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Processing techniques of acrylic resin in removable and maxillofacial prosthesis: A review

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ABSTRACT

Compression molding with heat activation for resin polymerization is the conventional method for processing acrylic resin in removable and maxillofacial prosthesis. Overtime, different processing methods have been improved to overcome physical and chemical problems in cured resin with conventional technique. Enough knowledge about each method is necessary for both dentist and laboratory technician. The aim of this study is review the improved techniques for curing resin and comparison between them. An online search of PubMed, Scopus, Science Direct, and Google Scholar was conducted using key words "denture possessing technique" and "acrylic resins" from 1970 until September 2018. The most common and successful techniques are injection molding and conventional methods. CAD/CAM technologyis especially useful for maxillofacial prosthesis but still needs more studies.

Keywords: Denture possessing technique, Acrylic resins, Maxillofacial prosthesis, Removable prosthesis.

Introduction

Removable and maxillofacial prosthesis is used for patients to restore esthetic and function. Most of them are fabricated from poly methyl methacrylate resin (PMMA) with or without metal framework. Adequate materials and processing methods should have some requirements such as adequate resistance, hardness and strength, dimensional and color stability, easy cleansing and fabrication, non toxic and inexpensive [1].

Compression molding with heat activation for resin polymerization is the conventional method for processing acrylic resin. In this method after wax elimination, the dough is packed in the gypsum mold, and the flasks are placed under pressure in a water bath to initiate polymerization of the resin. This technique is more familiar for dental technician; however, there are some problems during and after resin polymerization such aspolymerization and thermal shrinkage, dimensional changes of denture bases and changes in occlusal vertical dimension. Dimensional changes are related to the different coefficients of thermal expansion of the acrylic resin and the gypsum matrix that result in an internal elastic stress in the cured base [2,3]. Therefore, different processing methods have been improved to reduce physical and chemical problems

in cured acrylic resin in denture bases and maxillofacial prosthesis. They should be fabricated with least dimensional changes, on the other hand maxillary obturators should be hollow to have less weight so choosing the suitable method for obtaining successful treatment outcome is important for both dentist and laboratory technician.

The aim of this study is review the literature for improved methods for processing acrylic resin and comparison between them. Among methods, five processing methods are most popular and more discussed in literature, including: Pour resin technique (Fluid.T), injection molding technique, light activated resin, microwave cured technique, CAD/CAM technique. However, up to our research no study has reviewed these five methods in a comparative way, so we focused on the articles that compared between at least two methods.

We reviewed the available papers discussing acrylic resin processing technique. An online search of PubMed, Scopus, Science Direct, and Google Scholar was conducted using key words "denture possessing technique" and "acrylic resins" and " maxillofacial prosthesis" and "removable prosthesis" from 1970 until September 2018. Studies with results not including the comparison or not peer reviewed were excluded.

Pour resin technique (Fluid.T)

The fluid resin technique, using chemically cured pourable acrylic resins with hydrocolloid molds, was developed in 1955. It has undergone various changes over time [4]. Nowadays, a new processing technique for fluid resin is introduced. Curing temperature is 45 C with a pressure chamber. It was claimed that warp age of the denture base is virtually eliminated and optimal translucency is provided. The most difference between these resins and the conventional chemically activated resins is the smaller size of the powder that results in a more fluid mix in first [1]. In this technique fluid mix poured into a reversible hydrocolloid mold. The good adaptation of denture base in this technique comes from atmospheric pressure around the mold because hydro-flask cut down the air trapping in the processed resin.

Other advantages are simplification of flasking, deflasking and finishing procedure. Decreased probability of damage to prosthetic teeth and denture bases during flasking. On the other hand disadvantages are noticeable shifting of prosthetic teeth during processing. Poor bonding between the denture base material & acrylic resin teeth and technique sensitivity [4,5].

Injection-molding technique

The injection-molding technique is introduced in 1942. In this technique denture base fabricated in aspecial flask. At first one half of flask is filled with dental stone & master cast is inserted in it, then sprues are attached to the wax denture base, flask is filled with freshly dental stone. After wax elimination the resin is injected in the mold cavity, then flask is placed in boiling water bath for polymerization of denture base resin. As it polymerizes, additional resin is injected into the mold cavity and reduced polymerization shrinkage [6]. The most advantage of this method is the constant injection pressure compensates for the gradual shrinkage of the acrylic resin as the denture base is cured under heat and pressure. It was resulting in denture bases that fit with a smaller degree of error [7]. Other advantages are: no need to open and press, the flask is resisted to corrosion, better accuracy and adaptation to underlying soft tissue, less changes in vertical dimension and reduced need for occlusal adjustment after processing, more strength and density in denture base [8]. Disadvantages are; high cost and technique sensitivity, some researcher reported nosignificant advantages over conventional method [6].

Light cured technique

This method composed of composite matrix of urethane dimethacrylate, micro fine silica & high molecular weight acrylic resin monomer that was activated with visible light camphorquinone as an initiator. At first put resin on the master cast in a light chamber with the visible light of 400 to 500nm for about 10 minutes. After initial curing of the resin base, the teeth are repositioned on the base using a light-cured template, followed by a final cure in the light chamber [1].

Advantages are:

- No allergy to PMMA (there isn't any methyl methacrylate monomer).

- Less polymerization shrinkage than conventional resins.

- Good adaptation to the underlying tissues.

Disadvantages are

- Deformation of the dentures during function.

- Inferior bond strength of VLC resins to resin denture.

- Some concerns about biocompatibility of VLC denture base resins [1].

Microwave activated resin

It was introduced in 1968, use of resin materials with microwave activation. The procedure was improved with a special glass fiber-reinforced plastic flask [9]. The resin is mixed and exposed to radio waves with a short curing cycle of about 3 minutes at 500 to 600 W/cycle. As the degree of polymerization increases, monomer content decreases proportionally. This technique has some advantages; it is cleaner, denture tooth movements is lower, equal distribution of temperature throughout the resin and gypsum mold, and increased homogeneity of the dough. Disadvantages are high equipment expenses and fragility of the plastic flasks [8].

CAD/CAM technique

Use of CAD/CAM for processing denture can be done in two types: additive (RP) or subtractive (milling). Subtractive technique is done by milling from a block by a CNC machine. The CAM software automatically transfers the CAD model into tool path for the CNC machine [10]. In RP physical models is build upfrom three-dimensional electronic information by layered manufacturing. Advantages are reduced treatment sessions, use of pre-polymerized acrylic resin, decreased shrinkage, increase strength and fit of dentures, also ability to form complex anatomic features especially in maxillofacial prosthesis. Disadvantages are some challenges due to impression-taking and OVD recording procedures and maintenance of lip support and mandibular occlusal plane, which are same as conventional process, expensive materials and increased laboratory cost [11,12].

Discussion

Different methods of processing denture base were devised to overcome the problems of the conventional method, however each of these methods has some disadvantages that make it difficult for dentist or technician to choose. Antonopoulos et al. compared the fluid resin dentures with the dentures constructed by the compression-molding heat-curing technique and found the fluid resin complete dentures underwent larger dimensional changes than the conventionally processed heat-cured dentures [13]. Al-Aaloosi et al. found that linear dimensional changes in fluid resin is less than heat-cured resins but decrease in vertical dimension of occlusion still exists as a disadvantage of the fluid resin systems [5]. Articles related to this method were limited to the 1980s, and practically this method did not attract much support. Gharachahi et al. found significant difference in flexural strength of injection-molded acrylic resin that was higher than conventional method [8]. They also resulted in a higher dimensional accuracy in injection molded technique compared to conventional molding [6]. Sykora et al. reported higher dimensional accuracy for injection-molding technique, in comparison to the conventional method and determined that was related to smaller resin particles compared to the conventional acrylic resin and lower polymerization temperature [14], Nagaviro et al. demonstrated that dimensional change of the injection molding material after processing was less than compression molding material. They also suggested that long curing procedure provided less dimensional change [16]. Parvizi et al found that linear dimensional changes of conventionally resin is superior than injection molded denture base materials [7]. Chintalacheruvu found injection molding techniques exhibited less processing errors as compared to compression molding technique with statistical significance [17]. However Keenan et al found little advantage of injection molding toward conventional compression molding [15].

Today, injection molding technique is very popular, and companies offer a variety of advanced devices and equipment for this method. Some of examples are: Swiss Jet (Heat & Self cure), Success (Heat cure), Ivocap (high impact/ Heat cure), Ivoabase (Ivobase hybrid or Ivobase high impact/Self cure), Deflex (Polyamid or Self cure). Ali et al showed that light and heat-cured PMMA has significantly higher surface hardness, flexural strength, and flexural modulus than heat-only cured and self-cured denture base systems [18].

Hashem et al demonstrated that light cured has better mechanical properties including flexural, tensile and compressive strength than conventional heat cured acrylic resin [19]. This technique also failed to find a higher position than conventional technique and is limited to repair condition because of some problems such as deformation of the dentures during functionand Inferior bond strength of VLC resins to resin denture [1,20]. Nelson et al investigated the vertical dimension of occlusion in complete dentures after processing with conventional and microwave procedures. It was less than 1 mm in both methods and is clinically

acceptable [21]. Jadhav et al found microwave PMMA has higher impact strength than conventional PMMA [22]. However Al-Dobaei et al concluded microwave curing technique increased the flexural strength of the acrylic resin but reduced its impact strength [23]. Compagnoni reported same porosity between microwave and conventional heat-polymerized denture base resin. Although studies on this technique continue, but because of the expensive equipment, microwave technique could not be used as a routine in laboratories [24].

Goodacre et al compared the conventional technique with pour, injection, and CAD-CA mtechniques and found the most accuracy for CAD-CAM fabrication technique [25]. They also demonstrated that tooth movement is detectable for all processing technique. However, CAD-CAM monolithic technique has the high reproducibility, followed by pack-and-press, CAD-CAM-bonded, injection, and fluid resin [26]. Computer-aided technology for complete dentures is in advanced. However, more prospective clinical trials are necessary to validate this technology [11].

Uzun et al ranked the transverse strength of 4 acrylic resins as high to low respectively: Microwave-cured acrylic resin ≥ Heat-cured resins ≥ self cured resin ≥ visible light-cured acrylic resin showed the lowest [27]. Jorge et al indicated that autopolymerized resins are more cytotoxic than the heat-polymerized denture base resins and microwave cured resinhas least cytotoxicity, probably because of less content of monomers. Increasing the polymerization time inlight cured resin may decrease resin toxicity [28].

Some studies demonstrated that heat activated resins produced higher bond strength to denture teeth than the microwave activated, visible light cure, pour-type or self cure acrylic resins [29-33]. Nevertheless another studies indicated higher bond strengths with microwave activated resin than with the heat-activated resins and recommended use of bonding agent with a visible light-cure resin [34-36].

Conclusion

Few studies have compared all types and techniques of resin processing in terms of cytotoxicity, color stability, bond and fracture strength at the present time. The most common and successful techniques are Injection molding and conventional methods. CAD/CAM technology is especially useful for maxillofacial prosthesis but it still needs more studies.

Conflict of Interest

There is no conflict of interest to declare.

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