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Case report

Comparison of Fabrication Techniques for Removable Dentures Using Different Acrylic Resins: A Case Report

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Abstract
Removable dentures are an important service in dentistry for patients due to high access to dentures at a low cost and ease of manufacturing. These prostheses are primarily made from acrylic resin and fall under various types depending on the specific polymerization methods. In this study, we inspected two methods to fabricate maxillary complete dentures using a flasking method (heat cured) and a sprinkle-on method (cold cured). The methods consisted of similar steps before the differences in the methods occurred. The sprinkle-on method certainly demonstrated value due to the great stability of the denture as well as excellent adaptation to the ridge; however, the aesthetic aspect of the denture was poor, especially with the cold-cured acrylic. Furthermore, the cold-cured acrylic had produced some porosity and voids in the denture base. The flasking method was more time-consuming, as it required more equipment; however, the aesthetics of the denture were better and had fewer processing defects.
Keywords. Complete Denture, Hot Acrylic Resin, Cold Acrylic Resin, Sprinkle Method, Flasking Method.

Introduction

Regardless of the cause- aging, disease, or trauma- losing teeth is a publicly visible issue. A patient who is faced with tooth loss struggles greatly with treatment options that are both aesthetically appealing and functionally useful. Each treatment requires the dentist to evaluate the patient thoroughly through oral anatomy, health, and even expectations before deciding on a prosthetic option [1-3]. The available options for treatment include dental implants, bridges, and partial dentures. Removable complete dentures, as most of the therapeutic procedures' dentures for totally edentulous patients, remain the most cost-effective, along with a widely utilized option, dentures for ease of use. Part of the reason for the enduring popularity is that other parts of the armor denture enable such patients to attain brilliant denture bone and socket dentures. These have immensely enhanced the creation of polymer bases of acrylic dentures and chrome cobalt alloys for the past several decades [4-7].
A complete denture is a removable prosthesis that replaces all missing teeth in either the maxillary or mandibular arch [8,9]. Dentists should concentrate on creating high-quality dentures to enhance patient comfort and function [10]. Every stage of denture construction is important for acceptance. Effective retention is achieved through close mucosal contact of the denture base [11-13]. The success of a complete denture depends on various clinical and laboratory factors, especially its retention, stability, and comfort. Retention, in particular, is enhanced through close contact between the denture base and the mucosa, which relies on factors such as adhesion, cohesion, surface tension, salivary film consistency, and atmospheric pressure [12]. To meet these requirements, materials used for denture bases must possess ideal mechanical and biological properties. Polymethyl methacrylate (PMMA) is the most commonly used material due to its biocompatibility, ease of manipulation, affordability, and acceptable aesthetics [14]. However, PMMA can exhibit dimensional changes during polymerization, potentially affecting the fit of the denture base [15,16].
This study aimed to compare two fabrication methods for maxillary complete dentures—the flasking technique and the sprinkle-on technique—using different types of acrylic resins (heat-cured and cold-cured). The objective is to evaluate each method in terms of retention, aesthetics, and processing practicality, providing insight into optimizing denture fabrication for both clinicians and technicians.

Case Report

A 59-year-old man came to the clinic two years ago. He was already an experienced denture wearer. He wanted a new denture with the same design. All the upper teeth are missing. He is experiencing instability

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and poor oral hygiene, and he wants a new denture. His denture showed discoloration. Diagnoses showed that the patient had a U-shaped arch [12].

Flasking Technique (Heat-Cured Acrylic Resin)

First, take a first impression of the patient's mouth using special trays for edentulous patients. Pour the impression in dental stone while using a vibrator to remove bubbles. Next, construct custom trays based on the preliminary impressions to fit the patient's oral anatomy. Carve the bite rims for proper lip support and mark the position of incisal edges. Select the fitting tooth mold and shade for the patient. Then, mount both upper and lower master casts formed from the custom tray impression and bite rim measurements using an articulator to represent the patient's jaw relationship. Set the teeth according to functional and aesthetic requirements, adding wax around the teeth to form natural-looking gingival contours. After obtaining the clinician and patient approval during the try-in, flask the denture by securing the model with plaster in the bottom flask. When the plaster dries, apply a separating medium, place the upper flask, and fill it with additional plaster. Heat the flask till the wax melts, then flush it out, leaving the mold for acrylic filling. Improving the retention with a posterior palatal seal by drawing a line on the palate, extending approximately 2mm beyond the upper denture.

Mix the acrylic resin according to the manufacturer's instructions, pack it into the prepared mold, and compress it to remove air bubbles. Cure the denture for 1.5 hours and then place it in a water bath for 20 minutes. Deflask and clean the denture, then hand-finish it to eliminate excess acrylic. Finally, polish the denture with mops and paste to achieve a natural-looking luster. Figure 1 shows some steps of the flasking method.

Figure 1. Some steps of the flasking method.

Sprinkle-On Method

Prior to the sprinkle-on process, for two additional dentures, apply a separating agent to the cast so the acrylic does not stick to it. After that, syringe both cold and hot acrylic powder into the cast for each denture then pour the corresponding monomer. Careful repetition of this process will achieve the desired reinforcement to increase the thickness and strength of the denture. Ensure every layer is fully set before proceeding to the next step. After attaining the desired thickness, trim and shape the denture with dental instruments. Depending on the materials used, place the dentures in a curing unit or follow the suggested polymerization and final curing steps from the manufacturer. Once the dentures are completely cured, make adjustments to optimize fit, comfort, and aesthetics. Adjustments may entail trimming superficial excess denture material and refining the contours of the denture. Then, clean, smooth, glossy finish and polish the denture with dental polishing materials. Some steps of the sprinkle-on method are illustrated in Figure 2.

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Figure 2. Some steps of sprinkle on method

Discussion

The majority of dentists and technicians try to save time and effort and make dental prostheses in the shortest time possible, and they also want maximum precision with no mistakes [17]. In this study, two techniques of complete denture production were compared. Both of these techniques can provide high-quality complete dentures, and the selection is usually based on the preference, experience of the dentist or the laboratory, and the individual needs of the patient's case [18]. In addition, for a denture to become comfortable and retentive, the denture base material should fulfill some requirements to achieve satisfactory performance [14]. Both the technician and the dentist must observe that the material should be able to withstand occlusal loading, be workable, low in toxicity while being fabricated, biocompatible with the oral environment, dimensionally stable, radiopaque, and simple to repair [19]. On the other hand, from the patient's point of view, the denture must be comfortable, well-fitting, in no way traumatizing to the tissue, and simple to clean [20]. Be aesthetically satisfactory both immediately after insertion and in the longer term [21].

Flasking technique of full denture fabrication typically takes longer compared to the sprinkle-on technique, especially with heat-cured acrylic resins. The reason behind this extended duration is that the flasking procedure entails multiple steps such as investing, wax elimination, packing, and long polymerization. For example, conventional heat-cure resins are typically subjected to a polymerization cycle at 74°C for about 1.5 hours for the best adaptation and reduction of dimensional changes [22].

In contrast, the sprinkle-on technique employs self-cure (cold-cure) acrylic resins, which cure at room temperature, saving a lot of processing time. Nevertheless, it entails careful and gentle handling when applying the acrylic material onto the cast to avoid complications like porosity and uneven distribution. Hand layering in the sprinkle-on technique requires careful handling to achieve the integrity and fit of the completed denture [23, 24, 25]. It is interesting to point out that cold-cure acrylic resin, also referred to as self-curing or auto polymerizing acrylic, has a relatively shorter curing time than heat-cured acrylic [26]. Additionally, dentures fabricated by the flasking method were free of flash and porosity, and easily trimmed and polished. The polished surface and the inner unpolished surface were smooth, with no cleaning difficulty and without retention promotion or sequestration of secretions [24, 27, 28].

In the heat-curing method, polymerization of the monomer methyl methacrylate (MMA) for the production of polymethyl methacrylate (PMMA) is done by heating the mixture, typically in a water bath. Heat activates initiators like benzoyl peroxide to generate free radicals, which carry out the propagation of the chain reaction of the polymer. The process yields a dense and strong denture base with favorable mechanical properties [29].

In (Cold-Cure), chemically activated resins employ a tertiary amine, e.g., dimethyl-p-toluidine, to activate benzoyl peroxide at room temperature. This eliminates extrinsic sources of heat and is indicated for immediate repairs or temporary dentures. The polymerization is not as complete as in the heat-cured types, with possible implications on the strength and hardness of the material [30-33]. Both curing techniques are directed towards complete polymerization reaction, transforming monomers into a stable polymer network. This is a must in a bid to render the resulting denture to have the necessary hardness, strength, and biocompatibility for successful oral rehabilitation [14]. In addition, curing entails the use of heat and pressure or chemical initiators to activate the polymerization process in order to allow the monomers to be

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converted into a solid polymer. The process guarantees hardening of the denture material in order to attain the necessary physical properties [2,14,34].
Additionally, the sprinkle-on method provides fast creation of stable, precise, and firm record bases with uniform thickness that can be removed and reseated easily on the cast. The method also allows for easy creation of anatomically contoured occlusal rims to increase the stability of the record base. However, the rapid hardening process demands that the dental technician be effective and rapid in handling and pouring the cold-cure acrylic onto the denture cast [35, 36, 37]. As mentioned earlier, the flasking technique is well known in prosthodontics for the fabrication of denture bases with greater uniformity, density, dimensional stability, and strength. Various studies have evaluated the impact of various flasking techniques and materials on denture base quality [38].
[39] stated that the impact of flask-closure techniques and alteration of post-pressing waiting times on the adaptation of upper denture bases. Their results indicated that applying a clamp traditionally and an instant post-pressing period enhanced base adaptation for a heat-cure resin base. This seems to support that the flasking method can affect the interface and retention of the denture base [22].
As stated in 'Dental Laboratory Procedures: Complete Dentures,' the sprinkle-on technique may introduce some voids on the denture base plate that can weaken its structural integrity and reduce the hygienic conditions of the base plate. Using quality auto polymerizing resins while keeping the resin surface wet with monomer can improve the process. Also, covering the baseplate with an inverted plaster bowl or placing it in a humidor during polymerization can reduce surface voids. Moreover, pressure-pot curing is known for solving polymeamer dissolving porosity problems [40-43].
Furthermore, studies have shown that the ratio of powder to liquid in the resin mix significantly affects porosity. A higher powder-to-liquid ratio tends to produce a mass with less porosity, while an excess of liquid increases the tendency toward porosity in the finished product [44]. Figure 3 shows the porosity in the cold acrylic denture.

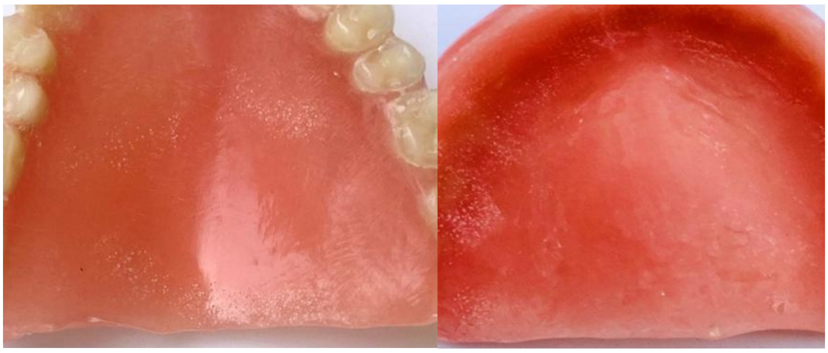

Figure 3. The porosity in the cold acrylic denture

In addition, the bonding between cold-curing acrylic resin and acrylic resin teeth increases tooth retention and makes denture bases more durable, since the plastic teeth become part of the denture base. Such bonding is attained by treating the necks of the teeth with a solution consisting of equal parts methylene chloride and cold-curing methyl methacrylate monomer [45].
This procedure is a combination of application of solvent to the dentures and polymerization bonding, with over 80% of the tensile strength of acrylic resin denture base materials achieved. Bonding was verified in experimental dentures consisting of compression-molded and pour-type poly(methyl methacrylate) [46].
The resin teeth were integrated into the denture as shown by their retention within the base. [47], stated that the bond was noted to be increased by increasing the temperature of polymerization, which allows for the diffusion of monomers into the acrylic teeth. Microscopy revealed that the interface between the polymer teeth and the heat-cured denture base polymer was diffuse, indicating a good interpenetrating polymer network [48]. Under stress, the fracture lines now take place inside the teeth and not at the interfaces between the tooth-denture bases as was the case earlier [49] .This method needs no more time or apparatus than is utilized with current laboratory methods.
Aesthetic variations among heat-cured and cold-cured acrylic resins in removable partial dentures have been reported in dental literature. Cold-cured acrylic resins, particularly those cured by the sprinkle technique, are said to be of poorer aesthetic quality than their heat-cured counterparts.
[50] compared and investigated the color stability of denture teeth fabricated using heat-cured and self-cured (cold-cured) acrylic resins. The result revealed that cold-cured acrylic resins exhibited significantly more discoloration with time, in comparison to heat-cured resins. This higher discoloration is caused by the

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higher residual monomer content and amine accelerator consumption in the cold-cured resins, which are susceptible to oxidation and thus cause color instability.

In addition, one of the articles in Dental Update explains the shortcomings of cold-cured PMMA as possessing much lower strength and compromised color stability through the oxidation of the amine accelerator. Heat-cured PMMA is favored, on the other hand, since it has better mechanical properties, as well as color stability [51]. Figure 4 shows the difference in color between in the tree dentures.

Figure 4. The difference in color between in the tree dentures

Cold-cured PMMA employs chemical initiators such as dimethyl-p-toluidine to activate benzoyl peroxide and initiate polymerization without the application of any external heat. The process features a significantly lower degree of polymerization than heat-cured PMMA, with greater quantities of residual unreacted methyl methacrylate (MMA) monomers [2]. The residual monomers tend to leach out, at the expense of mechanical properties like strength and hardness [52].

Quantitative differences in residual monomer content have also been quantified using research, and it was identified that cold-polymerized PMMA has around 5% residual MMA, and heat-polymerized PMMA has 0.2–0.5%. The fast polymerization at room temperature in cold-cured PMMA frequently generates a non-homogenized porous structure, which is the reason for the greater residual monomer content [53].

Influence on Mechanical Strength: Residual monomer plasticizes the polymer matrix, decreasing the interchange forces and allowing the material to be more easily deformed under load. The influence is more pronounced for cold-cured PMMA because of its greater residual monomer content; thus it has inferior mechanical properties compared to heat-cured PMMA [54,55]. The residual MMA content is greatly influenced by both the polymerization temperature and time. For instance, the curing temperature of auto polymerizing resins from 30°C to 60°C decreased the residual MMA content from 4.6 wt% average to 3.3 wt%. In the case of heat-cured resins, a curing cycle of 70°C with a step at 100°C greatly decreased the residual monomer content compared to curing at 70°C alone [53].

Actually, a lot of research has been done on the color stability of denture base acrylic resins, especially cold-cured (self-polymerized) resins. Compared to heat-cured acrylic resins, cold-cured acrylic resins are found to be more prone to color change over time [56]. This vulnerability is mostly caused by contamination of materials and the color stability of acrylic resins may suffer during the manufacturing process. Over time, these contaminants may interact with the resin matrix and cause discoloration.

Because of their lower degree of polymerization, cold-cured acrylic resins will have a higher residual monomer content. With time, the remaining unreacted monomers will seep out, causing optical alterations in the denture base that will eventually result in color changes [57, 58]. Discoloration may result from oxidation reactions caused by the use of tertiary amines as chemical accelerators in cold-cured resins, which can result in colored degradation products.

Compared to heat-cured resins, cold-cured resins may have a rougher surface texture and absorb more water. These traits may make it easier for pigments from food and drink to be absorbed, which would exacerbate color changes [59, 60]. Figure 5 shows the difference between the cold and hot acrylic resin is clearly.

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Figure 5. The difference between the cold and hot acrylic resins is clearly A show denture made by hot acrylic resin. B shows a denture made by cold acrylic resin

In investigations, various factors such as atmospheric pressure, adhesion, cohesion, and surface tension have been considered in retention studies, but [61] argue that much more emphasis has to be placed on good base adaptation and border seal to maintain the benefits of saliva flow.

This adaptation is due to several factors, which include laboratory and clinical procedures. Concerning laboratory techniques, denture base thickness is of paramount importance for dimensional stability and adaptability. [39], investigated the influence of various thicknesses of base on the processing of maxillary complete dentures. Maxillary complete dentures processed through differing base thickness. It was concluded that the bases of intermediate thickness (2.50 mm) showed the best stability while the thinner bases (1.25 mm) gave more tooth movement and dimensional changes during processing [62, 63, 64].

Moreover, the thickness of the denture base, material types, as well as packing and processing methods, are considerable variables that affect the final adaptation [65]. In the current study, the results indicated that the sprinkle-on technique yielded a better fit on the ridge compared to other methods because one of the advantages of the sprinkle-on method was its ability to reduce polymerization shrinkage, a common problem denture base fabrication suffers from, by applying the material in layers to reduce the internal stresses that distort the cure process, helping obtain a better fit of the denture base. [14], explained that polymerization shrinkage is a considerable factor that influences the clinical adaptation of denture bases, more so than the palatal vast majority identify. Moreover, the implications of approaches taken to limit shrinkage in the overall fit, retention, and comfort of complete dentures.

Among the methods, the sprinkle-on technique had significant advantages. The results suggested that the sprinkle-on technique had a superior adaptation of the denture base to the ridge and palate, compared to other processing methods. The study attributed improved fit to reductions in polymerization shrinkage, which generally occurs when items are cured. Consequently, the sprinkle-on method improves denture base adaptation through limiting shrinkage, ultimately contributing to superior denture performance and patient satisfaction [66, 67, 68, 69]. Figure 6 shows the vary in the thickness especially in the last portion of the base .

Figure 6. The variation in the thickness, especially in the last portion of the base

As mentioned earlier, the most important part in the fabrication of a complete denture is improving the retention [61]. Additionally, there are various methods to enhance retention, with some having significant impacts. For example, different types of spacers can be used. In this study, the sprinkle-on technique, while advantageous in certain aspects, poses challenges concerning spacer incorporation. This denture does not allow for spacers to be used, because of how it is applied; therefore, it might not be great at delivering cohesion in regards to allowing adequate adaptation to the underlying tissues. If there are uneven stresses

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because of an irregular denture base, this can place uneven tension on the tissues and affect the comfort or fit of the denture [70, 71]. On the other hand, it is possible to use spacers in the flask method of processing a denture. The flask method allows for greater control of where to specify spacers and the thickness of these spacers to adapt the denture base to the underlying tissues. The use of spacers with the flask method has been correlated with improved stress distribution and denture stability [72]. It was elaborated that spacers help distribute the forces on the denture uniformly through the stresses being distributed throughout the underlying tissues.

Conclusion

This investigation indicates that although the flasking and sprinkle-on systems are unique and separate approaches for the fabrication of complete dentures, they both have advantages and disadvantages. While the flasking technique is time-consuming and requires equipment, it shows enhanced aesthetics and surface quality. Contrastingly, the sprinkle-on methodology is less time-consuming and easier than the flasking route, providing adequate denture stability and fit across the denture ridge without much effort. The only issue with the sprinkle-on technique is the limitations of cold-cured acrylic aesthetically, and some limitations on spacer techniques. Ultimately, the route chosen by the technician should be based on the requirements of the clinical case being completed, the desired properties of the final prosthesis, and the technician's expertise. Future studies may compare the same two methods in terms of residual monomer content and explore alternative fabrication techniques, such as the injection molding method.

Conflict of interest. Nil

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