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Review

Different Polymers for the Base of Removable Dentures? Part II: A Narrative Review of the Dynamics of Microbial Plaque Formation on Dentures

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Abstract: This review focuses on the current disparities and gaps in research on the characteristics of the oral ecosystem of denture wearers, making a unique contribution to the literature on this topic. We aimed to synthesize the literature on the state of current knowledge concerning the biological behavior of the different polymers used in prosthetics. Whichever polymer is used in the composition of the prosthetic base (poly methyl methacrylate acrylic (PMMA), polyamide (PA), or polyether ether ketone (PEEK)), the simple presence of a removable prosthesis in the oral cavity can disturb the balance of the oral microbiota. This phenomenon is aggravated by poor oral hygiene, resulting in an increased microbial load coupled with the reduced salivation that is associated with older patients. In 15–70% of patients, this imbalance leads to the appearance of inflammation under the prosthesis (denture stomatitis, DS). DS is dependent on the equilibrium—as well as on the reciprocal, fragile, and constantly dynamic conditions—between the host and the microbiome in the oral cavity. Several local and general parameters contribute to this balance. Locally, the formation of microbial plaque on dentures (DMP) depends on the phenomena of adhesion, aggregation, and accumulation of microorganisms. To limit DMP, apart from oral and lifestyle hygiene, the prosthesis must be polished and regularly immersed in a disinfectant bath. It can also be covered with an insulating coating. In the long term, relining and maintenance of the prosthesis must also be established to control microbial proliferation. On the other hand, several general conditions specific to the host (aging; heredity; allergies; diseases such as diabetes mellitus or cardiovascular, respiratory, or digestive diseases; and immunodeficiencies) can make the management of DS difficult. Thus, the second part of this review addresses the complexity of the management of DMP depending on the polymer used. The methodology followed in this review comprised the formulation of a search strategy, definition of the inclusion and exclusion criteria, and selection of studies for analysis. The PubMed database was searched independently for pertinent studies. A total of 213 titles were retrieved from the electronic databases, and after applying the exclusion criteria, we selected 84 articles on the possible microbial interactions between the prosthesis and the oral environment, with a particular emphasis on *Candida albicans*.

Keywords: *Candida* spp.; dental plaque biofilm; denture management; denture hygiene; denture stomatitis; microbiome; systemic

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1. Introduction

The dynamic and fragile balance of the oral cavity ecosystem depends on pH, thermal fluctuations, humidity, enzymes, and microflora [1]. Against the backdrop of these conditions, there is an interaction between the oral environment and the physical and chemical characteristics of the basic materials of prostheses [2]. The traditional polymerization reaction of polymer chains proceeds with increasing heat until the monomers transform into a polymer. However, the use of this technique produces residual monomers that can negatively affect the physical, mechanical, and biological properties of the base of the prosthesis [3,4]. To remedy this, new hardening procedures have recently emerged. Therefore, the use of processing techniques such as injection molding, microwave energy, autoclaving, high-pressure thermal polymerization, CAD/CAM milling, and 3D printing have been proposed [5,6].

A thorough long-term in vivo evaluation to verify that the different basic thermoplastic resins for removable prostheses are biocompatible and exhibit insignificant cytotoxicity remains to be carried out. In fact, these base resins for prostheses that are in permanent contact with the mucous membranes can release cytotoxic components locally, causing irritation and inflammation [7].

Immediately after brushing or prophylaxis, the denture in the mouth is covered with a salivary pellicle, which precedes colonization by the first pioneer bacteria. Subsequently, the succession of early (*Streptococcus* species) and late colonizers in the biofilm, under optimal conditions, will favor the survival of new species. Microorganisms from the biofilm on the denture surface can penetrate the different polymer biomaterials.

A recent in vitro study tested the polymethyl methacrylate (PMMA) denture base material Vertex RS (Vertex-Dental, Soesterberg, The Netherlands) immersed for 30, 60, and 90 days in a suspension of *Candida albicans*. The authors highlighted blastospores and pseudohyphae on the surface of this material, which were detected in the crystallized structures as well as in traces after grinding. These authors put forward the hypothesis that the penetration of *C. albicans* stems from the deterioration of the material surface, leading to the formation of microporosities, which makes disinfection difficult and thus facilitates recolonization [8].

In vivo analysis of the interactions between the denture surfaces, saliva, eukaryotic and prokaryotic microorganisms that can cause infections such as denture stomatitis (DS) is of great importance for the prevention and treatment of these pathologies. Among the eukaryotes, *Candida* species have been reported to have the ability to attach to bacterial biofilms at almost every stage of formation, referred to as a "mycofilm".

The behavior of this mycofilm is modified and fluctuates depending on the properties of the surface of the polymers, the interactions between the microorganisms, the architecture of the biofilm, and the saliva and environmental conditions, with the last two being dependent on the general state of the prosthesis wearer [5].

This review aims to shed light on the indications for the different polymers used in the composition of prosthetic bases from a biological point of view considering the oral cavity. The behavior of these materials with respect to microorganisms depends on the adhesion, aggregation, and accumulation of prosthetic microbial plaque. These phenomena depend on the state of the surface of the materials (roughness, wettability, and free energy) but also on the patient's hygiene with respect to the prosthesis, on the clinical need for relining, and on the general state of the patient. The objective of this review is to provide an update on the specificities of polymers (PMMA, polyamide (PA), and polyether ketone (PEEK)) used as a prosthetic base to facilitate the maintenance of a healthy oral environment.

2. Materials and Methods

The methodology used for this review comprised the formulation of a search strategy, with inclusion and exclusion criteria defined and applied to retrieve studies. After selecting relevant studies, data were extracted to summarize the results. The PubMed database was searched to gather the relevant literature published on the topic. The search terms used were "dental plaque biofilm", "*Candida* spp.", "denture management", "denture hygiene", and "denture stomatitis." The inclusion criteria were (a) articles written in English that (b) dealt with the microbial flora interactions between the polymer in the denture base and the oral environment, with the occurrence of DS, and (c) articles that reported on the control of the microbial plaque of dentures (DMP). Articles that did not meet the predetermined inclusion criteria were excluded and the articles selected for the final analysis were obtained as full text.

3. Results

The current analysis focused on prosthetic microbial plaque and considered different parameters that can influence this type of colonization. Given the abundance of data obtained, we grouped the results by theme into five tables and two supplemental tables. Table 1 describes the chemical composition, roughness (Ra), and surface free energy (SFE) of the polymers (PMMA, PA, and PEEK). These parameters have the potential to affect bacterial adherence [9]. Indeed, a low value of SFE is sought to resist plaque in in vitro studies. Concerning the critical surface energy of acrylic materials, the zone of good adhesion is located at values greater than 40 mJ/m^2 [10]. Table 2 lists the different protocols for polishing the PMMA, PA, and PEEK polymers of the prosthetic base (mechanical polishing and/or chemical polishing). CAD/CAM-milled acrylic resins have lower Ra values than heat-cured PMMA. Mechanical polishing of PMMA is superior to chemical polishing. Polishing the PAs makes it possible to obtain a roughness close to 0.2 µm. Chairside polishing of PEEK also makes it possible to obtain clinically acceptable values. Table 3 describes the frequency and protocol for cleaning dentures. A protocol of daily cleaning for dentures is recommended for the three polymers. The cleanser tablets tested were more effective for PMMA and PEEK than for thermoplastic polyamide. On the other hand, self-polymerized and injection-molded polyamide showed higher solubility than PMMA. Concerning PEEK, the cleaning tablets were effective wit, low solubility. Generally speaking, denture cleansers increased the roughness of all PMMA. Concerning liquid cleansers, the best result was obtained with 2% CHG and 0.5%–1% NaOCL for PMMA. Thermo-injected polyamide base resins for prostheses colonized by *C. albicans* and disinfected with 0.12% chlorhexidine and Neem demonstrated the highest antimicrobial level. Table 4 presents the data on denture relining. Good relining was obtained with conventional thermoset PMMA and the CAD/CAM-milling block. PAs had low adhesion strength, PEEK required specific preparation and exhibited a mixed type of failure involving adhesion and cohesion. Table 5 shows a synthesis of the results concerning polymers (PMMA, PA, PEEK) for denture microbial plaque formation, polishing, relining, and hygiene. Overall, PMMA presented advantages over PA and PEEK in most of the sections mentioned. In vitro coating or the addition of antimicrobial components was desirable with PMMA. The effects of the incorporation of different nanoparticles (AgNP, silver-zinc zeolite, TiO_2 and Fe_2O_3) or natural compounds such as oleic acid (OA), in PMMA produces antifungal and antibacterial effects, limiting the development of biofilm on the surface of the prosthesis. However, if the dosage of these components was not respected, harmful mechanical effects were observed, as well as undesirable cytotoxic effects (Table S1). The in vitro comparison between PMMA and polyamide regarding cytotoxicity did not reveal obvious differences. Studies remain disparate with regard to the materials studied and the protocols used. The results fluctuated depending on the duration of the experiments and different parameters such as temperature and surface condition (Table S2).

Table 1. Chemical composition, surface roughness (Ra), and surface-free energy (SFE) of polymers (PMMA, PA, and PEEK) have the potential to affect bacterial adherence.

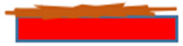
Polymers	Mean Surface Roughness (Ra) ± SD in µm Ra Threshold of 0.2 µm 	Surface-Free Energy (SFE) (N/m; mJ/m^2) SFE Threshold of 40 mJ/ m^2 	*C. albicans* Adherence 	Bacterial Adherence 
PMMA	**CAD/CAM PMMA:** Al-Dwairi ZN et al. 2019 [11]: 0.16 ± 0.03 µm (AvaDent PMMA billets; Global Dental Science, Scottsdale, AZ); Al-Dwairi ZN et al. 2019 [11]: 0.12 ± 0.02 µm (Tizian Blank PMMA; Schütz Dental, Rosbachvor der Höhe, Germany) Benli M et al. 2020 [12]: 0.19 ± 0.01 µm (Amann Girrbach AG, Koblach, Austria) Radford DR et al. 1998 [13]: 0.66 ± 0.34 µm (Trevalon Clear; Dentsply Ltd., De Trey Division, Weybridge, UK) Steinmassl et al. 2018 [14]: All CAD/CAM dentures had lower mean surface roughness values than conventional dentures. Steinmassl et al. 2018 [14]: −0.28 ± 0.16 µm AvaDent Digital Dentures (AD; Global Dental Science Europe BV, Tilburg, the Netherlands); Steinmassl et al. 2018 [14]: −0.44 ± 0.13 µm Baltic Denture System (BDS; Merz Dental GmbH, Lütjenburg, Germany); Steinmassl et al. 2018 [14]: −0.28 ± 0.01 µm Vita VIONIC (VV; Vita Zahnfabrik, Bad Säckingen, Germany); Steinmassl et al. 2018 [14]: −0.04 ± 0.01 µm Whole You Nexteeth (WN; Whole You Inc., San Jose, CA, USA) Steinmassl et al. 2018 [14]: −0.30 ± 0.10 µm Wieland Digital Dentures (WDD; Wieland Dental + Technik GmbH & Co. KG, Pforzheim, Germany/Ivoclar Vivadent AG, Schaan, Liechtenstein); Schubert et al. 2020 [15]: 0.07 ± 0.01 µm (Med 610 Stratasys, Eden Prairie, MN, USA); Schubert et al. 2020 [15]: 0.07 ± 0.01 µm (V-Print splint Voco, Cuxhaven, Germany); Schubert et al. 2020 [15]: 0.09 ± 0.01 µm FREEPRINT ortho 385 Detax, Ettlingen, G); Schubert et al. 2020 [15]: 0.06 ± 0.01 µm Dental LT Clear Formlabs, Somerville, MA, USA) Schubert et al. 2020 [15]: 0.06 ± 0.01 µm (M-PM crystal Merz Dental, Luetjenburg, Germany. 0.04 ± 0.01 Therapon Transpa Zirkonzahn, Gais, Italy) **Conventional heat-polymerized PMMA:** Al-Dwairi ZN et al. 2019 [11]: 0.22 ± 0.07 µm (Meliodent conventional PMMA, Heraeus Kulzer, Hanau Germany) Sultana N et al. 2023 [16]: 0.11 ± 0.04 µm (DPI Heat Cure; Dental Products of India, Mumbai, Maharashtra, India) Schubert et al. 2020 [15]: 0.04 ± 0.01 µm (Erkodur Erkodent, Pfalzgrafenweiler, Germany); Schubert et al. 2020 [15]: 0.05 ± 0.01 µm (PalaXpress ultra Kulzer, Hanau, Germany) Schubert et al. 2021 [15]: 0.04 ± 0.01 µm (Erkodur, Erkodent Pfalzgrafenweiler, Germany), Schubert et al. 2021 [15]: 0.05 ± 0.01 µm (PalaXpress ultra; Kulzer, Hanau, Germany) Steinmass et al. 2018 [14]: 0.55 ± 0.14 µm Candulor Aesthetic Red: Candulor AG, Glattpark, Germany) **Injection-molded technique:** Sultana N et al. 2023 [16]: 0.06 ± 0.02 µm (SR Ivocap High Impact; Ivoclar Vivadent AG, Schaan, Liechtenstein) Abuzar MA et al. 2010 [17]: 0.99 ± 0.12 µm before polishing (Vertex RS, Vertex-Dental BV, Zeilthe Netherlands) which was reduced more than 20 times to 0.04 ± 0.007 µm after polishing.	**CAD/CAM PMMA:** Steinmassl et al. 2018 [14]: SFE mean values between 31.82 and 33.68 mJ/m^2 for all the CAD/CAM dentures: AvaDent Digital Dentures (AD; Global Dental Science Europe BV, Tilburg, the Netherlands); Baltic Denture System (BDS; Merz Dental GmbH, Lütjenburg, Germany); Vita VIONIC (VV; Vita Zahnfabrik, Bad Säckingen, Germany); Whole You Nexteeth (WN; Whole You Inc., San Jose, USA); Wieland Digital Dentures (WDD; Wieland Dental + Technik GmbH & Co. KG, Pforzheim, Germany/Ivoclar Vivadent AG, Schaan, Liechtenstein) Steinmass et al. 2018 [14]: 66.62 ± 3.02 mJ/m^2 WN with coating. Schubert et al. 2020 [15]: 68.44 ± 1.98 mN/m (V-Print splint Voco, Cuxhaven, Germany); Schubert et al. 2020 [15]: 69.81 ± 2.16 mN/m FREEPRINT ortho 385 Detax, Ettlingen, G); Schubert et al. 2020 [15]: 70.86 ± 0.31 mN/m Dental LT Clear Formlabs, Somerville, MA, USA); Schubert et al. 2020 [15]: 65.31 ± 0.88 mN/m (M-PM crystal Merz Dental, Luetjenburg, Germany. 63.66 ± 3.09 mN/m Therapon Transpa Zirkonzahn, Gais, Italy) **Conventional heat-polymerized PMMA:** Cabanillas B et al. 2021 [18]: −40.3 ± 0.3 N/m (PMMA; Vitacryl; A. Tarrillo Barba, Lima, Peru) Cabanillas B et al. 2021 [18]: −39.5 ± 0.3 N/m (PMMA; Triplex; Ivoclar Vivadent, Ellwangen, Germany) Steinmassl et al. 2018 (14): −33.00 ± 0.97 mJ/m^2 conventional heat-polymerized resin (Candulor Aesthetic Red; Candulor AG, Glattpark, Germany) Schubert et al. 2021 [15]: −62.67 ± 3.43 mN/m Erkodur. Erkodent, Pfalzgrafenweiler, Germany) Schubert et al. 2021 [15]: −65.02 ± 2.41 mN/m PalaXpress ultra; Kulzer, Hanau, Germany) A decrease in SFE energy was observed for denture acrylic resins after storage in substances for the hygiene of dentures; calculated values of SFE (42.2–46.0 mJ/m^2) showed the hydrophobic character of the surface and may increase bacterial adhesion (Rutterman 2011 [9]). Incubation conditions such as saline solution and substances for the hygiene of dentures had no significance impact on the SFE value. Liber-Kne'c, 2021 [10]. Gad MM et al. 2022 [19]: low SFE of denture base resin (hydrophobe)	**CAD/CAM PMMA:** Osman RB et al. 2023 [20] Schubert et al. 2018 [15]: in vitro CAD/CAM, 3D printing and milling increased the adherence of *C. albicans* compared to conventional manufacturing **Conventional heat-polymerized PMMA:** Cabanillas B et al. 2021 [18]: no difference between tow PMMA, the adhesion per cell/field of *C. albicans*, Vitacryl (A. Tarrillo Barba, Lima, Peru) presented 15.7 ± 1.1, N/m Triplex (Ivoclar Vivadent, Ellwangen, Germany) had 16.7 ± 2.3 N/m.	**CAD/CAM PMMA:** Steinmass et al. 2018 [14]: CAD/CAM dentures had smoother and more hydrophilic surfaces than conventional dentures; there was no difference in their free-surface energy except after coated dentures. Below the Ra threshold of 0.2 µm there was a slightl but insignificant correlation between Ra and microbial adhesion (*C. albicans* and *S. mutans*). **Conventional heat-polymerized PMMA** Moslehifard E et al. 2022 [21]: Injection vertex acrylic resin (Vertex Castaravia, Vertex Dental Zeist, the Netherlands) improved the decreased surface roughness of the denture base. Bacterial adherences decreased compared with the conventional method. (Vertex dental, Ist, the Netherlands)

Table 1. *Cont.*

Polymers	Mean Surface Roughness (Ra) ± SD in µm Ra Threshold of 0.2 µm 	Surface-Free Energy (SFE) (N/m; mJ/m^2) SFE Threshold of 40 mJ/ m^2 	*C. albicans* Adherence 	Bacterial Adherence 
PA	Abuzar MA et al. 2010 [17]: 1.11 ± 0.17 µm (Flexiplast, Bredent GmbH & Co KG, Senden, Germany) Sultana N et al. 2023 [16]: 0.19 ± 0.01 (Macro Flexi Dental Resin; Macro Dental World Pvt. Ltd., Jalandhar, Punjab, India)	Takabayashi 2010 [22]: hydrophilic nature Lucitone FRS.	Freitas-Fernandes 2014 [23]: highest *C. albicans* adherence on polyamide (Flexite MP/PMMA (Acron MC).	Sultana et al. 2023 [16]: The highest microbial adhesion was observed in injection-molded polyamide/PMMA.
PEEK	Benli M et al. 2020 [12]: 0.13 ± 0.01 µm (PEEK 100%; Amann Girrbach AG, Koblach, Austria) Batak B et al. 2021 [24]: Milled 100% PEEK were above 0.2 µm before and after polishing (Coprapeek; White Peaks Dental Systems GmbH & Co KG) Vulović S et al. 2022 [25]: Comparing PEEK (breCAM.BioHPP; Bredent group, Senden, Germany) and other CAD/CAM materials showed that samples of PEEK were slightly rougher than samples of PMMA. The reason for this could be related to the ceramic particles added to PEEK.	Hirasawa M et al. 2018 [26]: PEEK with lower SFE was hydrophobic and facilitated hydrophobic bacterial growth.	da Rocha LGDO et al. 2022 [27]: In vitro, hydrophobic *C albicans* facilite sessile yeast formation on the surface of PEEK/titanium alloy.	D'Ercole S et al. 2020 [28]: PEEK showed antiadhesive and antibacterial properties between 24 and 48 h against oral bacteria such as *Streptococcus oralis*. Ichikawa, T et al. 2019 [29]: Only one report showed clear plaque accumulation on the surface of claps PEEK after 2 years. Barkamo S et al. 2019 [30]: PEEK Ra of blasted surface > polished surface and facilited the adherence of bacteria, including *Streptococcus sanguinis*, *Streptococcus oralis*, and *Streptococcus gordonii*.

PMMA, polymethyl methacrylate; PEEK, polyether ether ketone; PA, polyamide; µm, micrometers. Higher SFE, improved wettability, and diminished CA reduce the adherence of *C. albicans*. A low value of SFE is sought to resist plaque in in vitro studies; conversely, high-energy surfaces collect more plaque and select specific bacteria. PMMA (injection-molded technique) showed better result than PA and PEEK for Ra, SFE, and bacterial adherence. A decrease in surface energy SFE was observed for denture acrylic resins after storage in denture hygiene substances, but calculated SFE values (42.2 to 46.0 mJ/m^2) showed that they were hydrophobic.

Table 2. Different polishings of the polymers of the prosthetic base (mechanical polishing and/or chemical polishing in in vitro studies).

Polymers	Different Brands of Resin	Mechanical Polishing (MP) 	Chemical Manually Polishing (CP) 	Findings and Results µm
PMMA	1—Heat-cured (HC) PMMA (Vertex RS Dentimex, the Netherlands); 2—prepolymerized block of CAD/CAM (Polident d.o.o. Volčja Draga 42, Sl-5293 Volčja Draga, Slovenia)	Polishing wheels, felt cones with pumice slurry, rubber polishers with RHPL and universal polishing paste (loose abrasives (aluminumoxide-Al_2O_3) in paste, Ivoclar Vivadent, Schaan, Liechtenstein), K50	Immersing them in a preheated jar at 75 ± 1 °C containing MMA monomer (Lang Dental Mfg. Co., Wheeling, IL, USA).	1—Heat-cured PMMA denture base material in both methods showed the highest mean Ra value (2.44 ± 0.07 and 2.72 ± 0.09 for MP and CP, respectively); 2—CAD/CAM denture base material showed the lowest mean values (1.08 ± 0.23 and 1.39 ± 0.31 for MP and CP, respectively) [31].

Table 2. *Cont.*

Polymers	Different Brands of Resin	Mechanical Polishing (MP) 	Chemical Manually Polishing (CP) 	Findings and Results µm
PMMA	1—Heat cured (Probase Hot, Ivoclar Vivadent Inc., Schaan, Lichtenstein); 2—Probase Cold (cold-curing denture base, Ivoclar Vivadent Inc., Lichtenstein); 3—Palapress (Heraeus Kulzer, Hanau, Germany); 4—SR Ivocap (heat/pressure-curing (Ivoclar Vivadent Inc., Lichtenstein)	Polished with a mechanical milling system. The working tool speed was 5000 rpm as it progressed in the horizontal direction.	Manually polished. The polishing steps were the steps of ISO 20795 standard [32]	The Ra for the manually polished samples was globally significantly higher than for the mechanically polished samples [33].
	1—heat-cured acrylic resin (Lucitone 199, Dentsply International, York, PA, USA); 2—auto-cured (AC) acrylic resin (Dentsply International Inc, York, PA, USA).	MP was performed with a felt-cone with pumice slurry and a wet felt-cone with caulk powder and water.	After finishing, the HC and AC specimens were immersed in MMA monomer heated approximately to 75 °C ± 1 °C for 10 secoIds.	The Ra in order of decreasing values were CP-HC: 1.41, CP-AC: 1.34, MP-AC: 0.73, and MP-HC: 0.63. MP was the most effective polishing technique for HC and AC resins [34].
	1—HC: (Lucitone, Dentsply International Inc., York, PA, USA); 2—LC (light cured) acrylic resin (Eclipse, Dentsply Interna, Inc.). Both HC and LC prealably polishing was carried out with 360-grit sandpaper mounted on a lathe.	Performed with an automatic polishing machine (The Wirtz, Jean Wirtz, Dusseldorf W, Germany) for 2 min, under 50 rpm and 500 g of load with RHPL.	Performed by immersing the HC and LC specimens in Jet Seal Liquid (MMA at 75 ± 1 °C; Lang Dental Mfg. Co., USA).	RHPL, UPP, and K50 agents produced superior surface smoothness for all acrylic resin specimens and a mean Ra significantly below the threshold Ra of 0.2 µm. MP was the most effective polishing technique [35].
	Three HC acrylic resin materials (1—DPI, 2—Meliodent, 3—Trevalon Hi) were grouped as Group A (unfinished), Group B (finished), Group C (polishing paste), Group D (polishing cake), and Group E (pumice and gold rouge).	Materials used: universal polishing paste (Ivoclar), polishing cake (Bego), pumice (micro-white, Asian chemicals), and gold rouge (Bego). Instruments used: felt cone, soft cloth wheels (which were prepared), polishing unit (Kavo), and a timer.	NR	Smoother surfaces were achieved with Trevalon HI, Meliodent, and DPI. The best results among the polishing materials came from the polishing paste, followed by the polishing cake, pumice, and gold rouge [36].
	CAD/CAM, HC, acrylic resin CAD/CAM dentures (1–5) and conventional dentures (6). 1—standardized denture resin specimens: AvaDent Digital Dentures (AD; Global Dental Science Europe BV, Tilburg, Pays-Basque); 2—BalticDenture System (BDS; Merz Dental GmbH, Lütjenburg, Germany); 3—Vita VIONIC (VV; Vita Zahnfabrik, Bad Säckingen, Germany); 4—Whole You Nexteeth (WN; Whole You Inc., San Jose, CA, USA); 5—Wieland Digital Dentures (WDD; Wieland Dental + Technik GmbH & Co. KG); 6—Pforzheim, Germany/Ivoclar Vivadent AG, Schaan, Liechtenstein, with conventionally manufactured denture surfaces (control group).	NR	All dentures were manually finished. The mucosal surfaces were left unfinished and were examined.	All CAD/CAM dentures exhibited smoother and more hydrophilic surfaces than conventional dentures. Significant differences were found for AD, VV, WN, and WDD compared to the control group [14].

Table 2. *Cont.*

Polymers	Different Brands of Resin	Mechanical Polishing (MP) 	Chemical Manually Polishing (CP) 	Findings and Results µm
PMMA	**CAD/CAM, HC, acrylic resin** 1—CAD/CAM 3D-printed resin (3D) (CediTEC DB; VOCO GmbH, Germany); 2—CAD/CAM-milled resin (M) (V—Print dentbase; VOCO GmbH, Cuxhaven, Germany); 3—heat-polymerized resin (HP) (Probase® Hot; Ivoclar Vivadent, Liechtenstein); 4—autopolymerized resin (AP) (Probase® Cold; Ivoclar Vivadent, Liechtenstein); 5—injected molded resin (IM) (iFlexTM; tcs®, Signal Hill, CA, USA)	Mechanical technique with the Jota® 1877 denture polish kit (Jota AG, Rüthi, Switzerland) protocol.	Manual technique with the Jota® 1877 denture polish kit (Jota AG, Rüthi, Switzerland) protocol.	The resins submitted to manual polishing showed significantly lower mean surface roughness values than the control resin. CAD/CAM-milled acrylic resins demonstrated lower values of Ra compared to the conventional PMMA [37].
PA	1—HC PA (Vertex RS Dentimex, the Netherlands); 2-(Breflex, Bredent, Gmbh. Co.K.G. Senden, Germany); 3-CAD/CAM. (prepolymerized block acrylic resin denture base material (Polydent d.o.o. Volčja Draga 42, Sl-5293 Volčja Draga, Slovenia)	MP for HC, PA, and CAD/CAM specimens was performed using polishing wheels, felt cones with pumice slurry, rubber polishers with RHPL and universal polishing paste, and Abraso-Star K50 (K50) with light pressure for 15 s.	CP for HC, PA, and CAD/CAM specimens was performed by immersing them in a preheated jar at 75 ± 1 °C for 10 s.	PA surface roughness values: 1.77 ± 0.06 (MP) and 2.18 ± 0.10 (CP). PA contact angles: 67.90 ± 2.56 (MP) and 71.40 ± 2.50 (CP) (hydrophilicity). PA surface roughness values > CAD/CAM, PMMA values [31].
	Polyamide (Valplast, Valplast International Corp., Long Beach, NY, USA)	NR	The polyamide was polished with Tripoli-Paste and Val-Mirror-Shine polishing paste (Weithas Corp., Lütjenburg, Germany).	Ra (PA 0.20 µm) did not change significantly after thermocycling or storage. Neither Ra nor the elasticity of PA was altered by artificial aging [38].
PEEK	High-purity (non-filler type) PEEK (JUVORA Dental Disc Invibio Biomaterial Solutions, Lancashire, UK)	NR	No additional polishing (NT), polishing using a Iber point (C), polishing using "silky shine" and a soft brush (S), polishing using "aqua blue paste" and a soft brush (A), protocol C followed by protocol S (CS), protocol C followed by protocol A (CA), protocol C followed by protocols S and A (CSA).	The PEEK polishing"chairside protocol produced clinically acceptable surface roughness, achieved using a brush and a mild polishing agent for more than 3 min [39].
	PEEK (PEEK-IOF) BioHPP inorganic ceramics and metal oxides	NR	Polished with 1000-grit SiC paper. A high-gloss finish was added using a 1 µm diamond paste applied with a cotton buff.	PEEK displayed the greatest change (increase) in contact angle values after air-polishing treatment. However, this effect could be prevented by veneering PEEK-IOF with DMA-nano components [40].

Table 2. *Cont.*

Polymers	Different Brands of Resin	Mechanical Polishing (MP) 	Chemical Manually Polishing (CP) 	Findings and Results µm
PEEK	1—PEEK bioHPP (bredent Gmbh & Co. Press mode); 2—autopolymerizing denture PMMA (uniling PF 20, bredent Gmbh & Co. KG). All specimens were prepolished with a fine pumice stone (ERNST HINRICHIS Dental GmbH) and goat-hair brushes (bredent GmbH & Co. KG, Weissenhorner Str. 2, 89250 Senden, Germany).	Four laboratory polishing methods. 1—ABR: Abrasive polishing paste (bredent GmbH & Co. KG); 2—OPA: Opal L polishing paste (Renfert GmbH); 3—CER: Ceragum silicone polisher (bredent GmbH & Co. KG); 4—DIA: Diagen-Turbo, Ginder (bredent GmbH & Co. KG).	Three chairside methods: 1—SUP: Super-snap, polishing discs (Shofu dental GmbH); 2—PRI: prisma gloss, polishing paste (Dentsply De trey GmbH); 3—ENH: enhance, polishing system (Dentsply De trey GmbH).	Chairside polishing methods resulted in lower SR than laboratory-based methods. Both the SUP and PRI protocols led to PEEK surfaces with lower SR than ENH [41].

HC, heat-cured; LC, light-cured; MP, mechanical polishing; CP, chemical polishing; PMMA, polymethylmethacrylate resin; MMA, methyl-methacrylate monomer; DMA, dimethyl-methacrylate; PA, polyamide; PEEK, polyetheretherketone; SEM, scanning electron microscopy; AC, auto-cured denture base acrylic resins; RHPL, Resilit High-luster Polishing Liquid; UPP, universal polishing paste; K50, Abraso-Star K50; SR, surface roughness; AD, AvaDent; BDS, Baltic Denture System; VV, Vita VIONIC; WN, Whole You Nexteeth; WDD, Wieland digital dentures; DPI, dental promotion and innovation; CAD/CAM, computer-aided design/computer-aided manufacturing. CAD/CAM-milled acrylic resins had lower Ra values than heat-cured PMMA. Mechanical polishing of PMMA was superior to chemical polishing. Polishing the PAs made it possible to obtain a roughness close to 0.2 µm. Chairside polishing of PEEK also made it possible to obtain clinically acceptable values.

Table 3. Frequency and protocol for cleaning various polymer denture bases.

Polymer	Frequency of Use of Denture Cleansers (DC) against *Candida* spp. Adhesion 	Denture Cleaning Treatment and Brushing Regimens (Night–Day) 	Ultrasonic Denture Hygiene 	Tablet Composition May Directly Affect *C. albicans* Biofilm 	Other Disinfectant Against Inhibition of *C. albicans* (Oil, GSE, Ozone Neem) 	Immersion of Denture in Chlorhexidine Digluconate (CHG) Sodium Hypochlorite (NaOCL) 
PMMA	The daily use of a DC overnight significantly reduced the total bacterial count [42–46].	The biofilm model on PMMA remained largely unaffected by brushing only [45]. Before overnight (8 h) storage conditions for limited colonization of *C. albicans* it is desirable to brush or use an alkaline peroxide-based tablet [47].	No statistically significant difference in total bacterial level between ultrasonic cleaning and brushing was found [44]. The adjunctive use of cetylpyridinium chloride with ultrasonic cleaning did not yield additional benefits [46].	Tow conventional heat-cured acrylic resins (1—QC-20 (Dentsply, Addlestone, UK), 2—Acron-hi^{TM} (Kemdent, Swindon, UK) and one polyamide (Deflex^{TM}) were tested with the following solutions: 1—Polident 3 min™, 2—Corega™, and 3—Fittydent™. Polident 3 min^{TM} and Corega^{TM} tablets should be used for all denture resin types, whereas Fittydent^{TM} should only be proposed for those who use Deflex™ [48]. HC PMMA resin (Vertex-DentalV., Zeist, the Netherlands) was subjected to a 4-week incubation with a daily change of 4 solutions (1—Clene® (Bitec global group, Japan), 2—Polident® (PTI Royston LLC, USA), 3—3% sodium bicarbonate (NaHCO3, Tianjin Lisheng Pharmaceutical Co. LTD, China), 4—phosphate-buffer Saline (PBS, Gi bco® Invitrogen™, Cambridge, MA, USA)). Clene®, and Polident® decreased fungal growth by approximately 98% and 100%, respectively [49].	Disc of 3D-printable resin (NextI Denture 3 D+, Soesterberg, The Netherlands) mixed with phytochemical-filled microcapsules and immersed in an effervescent tablet (Polident Quick, GSK Ireland) seemed to be a more effective inhibition of fungal cell growth compared with sterile tap water storage [50]. The treatment with 1% grapefruit seed extract (GSE) for 5 min almost eliminated the biofilm that formed on the resin [51]. Denture base PMMA (ACRON, GC, and Tokyo, Japan) immersed in ozone ultrafine bubble water (OUFBW) inhibited the early formation of *C. albicans* biofilms [52].	Specimens (acrylic resin Lucitone 550, Dentsply Ind. Com; Ltd.a., Petropolis, RJ, Brazil) were immersed for three cycles of 8 h in 2% CHG or 1% NaOCL. Residues of CHG were cytotoxic to gingival fibroblasts compare toIaOCL [53]. The in vitro effectiveness of five denture cleansers (Fittydent tablets, 2% CHG, 0.2% CHG, 0.5% and 1% NaOCL), was tested for microbial adhesion to the surface of base resins for conventional and CAD/CAM (milling and 3D printing) dentures: 1—conventional (Meliodent, Kulzer GmbH; Heraeus Kulzer Germany); 2—milling, Zintec CAD software (Wieland Digital Denture (Danbury, CT, USA)); and 3—3D-printed Denture I NextDent, Soesterberg, the Netherlands). The denture cleansers increased the roughness of all PMMAs. Concerning cleansers, the best result was obtained with 2% CHG and 0.5% and 1% NaOCL [54].

Table 3. *Cont.*

Polymer	**Frequency of Use of Denture Cleansers (DC) against *Candida* spp. Adhesion** 	**Denture Cleaning Treatment and Brushing Regimens (Night–Day)** 	**Ultrasonic Denture Hygiene** 	**Tablet Composition May Directly Affect *C. albicans* Biofilm** 	**Other Disinfectant Against Inhibition of *C. albicans* (Oil, GSE, Ozone Neem)** 	**Immersion of Denture in Chlorhexidine Digluconate (CHG) Sodium Hypochlorite (NaOCL)** 
PA	After 20 days immersed in Corega Protefix, and Valclean, the highest surface roughness was observed in the Valplast polyamide resin. No difference was observed in PMMA resins (Paladent) [55].	Among the three commonly used DCs with different pH (Valclean—acidic, Clinsodent—alkaline, and Polident—neutral), Valclean showed statistically significant greater stain removal efficiency than Polident or Clinsodent [56].	Valplast was found to have a significantly lower gloss and a higher roughness than Paladon 65 before cleansing. After cleansing (control; Val-Clean, peroxide cleanser; Corega Extradent, peroxide cleanser), the gloss of both materials decreased and only the roughness of Paladon 65 increased [57,58].	The tested cleanser tablets were more effective for PMMA resin than for thermoplastic polyamide resin [59]. For patients who have polyamide-based prosthesis, the use of citric acid-based cleansers may be more recommended than sodium perborate [59].	Compared with Curaprox (eucalyptus oil, Curaprox, UK, Huntingdon, UK) the effervescent tablets (Corega, Protefix, Perlodent) significantly altered the surface hardness and roughness of the polyamide (Deflex-Nuxen SRL, Buenos Aires, Argentina) [60].	Thermo-injected polyamide denture resin base colonized with *C. albicans* and disinfected with 0.12% chlorhexidine and Neem extract demonstrated the highest antimicrobial efficacy, with decreased surface roughness and no alteration in denture hardness [61].

Table 3. *Cont.*

Polymer	Frequency of Use of Denture Cleansers (DC) against *Candida* spp. Adhesion 	Denture Cleaning Treatment and Brushing Regimens (Night–Day) 	Ultrasonic Denture Hygiene 	Tablet Composition May Directly Affect *C. albicans* Biofilm 	Other Disinfectant Against Inhibition of *C. albicans* (Oil, GSE, Ozone Neem) 	Immersion of Denture in Chlorhexidine Digluconate (CHG) Sodium Hypochlorite (NaOCL) 
PEEK	Daily DC recommended	Individual prophylaxis can be conducted with toothbrushes. For professional prophylaxis, air-abrasion devices using gentle powders are effective. Laboratory protocols should include gentle cleaning methods like ultrasonic bath [41].	PEEK prophylaxis in laboratory protocol includes gentle cleaning methods like ultrasonic bath [41].	Four dentures (1—SR Triplex Hot heat-polymerized PMMA (Ivoclar Vivadent AG., Schaan, Leichenstein); 2—SR Triplex cold auto-polymerized PMMA (Ivoclar Vivadent AG., Schaan, Leichenstein); 3—Deflex Injection molded polyamide, Nuxen —L, Buenos Aires, Argentina); 4—unfilled PEEK CAD/CAM Juvora Dental Disc (Juvora, London, UK) were tested. Three denture cleansers (DCs) after immersion for 120 days in a chemical solution applied to PEEK and other denture base materials (DBMs) on long-term water sorption and solubility were compared: Corega tablet (CT), Protefix tablet (PT) (Queisser Pharma, Flensburg, Germany), and 1% sodium hypochlorite (NaOCl) solution (SH) (Aklar Kimya, Ankara, Turkey), as well as a control (distilled water, DW). The PEEK group showed lower mean solubility values in DC than the other DBM groups. Auto-polymerized and injection-molded polyamide showed higher solubility [62].	Higher numbers of *Strep. oralis* and *C. albicans* on PEEK specimens confirmed the impact of the higher surface roughness and contact angle values on the microbial adhesion and described PEEK as less desirable than CoCr from a microbiological perspective [63].	PEEK seemed to be more stable against discolorations than other denture resin materials. Regarding the cleaning potential, individual prophylaxis can be conducted with toothbrushes. For professional prophylaxis, air-abrasion devices using gentle powders are effective. Laboratory protocols should include gentle cleaning methods like ultrasonic bath. Regarding the cleaning potential, individual prophylaxis can be conducted with toothbrushes. For professional prophylaxis, air-abrasion devices using gentle powders are effective [41,42].

PBS, phosphate-buffer saline; DC, denture cleanser; DCI, denture cleanliness index; CoCr, cobalt chromium; CFU, colony-forming units; GSE, Grapefruit seed extract; P, polident; OUFBW, ozone ultrafine bubble water. Daily frequency protocol (DC with brushing) for cleaning denture is recommended for the three polymers. The cleaning tablets tested proved effective for all PMMA and PEEK resins, whereas for the same result, thermoplastic polyamide resin required specific tablets. On the other hand, self-polymerized and injection-molded polyamide showed higher solubility than PMMA. Concerning PEEK, the cleaning tablets were effective with low solubility. Generally speaking, denture cleansers increased the roughness of all PMMAs. Concerning liquid cleansers, the best result was obtained with 2% CHG for CAD/CAM PMMA and 0.5% and 1% NaOCL for all PMMAs. Regarding thermo-injected polyamide-based resins colonized by *C. albicans*, disinfection with 0.12% chlorhexidine demonstrated the highest antimicrobial level.

Table 4. Comparison of different relining prosthetic base polymers (PMMA, polyamide, and PEEK).

Polymers	Relining Materials	Findings
Unique relining materials	Two heat-cured acrylic dentures (PMMA)—Lang (Lang Dental MFG Co., Wheeling, IL, USA) and VIx RS (Vertex Dental, Zeist, the Netherlands)—were prepared in the dental laboratory. Six silicone relining chairside self-cured materials were used: 1—Mucopren soft, (Kettenbach, es chenburg, Germany); 2—Mucosoft (Parkell, NY, USA); 3—Mollosil® plus (Detax Ettlinghen, Germany); 4—Sofreliner Touch (Tokuyama, Tokyo, Japan),; 5—GC Reline™ Ultrasoft (GC Dental Products Co, Tokyo, Japan); 6—Silagum automix comfort (DMG, Hamburg, Germany). One self-curing (PEMA) chairside reline resin (Rebase II, Tokuyama, Tokyo, Japan) was used.	The contact angle increased for the materials in the following order: PMMA, PEMA, and silicone. The wettability of the denture relining except RebaseII and Mollosil® plus was increased after water storage (24 h). The HC PMMA denture base showed the highest wettability. It can be suggested that heat-cured PMMA resin should provide superior denture retention and patient comfort than self-cured PEMA and silicone denture relining material [64].
Conventional heat-polymerized PMMA **PMMA and PMMA MMA pretreatment**	Soft liner type (silicone-based or PMMA-based)	The highest bond strength was observed in samples with silicone-based soft liners regardless of pretreatment. Silicone-based liners underwent adhesive failures, whereas PMMA-based liners underwent cohesives failures. In vitro exposure to *C. albicans* biofilms reduced the adhesion of denture liners to PMMA resin, suggesting that MMA pretreatment is recommended for relining procedures [65].
CAD/CAM PMMA **Dimethacrylate-based additively manufactured** **PMMA-based conventionally fabricated denture-base resins**	The tensile force applied to different materials was tested: 1—Heat-cured laboratory-side soft reliner; 2—Self-cured chairside soft reliner; 3—Self-cured chairside hard reliner.	The highest tensile bond strength was found between the conventional base and the self-cured chairside hard reliner (but no significant results were found with the laboratory-side reliner) [66].
CAD/CAM PMMA **3D-printed denture base by SLA method using DENTCA Denture Base II (DENTCA Inc., Torrance, CA, USA)**	Six surface treatment were applied to chairside relining materials with Tokuyama Rebase II Normal (PEMA) (Tokuyama Dental Corp, Tokyo, Japan): 1—no surface treatment (control); 2—Tokuyama Rebase II Normal adhesive (A); 3—Rocatec pre–sandblasting (Al_2O_3-110 µm)) (P); 4—Rocatec Pre + Tokuyama rebase II Normal adhesive (PA); 5—Rocatec Pre + ESPE silane (PS); 6—Rocatec system (Rocatec Pre + Rocatec Plus (Silica Al_2O_3-110 µm) + ESPE Sil (PPS).	The best adhesive and cohesive strength was obtained with the Rocatec system applied to a 3D-printed denture [67].
CAD/CAM PMMA **Conventional HC PMMA (ProBase Hot, Ivoclar Vivadent, Schaan, Liechtenstein)** **Milled Ivobase (Ivo-Base CAD for Zenotec, Wieland Dental, Pforzheim, Germany)** **Milled Ivotion (Ivotion A2/Pink V Denture Disc, Ivoclar Vivadent, Schaan, Liechtenstein)** **3D-printed group (NextDent DentuID+, NextDent B.V., Soesterberg, the Netherlands)**	Conventional relining PMMA resin (ProBase Cold, Ivoclar Vivadent, Schaan, Liechtenstein) monomer of the reliner (ProBase Cold Monomer, Ivoclar Vivadent, Schaan, Liechtenstein)	The shear bond strength of relined 3D-printed resins for a complete denture was lower than relined resins employed for CAD/CAM milling and conventional HC. When considering 3D-printing for CRDP fabrication, it is advisable to use it in clinical situations where frequent denture relining is not anticipated [68].
POLYAMIDE **Thermoplastic polyamide resin (Biotone; BT), injection mold (High Dental, Osaka Japan)** **Conventional heat-polymerized PMMA (Paladent 20; PAL20. Heraeus Kulzer, Hanau, Germany).** **Thermoplastic acrylic resin (Acrytone; ACT) (High Dental, Osaka, Japan)**	Tow chairside relining resins: Tokuyama Rebase II; TR II. PEMA (autopolymerizing polyethyl methacrylate) (Tokuyama Dental corp. Tokyo, Japan); Mild Rebaron LC, MRL, a light-activated PEMA (GC, Tokyo, Japan).	Among the three denture base resins, polyamide resin exhibited lower bond strength. However, no significant difference was observed for thermoplastic polyamide resin [69].

Table 4. *Cont.*

Polymers	Relining Materials	Findings
POLYAMIDE/PMMA/CAD/CAM **One polyamide (Vertex Thermosens, the Netherlands)** **One conventional PMMA (Meliodent HC, Kulzer, Hanau, Germany)** **Three PMMAs, CAD/CAM denture base material/subtractive (Ivoclar Vivadent, Schaan Liechtenstein)** **Polident pink disc basic, subtractive (Volcja draga, Slovenia)** **Anaxdent pink blank (U. Anaxdent GmbH, Germany)** **Two PMMAs CAD/CAM denture base material/additive (Freeprint Denture, Imprimo, Germany)** **Imprimo LC Denture, Iserlhon, Germany**	Two soft denture liners: Soft denture liner, acrylate-based, direct relining method (GC Europe, Leuven, Belgium); Reline II soft, silicone-based, direct relining method (GC Europe, Leuven, Belgium).	Relining polyamide denture base materials showed lower values of tensile bond strength with silicone-based soft liner than HC PMMA and subtractive denture base materials. The basic Polident pink CAD/CAM disc showed the highest tensile bond strength value in combination with the silicone-based soft liner [70].
PEEK	Surface treatment of PEEK begins with sulfuric acid etching, which promotes the highest bond strength, followed by air abrasion of the alumina particles. Then, the use of specific adhesives containing MMA, PETIA (pentaerythritol triacrylate), and dimethacrylates is recommended [71].	Sulfuric acid and alumina-particle air abrasion were the most effective surface treatments for promoting adhesion to PEEK. For clinical use, air abrasion with alumina particles can be considered the preferred solution [71]. In vitro PEEK presented a mixed type of failure involving adhesion and cohesion [72].

CRDPs, complete removable dental prosthesis; PMMA, polymethylmethacrylate resin; PA, polyamide; PEEK, polyetheretherketone; SR, surface roughness; PBS, phosphate-buffered saline; SBS, shear bond strength; RMGI, resin-modified glass ionomer cement. The best relining was obtained with conventional thermoset PMMA and a CAD/CAM-milling block. A specific system is necessary to obtain adhesive and cohesive strength with a relining 3D-printed denture base. PAs have low adhesion strength. PEEK is still under investigation, requires specific preparation, and exhibited a mixed type of failure involving adhesion and cohesion.

Table 5. Synthesis of the results concerning polymers (PMMA, PA, PEEK) for denture microbial plaque formation, polishing, relining, and hygiene.

Polymers	**Microbial Adherence Treshold SFE: 40 mJ/m^2**	**Polishing Treshold RA: 0.2 µm**	**Antimicrobial Nanoparticules**	**Relining**	**Cytotoxicity**	**Hygiene**	**General Condition**
PMMA	Lower	Ra. Conventional injection-molded PMMA technique [16]. Sultana N et al. 2023 [16]: 0.06 ± 0.02 µm (SR Ivocap High Impact; Ivoclar Vivadent AG, Schaan, Liechtenstein) CAD/CAM acrylic resins demonstrated lower values of Ra compared to conventional PMMA [37].	The antifungal/antimicrobial effect of the material incorporated into the resin may have had a superior effect in preventing DS over simply coating the surface of the denture base [73].	The highest tensile bond strength was between the conventional base and the self-cured chairside hard reliner [66]. The shear bond strength of the relined 3D-printed resins for a complete denture was lower than the relined resins employed for CAD/CAM milling and conventional HC [68].	Lower level of cytotoxicity	PMMA is easy to maintain in the long term. CAD/CAM-milled prostheses are suggested in the presence of denture stomatitis due to reduced attachment of *Candida albican* [74].	Suitable for the majority of clinical indications, and small amounts of MMA for hypoallergenics patients
Polyamide	Higher	Clinicaly level > PMMA	Polyamide resin presented more viable cells of *Candida albicans*/PMMA [23].	Lower bond strengh	Toxicity profile	Difficult in the long term while respecting the manufacturer's constraints	Temporary removable prosthesis, Parkinson's disease, microstoma
PEEK	Intermediate	Chairside > laboratory method	Chitosan-based hybrid coatings on the PEEK surface contributed to the development of a biocompatible material (antibacterial, anti-inflammatory) [75].	Still under investigation	No evidence of cell damage caused by PEEK [76,77].	Efficacity decrease on the long term	Patients with low stress tolerance and sensitivity to metallic materials

Overall, PMMA presented advantages over PA and PEEK in most of the sections mentioned.

4. Discussion

A removable prosthesis residing in the oral cavity exposes the existing planktonic microbiota (bacteria, archaea, viruses, and eukaryotic organisms) to stress [78–80]. These conditions are favorable for the growth of DMP [81–83]. Quantitatively, this biofilm is defined as a community of more than 10^{11} microorganisms per gram of dry weight [84,85], attached to the extrados and intrados of the surface of the prosthesis and sur-rounded by an extracellular matrix (ECM) produced by the bacteria and *Candida* themselves [86,87]. This matrix, composed of macromolecules such as exopolysaccharides, proteins, and DNA [88], provides structural integrity to the biofilm and offers a physical barrier that may be impenetrable to drugs.

In contact between the soft tissues, living tissue and the inert polymer provide another favorable environment in the oral cavity for microbial colonization [89–91]. At the level of the intrados, this decreased space leads to a reduction in oxygenation, salivary flow, and pH, which promotes the activity of secreted aspartyl proteinases (SAPs) in the matrix. This environment plays a central role in the pathogenicity of *Candida* [92–94].

The maturation of the *C. albicans* biofilm proceeds according to the same steps but more slowly than the bacterial biofilm. The presence of hyphae and pseudohyphae is the main difference between the two biofilms. Recent targeted studies have explained the initial adhesion to the prosthetic surface, the subsequent development of mature biofilms [95], the formation of the extracellular matrix, and finally, the dispersal mechanism [96–98] (Figure 1).

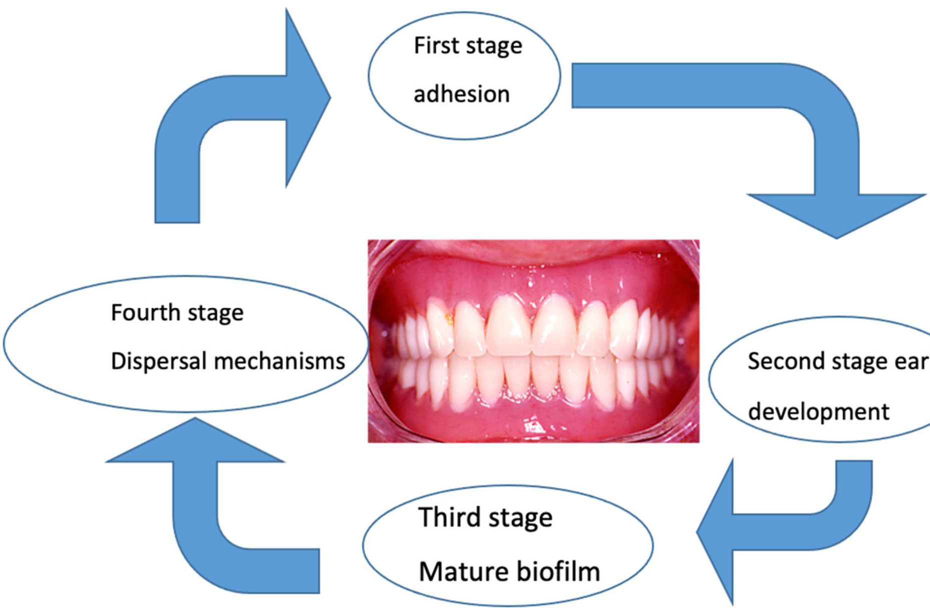


Figure 1. Biofilm envelops the denture in distinct stages. In the transition from the planktonic, free-floating state to the sessile state, attached microorganisms begin radically changing their gene and protein expression profiles.

Up to three quarters of patients who wear removable prostheses can develop an inflammation called "denture stomatitis" (DS). This pathology is characterized by an imbalance of the microbial flora or dysbiosis, resulting simultaneously in an abundance of opportunistic pathogens such as *C. albicans* [99,100], the differential proliferation of certain bacterial species determined using culture and next-generation sequencing (NGS) [101–109], and a decrease in microbial diversity [102–104].

Dental surgeons aware of the risk posed by this infectious condition to vulnerable patients should regularly check the oral health of users of removable prostheses [110]. For this, although DMP cannot be totally eradicated, it can be controlled through oral hygiene practices that include a daily regimen of brushing the mucous membrane and the denture, followed by rinsing with an antiseptic mouthwash [111–113]. Maintaining a healthy state helps to avoid the transition from a harmless commensal to a pathogen.

An oral hygiene regime adapted to the different polymers requires knowledge of the particularities of the materials used as well as the effects of their modifications (polishing and relining) on the oral microbiota [114]. The objective of this review is to provide an update of the specificities of the polymers (PMMA, PA, and PEEK) used in prosthetic bases to help facilitate the maintenance of a healthy oral environment.

Several current precautions and methods make it possible to limit the drift of the oral microbiota toward dysbiosis in wearers of removable prostheses.

4.1. Polymers in the Oral Environment

Once it is introduced in the mouth, a denture is rapidly coated by saliva and constitutes the ideal platform for dynamic microbial growth of DMP [115–117]. These biofilms represent a wide range of microorganisms, comprising all three domains of life. Their proximity to the denture polymer offers numerous possibilities for physical and chemical interactions between different species and kingdoms (Delaney, C.; 2019) [118]. On the other hand, the interaction between the prosthetic base and the biofilm on the surface of the oral mucosa can favor the release of potentially toxic substances from the polymer that in turn interact with the host tissues [119].

Biofilm development under an acrylic denture increases the risk of DS fivefold compared with a metallic denture [120]. Another drawback associated with poor denture hygiene is bad breath, which can be the cause of patient discomfort [121]. These bad odors are related to the microbial plaque of the denture [122]. Studies using new technologies (next-generation sequencing, NGS) in the field of bacterial identification highlighted the emergence of the phyla Firmicutes and Fusobacteria and the genera Leptotrichia, Atpobium, Megasphaera, Oribacterium, and Campylobacter as being associated with the bad smell of prostheses. Here, good oral hygiene is essential to combat bad odors [123].

In DS, lack of or ineffective brushing in the absence of a cleanser promotes the rapid growth of biofilm on the surface of prostheses [9,10]. Clinically, the selection of polymer used for the prosthetic base must consider the adhesion of microorganisms. This colonization promotes the penetration of the microbiota and reduces the fracture resistance of prostheses [124].

4.1.1. Polymer and Microbial Adhesion

A roughness (Ra) promotes adhesion and bacterio-fungal aggregation on acrylic resins [125]. However, some authors point out that the initial colonization does not differ in accordance with the range of dental materials [126,127]. In the same way, research has not highlighted a link between the roughness of the surface, the hydrophobicity/hydrophilicity of the acrylic resin, and the metabolic activity of adherent *C. albicans* cells [128]. Aggregation of *C. albicans* with other microorganisms and the influence of saliva, through its antimicrobial power, flow, and composition, seem to dominate the conditions of adhesion to the surface of a prosthesis (roughness and SFE) [129]. For other authors, *Candida* adhesion was strongly affected by Ra, saliva, and bacteria, but not by SFE [125]. Despite this discrepancy, the results suggest that a reduction in the *C. albicans* biofilm may be related to modifications of the surface of the PMMA thanks to the coating. The coating promotes hydrophilicity and in addition to the influence of roughness [130]. In addition, the DMP is subject to various mechanical constraints such as food tenacity, temperature fluctuations, chewing forces, and the load of the prosthetic device [104–131]. Microbial adhesion has been studied in relation to PMMA, in particular, and much less so in relation to PA and PEEK.

4.1.2. PMMA and Adhesion

PMMA is naturally hydrophobic [19] Gad MM, 2022, but this material, which is used in the composition of dentures, contains many carboxylate and methyl ester groups. This chemical composition, on the one hand, accounts for the hydrophilic nature of the dentures and, on the other hand, produces a large amount of SFE. In vitro, the adhesion of Pseudomonas fluorescens proved to be favorable to hydrophobic surfaces, with the lowest adhesion threshold for a roughness of 0.4 µm. Although the weakest adhesion of mammalian cells occurred at a roughness of 0.1 µm, the latter was favored in the presence of hydrophilic surfaces (PMMA) Choi SY, 2016 [132]. However, the variations in the chemical composition of the material used for the denture base partly explain the disparity in characteristics between the different brands of PMMA on the market Sipahi, 2001 [133]. Compared to the traditional fabrication method, acrylic resin injection offers a reduction in the surface roughness of the prosthesis base as well as decreased bacterial adhesion [21] Moslehifard E, 2022 (Table 1).

4.1.3. Polyamide and Adhesion

Analysis of the adhesion of microorganisms, in particular, yeasts, to PA remains very limited. Nevertheless, an experiment conducted on the effect of a prosthetic cleanser on the formation of a mycofilm on a PA resin (Flexite MP) and a polymethyl methacrylic resin (Acron MC) showed that *C. albicans* had a significantly higher growth rate on PA than on PMMA de Freitas Fernandes FS [134].

As a crystalline polymer, PA has better biocompatibility for patients who are allergic to acrylic resins. But over time, PA has significant disadvantages, displaying high water absorption, increased solubility, an overly rough surface, and bacterial contamination. In addition, this material remains difficult to polish and may result in color deterioration in the mouth Vojdani, 2015 [135]. Higher microbial adhesion was recently observed on injection-molded PA than PMMA (Table 1) [16] Sultana, 2023.

In order to remedy this, minimal changes in the injection manufacturing protocol of two PA prosthetic base materials were tested in vitro (Perflex Biosens (BS), Netanya, Israel and VertexTM ThermoSens (TS), Soesterberg, The Netherlands. By slightly modifying the melting temperature (5 °C) and pressure (0.5 bar), no improvement in the surface finish was observed for Biosens, whereas for ThermoSens, the surface roughness was significantly reduced Chuchulska, 2022 [136].

4.1.4. PEEK and Adhesion

As early as 2007, Kurtz et al. emphasized the non-allergenic properties of PEEK and its low affinity for dental plaque. PEEK is considered hydrophobic and has a low SFE. As a result, *C. albicans* adhesion is facilitated [27,137]. This was compared to the formation of biofilm on the surface of different materials in vitro (zirconia, titanium, PMMA, and PEEK). In their study, PEEK and PMMA yielded the same results but were linked to less biofilm formation than zirconia and titanium. However, the surface condition of PEEK was smoother than that of zirconia and titanium [138]. It has been reported that PEEK has good biocompatibility in vitro and in vivo, causing neither toxic nor mutagenic effects nor clinically significant inflammation. In addition, PEEK lends itself to sufficiently effective polishing so as to delay the fixing of microbial plaque [139]. PEEK without any additives is biologically inert and naturally hydrophobic when in contact with saliva. The 80°–90° contact angle of saliva can be reduced by adding plasma coatings, which are effective methods for modifying surface properties [140] to improve the hydrophilicity [138].

When comparing PEEK with other computer-aided design/computer-aided manufacturing (CAD/CAM) materials, PEEK samples are slightly rougher than PMMA samples. The reason is linked to the ceramic particles that are added to PEEK [25] (Table 1).

4.1.5. Polymer and Accumulation of DMP

After the adhesion of the first colonizers on the denture surface, to preventively limit the accumulation of microorganisms, and particularly of *Candida* and bacteria populations, several parameters can be modified to facilitate the optimization of the manufacture of polymers. The incorporation of antifungal agents into denture base resin may reduce the colonization of *C. albicans* [141]. There are few data on PAs and PEEKs, whereas PMMAs, in contrast, have been the subject of numerous experiments (Table 3).

For example, nanoparticles (such as fluoridated apatite-coated titanium dioxide, FAp-TiO_2) in PMMA facilitate the production of reactive oxygen species by promoting the photocatalytic effect after irradiation, which neutralizes the attachment of *C. albicans.* This effect is sought to facilitate the maintenance of removable prostheses in geriatric patients [142]. The incorporation of bioactive glass (BAG) in thermopolymerized or polymerized acrylic resins at room temperature significantly lowers the adhesion of *C. albicans*. For both types of polymerization, the hardness of acrylic resins is improved by adding BAG [140].

Another parameter can be modified to promote hydrophilicity to limit the adhesion of *C. albicans* on an acrylic resin denture with photopolymerized coating [143]: Plasma treatment of PMMA on the surface increases SFE, facilitates wettability, and lowers the contact angle, all of which reduce the adhesion of *C. albicans* [144,145]. In contrast, trimethylsilane coating increases hydrophobicity, reduces wettability of the denture base surface, and inhibits the adhesion of *C. albicans* [146]. The TiO2 coating creates a super-hydrophilic surface. It thus promotes wettability, which is essential for reducing *Candida* adhesion. The implementation of the PMMA surface coating involves only moderate costs while preserving the properties of the original material [147,148]. Recently, to assess the effectiveness and the antibacterial properties of a silver nanoparticle (NAg), a solution of NAg mixed with acrylic acid and methyl methacrylate (MMA) monomer was tested (in vitro and in vivo on animals) and compared with a PMMA solution without NAg. The results concerning the state of the prosthetic surface, the mechanical properties, the antimicrobial effect of NAg, the longevity, and the biological and toxic harmlessness of the NAg/PMMA prosthesis base were superior to the PMMA base without NAg. However, clinical confirmation must be provided by studies with humans [41–44,140,149–151].

4.1.6. Polishing to Limit Microbial Adhesion

The adhesion of early microbial colonizers is closely related to the finish of the denture surface. This adhesion during the initial phase of microbial colonization on flexible prostheses is similar to that of acrylic resin prostheses. This result was confirmed by a laboratory study showing that acrylic resin and PA resin are easily colonized by *Candida* species. However, the growth rate of this fungus is significantly higher on PA resin than on PMMA ($p < 0.001$) [152].

Different tests of the surface condition of the material (polishing) have shown that the polishing method alone (wood sandpaper: grit 180) is essential in terms of roughness compared with the drying method of self-curing acrylic resin. Moreover, chemical polishing (at 70 °C for 10 s) aggravates the roughness [74,153]. Regarding PMMA resin, the residual monomer acts on the SFE by reducing adhesion and *Candida* growth [134]. For PA resin (Breflex polyamide, Bredent, GmbH Co. KG, Senden, Germany) fabricated using the injection-molding technique, no significant correlation was observed in contact angles for mechanical polishing versus chemical polishing. This difference was related to the specific physical properties of the materials used [31].

The design and manufacture of CAD/CAM prostheses machined from blocks of polymerized PMMA under high temperature and high pressure led to a smoother surface finish than PMMA-HC based on CAD/CAM prostheses [154]. As a result, for patients at risk of *Candida* fungal infection, the surface properties of CAD/CAM PMMA represent a possibility of reduced adhesion of this fungus (Table 2).

Quezada (2022) [37] and Corsalini (2009) [33], using the same in vitro mechanized and manual polishing methods, attempted to standardize a polishing protocol. However, since contradictory results were reported, with one favoring the manual method and the other the mechanized method, new investigations have to be carried out.

An explanation for the contradictory results is offered by previous research. The structure of PMMA directly after polymerization had a low initial roughness, and subsequent polishing made it easy to reach clinically acceptable values. On the other hand, PAs were more difficult to polish due to their fibrous semi-flexible structure and low surface hardness [155]. Although PEEK and PMMA have similar values of Vickers hardness, the composition and the state of the surface roughness differed between the two materials [156]. Therefore, surface polishing that is specific to the two materials is required.

Thus, regarding the polishing of PEEK, Kurahashi et al. (2020) [39] suggest the use of a soft brush coupled with a cleaning agent for more than 3 min to achieve clinically acceptable surface roughness (Table 2).

Heimer et al. [41] compared the effects of laboratory and chairside polishing methods on the surface roughness of PEEK and reported that chairside polishing of PEEK yielded lower surface/laboratory roughness values (Table 2).

Fused deposition modeling of PEEK is one of the most practical additive techniques; compared to other polymers, PEEK remains stable over the long term regarding its wear and color [157,158]. The biocompatibility and biostability of PEEK are supported by the U.S. FDA drug and device master files [159]. Another way to limit the initial adhesion of microorganisms and particularly of *C. albicans* on the prosthetic surface is to use a coating.

4.1.7. Denture Base Surface Coating to Limit Adhesion

Among the types of coatings available, cold plasma under heat-polymerized acrylic resin prevents the early adherence of *C. albicans* [160]. Another goal for coating the polymer (PMMA) with creamers is to enhance the resistance of the denture base surface. Indeed, coating creamers (inorganic–organic hybrid polymeric) enhance the scratch resistance of PMMA denture resin (increasing the flexural strength (FS), flexural modulus (FM), and hardness) [161,162]. To date, in view of the diverse results of experiments, no consensus has been reached on this topic. To fight against the adhesion of *Candida*, the surface of the denture base must be smooth, hydrophilic, and without roughness. Further investigations are needed to better understand the correlation between factors affecting the hydrophobicity of the denture base and the adhesion of *C. albicans.*

4.1.8. Effects of Cleaning on Denture Materials (Table 3)

Currently, the use of a prosthesis cleanliness index makes it possible to assess the hygiene of prostheses by visualizing the quantity of stains on the intrados of the denture. Rinsing beforehand eliminates invisible microbial plaque. The scores, ranging from 0 (best) to 4 (worst), help to adapt the hygiene instructions for the wearers of dental prostheses [163].

The use of bleach-based cleansers, according to the recommended dosages (containing 1.5% or 2% *w*/*v* sodium hypochlorite and/or 1.7% *w*/*v* sodium hydroxide) and duration of use (at least 3 min daily), is associated with sufficient antimicrobial activity against *Streptococcus mutans* and *C. albicans*, without any changes to acrylic color, surface roughness, or mechanical properties [164,165]. However, in the long term, these cleansers corrode and tarnish metal prostheses. Effervescent cleansers have also proven their effectiveness, but they are not recommended in the presence of prosthesis relining materials.

Manual brushing with a toothbrush plus soap and water is the most common method for maintaining removable dentures (Milward P, 2013) [166]. Several adjuvants to increase the effectiveness of manual cleaning in the form of pastes, gels, foams, and powders are on the market [167].

The use of antiseptics to inhibit or eliminate microorganisms and immersion in a chemical solution for 8 h are recommended. Sodium hypochlorite, chlorhexidine diglconate, and alcohol can disinfect or reduce the dental plaque on acrylic resin dentures without being cytotoxic [110,112,113]. The different methods of cleaning dentures can influence the physical and aesthetic characteristics of the prosthesis materials. Also, in order to ensure the clinical durability of removable prostheses, patients and clinicians should be aware of the manufacturer's instructions for use [168].

Although there is no consensus regarding how to best maintain prosthetic hygiene compatible with the patient's state of health [61], the disadvantages of many procedures have been thoroughly evidenced [169].

Hydrogen peroxide-based disinfectants should not be used regularly, as they cause surface roughness of the PMMA. NaOCl is less aggressive and generates slight alterations on the surface of the prosthetic base [170]. In addition, sodium hypochlorite was found to be non-cytotoxic after six months of use [171].

Flexural strength is reduced by immersion cleaning of removable PMMA prostheses modified with nano-ZrO_2. Thus, a significant decrease in this resistance after immersion in different denture cleansers was reported, which was strong for sodium hypochlorite, intermediate for Corega, and low for Renew [170,172,173]. Several habits should be avoided, such as rinsing with boiling water and prolonged maintenance in a dry atmosphere or water, because these alter the qualities of PMMA and promote microbial colonization. Both bleach and isopropyl alcohol (IPA) are highly antimicrobial, but bleach is incompatible with components of metal dental prostheses and IPA mouthwashes damage PMMA [174].

Concerning denture cleaning tablets, the polarity of the resins, the concentrations of the tablets, and the chemical content of the cleanser may directly affect the formation of *C. albicans* biofilm [68]. Thus, the dosage and prescription of disinfecting tablets can vary depending on the resin used to make the prosthetic base. In tablet form, Polident® has been proven to be effective as a denture cleanser. But after 30 days of immersion in a solution based on Polident®, the heat-polymerized acrylic resin may undergo alterations to its physical and mechanical properties. This may be related to the accelerated aging of resins caused by chemicals found in denture cleansers [175].

The mechanical properties of PEEK do not change during the sterilization process. An in vitro study showed that the solubility of PEEK in physiological saliva and distilled water is lower than that of PMMA [156]. In the study by Demirci under the same conditions, the solubility values of PEEK in distilled water were found to be similar to those of PMMA (HP: Ivoclar Vivadent AG., Schaan, Liechtenstein). In the presence of a cleanser (Corega tablet, Protefix tablet (PT), 1% sodium hypochlorite (NaOCl)), the solubility values of PEEK were found to be lower than those of PMMA. In this study, higher water sorption and solubility values were observed than those obtained by Lieberman [156]. The explanation proposed mentions the consequences of the effects of cleansers on PEEK and PMMA surfaces for 120 days. Thus, for these authors, the water sorption and solubility values of PEEK can be attributed to the molecular imbalance occurring on the surface of the PEEK [62].

The use of microwave disinfection in combination with denture cleansers and brushing has also been shown to effectively disinfect dentures, although microwaves may also physically distort denture resin [176]. The personalized implementation of the currently available means for disinfection is informed by the general condition of the patient, the material composition of the prosthetic base, and the presence or absence of DS.

4.2. Denture Base Relining (Table 4)

After some time (following bone resorption), it is necessary to reline the intrados in order to improve the stability, support, and retention of removable dentures. There are several commonly used relining materials, such as cold or hot polymerization, polymerization in visible light, and acrylic resins polymerized in microwaves [177,178].

At the interface between the reliner and the prosthetic base, the bond strength depends on the chemical composition of the two materials that come into contact with each other [179]. The bonding strength can be improved by treating the two surfaces that are in contact with each other [179–182]. The parameter characteristic of relining is the shear bond strength (SBS). This parameter is better for relining using thermosetting resin as well as both CAD/CAM and conventional thermosetting denture resin compared to self-curing relining resin [183,184]. An in vitro study showed that reliners with thermopolymerizable acrylic resins had an increased SBS compared to reliners with self-curing acrylic resins. This also applied to bases of conventional dental prostheses and CAD/CAM but without a significant difference. However, there was a significant difference between autopolymerizing acrylic resin bond strength with CAD/CAM and conventional denture bases.

Autopolymerizing reliner material seems to produce a stronger bond with CAD/CAM denture bases. It has been pointed out that self-curing relining material appears to produce a significantly stronger bond with a CAD/CAM denture base compared to a conventional resin base [184]. Recently, various in vitro tests of the adhesion of composite materials on thermosetting resins, on CAD/CAM, and on printed groups yielded the following results: In order of the best performance regarding the adhesion of high-viscosity/low-viscosity composites (SR Nexco, high viscosity (SR); and Kulzer Creactive, low viscosity (K)), the thermosetting resin group was first, followed by the CAD/CAM group, and finally the 3D-printed groups. However, the differences noted between these groups were not significant [185].

To assess the maintenance of rebased resin bases, five disinfectant solutions were tested: sodium hypochlorite, sodium perborate, chlorhexidine gluconate, apple vinegar, and distilled water. A prosthesis base (Vipi Wave) rebased with an acrylic resin (Tokuya-ma Rebase Fast II) after dipping showed alterations in its roughness regardless of the solution used [173,186]. Kim et al. tested relining using two hard resins, one of the self-hardening type (Tokuyama rebase II) and the other of the light-activated type (Mild Rebaron LC). They carried out these two relinings on a thermoplastic polyamide resin (Biotone; BT), on a classic thermopolymerizable acrylic resin (Paladent 20; PAL20), and, finally, on a thermoplastic acrylic resin (Acrytone; ACT). The results showed that the thermoplastic polyamide resin (Biotone) had the lowest adhesion strength of the three materials tested [69].

More recently, Vuksic Josip et al. (2023) [70] tested relining (with a soft denture liner and a silicone-based, direct relining method) on several resins: (1) Meliodent heat cure (Kulzer, Hanau, Germany), denture base material, PMMA, heat-cured; (2) Vertex Thermosens (Vetex Dental, Soesterberg, The Netherlands), denture base material, PA, technical injection; (3) three CAD/CAM subtractive materials; and (4) two CAD/CAM additive materials. With the same reliner (GC Reline II Soft), the bond strength of the PA (Vertex) and both additive manufactured denture bases was significantly lower than that of the three materials used for subtractive denture fabrication and heat-cured PMMA (Table 4). However, the authors expressed their reservations because, to date, there are only a few studies available, mainly on flexible rebasing. The tests differ between these studies, and different materials were used as controls (PMMA from different manufacturers).

The bioinert nature of PEEK can make adhesive bonding difficult. The SBS of PEEK can be increased by roughening the material or by embedding molecules on the surface through sandblasting, acid treatment, laser, or adhesive systems.

SBS values greater than 10 MPa between PEEK and resin-based composites have been reported to be clinically acceptable. However, the hydrophobic surface and low SFE of PEEK make it difficult to establish a strong and long-lasting bond. Therefore, PEEK material surface treatments and adhesive systems with resin are hot research topics focused on the application of PEEK in the restorative field. Modalities concerning the effectiveness of bonding to the surface of PEEK are not yet sufficiently developed for routine use.

4.3. General Conditions and Dentures

Whichever material is chosen, after adhesion, inadequate oral hygiene facilitates the accumulation of biofilm, colonizing the surface of the prosthesis. This biofilm can constitute a risk factor for infection, especially for patients who are older or who are immunocompromised and/or have endocrine deficiency [187]. For these patients, special vigilance is necessary regarding prosthetic oral hygiene in order to avoid infectious complications.

Indeed, this additional microbial load can lead to an imbalance between bacterial species, bacteriophages, and fungi, thus promoting the resistance and virulence of mycofilms to the detriment of the host. The secretions of bacteria and fungi, by participating in the aggression of biotic surfaces (mucous membranes and teeth), promote the production of various inflammatory mediators such as cytokines [188]. The use of removable prostheses in these conditions after a certain period of time promotes bone resorption.

Some older denture wearers have medical conditions such as arthritis and dementia that can impair their ability to carry out oral hygiene procedures effectively, thus requiring assistance from caretakers and some education [189]. Specific treatments are available if a *Candida* infection is suspected [190], with accompanying denture disinfection/cleaning or replacement [8]. Other conditions such as Parkinson's disease can lead to dentures falling out of patients' hands because of trembling. In these cases, thanks to its flexibility, the PA prosthesis makes it possible to overcome small bone and mucous undercuts. Crossing this undercut promotes retention. The prosthetic base made of PA, due to its high resilience and impact resistance, is less prone to fractures than PMMA [191].

For patients who are hypoallergenic to prosthetic materials, different alternatives exist. Whether PMMA, PEEK, or PA, the polymerization reaction releases more or fewer toxic molecules. By dissolving in the saliva, these molecules can diffuse away from the mouth [192,193]. These are essentially, after the polymerization, the residual monomers (MMA, methyl methacrylate; BuMA, butyl methacrylate; EMA, ethyl methacrylate; EGDMA, ethylene glycol dimethacrylate) that are responsible for the toxic and allergenic effects of acrylates [194].

This residual monomer depends both on the method of polymerization (duration, cold or heat) and on the volume of the prosthetic base; it only becomes stable after 2 weeks of wearing the dentures. It is low for thermopolymerized resins and at the palatal level of the thin prosthetic base [8].

Moreover, the acidic environment and the temperature of the oral cavity promote the release of substances contained in resins such as formaldehydes, benzoyl peroxides, benzoic acid, hydroquinone, and phthalates, as well as cobalt, nickel, and beryllium. With respect to the mucous membrane, these products can cause type IV allergic reactions, or an intolerance can appear in the long term [195].

As a remedy, so-called hypoallergenic resins for dental prostheses have appeared on the market. To be suitable for hypoallergenic patients, the denture base resins should contain only a very small amount of MMA [196].

MMA can be replaced by diurethane dimethacrylate, polyurethane, polyethylene terephthalate, polyethylene terephthalate, or polybutylene terephthalate. However, only two of these have similar mechanical characteristics to PMMA resin standards: Polyan Plus® and TMS Acetal Dental [195].

The in vitro comparison between PMMA and PA regarding cytotoxicity has not revealed any obvious differences. Findings remain disparate about the materials studied and the protocols used. The results vary depending on the duration of the experiments and on the different parameters analyzed, such as temperature and surface condition supplement II. For patients with low stress tolerance and sensitivity to metallic materials, PEEK is indicated for partial removable prostheses. PA bases are also an alternative for patients who are allergic to other denture base materials and for patients with microstomia [26].

5. Conclusions

Regarding the choice between different polymers and in view of the complexity of DMP, we still lack sufficient knowledge about the characteristics of denture biofilms. Thus, the tolerance of DMP to existing antifungal drugs, its ability to evade components of the host's immune system, and its resistance to the mechanical forces underlying the prosthesis make it a central subject of studies.

To summarize, Table 5 highlights the pertinent points that facilitate the differentiation between indications for PMMA, PA, and PEEK concerning DMP formation.

1. To limit the adhesion and accumulation of prosthetic microbial plaque, removable prostheses milled from a PMMA block best meet this requirement. Those made from PA are less efficient in terms of the colonization of microorganisms. As for PEEK, the long-term anti-adhesion properties seem to gradually diminish.
2. Regarding the polishing and maintenance of removable prostheses, PMMA is also more efficient than PA and PEEK.

3. Relined PMMA bases, both via thermosetting and machining, are easy to implement and effective.

This calls for the establishment of an effective strategic plan in the fight against persistent oral–prosthetic microbial infections that are likely to spread remotely via saliva or the bloodstream, such as DS.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/polym16010040/s1, Table S1: In vitro coating or addition of antimicrobial components in PMMA.; Table S2: Cytotoxicity and biocompatibility of PMMA and polyamide. References [142,197–213] are cited in the supplementary materials.

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References

1. Jorge, J.H.; Giampaolo, E.T.; Vergani, C.E.; Machado, A.L.; Pavarina, A.C.; Carlos, I.Z. Biocompatibility of denture base acrylic resins evaluated in culture of l929 cells. effect of polymerisation cycle and post-polymerisation treatments. *Gerodontology* **2007**, *24*, 52–57. [CrossRef] [PubMed]
2. Sehajpal, S.B.; Sood, V.K. Effect of metal fillers on some physical properties of acrylic resin. *J. Prosthet. Dent.* **1989**, *61*, 746–751. [CrossRef] [PubMed]
3. Urban, V.M.; Machado, A.L.; Oliveira, R.V.; Vergani, C.E.; Pavarina, A.C.; Cass, Q.B. Residual monomer of reline acrylic resins: Effect of water-bath and microwave post-polymerization treatments. *Dent. Mater.* **2007**, *23*, 363–368. [CrossRef] [PubMed]
4. Ayman, A.-D. The residual monomer content and mechanical properties of CADnCAM resins used in the fabrication of complete dentures as compared to heat cured resins. *Electron. Physician* **2017**, *9*, 4766–4772. [CrossRef]
5. Anadioti, E.; Musharbash, L.; Blatz, M.B.; Papavasiliou, G.; Kamposiora, P. 3D printed complete removable dental prostheses: A narrative review. *BMC Oral Health* **2020**, *20*, 343. [CrossRef]
6. Dimitrova, M.; Corsalini, M.; Kazakova, R.; Vlahova, A.; Chuchulska, B.; Barile, G.; Capodiferro, S.; Kazakov, S. Comparison between Conventional PMMA and 3D Printed Resins for Denture Bases: A Narrative Review. *J. Compos. Sci.* **2022**, *6*, 87. [CrossRef]
7. Patil, S.; Licari, F.W.; Bhandi, S.; Awan, K.H.; Badnjević, A.; Belli, V.; Cervino, G.; Minervini, G. The cytotoxic effect of thermoplastic denture base resins: A systematic review. *J. Funct. Biomater.* **2023**, *14*, 411. [CrossRef]
8. Chladek, G.; Nowak, M.; Pakieła, W.; Mertas, A. Effect of Candida Albicans Suspension on the Mechanical Properties of Denture Base Acrylic Resin. *Materials* **2022**, *15*, 3841. [CrossRef]
9. Rüttermann, S.; Trellenkamp, T.; Bergmann, N.; Raab, W.H.R.; Ritter, H.; Janda, R. A new approach to influence contact angle and surface free energy of resin-based dental restorative materials. *Acta Biomater.* **2011**, *7*, 1160–1165. [CrossRef]
10. Liber-Knéc, A.; Łagan, S. Surface Testing of Dental Biomaterial Determination of Contact Angle and Surface Free Energy. *Materials* **2021**, *14*, 2716. [CrossRef]
11. Al-Dwairi, Z.N.; Tahboub, K.Y.; Baba, N.Z.; Goodacre, C.J.; Özcan, M. A Comparison of the Surface Properties of CAD/CAM and Conventional Polymethylmethacrylate (PMMA). *J. Prosthodont.* **2019**, *28*, 452–457. [CrossRef] [PubMed]
12. Benli, M.; Eker Gümüş, B.; Kahraman, Y.; Gökçen-Rohlig, B.; Evlioğlu, G.; Huck, O.; Özcan, M. Surface roughness and wear behavior of occlusal splint materials made of contemporary and high-performance polymers. *Odontology* **2020**, *108*, 240–250. [CrossRef] [PubMed]
13. Radford, D.R.; Sweet, S.P.; Challacombe, S.J.; Walter, J.D. Adherence of candida albicans to denture base materials with different surface finishes. *J. Dent.* **1998**, *26*, 577–583. [CrossRef] [PubMed]
14. Steinmassl, O.; Dumfahrt, H.; Grunert, I.; Steinmassl, P.A. Influence of cad/cam fabrication on denture surface properties. *J. Oral Rehabil.* **2018**, *45*, 406–413. [CrossRef] [PubMed]
15. Schubert, A.; Bürgers, R.; Baum, F.; Kurbad, O.; Wassmann, T. Influence of the Manufacturing Method on the Adhesion of *Candida albicans* and *Streptococcus mutans* to Oral Splint Resins. *Polymers* **2021**, *13*, 1534. [CrossRef] [PubMed]
16. Sultana, N.; Ahmed, S.; Nandini, V.V.; Lathief, J.; Boruah, S. An in vitro comparison of microbial adhesion on three different denture base materials and its relation to surface roughness. *Cureus* **2023**, *15*, e37085. [CrossRef] [PubMed]
17. Abuzar, M.A.; Bellur, S.; Duong, N.; Kim, B.B.; Lu, P.; Palfreyman, N.; Surendran, D.; Tran, V.T. Evaluating surface roughness of a polyamide denture base material in comparison with poly(methyl methacrylate). *J. Oral Sci.* **2010**, *52*, 577–581. [CrossRef]
18. Cabanillas, B.; Mallma-Medina, A.; Petkova-Gueorguieva, M.; Alvitez-Temoche, D.; Mendoza, R.; Mayta-Tovalino, F. Influence of the surface energy of different brands of polymethyl methacrylate on the adherence of candida albicans: An In Vitro Study. *J. Int. Soc. Prev. Community Dent.* **2021**, *11*, 6–12.

19. Gad, M.M.; Abualsaud, R.; Khan, S.Q. Hydrophobicity of denture base resins: A systematic review and meta-analysis. *J. Int. Soc. Prev. Community Dent.* **2022**, *12*, 139–159. [CrossRef]
20. Osman, R.B.; Khoder, G.; Fayed, B.; Kedia, R.A.; Elkareimi, Y.; Alharbi, N. Influence of Fabrication Technique on Adhesion and Biofilm Formation of Candida albicans to Conventional, Milled, and 3D-Printed Denture Base Resin Materials: A Comparative In Vitro Study. *Polymers* **2023**, *15*, 1836. [CrossRef]
21. Moslehifard, E.; Ghaffari, T.; Abolghasemi, H.; Maleki Dizaj, S. Comparison of conventional pressure-packed and injection molding processing methods for an acrylic resin denture based on microhardness, surface roughness, and water sorption. *Int. J. Dent.* **2022**, *2022*, 7069507. [CrossRef] [PubMed]
22. Takabayashi, Y. Characteristics of denture thermoplastic resins for non-metal clasp dentures. *Dent. Mater. J.* **2010**, *29*, 353–361. [CrossRef] [PubMed]
23. de Freitas-Fernandes, F.S.; Cavalcanti, Y.W.; Ricomini, A.P.F.; Silva, W.J.; Cury, A.A.D.B.; Bertolini, M.M. Effect of daily use of an enzymatic denture cleanser on candida albicans biofilms formed on polyamide and poly(methyl methacrylate) resins: An in vitro study. *J. Prosthet. Dent.* **2014**, *112*, 1349–1355. [CrossRef] [PubMed]
24. Batak, B.; Çakmak, G.; Johnston, W.M.; Yilmaz, B. Surface roughness of high-performance polymers used for fixed implant-supported prostheses. *J. Prosthet. Dent.* **2021**, *126*, 254.e1–254.e6.
25. Vulović, S.; Todorović, A.; Stančić, I.; Popovac, A.; Stašić, J.N.; Vencl, A.; Milić-Lemić, A. Study on the surface properties of different commercially available cad/cam materials for implant-supported restorations. *J. Esthet. Restor. Dent.* **2022**, *34*, 1132–1141. [CrossRef] [PubMed]
26. Hirasawa, M.; Tsutsumi-Arai, C.; Takakusaki, K.; Oya, T.; Fueki, K.; Wakabayashi, N. Superhydrophilic co-polymer coatings on denture surfaces reduce candida albicans adhesion—An in vitro study. *Arch. Oral Biol.* **2018**, *87*, 143–150. [CrossRef] [PubMed]
27. da Rocha, L.G.D.O.; Ribeiro, V.S.T.; de Andrade, A.P.; Gonçalves, G.A.; Kraft, L.; Cieslinski, J.; Suss, P.H.; Tuon, F.F. Evaluation of staphylococcus aureus and candida albicans biofilms adherence to peek and titanium-alloy prosthetic spine devices. *Eur. J. Orthop. Surg. Traumatol.* **2022**, *32*, 981–989. [CrossRef]
28. D'Ercole, S.; Cellini, L.; Pilato, S.; Di Lodovico, S.; Iezzi, G.; Piattelli, A.; Petrini, M. Material characterization and *Streptococcus oralis* adhesion on polyetheretherketone (peek) and titanium surfaces used in implantology. *J. Mater. Sci. Mater. Med.* **2020**, *31*, 84. [CrossRef]
29. Ichikawa, T.; Kurahashi, K.; Liu, L.; Matsuda, T.; Ishida, Y. Use of a polyetheretherketone clasp retainer for removable partial denture: A case report. *Dent. J.* **2019**, *7*, 4. [CrossRef]
30. Barkarmo, S.; Longhorn, D.; Leer, K.; Johansson, C.B.; Stenport, V.; Franco-Tabares, S.; Kuehne, S.A.; Sammons, R. Biofilm formation on polyetheretherketone and titanium surfaces. *Clin. Exp. Dent. Res.* **2019**, *5*, 427–437. [CrossRef]
31. Alammari, M.R. The influence of polishing techniques on pre-polymerized cad/cam acrylic resin denture bases. *Electron. Physician* **2017**, *9*, 5452–5458. [CrossRef] [PubMed]
32. *ISO 20795-1:2008*; Dentistry—Part 1: Denture Base Polymers. International Organization for Standardization: Geneva, Switzerland, 2008.
33. Corsalini, M.; Boccaccio, A.; Lamberti, L.; Pappalettere, C.; Catapano, S.; Carossa, S. Analysis of the performance of a standardized method for the polishing of methacrylic resins. *Open Dent. J.* **2009**, *3*, 233–240. [CrossRef] [PubMed]
34. Al-Rifaiy, M.Q. The effect of mechanical and chemical polishing techniques on the surface roughness of denture base acrylic resins. *Saudi Dent. J.* **2010**, *22*, 13–17. [CrossRef] [PubMed]
35. Al-Kheraif, A.A. The effect of mechanical and chemical polishing techniques on the surface roughness of heat-polymerized and visible light-polymerized acrylic denture base resins. *Saudi Dent. J.* **2014**, *26*, 56–62. [CrossRef] [PubMed]
36. Rao, D.C.; Kalavathy, N.; Mohammad, H.S.; Hariprasad, A.; Kumar, C.R. Evaluation of the surface roughness of three heat-cured acrylic denture base resins with different conventional lathe polishing techniques: A comparative study. *J. Indian. Prosthodont. Soc.* **2015**, *15*, 374–380. [CrossRef] [PubMed]
37. Quezada, M.M.; Salgado, H.; Correia, A.; Fernandes, C.; Fonseca, P. Investigation of the effect of the same polishing protocol on the surface roughness of denture base acrylic resins. *Biomedicines* **2022**, *10*, 1971. [CrossRef] [PubMed]
38. Wieckiewicz, M.; Opitz, V.; Richter, G.; Boening, K.W. Physical properties of polyamide-12 versus pmma denture base material. *Biomed Res. Int.* **2014**, *2014*, 150298. [CrossRef] [PubMed]
39. Kurahashi, K.; Matsuda, T.; Ishida, Y.; Ichikawa, T. Effect of polishing protocols on the surface roughness of polyetheretherketone. *J. Oral Sci.* **2020**, *62*, 40–42. [CrossRef]
40. Sturz, C.R.; Faber, F.J.; Scheer, M.; Rothamel, D.; Neugebauer, J. Effects of various chair-side surface treatment methods on dental restorative materials with respect to contact angles and surface roughness. *Dent. Mater. J.* **2015**, *34*, 796–813. [CrossRef]
41. Heimer, S.; Schmidlin, P.R.; Roos, M.; Stawarczyk, B. Surface properties of polyetheretherketone after different laboratory and chairside polishing protocols. *J. Prosthet. Dent.* **2017**, *117*, 419–425. [CrossRef]
42. Heimer, S.; Schmidlin, P.R.; Stawarczyk, B. Discoloration of pmma, composite, and peek. *Clin. Oral Investig.* **2017**, *21*, 1191–1200. [CrossRef] [PubMed]
43. Nishi, Y.; Seto, K.; Murakami, M.; Harada, K.; Ishii, M.; Kamashita, Y.; Kawamoto, S.; Hamano, T.; Yoshimura, T.; Kurono, A.; et al. Effects of denture cleaning regimens on the quantity of *Candida* on dentures: A cross-sectional survey on nursing home residents. *Int. J. Environ. Res. Public. Health.* **2022**, *19*, 15805. [CrossRef] [PubMed]

44. Duyck, J.; Vandamme, K.; Krausch-Hofmann, S.; Boon, L.; De Keersmaecker, K.; Jalon, E.; Teughels, W. Impact of denture cleaning method and overnight storage condition on denture biofilm mass and composition: A cross-over randomized clinical trial. *PLoS ONE* **2016**, *11*, e0145837. [CrossRef] [PubMed]
45. Brown, J.L.; Young, T.; McKloud, E.; Butcher, M.C.; Bradshaw, D.; Pratten, J.R.; Ramage, G. An in vitro evaluation of denture cleansing regimens against a polymicrobial denture biofilm model. *Antibiotics* **2022**, *11*, 113. [CrossRef] [PubMed]
46. Chan, R.; Zhang, J.; McGrath, C.; Tsang, P.; Lam, O. A randomized trial of the effectiveness of an ultrasonic denture hygiene intervention program among community dwelling elders. *Eur. Oral Res.* **2023**, *57*, 83–89. [CrossRef] [PubMed]
47. Verhaeghe, T.V.; Wyatt, C.C.; Mostafa, N.Z. The effect of overnight storage conditions on complete denture colonization by *Candida albicans* and dimensional stability: A systematic review. *J. Prosthet. Dent.* **2020**, *124*, 176–182. [CrossRef] [PubMed]
48. Hayran, Y.; Sarikaya, I.; Aydin, A.; Tekin, Y.H. Determination of the effective anticandidal concentration of denture cleanser tablets on some denture base resins. *J. Appl. Oral Sci.* **2018**, *26*, e20170077. [CrossRef] [PubMed]
49. Han, Y.; Liu, X.; Cai, Y. Effects of two peroxide enzymatic denture cleaners on *Candida albicans* biofilms and denture surface. *BMC Oral Health* **2020**, *20*, 193. [CrossRef]
50. Jo, Y.H.; Lee, W.J.; Yoon, H.I. Feasibility of microencapsulated phytochemical as disinfectant for inhibition of *Candida albicans* proliferation on denture base produced by digital light processing. *PLoS ONE* **2023**, *18*, e0287867. [CrossRef]
51. Tsutsumi-Arai, C.; Takakusaki, K.; Arai, Y.; Terada-Ito, C.; Takebe, Y.; Imamura, T.; Ide, S.; Tatehara, S.; Tokuyama-Toda, R.; Wakabayashi, N.; et al. Grapefruit seed extract effectively inhibits the *Candida albicans* biofilms development on polymethyl methacrylate denture-base resin. *PLoS ONE* **2019**, *14*, e0217496. [CrossRef]
52. Shichiri-Negoro, Y.; Tsutsumi-Arai, C.; Arai, Y.; Satomura, K.; Arakawa, S.; Wakabayashi, N. Ozone ultrafine bubble water inhibits the early formation of *Candida albicans* biofilms. *PLoS ONE* **2021**, *16*, e0261180. [CrossRef] [PubMed]
53. Procopio, A.L.F.; da Silva, R.A.; Maciel, J.G.; Sugio, C.Y.C.; Soares, S.; Urban, V.M. Antimicrobial and cytotoxic effects of denture base acrylic resin impregnated with cleaning agents after long-term immersion. *Toxicol. Vitr.* **2018**, *52*, 8–13. [CrossRef] [PubMed]
54. Alfouzan, A.F.; Tuwaym, M.; Aldaghri, E.N.; Alojaymi, T.; Alotiabi, H.M.; Taweel, S.M.A.; Al-Otaibi, H.N.; Ali, R.; Alshehri, H.; Labban, N. Efficacy of denture cleansers on microbial adherence and surface topography of conventional and cad/cam-processed denture base resins. *Polymers* **2023**, *15*, 460. [CrossRef] [PubMed]
55. Durkan, R.; Ayaz, E.A.; Bagis, B.; Gurbuz, A.; Ozturk, N.; Korkmaz, F.M. Comparative effects of denture cleansers on physical properties of polyamide and polymethyl methacrylate base polymers. *Dent. Mater. J.* **2013**, *32*, 367–375. [CrossRef] [PubMed]
56. Richa, G.; Reddy, K.M.; Shastry, Y.M.; Aditya, S.V.; Babu, P.J.K. Effectiveness of denture cleansers on flexible denture base resins in the removal of stains colored by food colorant solution: An in vitro study. *J. Indian. Prosthodont. Soc.* **2022**, *22*, 288–293. [CrossRef] [PubMed]
57. Polychronakis, N.C.; Polyzois, G.L.; Lagouvardos, P.E.; Papadopoulos, T.D. Effects of cleansing methods on 3-D surface roughness, gloss, and color of a polyamide denture base material. *Acta Odontol. Scand.* **2015**, *73*, 353–363. [CrossRef] [PubMed]
58. Polychronakis, N.; Polyzois, G.; Lagouvardos, P.; Andreopoulos, A.; Ngo, H.C. Long-term microwaving of denture base materials: Effects on dimensional, color, and translucency stability. *J. Appl. Oral Sci.* **2018**, *26*, e20170587. [CrossRef]
59. Ozyilmaz, O.Y.; Kara, O.; Akin, C. Evaluation of various denture cleansers on color stability and surface topography of polyetherketoneketone, polyamide, and polymethylmethacrylate. *Microsc. Res. Tech.* **2021**, *84*, 3–11. [CrossRef]
60. Ozyilmaz, O.Y.; Akin, C. Effect of cleansers on denture base resins' structural properties. *J. Appl. Biomater. Funct. Mater.* **2019**, *17*, 2280800019827797. [CrossRef]
61. Tulbah, H.I. Anticandidal efficacy on polymide based denture resin using Photodynamic therapy, chemical and herbal disinfectants and their effect on surface roughness and hardness. *Photodiagn. Photodyn. Ther.* **2022**, *39*, 102874. [CrossRef]
62. Demirci, F.; Tanik, A. Comparison of the effect of denture cleansers on long-term water sorption and solubility of polyetheretherketone with other denture base materials. *Clin. Exp. Health Sci.* **2022**, *12*, 672–677. [CrossRef]
63. Vulović, S.; Popovac, A.; Radunović, M.; Petrović, S.; Todorović, M.; Milić-Lemić, A. Microbial adhesion and viability on novel CAD/CAM framework materials for implant-supported hybrid prostheses. *Eur. J. Oral Sci.* **2023**, *131*, e12911. [CrossRef] [PubMed]
64. Jin, N.Y.; Lee, H.R.; Lee, H.; Pae, A. Wettability of denture relining materials under water storage over time. *J. Adv. Prosthodont.* **2009**, *1*, 1–5. [CrossRef] [PubMed]
65. Mendonça e Bertolini, M.d.; Cavalcanti, Y.W.; Bordin, D.; Silva, W.J.; Cury, A.A. *Candida albicans* biofilms and MMA surface treatment influence the adhesion of soft denture liners to PMMA resin. *Braz. Oral Res.* **2014**, *28*, 61–66. [CrossRef] [PubMed]
66. Koseoglu, M.; Tugut, F.; Akin, H. Tensile bond strength of soft and hard relining materials to conventional and additively manufactured denture-base materials. *J. Prosthodont.* **2023**, *32*, 74–80. [CrossRef] [PubMed]
67. Park, S.J.; Lee, J.S. Effect of surface treatment on shear bond strength of relining material and 3D-printed denture base. *J. Adv. Prosthodont.* **2022**, *14*, 262–272. [CrossRef] [PubMed]
68. Mert, D.; Kamnoedboon, P.; Al-Haj Husain, N.; Özcan, M.; Srinivasan, M. CAD-CAM complete denture resins: Effect of relining on the shear bond strength. *J. Dent.* **2023**, *131*, 104438. [CrossRef]
69. Kim, J.H.; Choe, H.C.; Son, M.K. Evaluation of adhesion of reline resins to the thermoplastic denture base resin for non-metal clasp denture. *Dent. Mater. J.* **2014**, *33*, 32–38. [CrossRef]
70. Vuksic, J.; Pilipovic, A.; Poklepovic Pericic, T.; Kranjcic, J. Tensile bond strength between different denture base materials and soft denture liners. *Materials* **2023**, *16*, 4615. [CrossRef]

71. Soares Machado, P.; Cadore Rodrigues, A.C.; Chaves, E.T.; Susin, A.H.; Valandro, L.F.; Pereira, G.K.R.; Rippe, M.P. Surface treatments and adhesives used to increase the bond strength between polyetheretherketone and resin-based dental materials: A scoping review. *J. Adhes. Dent.* **2022**, *24*, 233–245.
72. Parkar, U.; Dugal, R.; Madanshetty, P.; Devadiga, T.; Khan, A.S.; Godil, A. Assessment of different surface treatments and shear bond characteristics of poly-ether-ether-ketone: An in vitro SEM analysis. *J. Indian. Prosthodont. Soc.* **2021**, *21*, 412–419. [PubMed]
73. Gad, M.M.; Fouda, S.M. Current perspectives and the future of *Candida albicans*-associated denture stomatitis treatment. *Dent. Med. Probl.* **2020**, *57*, 95–102. [CrossRef]
74. Meirowitz, A.; Rahmanov, A.; Shlomo, E.; Zelikman, H.; Dolev, E.; Sterer, N. Effect of denture base fabrication technique on *Candida albicans* adhesion in vitro. *Materials* **2021**, *14*, 221. [CrossRef] [PubMed]
75. Przykaza, K.; Jurak, M.; Kalisz, G.; Mroczka, R.; Wiacek, A.E. Characteristics of hybrid bioglass-chitosan coatings on the plasma activated peek polymer. *Molecules* **2023**, *28*, 1729. [CrossRef] [PubMed]
76. Katzer, A.; Marquardt, H.; Westendorf, J.; Wening, J.V.; von Foerster, G. Polyetheretherketone—Cytotoxicity and mutagenicity in vitro. *Biomaterials* **2002**, *23*, 1749–1759. [CrossRef] [PubMed]
77. Ning, L.; Deqiang, C.; Xiyan, G.; Lirong, L.; Weizeng, C. Biological Tribology Properties of the Modified Polyether Ether Ketone Composite Materials. *Rev. Adv. Mater. Sci.* **2020**, *59*, 399–405. [CrossRef]
78. Hao, Y.; Huang, X.; Zhou, X.; Li, M.; Ren, B.; Peng, X.; Cheng, L. Influence of dental prosthesis and restorative materials interface on oral biofilms. *Int. J. Mol. Sci.* **2018**, *19*, 3157. [CrossRef]
79. Sachdeo, A.; Haffajee, A.D.; Socransky, S.S. Biofilms in the edentulous oral cavity. *J. Prosthodont.* **2008**, *17*, 348–356. [CrossRef]
80. Sang, T.; Ye, Z.; Fischer, N.G.; Skoe, P.E.; Echeverría, C.; Wu, J.; Aparicio, C. Physical-chemical interactions between dental materials surface, salivary pellicle and *Streptococcus gordonii*. *Colloids Surf. B* **2020**, *190*, 110938. [CrossRef]
81. Mitchell, K.F.; Zarnowski, R.; Sanchez, H.; Edward, J.A.; Reinicke, E.L.; Nett, J.E.; Mitchell, A.P.; Andes, D.R. Community participation in biofilm matrix assembly and function. *Proc. Natl. Acad. Sci. USA* **2015**, *112*, 4092–4097. [CrossRef]
82. Ercalik-Yalcinkaya, S.; Ozcan, M. Association between oral mucosal lesions and hygiene habits in a population of removable prosthesis wearers. *J. Prosthodont.* **2015**, *24*, 271–278. [CrossRef] [PubMed]
83. Latib, Y.O.; Owen, C.P.; Patel, M. Viability of *Candida albicans* in denture base resin after disinfection: A preliminary study. *Int. J. Prosthodont.* **2018**, *31*, 436–439. [CrossRef] [PubMed]
84. Cruz, P.C.; Andrare, I.M.; Peracini, A.; Souza-Gugelmin, M.C.M.; Silva-Lovato, C.H.; de Souza, R.F.; Paranhos, H.d.F.O. The effectiveness of chemical denture cleansers and ultrasonic device in biofilm removal from complete dentures. *J. Appl. Oral Sci.* **2011**, *19*, 668–673. [CrossRef] [PubMed]
85. Axe, A.S.; Varghese, R.; Bosma, M.; Kitson, N.; Bradshaw, D.J. Dental health professional recommendation and consumer habits in denture cleansing. *J. Prosthet. Dent.* **2016**, *115*, 183–188. [CrossRef] [PubMed]
86. Abaci, Ö. Investigation of extracellular phospholipase and proteinase activities of *Candida* species isolated from individual's denture wearers and genotypic distribution of *Candida albicans* strains. *Curr. Microbiol.* **2011**, *62*, 1308–1314. [CrossRef] [PubMed]
87. Zarnowski, R.; Westler, W.M.; Lacmbouh, G.A.; Marita, J.M.; Bothe, J.R.; Bernhardt, J.; Lounes-Hadj Sahraoui, A.; Fontaine, J.; Sanchez, H.; Hatfield, R.D.; et al. Novel entries in a fungal biofilm matrix encyclopedia. *mBio* **2014**, *5*, e01333-14. [CrossRef] [PubMed]
88. Kavanaugh, J.S.; Flack, C.E.; Lister, J.; Ricker, E.B.; Ibberson, C.B.; Jenul, C.; Moormeier, D.E.; Delmain, E.A.; Bayles, K.W.; Horswill, A.R. Identification of extracellular DNA-binding proteins in the biofilm matrix. *mBio* **2019**, *10*, e01137-19. [CrossRef]
89. Cahn, L.R. The Denture sore mouth. *Ann. Dent.* **1936**, *3*, 33–36.
90. Koopmans, A.S.; Kippuw, N.; de Graaff, J. Bacterial involvement in denture-induced stomatitis. *J. Dent. Res.* **1988**, *67*, 1246–1250. [CrossRef]
91. Campos, M.S.; Marchini, L.; Bernardes, L.A.; Paulino, L.C.; Nobrega, F.G. Biofilm microbial communities of denture stomatitis. *Oral Microbiol. Immunol.* **2008**, *23*, 419–424. [CrossRef]
92. Salerno, C.; Pascale, M.; Contaldo, M.; Esposito, V.; Busciolano, M.; Milillo, L.; Guida, A.; Petruzzi, M.; Serpico, R. Candida-associated denture stomatitis. *Med. Oral Patol. Oral Cir. Bucal* **2011**, *16*, e139–e143. [CrossRef] [PubMed]
93. Schaller, M.; Borelli, C.; Korting, H.C.; Hube, B. Hydrolytic enzymes as virulence factors of *Candida albicans*. *Mycoses* **2005**, *48*, 365–377. [CrossRef] [PubMed]
94. Cavalcanti, Y.W.; Wilson, M.; Lewis, M.; Williams, D.; Senna, P.M.; Del-Bel-Cury, A.A.; Silva, W.J. Salivary pellicles equalize surfaces' charges and modulate the virulence of *Candida albicans* biofilm. *Arch. Oral Biol.* **2016**, *6*, 129–140. [CrossRef] [PubMed]
95. Rickard, A.H.; Gilbert, P.; High, N.J.; Kolenbrander, P.E.; Handley, P.S. Bacterial coaggregation: An integral process in the development of multi-species biofilms. *Trends Microbiol.* **2003**, *11*, 94–100. [CrossRef] [PubMed]
96. Ruhl, S.; Eidt, A.; Melzl, H.; Reischl, U.; Cisar, J.O. Probing of microbial biofilm communities for coadhesion partners. *Appl. Environ. Microbiol.* **2014**, *80*, 6583–6590. [CrossRef] [PubMed]
97. Fox, E.P.; Bui, C.K.; Nett, J.E.; Hartooni, N.; Mui, M.C.; Andes, D.R.; Nobile, C.J.; Johnson, A.D. An expanded regulatory network temporally controls *Candida albicans* biofilm formation. *Mol. Microbiol.* **2015**, *96*, 1226–1239. [CrossRef] [PubMed]
98. Li, P.; Seneviratne, C.J.; Alpi, E.; Vizcaino, J.A.; Jin, L. Delicate metabolic control and coordinated stress response critically determine antifungal tolerance of *Candida albicans* biofilm persisters. *Antimicrob. Agents Chemother.* **2015**, *59*, 6101–6112. [CrossRef]
99. Santana, I.L.; Gonçalves, L.M.; de Vasconcellos, A.A.; da Silva, W.J.; Cury, J.A.; Cury, A.A.D.B. Dietary carbohydrates modulate *Candida albicans* biofilm development on the denture surface. *PLoS ONE* **2013**, *8*, e64645. [CrossRef]

100. Arendorf, T.M.; Walker, D.M. The prevalence and intra-oral distribution of *Candida albicans* in man. *Arch. Oral Biol.* **1980**, *25*, 1–10. [CrossRef]
101. Morse, D.J.; Smith, A.; Wilson, M.J.; Marsh, L.; White, L.; Posso, R.; Bradshaw, D.J.; Wei, X.; Lewis, M.A.O.; Williams, D.W. Molecular community profiling of the bacterial microbiota associated with denture-related stomatitis. *Sci. Rep.* **2019**, *9*, 10228. [CrossRef]
102. O'Donnell, L.E.; Robertson, D.; Nile, C.J.; Cross, L.J.; Riggio, M.; Sherriff, A.; Bradshaw, D.; Lambert, M.; Malcolm, J.; Buijs, M.J.; et al. The oral microbiome of denture wearers is influenced by levels of natural dentition. *PLoS ONE* **2015**, *10*, e0137717. [CrossRef] [PubMed]
103. Teles, F.R.; Teles, R.P.; Sachdeo, A.; Uzel, N.G.; Song, X.Q.; Torresyap, G.; Singh, M.; Papas, A.; Haffajee, A.; Socransky, S. Comparison of microbial changes in early redeveloping biofilms on natural teeth and dentures. *J. Periodontol.* **2012**, *83*, 1139–1148. [CrossRef] [PubMed]
104. Murugesan, S.; Al Ahmad, S.F.; Singh, P.; Saadaoui, M.; Kumar, M.; Al Khodor, S. Profiling the salivary microbiome of the Qatari population. *J. Transl. Med.* **2020**, *18*, 127. [CrossRef] [PubMed]
105. Perić, M.; Živković, R.; Milić Lemić, A.; Radunović, M.; Miličić, B.; Arsenijević, V.A. The severity of denture stomatitis as related to risk factors and different *Candida* spp. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol.* **2018**, *126*, 41–47. [CrossRef] [PubMed]
106. Vila, T.; Sultan, A.S.; Montelongo-Jauregui, D.; Jabra-Rizk, M.A. Oral Candidiasis: A disease of opportunity. *J. Fungi* **2020**, *6*, 15. [CrossRef] [PubMed]
107. Steele, J.G.; Treasure, E.T.; Fuller, E.; Morgan, M.Z. Complexity and maintenance—A report from the Adult Dental Health Survey. In *Adult Dental Health Survey 2009—Northern Ireland Key Findings*; O'Sullivan, I., Ed.; The Health and Social Care Information Centre: London, UK, 2011; pp. 7–9.
108. Theilade, E.; Budtz-Jørgensen, E.; Theilade, J. Predominant cultivable microflora of plaque on removable dentures in patients with healthy oral mucosa. *Arch. Oral Biol.* **1983**, *28*, 675–680. [CrossRef] [PubMed]
109. Shi, B.; Wu, T.; McLean, J.; Edlund, A.; Young, Y.; He, X.; Lv, H.; Zhou, X.; Shi, W.; Li, H.; et al. The denture-associated oral microbiome in health and stomatitis. *mSphere* **2016**, *1*, e00215–e00216. [CrossRef] [PubMed]
110. Lof, M.; Janus, M.; Krom, B. Metabolic interactions between bacteria and fungi in commensal oral biofilms. *J. Fungi* **2017**, *3*, 40. [CrossRef]
111. Senpuku, H.; Sogame, A.; Inoshita, E.; Tsuha, Y.; Miyazaki, H.; Hanada, N. Systemic diseases in association with microbial species in oral biofilm from elderly requiring care. *Gerontology* **2003**, *49*, 301–309. [CrossRef]
112. Yildirim-Bicer, A.Z.; Peker, I.; Akca, G.; Celik, I. In vitro antifungal evaluation of seven different disinfectants on acrylic resins. *Biomed Res. Int.* **2014**, *2014*, 519098. [CrossRef]
113. Ardizzoni, A.; Pericolini, E.; Paulone, S.; Orsi, C.F.; Castagnoli, A.; Oliva, I.; Strozzi, E.; Blasi, E. In vitro effects of commercial mouthwashes on several virulence traits of *Candida albicans*, viridans streptococci and *Enterococcus faecalis* colonizing the oral cavity. *PLoS ONE* **2018**, *13*, e0207262. [CrossRef] [PubMed]
114. Bajunaid, S.O.; Baras, B.H.; Weir, M.D.; Xu, H.H.K. Denture acrylic resin material with antibacterial and protein-repelling properties for the prevention of denture stomatitis. *Polymers* **2022**, *14*, 230. [CrossRef] [PubMed]
115. Radford, D.R.; Challacombe, S.; Walter, J.D. Denture plaque and adherence of candida albicans to denture-base materials in vivo and in vitro. *Crit. Rev. Oral Biol. Med.* **1999**, *10*, 99–116. [CrossRef]
116. Zheng, W.; Tsompana, M.; Ruscitto, A.; Sharma, A.; Genco, R.; Sun, Y.; Buck, M.J. An accurate and efficient experimental approach for characterization of the complex oral microbiota. *Microbiome* **2015**, *3*, 48. [CrossRef] [PubMed]
117. Fujinami, W.; Nishikawa, K.; Ozawa, S.; Hasegawa, Y.; Takebe, J. Correlation between the relative abundance of oral bacteria and *Candida albicans* in denture and dental plaques. *J. Oral Biosci.* **2021**, *63*, 175–183. [CrossRef] [PubMed]
118. Delaney, C.; O'Donnell, L.E.; Kean, R.; Sherry, L.; Brown, J.L.; Calvert, G.; Nile, C.J.; Cross, L.; Bradshaw, D.J.; Brandt, B.W.; et al. Interkingdom interactions on the denture surface: Implications for oral hygiene. *Biofilm* **2019**, *1*, 100002. [CrossRef] [PubMed]
119. Kostic, M.; Pejcic, A.; Igic, M.; Gligorijević, N. Adverse reactions to denture resin materials. *Eur. Rev. Med. Pharmacol. Sci.* **2017**, *21*, 5298–5305.
120. Figueiral, M.H.; Azul, A.; Pinto, E.; Fonseca, P.A.; Branco, F.M.; Scully, C. Denture-related stomatitis: Identification of aetiological and predisposing factors? A large cohort. *J. Oral Rehabil.* **2007**, *34*, 448–455. [CrossRef]
121. Coulthwaite, L.; Verran, J. Development of an in vitro denture plaque biofilm to model denture malodour. *J. Breath Res.* **2008**, *2*, 017004. [CrossRef]
122. Yitzhaki, S.; Reshef, L.; Gophna, U.; Rosenberg, M.; Sterer, N. Microbiome associated with denture malodour. *J. Breath Res.* **2018**, *12*, 027103. [CrossRef]
123. Garg, R.; Garg, R.K. Denture hygiene, different strategies. *Webmed Cent. Dent.* **2010**, *10*, WMC00932.
124. Helal, M.A.; Fadl-Alah, A.; Baraka, Y.M.; Gad, M.M.; Emam, A.-N.M. In-vitro comparative evaluation for the surface properties and impact strength of CAD/CAM milled, 3D printed, and polyamide denture base resins. *J. Int. Soc. Prev. Community Dent.* **2022**, *12*, 126–131. [CrossRef] [PubMed]
125. Pereira-Cenci, T.; Cury, A.A.D.B.; Cenci, M.S.; Rodrigues-Garcia, R.C.M. In vitro candida colonization on acrylic resins and denture liners: Influence of surface free energy, roughness, saliva, and adhering bacteria. *Int. J. Prosthodont.* **2007**, *20*, 308–310. [PubMed]

126. Olms, C.; Yahiaoui-Doktor, M.; Remmerbach, T.; Stingu, C. Bacterial colonization and tissue compatibility of denture base resins. *Dent. J.* **2018**, *6*, 20. [CrossRef] [PubMed]
127. Mukai, Y.; Torii, M.; Urushibara, Y.; Kawai, T.; Takahashi, Y.; Maeda, N.; Ohkubo, C.; Ohshima, T. Analysis of plaque microbiota and salivary proteins adhering to dental materials. *J. Oral Biosci.* **2020**, *62*, 182–188. [CrossRef]
128. de Foggi, C.C.; Machado, A.L.; Zamperini, C.A.; Fernandes, D.; Wady, A.F.; Vergani, C.E. Effect of surface roughness on the hydrophobicity of a denture-base acrylic resin and *Candida albicans* colonization. *J. Investig. Clin. Dent.* **2016**, *7*, 141–148. [CrossRef]
129. Vila, T.; Rizk, A.M.; Sultan, A.S.; Jabra-Rizk, M.A. The power of saliva: Antimicrobial and beyond. *PLoS Pathog.* **2019**, *15*, 1008058. [CrossRef]
130. Queiroz, J.R.C.; Fissmer, S.F.; Koga-Ito, C.Y.; Salvia, A.C.R.D.; Massi, M.; Sobrinho, A.S.d.S.; Júnior, L.N. Effect of diamond-like carbon thin film coated acrylic resin on candida albicans biofilm formation: Effect of dlc film on biofilm formation. *J. Prosthodont.* **2013**, *22*, 451–455. [CrossRef]
131. Sarkar, A.; Kuehl, M.N.; Alman, A.C.; Burkhardt, B.R. Linking the oral microbiome and salivary cytokine abundance to circadian oscillations. *Sci. Rep.* **2021**, *11*, 2658. [CrossRef]
132. Choi, S.Y.; Habimana, O.; Flood, P.; Reynaud, E.G.; Rodriguez, B.J.; Zhang, N.; Casey, E.; Gilchrist, M.D. Material-and feature-dependent effects on cell adhesion to micro injection moulded medical polymers. *Colloids Surf. B Biointerfaces* **2016**, *145*, 46–54. [CrossRef]
133. Sipahi, C.; Anil, N.; Bayramli, E. The effect of acquired salivary pellicle on the surface free energy and wettability of different denture base materials. *J. Dent.* **2001**, *29*, 197–204. [CrossRef] [PubMed]
134. de Freitas Fernandes, F.S.; Pereira-Cenci, T.; da Silva, W.J.; Filho, A.P.R.; Straioto, F.G.; Del Bel Cury, A.A. Efficacy of denture cleansers on candida spp. biofilm formed on polyamide and polymethyl methacrylate resins. *J. Prosthet. Dent.* **2011**, *105*, 51–58. [CrossRef] [PubMed]
135. Vojdani, M.; Giti, R. Polyamide as a denture base material: A literature review. *J. Dent.* **2015**, *16*, 1–9.
136. Chuchulska, B.; Hristov, I.; Dochev, B.; Raychev, R. Changes in the surface texture of thermoplastic (monomer-free) dental materials due to some minor alterations in the laboratory protocol—Preliminary study. *Materials* **2022**, *15*, 6633. [CrossRef] [PubMed]
137. Hahnel, S.; Wieser, A.; Lang, R.; Rosentritt, M. Biofilm formation on the surface of modern implant abutment materials. *Clin. Oral Impl Res.* **2015**, *26*, 1297–1301. [CrossRef] [PubMed]
138. Skirbutis, G.; Dzingutė, A.; Masiliūnaitė, V.; Šulcaitė, G.; Žilinskas, J. A review of peek polymer's properties and its use in prosthodontics. *Stomatologija* **2017**, *19*, 19–23. [PubMed]
139. Neugebauer, J.; Adler, S.; Kisttler, F.; Kistler, S.; Bayer, G. The use of plastics in fixed prosthetic implant restoration. *Zwr-Ger. Dent. J.* **2013**, *122*, 242–245.
140. Gad, M.M.; Abu-Rashid, K.; Alkhaldi, A.; Alshehri, O.; Khan, S.Q. Evaluation of the effectiveness of bioactive glass fillers against candida albicans adhesion to PMMA denture base materials: An in vitro study. *Saudi Dent. J.* **2022**, *34*, 730–737. [CrossRef]
141. Khattar, A.; Alghafli, J.A.; Muheef, M.A.; Alsalem, A.M.; Al-Dubays, M.A.; AlHussain, H.M.; AlShoalah, H.M.; Khan, S.Q.; AlEraky, D.M.; Gad, M.M. Antibiofilm activity of 3D-printed nanocomposite resin: Impact of ZrO2 nanoparticles. *Nanomaterials* **2023**, *13*, 591. [CrossRef]
142. Sawada, T.; Sawada, T.; Kumasaka, T.; Hamada, N.; Shibata, T.; Nonami, T.; Kimoto, K. Self-cleaning effects of acrylic resin containing fluoridated apatite-coated titanium dioxide. *Gerodontology* **2014**, *31*, 68–75. [CrossRef]
143. Lazarin, A.A.; Machado, A.L.; Zamperini, C.A.; Wady, A.F.; Spolidorio, D.M.P.; Vergani, C.E. Effect of experimental photopolymerized coatings on the hydrophobicity of a denture base acrylic resin and on *Candida albicans* adhesion. *Arch. Oral Biol.* **2013**, *58*, 1–9. [CrossRef] [PubMed]
144. Qian, K.; Pan, H.; Li, Y.; Wang, G.; Zhang, J.; Pan, J. Time-related surface modification of denture base acrylic resin treated by atmospheric pressure cold plasma. *Dent. Mater. J.* **2016**, *35*, 97–103. [CrossRef] [PubMed]
145. Yildirim, M.S.; Hasanreisoglu, U.; Hasirci, N.; Sultan, N. Adherence of candida albicans to glow-discharge modified acrylic denture base polymers. *J. Oral Rehabil.* **2005**, *32*, 518–525. [CrossRef] [PubMed]
146. Liu, T.; Xu, C.; Hong, L.; Garcia-Godoy, F.; Hottel, T.; Babu, J.; Yu, Q. Effects of trimethylsilane plasma coating on the hydrophobicity of denture base resin and adhesion of *Candida albicans* on resin sur-faces. *J. Prosthet. Dent.* **2017**, *118*, 765–770. [CrossRef] [PubMed]
147. Darwish, G.; Huang, S.; Knoernschild, K.; Sukotjo, C.; Campbell, S.; Bishal, A.K.; Barão, V.A.; Wu, C.D.; Taukodis, C.G.; Yang, B. Improving polymethyl methacrylate resin using a novel titanium dioxide coating. *J. Prosthodont.* **2019**, *28*, 1011–1017. [CrossRef]
148. Zamperini, C.A.; Machado, A.L.; Vergani, C.E.; Pavarina, A.C.; Giampaolo, E.T.; da Cruz, N.C. Adherence in vitro of candida albicans to plasma treated acrylic resin. Effect of plasma parameters, surface roughness and salivary pellicle. *Arch. Oral Biol.* **2010**, *55*, 763–770. [CrossRef]
149. Sun, J.; Wang, L.; Wang, J.; Li, Y.; Zhou, X.; Guo, X.; Zhang, T.; Guo, H. Characterization and evaluation of a novel silver nanoparticles-loaded polymethyl methacrylate denture base: In vitro and in vivo animal study. *Dent. Mater. J.* **2021**, *40*, 1100–1108. [CrossRef]
150. Garcia, A.A.M.N.; Sugio, C.Y.C.; de Azevedo-Silva, L.J.; Gomes, A.C.G.; Batista, A.U.D.; Porto, V.C.; Soares, S.; Neppelenbroek, K.H. Nanoparticle-modified PMMA to prevent denture stomatitis: A systematic review. *Arch. Microbiol.* **2022**, *204*, 75. [CrossRef]

151. Apip, C.; Martínez, A.; Meléndrez, M.; Domínguez, M.; Marzialetti, T.; Báez, R.; Sánchez-Sanhueza, G.; Jaramillo, A.; Catalán, A. An in vitro study on the inhibition and ultrastructural alterations of candida albicans biofilm by zinc oxide nanowires in a PMMA matrix. *Saudi Dent. J.* **2021**, *33*, 944–953. [CrossRef]
152. Young, B.; Jose, A.; Cameron, D.; McCord, F.; Murray, C.; Bagg, J.; Ramage, G. Attachment of candida albicans to denture base acrylic resin processed by three different methods. *Int. J. Prosthodont.* **2009**, *22*, 488–489.
153. Mondelli, R.; Garrido, L.M.; Soares, A.; Rodriguez-Medina, A.; Mondelli, J.; de Lucena, F.; Furuse, A. Effect of simulated brushing on surface roughness and wear of bis-acryl-based materials submitted to different polishing protocols. *J. Clin. Exp. Dent.* **2022**, *14*, e168–e176. [CrossRef] [PubMed]
154. Al-Fouzan, A.F.; Al-mejrad, L.A.; Albarrag, A.M. Adherence of candida to complete denture surfaces in vitro: A comparison of conventional and CAD/CAM complete dentures. *J. Adv. Prosthodont.* **2017**, *9*, 402. [CrossRef] [PubMed]
155. Sahin, O.; Koroglu, A.; Dede, D.Ö.; Yilmaz, B. Effect of surface sealant agents on the surface roughness and color stability of denture base materials. *J. Prosthet. Dent.* **2016**, *116*, 610–616. [CrossRef] [PubMed]
156. Liebermann, A.; Wimmer, T.; Schmidlin, P.R.; Scherer, H.; Löffler, P.; Roos, M.; Stawarczyk, B. Physicomechanical characterization of polyetheretherketone and current esthetic dental cad/cam polymers after aging in different storage media. *J. Prosthet. Dent.* **2016**, *115*, 321–328. [CrossRef] [PubMed]
157. Liu, Y.; Fang, M.; Zhao, R.; Liu, H.; Li, K.; Tian, M.; Niu, L.; Xie, R.; Bai, S. Clinical applications of polyetheretherketone in removable dental prostheses: Accuracy characteristics, and performance. *Polymers* **2022**, *14*, 4615. [CrossRef] [PubMed]
158. 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. [CrossRef] [PubMed]
159. Behr, M.; Rosentritt, M.; Lang, R.; Handel, G. Glass fiber-reinforced abutments for dental implants. a pilot study: Glass fiber-reinforced abutments for dental implants. A pilot study. *Clin. Oral Implant. Res.* **2001**, *12*, 174–178. [CrossRef] [PubMed]
160. Pan, H.; Wang, G.; Pan, J.; Ye, G.; Sun, K.; Zhang, J.; Wang, J. Cold plasma-induced surface modification of heat-polymerized acrylic resin and prevention of early adherence of candida albicans. *Dent. Mater. J.* **2015**, *34*, 529–536. [CrossRef]
161. Gül, E.B.; Atala, M.H.; Eşer, B.; Polat, N.T.; Asiltürk, M.; Gültek, A. Effects of coating with different ceromers on the impact strength, transverse strength and elastic modulus of polymethyl methacrylate. *Dent. Mater. J.* **2015**, *34*, 379–387. [CrossRef]
162. Güngör, A.; Kayaman-Apohan, N.; Mert, A.; Kahraman, M.V. Preparation and characterization of light curable hybrid coating: Its potential application for dental restorative material. *J. Polym. Res.* **2008**, *15*, 389–395. [CrossRef]
163. Mylonas, P.; Milward, P.; McAndrew, R. Denture cleanliness and hygiene: An overview. *Br. Dent. J.* **2022**, *233*, 20–26. [CrossRef] [PubMed]
164. Estrela, A.; Estrela, C.R.A.; Barbin, E.L.; Spano, J.C.E.; Marchesan, M.A.; Pecora, J.D. Mechanism of action of sodium hypochlorite. *Braz. Dent. J.* **2002**, *13*, 113–117. [CrossRef] [PubMed]
165. De Sousa Porta, S.R.; de Lucena-Ferreira, S.C.; da Silva, W.J.; Del Bel Cury, A.A. Evaluation of sodium hypochlorite as a denture cleanser: A clinical study. *Gerodontology* **2015**, *32*, 260–266. [CrossRef] [PubMed]
166. Milward, P.; Katechia, D.; Morgan, M.Z. Knowledge of removable partial denture wearers on denture hygiene. *Br. Dent. J.* **2013**, *215*, E20. [CrossRef] [PubMed]
167. Kumar, B.; Sandhu, P.K.; Kumar, A.N.; Patil, C.P. A comparative study for plaque removing efficacy between commonly used denture cleansers in India. *J. Indian. Prosthodont. Soc.* **2017**, *17*, 295–300. [CrossRef] [PubMed]
168. De Souza, R.F.; de Freitas Oliveira Paranhos, H.; Lovato da Silva, C.H.; Abu-Naba'a, L.; Fedorowicz, Z.; Gurgan, C.A. Interventions for cleaning dentures in adults. *Cochrane Data-Base Syst. Rev.* **2009**, *4*, CD007395. [CrossRef] [PubMed]
169. Ramage, G.; O'Donnell, L.; Sherry, L.; Culshaw, S.; Bagg, J.; Czesnikiewicz-Guzik, M.; Brown, C.; McKenzie, D.; Cross, L.; MacInnes, A.; et al. Impact of frequency of denture cleaning on microbial and clinical parameters—A bench to chairside approach. *J. Oral Microbiol.* **2019**, *11*, 1538437. [CrossRef] [PubMed]
170. Costa, R.T.F.; Pellizzer, E.P.; Vasconcelos, B.C.d.E.; Gomes, J.M.L.; Lemos, C.A.A.; Moraes, S.L.D. Surface roughness of acrylic resins used for denture base after chemical disinfection: A systematic review and meta-analysis. *Gerodontology* **2021**, *38*, 242–251. [CrossRef]
171. Masetti, P.; Arbeláez, M.I.A.; Pavarina, A.C.; Sanitá, P.V.; Jorge, J.H. Cytotoxic potential of denture base and reline acrylic resins after immersion in disinfectant solutions. *J. Prosthet. Dent.* **2018**, *120*, 155. [CrossRef]
172. Gad, M.M.; Abualsaud, R.; Fouda, S.M.; Rahoma, A.; Al-Thobity, A.M.; Khan, S.Q.; Akhtar, S.; Al-Harbi, F.A. Effects of denture cleansers on the flexural strength of PMMA denture base resin modified with ZrO_2 nanoparticles. *J. Prosthodont.* **2021**, *30*, 2356244. [CrossRef]
173. Amaya, A.M.I.; Vergani, C.E.; Barbugli, P.A.; Pavarina, A.C.; Sanitá, P.V.; Jorge, J.H. Long-term effect of daily chemical disinfection on surface topography and *Candida albicans* biofilm formation on denture base and reline acrylic resins. *Oral Health Prev. Dent.* **2020**, *18*, 999–1010.
174. Kiesow, A.; Sarembe, S.; Pizzey, R.L.; Axe, A.S.; Bradshaw, D.J. Material compatibility and antimicrobial activity of consumer products commonly used to clean dentures. *J. Prosthet. Dent.* **2016**, *115*, 189–198. [CrossRef] [PubMed]
175. Yuan, S.P.; Lin, H.; Pan, S.; Lou, L.L.; Xu, Y.X. Effect of Polident denture cleansers on the properties of heat-polymerized denture base acrylic resin. *Beijing Da Xue Xue Bao Yi Xue Ban* **2012**, *44*, 946–949. [PubMed]
176. Sesma, N.; Rocha, A.L.; Lagana, D.C.; Costa, B.; Morimoto, S. Effectiveness of denture cleanser associated with microwave disinfection and brushing of complete dentures: In vivo study. *Braz. Dent. J.* **2013**, *24*, 357–361. [CrossRef] [PubMed]

177. Arun Kumar, P.; Iniyan, K.; Balasubramaniam, R.; Viswanathan, M.; Hines, P.J.; Monnica, V. The effect of surface treatments on the shear bond strength of acrylic resin denture base with different repair acrylic resin: An in vitro study. *J. Pharm. Bioall Sci.* **2019**, *11*, 380. [CrossRef] [PubMed]
178. Kreve, S.; Dos Reis, A.C. Denture liners: A systematic review relative to adhesion and mechanical properties. *Sci. World J.* **2019**, *2019*, 6913080. [CrossRef] [PubMed]
179. Ates, S.M.; Caglar, I.; Ozdogan, A.; Duymus, Z.Y. The effect of denture cleansers on surface roughness and bond strength of a denture base resin. *J. Adhes. Sci. Technol.* **2017**, *31*, 171–181. [CrossRef]
180. Kümbüloğlu, Ö.; Yildirim, B.; Al-Haj Husain, N.; Özcan, M. Adhesion potential of relining materials to polyamide and PMMA-based denture base materials: Effect of surface conditioning methods. *J. Adhes. Sci. Technol.* **2019**, *33*, 1939–1947. [CrossRef]
181. AlZaher, Z.A.; Almaskin, D.F.; Qaw, M.S.; Abu Showmi, T.H.; Abualsaud, R.; Akhtar, S.; Gad, M.M. Chemo-mechanical approach to improve repair bond strength of denture teeth. *Int. J. Dent.* **2020**, *2020*, 8870361. [CrossRef]
182. Choi, J.E.; Ng, T.E.; Leong, C.K.Y.; Kim, H.; Li, P.; Waddell, J.N. Adhesive evaluation of three types of resilient denture liners bonded to heat-polymerized, autopolymerized, or CAD-CAM acrylic resin denture bases. *J. Prosthet. Dent.* **2018**, *120*, 699–705. [CrossRef]
183. Takahashi, Y.; Chai, J. Shear bond strength of denture reline polymers to denture base polymers. *Int. J. Prosthodont.* **2001**, *14*, 271–275. [PubMed]
184. Taghva, M.; Enteghad, S.; Jamali, A.; Mohaghegh, M. Comparison of shear bond strength of CAD/CAM and conventional heat-polymerized acrylic resin denture bases to auto-polymerized and heat-polymerized acrylic resins after aging. *J. Clin. Exp. Dent.* **2022**, *14*, 72–78. [CrossRef] [PubMed]
185. Choi, J.J.E.; Ramani, R.S.; Ganjigatti, R.; Uy, C.E.; Plaksina, P.; Waddell, J.N. Adhesion of denture characterizing composites to heat cured, CAD/CAM and 3D printed denture base resins. *J. Prosthodont.* **2021**, *30*, 83–90. [CrossRef] [PubMed]
186. Luo, C.; Liu, Y.; Peng, B.; Chen, M.; Liu, Z.; Li, Z.; Kuang, H.; Gong, B.; Li, Z.; Sun, H. PEEK for oral applications: Recent advances in mechanical and adhesive properties. *Polymers* **2023**, *15*, 386. [CrossRef]
187. Müller, F. Oral hygiene reduces the mortality from aspiration pneumonia in frail elders. *J. Dent. Res.* **2015**, *94*, 14–16. [CrossRef] [PubMed]
188. Le Bars, P.; Kouadio, A.A.; Bandiaky, O.N.; Le Guéhennec, L.; de La Cochetière, M.F. Host's immunity and Candida species associated with denture stomatitis: A narrative review. *Microorganisms* **2022**, *10*, 1437. [CrossRef]
189. Ruiz Núñez, M.d.R.; Raulino, M.; Goulart Castro, R.; Schaefer Ferreira de Mello, A.L. Dental plaque control strategies for the elderly population: A scoping review. *Int. J. Dent. Hyg.* **2022**, *20*, 167–181. [CrossRef]
190. Patil, S.; Rao, R.S.; Majumdar, B.; Anil, S. Clinical appearance of oral candida infection and therapeutic strategies. *Front. Microbiol.* **2015**, *6*, 1391. [CrossRef]
191. Dhiman, R.; Chowdhury, S.R. Midline fractures in single maxillary complete acrylic vs flexible dentures. *Med. J. Armed Forces India* **2009**, *65*, 141–145. [CrossRef]
192. Takahashi, Y.; Imazato, S.; Russell, R.R.B.; Noiri, Y.; Ebisu, S. Influence of Resin Monomers on Growth of Oral Streptococci. *J. Dent. Res.* **2004**, *83*, 302–306. [CrossRef]
193. Kostić, M.; Igić, M.; Gligorijević, N.; Nikolić, V.; Stošić, N.; Nikolić, L. The use of acrylate polymers in dentistry. *Polymers* **2022**, *14*, 4511. [CrossRef] [PubMed]
194. Yoshii, E. Cytotoxic effects of acrylates and methacrylates: Relationships of monomer structures and cytotoxicity. *J. Biomed. Mater. Res. A* **1997**, *37*, 517–524. [CrossRef]
195. Hinz, S.; Bensel, T.; Bömicke, W.; Boeckler, A.F. In Vitro analysis of the mechanical properties of hypoallergenic denture base resins. *Materials* **2022**, *15*, 3611. [CrossRef] [PubMed]
196. Pfeiffer, P.; An, N.; Schmage, P. Repair strength of hypoallergenic denture base materials. *J. Prosthet. Dent.* **2008**, *100*, 292–301. [CrossRef] [PubMed]
197. Shibata, T.; Hamada, N.; Kimoto, K.; Sawada, T.; Sawada, T.; Kumada, H.; Umemoto, T.; Toyoda, M. Antifungal effect of acrylic resin containing apatite-coated TiO_2 photocatalyst. *Dent. Mater. J.* **2007**, *26*, 437–444. [CrossRef] [PubMed]
198. Casemiro, L.A.; Gomes Martins, C.H.; Pires-de-Souza, F.C.; Panzeri, H. Antimicrobial and mechanical properties of acrylic resins with incorporated silver-zinc zeolite—Part I. *Gerodontology* **2008**, *25*, 187–194. [CrossRef] [PubMed]
199. Acosta-Torres, L.S.; Mendieta, I.; Nunez-Anita, R.E.; Cajero-Juarez, M.; Castano, V.M. Cytocompatible antifungal acrylic resin containing silver nanoparticles for dentures. *Int. J. Nanomed.* **2012**, *7*, 4777–4786.
200. Monteiro, D.R.; Gorup, L.F.; Takamiya, A.S.; de Camargo, E.R.; Filho, A.C.R.; Barbosa, D.B. Silver distribution and release from an antimicrobial denture base resin containing silver colloidal nanoparticles. *J. Prosthodont.* **2012**, *21*, 7–15. [CrossRef]
201. Al-Bakri, I.; Harty, D.; Al-Omari, W.; Swain, M.; Chrzanowski, W.; Ellakwa, A. Surface characteristics and microbial adherence ability of modified polymethylmethacrylate by fluoridated glass fillers. *Aust. Dent. J.* **2014**, *59*, 482–489. [CrossRef]
202. Tsutsumi, C.; Takakuda, K.; Wakabayashi, N. Reduction of Candida biofilm adhesion by incorporation of prereacted glass ionomer filler in denture base resin. *J. Dent.* **2016**, *44*, 37–43. [CrossRef]
203. Siddiqui, M.N.; Redhwi, H.H.; Vakalopoulou, E.; Tsagkalias, I.; Ioannidou, M.D.; Achilias, D.S. Synthesis, characterization and reaction kinetics of PMMA/silver nanocomposites prepared via in situ radical polymerization. *Eur. Polym. J.* **2015**, *72*, 256–269. [CrossRef]

204. Lee, J.H.; El-Fiqi, A.; Jo, J.K.; Kim, D.A.; Kim, S.C.; Jun, S.K.; Kim, H.W.; Lee, H.H. Development of long-term antimicrobial poly(methyl methacrylate) by incorporating mesoporous silica nanocarriers. *Dent. Mater.* **2016**, *32*, 1564–1574. [CrossRef] [PubMed]
205. Kurt, A.; Erkose-Genc, G.; Uzun, M.; Emrence, Z.; Ustek, D.; Isik-Ozkol, G. The antifungal activity and cytotoxicity of silver containing denture base material. *Niger. J. Clin. Pract.* **2017**, *20*, 290–295. [CrossRef] [PubMed]
206. Petrović, M.; Randjelović, M.; Igić, M.; Randjelović, M.; Arsić Arsenijević, V.; Mionić Ebersold, M.; Otašević, S.; Milošević, I. Poly(methyl methacrylate) with oleic acid as an efficient *Candida albicans* biofilm repellent. *Materials* **2022**, *15*, 3750. [CrossRef] [PubMed]
207. Uzun, I.H.; Tatar, A.; Hacimuftuoglu, A.; Saruhan, F.; Bayindir, F. In vitro evaluation of long-term cytotoxic response of injection-molded polyamide and polymethyl methacrylate denture base materials on primary fibroblast cell culture. *Acta Odontol. Scand.* **2013**, *71*, 1267–1272. [CrossRef] [PubMed]
208. Wicks, R.; Babu, J.; Garcia-Godoy, F.; Tipton, D. Cytotoxic Effects of Three Denture Base Materials on Gingival Epithelial Cells and Fibroblasts: An in Vitro Study. *Int. J. Exp. Dent. Sci.* **2015**, *4*, 11–16. [CrossRef]
209. Jang, D.E.; Lee, J.Y.; Jang, H.S.; Lee, J.J.; Son, M.K. Color stability, water sorption, and cytotoxicity of thermoplastic acrylic resin for non-metal clasp denture. *J. Adv. Prosthodont.* **2015**, *7*, 278–287. [CrossRef]
210. Al-Dharrab, A.S. LA Biocompatibility and cytotoxicity of two different polymerized denture base resins cultured on human mesenchymal stem cells. *J. Int. Oral Health* **2016**, *8*, 1114–1118.
211. Lee, J.H.; Jun, S.K.; Kim, S.C.; Okubo, C.; Lee, H.H. Investigation of the cytotoxicity of thermoplastic denture base resins. *J. Adv. Prosthodont.* **2017**, *9*, 453–462. [CrossRef]
212. Elmwafya, D.A.; Abdallahb, R.; Osmand, A.A.M.F. Evaluation of Biologic and Some Physical Properties of Flexible Resin Modified with Antimicrobial Nanostructures. *Mansoura J. Dent.* **2019**, *6*, 34–44.
213. Cengiz, S.; Velioğlu, N.; Cengiz, M.İ.; Çakmak Özlü, F.; Akbal, A.U.; Çoban, A.Y.; Özcan, M. Cytotoxicity of acrylic resins, particulate filler composite resin and thermoplastic material in artificial saliva with and without melatonin. *Materials* **2022**, *115*, 1457. [CrossRef] [PubMed]