain study casts. Auto-polymerizing acrylic resin custom trays were fabricated on these casts. Record blocks were constructed to record tentative jaw relations and evaluate available inter-arch space, allowing for any necessary intraoral modifications. Final impressions were made using elastomeric impression material and poured in dental stone to obtain the master casts.

Prosthesis Fabrication

Group I (Heat-Cured Acrylic Resin): Conventional protocols were followed for the fabrication of the heat-cured acrylic RPDs, utilizing standard wax pattern fabrication, flasking, and heat-polymerization techniques.

Group II (Polyamide Resin): Master casts were duplicated using an agar duplicating material. To ensure mechanical retention, diatorics (T-shaped holes) were created in the selected artificial teeth. Following the wax try-in and the establishment of jaw relations, the models were waxed up, sprued, and invested in a specialized flask designed for injection molding. Wax elimination was achieved by submerging the flask in hot water for 5 minutes. After applying a separating medium and sealing the flask, the polyamide material was injected into the mold via the sprues using an injection molding machine. Upon deflasking, the sprue formers were removed using a cutting disk. The dentures were then trimmed and finished using vulcanite burs and mounted stones (green and pink) with a quick, light shaving motion to prevent overheating.

Group III (3D-Printed Resin): Master casts and opposing dentitions were scanned to generate virtual models and ensure proper occlusal contacts. The RPD frameworks and denture bases were designed using CAD software (Valleta 3D, exocad, Darmstadt, Germany), which established the path of insertion and blocked out undercuts. The denture bases were designed with specific socketed spaces to receive the artificial teeth. The design was exported as an STL file to the CAM software and printed using a 3D printing machine at a layer thickness of 100 microns. Following printing, the artificial teeth were bonded into the base sockets using uncured liquid 3D-printing resin to ensure optimal adhesion. The printed prostheses were washed in ethyl alcohol and subjected to a 30-minute post-curing cycle to ensure complete polymerization and minimize residual monomer.

Intervention and Follow-up

Following prosthesis delivery, patients were monitored for any necessary adjustments or complaints. The total evaluation period spanned 12 months per patient (three 3-month wear periods separated by 1-month washout periods). To standardize fungal colonization and exclude the immediate effects of food consumption, microbiological swabs were collected in the morning between 10:00 AM and 12:00 PM, ensuring the patient had worn the denture for several hours prior to sampling. During these visits, patients were also clinically examined for any signs of Candida-associated stomatitis.

Microbiological Evaluation

Culture media preparation: To create a selective culture medium for fungal growth, 65 g of Sabouraud's dextrose agar was dissolved in distilled water and mixed thoroughly to form a uniform suspension. The mixture was heated with frequent agitation until boiling, then sterilized in an autoclave at 118–121 °C for 15 minutes [14].

Germ tube assay: Human venous blood was collected and placed in a vertical test tube rack to allow for complete clotting. Following clot formation, the samples were centrifuged at 3000 rpm for 10 minutes to extract the serum.

Aerobic culture: Swab specimens from each patient were inoculated onto the prepared Sabouraud's agar Petri dishes. The plates were placed in an electric incubator at 37 °C for 48 hours. Following incubation, fungal colonies were counted and evaluated for growth characteristics.

Figure 1. Collection of a swab sample from the patient.

Figure 2. Candida albicans colonization on the polyamide resin denture base.

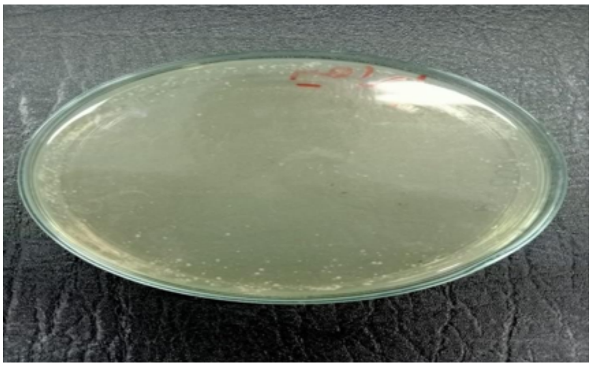

Figure 3. Candida albicans colonization on the 3D-printed resin denture base.

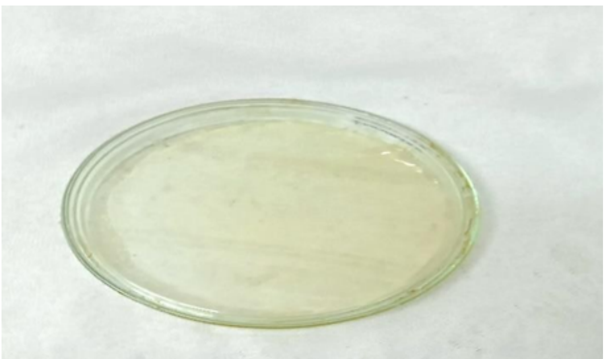

Figure 4. Absence of Candida albicans colonization on the heat-cured acrylic resin denture base.

Data were collected, tabulated, and statistically analyzed using IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp., Armonk, NY, USA). A repeated measures analysis of variance (ANOVA) was utilized to determine whether significant differences existed in fungal colonization among the three denture base materials. A p-value of < 0.05 was considered statistically significant.

RESULTS:

Table 1 demonstrates that there were statistically significant differences in Candida albicans growth among the three denture base materials during the first and third months of the evaluation period ($p = 0.038$). However, there were no statistically significant differences observed among the groups during the second month ($p = 0.165$)

Table 1. Comparison among heat-cured acrylic, polyamide, and 3D-printed dentures regarding the frequency of Candida albicans growth.

Time Point	Culture Result	Acrylic dentures (n = 12)	Polyamide dentures (n = 12)	3D-printed dentures (n = 12)	Chi-Square Value*	P-value	Significance
At 1st month	**Negative**	**12 (100.0%)**	**9 (75.0%)**	**12 (100.0%)**	**6.545***	**0.038**	**S**
	Positive	**0 (0.0%)**	**3 (25.0%)**	**0 (0.0%)**			
At 2nd month	**Negative**	**12 (100.0%)**	**9 (75.0%)**	**9 (75.0%)**	**3.600***	**0.165**	**NS**
	Positive	**0 (0.0%)**	**3 (25.0%)**	**3 (25.0%)**			
At 3rd month	**Negative**	**12 (100.0%)**	**9 (75.0%)**	**12 (100.0%)**	**6.545***	**0.038**	**S**
	Positive	**0 (0.0%)**	**3 (25.0%)**	**0 (0.0%)**			

S = Significant ($p < 0.05$); NS = Non-significant ($p > 0.05$). Data were analyzed using a Chi-square test.

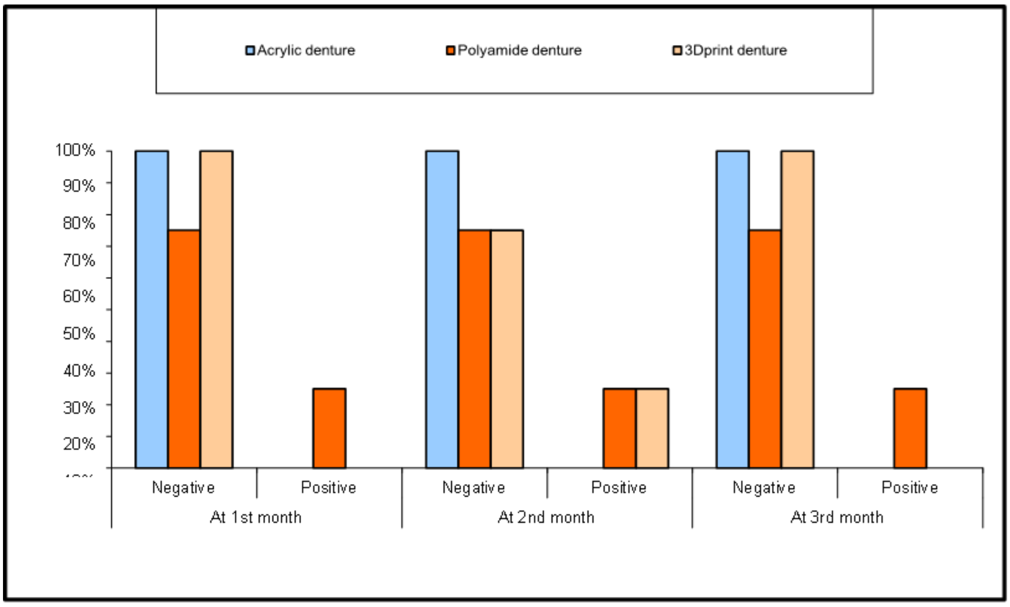

Figure 5. Graphic representation comparing the frequency of Candida albicans colonization among the heat-cured acrylic (Group I), polyamide (Group II), and 3D-printed (Group III) denture base materials.

DISCUSSION:

An ideal denture base material should possess favorable physical characteristics, including a high elastic modulus, proportional limit, resilience, adequate abrasion resistance, fatigue strength, and impact strength. Esthetically, it should offer sufficient translucency and be easily tinted or pigmented to match the natural color of the teeth and gingiva. Furthermore, the material must be cost-effective, easy to manipulate, repair, and clean, while maintaining a long shelf life [15].

Historically, heat-activated materials have dominated the fabrication of denture bases. Thermal energy, typically provided by a water bath or microwave oven, is required to initiate polymerization. Conventional heat-cured polymethyl methacrylate (PMMA) systems consist of a powder and a liquid component. The powder contains pre-polymerized PMMA spheres and a trace amount of benzoyl peroxide, which acts as the initiator. The liquid is predominantly unpolymerized methyl methacrylate (MMA) monomer, containing a small quantity of

**Author for Correspondence: Farid Abdel-Karim Hamam*

hydroquinone to act as an inhibitor and extend the material's shelf life [16].

Biocompatibility remains the most critical biological attribute of any dental material, defined as its ability to function safely and elicit a favorable host response within a biological environment. Notably, the leaching of uncured or residual monomer from polymerized denture bases has been directly linked to tissue inflammation, mucosal irritation, and cytotoxicity [17].

To overcome many of the limitations associated with conventional acrylic resins, thermoplastic resins were introduced in the 1950s. These flexible, biocompatible materials possess unique physical and mechanical properties. Due to their lighter weight and ability to engage deeper, more desirable undercuts, they offer improved adaptability and retention for partial dentures [9].

More recently, the widespread integration of computer-aided design and computer-aided manufacturing (CAD/CAM) has revolutionized prosthodontics, particularly in mitigating the severe shortage of qualified dental laboratory technicians. CAD/CAM systems are now widely utilized for fabricating both complete and partial dentures [4]. Several studies have investigated CAD/CAM PMMA dental prostheses, comparing their material properties to those of conventionally processed polymers [18]. In contrast to the traditional flask-pack-press method, digital workflows typically employ rapid prototyping (3D printing) or subtractive milling techniques [19]. The incorporation of CAD/CAM technology streamlines laboratory procedures, reduces time-consuming manual steps, and ensures the efficient, accurate, and reproducible fabrication of prostheses [20]. Currently, 3D printing is utilized across various dental disciplines—including prosthodontics, orthodontics, and maxillofacial surgery offering extensive customization and supporting advanced tissue and bone management during implant placement [21].

Candida albicans is a prevalent opportunistic pathogen in the oral cavity, particularly among denture wearers. The capacity of different denture base materials to resist or promote fungal colonization is a crucial clinical consideration. This study evaluated C. albicans growth on three materials: heat-cured acrylic resin, polyamide (nylon) resin, and 3D-printed resin.

The results revealed significant differences in the susceptibility of these materials to fungal colonization over time. The complete absence of C. albicans growth on the heat-cured acrylic resin (Group I) throughout the evaluation period suggests that this material offers superior resistance to fungal colonization. This aligns with its well-documented biocompatibility and widespread clinical use. This resistance may be attributed to its surface characteristics, which are less conducive to biofilm formation compared to alternative materials. Therefore, heat-cured acrylic resin remains a preferred choice for patients at a high risk of denture-related stomatitis.

Conversely, the polyamide resin (Group II) exhibited a 25% incidence of C. albicans colonization at both the one-month and three-month evaluation intervals, indicating a higher susceptibility to fungal adhesion over time. These findings corroborate previous research by Freitas et al. [22], which demonstrated that polyamide resins tend to support greater Candida biofilm formation than PMMA. This increased fungal growth is likely associated with the material's specific surface properties, including its flexibility and porosity, which can facilitate microbial adherence. This is further supported by Wesam et al. [23], who reported a significant difference in surface roughness between heat-cured acrylic and polyamide resins. Consequently, the increased susceptibility of polyamide suggests that patients utilizing these prostheses may require stricter hygiene protocols or targeted antifungal treatments.

Regarding the 3D-printed resin (Group III), the findings suggest that while additive manufacturing offers significant advantages in workflow customization, the material's potential to support fungal growth during long-term clinical use must be carefully monitored. The results highlight the critical role of material selection in preventing Candida infections in denture wearers.

It is important to note that the present findings contrast with several other studies in the literature. Hegab et al. [24] and Al-Fouzan et al. [25] reported that CAD/CAM-fabricated denture bases were superior to conventionally processed bases, exhibiting a higher contact angle, lower surface roughness, and consequently, decreased C. albicans adherence. Furthermore, Ahmed et al. [26] found that flexible polymeric denture base materials exhibited less Candida adherence on the intaglio surface compared to conventional heat-cured acrylics. These discrepancies may be attributed to variations in material composition, inherent hydrophilicity or hydrophobicity, surface-free energy, water sorption rates, and the specific manufacturing protocols utilized across different studies.

Given the significant differences observed in fungal colonization among the tested materials, the null hypothesis of the present study was rejected.

CONCLUSION:

In summary, the present findings demonstrate that Candida albicans colonization varies significantly depending on the type of denture base material utilized. Overall, conventional heat-cured acrylic resin exhibited a significantly lower susceptibility to fungal adhesion compared to polyamide and 3D-printed resin alternatives.

REFERENCES

1. Gungor H, Gundogdu M, Duymus ZY. Investigation of the effect of different polishing techniques on the surface roughness of denture base and repair materials. J Prosthet Dent. 2014;112(6):1271-1277. doi: 10.1016/j.prosdent.2014.03.023
2. Silva CS, Machado AL, Chaves CA, Pavarina AC, Vergani CE. Effect of thermal cycling on denture base and autopolymerizing reline resins. J Appl Oral Sci. 2013;21(3):219-224. doi: 10.1590/1678-775720130047
3. Darwish ET. The effect of different denture base material on microbial flora growth. Curr Sci Int. 2017;6(2):314-320.
4. Baba NZ, Goodacre CJ, Kattadiyil MT, Masri R, Driscoll

CF. Clinical applications of digital technology in prosthodontics. In: Masri R, Driscoll CF, editors. Clinical Applications of Digital Dental Technology. Hoboken (NJ): John Wiley & Sons, Inc; 2015.

5. Alp G, Murat S, Yilmaz B. Comparison of flexural strength of different CAD/CAM PMMA-based polymers. J Prosthodont. 2019;28(2): e491-e495. doi: 10.1111/jopr.12755
6. Goodacre CJ, Garbacea A, Daher T, Marchack CB, Lowry F. CAD/CAM fabricated complete dentures: concepts and clinical methods of obtaining required morphological data. J Prosthet Dent. 2012;107(1):34-46. doi: 10.1016/S0022-3913(12)60012-6
7. Saponaro PC, Yilmaz B, Heshmati RH, McGlumphy EA. Clinical performance of CAD-CAM-fabricated complete dentures: A cross-sectional study. J Prosthet Dent. 2016;116(3):431-435. doi: 10.1016/j.prosdent.2016.03.017
8. Kattadiyil MT, Jekki R, Goodacre CJ, Baba NZ. Comparison of treatment outcomes in digital and conventional complete removable dental prosthesis fabrication in a predoctoral setting. J Prosthet Dent. 2015;114(6):818-825. doi: 10.1016/j.prosdent.2015.08.001
9. Anusavice KJ, Shen C, Rawls HR. Phillips' Science of Dental Materials. 11th ed. St. Louis (MO): Saunders; 2003. p. 41-43.
10. Felton D, Cooper L, Duqum I, Minsley G, Guckes A, Haug S, et al. Evidence-based guidelines for the care and maintenance of complete dentures: a publication of the American College of Prosthodontists. J Prosthodont. 2011;20(Suppl 1): S1-S12. doi: 10.1111/j.1532-849X.2010. 00683.x
11. Francis P, Walsh TJ. Current approaches to the management of fungal infections in cancer patients. Oncology (Williston Park). 1992;6(4):81-92.
12. Odds FC. Candida and candidiasis. 2nd ed. London: Bailliere Tindall; 1988.
13. Almufleh B, Emami E, Alageel O, de Melo F, Seng F, Caron E, et al. Patient satisfaction with laser-sintered removable partial dentures: A crossover pilot clinical trial. J Prosthet Dent. 2018;119(4):560-567. doi: 10.1016/j.prosdent.2017.04.021
14. Saigal S, Bhargava A, Mehra SK, Dakwala F. Identification of Candida albicans by using different culture medias and its association in potentially malignant and malignant lesions. Contemp Clin Dent. 2011;2(3):188-193. doi: 10.4103/0976-237X.86454
15. Anusavice KJ, Shen C, Rawls HR. Phillips' Science of Dental Materials. 12th ed. Amsterdam: Elsevier Health Sciences; 2012.
16. Lassila LV, Vallittu PK. Denture base polymer Alldent Sinomer: mechanical properties, water sorption and release of residual compounds. J Oral Rehabil. 2001;28(7):607-613. doi: 10.1046/j.1365-2842.2001.00725.x
17. Lung CY, Darvell BW. Minimization of the inevitable residual monomer in denture base acrylic. Dent Mater. 2005;21(12):1119-1128. doi: 10.1016/j.dental.2005.03.003
18. Davda K, Osnes C, Dillon S, Wu J, Hyde T, Keeling A. An investigation into the trueness and precision of copy denture templates produced by rapid prototyping and conventional means. Eur J Prosthodont Restor Dent. 2017;25(4):186-192. doi: 10.1922/EJPRD_01716Davda07
19. Kalberer N, Mehl A, Schimmel M, Müller F, Srinivasan M. CAD-CAM milled versus rapidly prototyped (3D-printed) complete dentures: An in vitro evaluation of trueness. J Prosthet Dent. 2019;121(4):637-643. doi: 10.1016/j.prosdent.2018.09.001
20. Mörmann WH. The origin of the Cerec method. Int J Comput Dent. 2004;7(1):11-24.
21. Hegedűs V, et al. User experience and sustainability of 3D printing in dentistry. Int J Environ Res Public Health. 2022;19(4):1921. doi: 10.3390/ijerph19041921
22. Freitas FS, Paranhos HF, Lara EH, et al. Efficacy of denture cleansers on Candida spp. biofilm formed on polyamide and polymethyl methacrylate resins. J Prosthet Dent. 2011;105(1):51-58. doi: 10.1016/S0022-3913(10)60192-1
23. Badr WE, Sakr HM, Masoud MA, Quassem MA. Comparative study of some properties of flexible and conventional heat-cured acrylic resin denture base material. Al-Azhar J Dent Sci. 2018;21(1):87-91. doi: 10.21608/ajdsm.2020.71480
24. Hegab, et al. Candida albicans colonization on denture base material fabricated by different methods (in-vitro study). Alexandria Dent J. 2025. doi: 10.21608/adjalexu.2025.360111.1594
25. Al-Fouzan AF, Al-Mejrad LA, Albarrag AM. Adherence of Candida to complete denture surfaces in vitro: A comparison of conventional and CAD/CAM complete dentures. J Adv Prosthodont. 2017;9(5):402-408. doi: 10.4047/jap.2017.9.5.402
26. Ahmed EM, Esmat AM, Hassan HG. Candida albicans colonization on different polymeric denture base materials in controlled type II diabetic patients. J Arab Soc Med Res. 2019;14(2):95–101. doi: 10.4103/jasmr.jasmr_17_19