CAD/CAM Denture Base Materials

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The data about bond strength between digitally produced denture base resins and artificial teeth are scarce. No statistical differences between heat-polymerized and CAD/CAM (milled) denture base materials when attached with different types of artificial teeth, while one study showed higher values of CAD/CAM (milled) denture base materials. Bonding agents ensure bonding strength at least similar to the conventional methods. In order to improve the quality of future studies, it would be advantageous to use a larger number of specimens with standardized dimensions and a blinded testing machine operator to decrease the risk of bias.

Keywords: dentures ; CAD/CAM ; artificial teeth

1. Introduction

Edentulism is defined as a complete absence of teeth and is considered a disability by the World Health Organization (WHO) [1]. The prevalence of reported causes for tooth loss is as follows: caries (36.0% to 55.3%); periodontitis (24.8% to 38.1%); trauma (0.8% to 4.4%), periapical disease (7.3% to 19.1%); orthodontics (2.5% to 7.2%); and other reasons (4.5% to 9.2%) [2]. Following tooth loss, the underlying bone continues to resorb, and there are changes to patients' facial appearance and facial height [3]. Moreover, elderly people who wear complete dentures are more likely to experience denture stomatitis, an inflammatory condition of the palatal mucosa, as well as angular cheilitis, oral candidosis, and traumatic ulcers [3]. Dental health has a significant impact on quality of life; edentulism negatively affects patients' quality of life because it decreases chewing capacity, enervates phonetics, and impairs aesthetics [4]. The loss of chewing efficacy can result in a decreased intake of food (e.g., vegetables and fruit), which could lead to malnutrition. Simultaneously, edentulous patients cannot meet dietary recommendations [5]. In addition, edentulism can be connected with several systematic conditions such as pneumonia, adiposity, neck and head carcinoma, and a higher risk of mortality [1]. Studies showed different prevalences of edentulism. Females have higher prevalence of edentulism when compared to males, especially females with poor profit and lower degree of education [6]. In a review, Polzer et al. [7] determined that the prevalence of edentulism ranges from 1.3% to 78% for people aged 65 and older. Inter- and intracountry differences in the prevalence of edentulism exist, but comparison between nations is challenging because of different factors (e.g., erudition, economical instance, dental health competence, and beliefs and attitudes towards oral health) which can influence the outcome [3][8]. Manifestations of edentulism are constantly falling in developed countries, whilst in developing countries, the opposite trend has been observed [9]. Nevertheless, a study by Douglass et al. [10] showed increasing edentulism as a result of aging and longer life expectancy. The higher number of elderly people could be caused by demographic changes which can be seen in the majority of countries [11]. A total of 703 million people worldwide are aged 65 years and above, and it is predicted that the given number will double by 2050.

Complete dentures have been used for many years and are considered the gold standard for treating patients with this condition [4][7][12][13][14]. Although other types of prosthodontic solutions for edentulism are accessible, such as implant-supported dentures, most patients decide to wear conventional ones, mainly because of financial causes [15][16][17]. Until today, polymethyl methacrylate (PMMA) has remained the most accepted denture base resin [18][19]. PMMA conforms to some of the requirements for a perfect denture base resin, which include easy mending, optimal appearance, and a tolerable price [13][20]. Common manipulation is also one of the advantages and is started by mixing methyl methacrylate (monomer) and polymethyl methacrylate (polymer) [18]. The polymerization process of a given type of PMMA (heat-polymerized resin) is terminated after a certain exposure time to heat. Despite all the advantages, polymerization shrinkage of 6% can be interpreted as the main disadvantage [18]. Moreover, the chemical reaction between methyl methacrylate and polymethyl methacrylate is never complete. Leftovers of the residual monomer after the polymerization process can modify the mechanical properties of the material and cause allergic reactions (e.g., oedema, stomatitis, and ulcerations) [18][21].

Bonding between the denture base material and the artificial teeth is imperative for completeness of dentures and patient's quality of life. Resin artificial teeth are used more frequently when compared to porcelain ones because of the chemical bonding that occurs and simple occlusal adaptation [22]. Furthermore, resin denture teeth are persistent to thermal changes and are less pervious to fracture under impact [22].

2. Shear Bond Strength between Milled Denture Base Materials and Artificial Teeth

The effects of complete tooth loss can be minimized through rehabilitation with dental prostheses, which is the most cost-effective and most widely used treatment. Modifications in the orofacial muscles, combined with the necessary prosthodontic rehabilitation, repair impaired self-esteem and improve confidence by renewing the patient's appearance [23].

Shear bond strength is the strength between two materials, and it shows how much each material resists the load before it fractures under a shear force [24][25]. Considering the fact that debonding can occur between denture base resins and an artificial tooth for different reasons, shear bond strength values should be as high as possible [24]. Generally, the shear bond strength test is standardly used for investigating the bond strength between denture base resin and artificial tooth resin [4][24][26][27][28][29]. Apart from the shear bond strength testing, some other testing procedures are available. Flexural bond strength (FBS) testing represents a novel method for the measurement of bond strength [30]. However, not enough studies have been conducted so far regarding flexural bond strength as a new testing modality [30]. Shear bond strength testing is most widely used because of its simplicity and ease of specimen preparation—no additional treatment of specimens is required after the bonding proceeding [31][32]. Considering the fact that the crosshead speed of the universal testing machine has an impact on shear bond strength values, the recommended crosshead speed is set between 0.45 and 1.05 mm/min [33], which all included studies accomplished.

The reported values of shear bond strength between denture base resins and artificial teeth vary [27][28][34][35][36][37]. This could be credited to the absence of standardization of testing methods as well as the variety of denture base materials available on the market [24]. The literature agrees that with different types of denture base materials (cold-polymerized, heat-polymerized, microwave-polymerized, light-polymerized, and others) differences in shear bond strength values to prefabricated denture teeth can be expected [27][35]. Studies also showed that different types/materials of prefabricated denture teeth can have different shear bond strengths with denture base resin. When comparing monomer diffusion between heat-polymerized denture base resin and different types of artificial teeth during the bonding procedure, it could be noted that the diffusion rate is higher in acrylic teeth in comparison with cross-linked and composite teeth [26]. Since acrylic teeth can chemically bond to heat-polymerized denture base resin via high monomer diffusion, high shear bond strength values are foreseen [24][38]. To achieve adequate chemical bonding, as with a milled denture base, different bonding agents are applied [24][39][40][41][42]. In a systematic review of bonding to CAD/CAM indirect resin materials, Mine et al. [42] concluded that the appliance of methyl methacrylate adhesives enhances the bonding of CAD/CAM (milled) materials.

A review of recent studies showed different results for the shear bond strength between CAD/CAM (milled) denture base resins and artificial teeth and control groups (heat-polymerized denture base resins and artificial teeth). In a study by Prpić et al. [24] and a study by Han et al. [26], shear bond strength values between (different) denture teeth and CAD/CAM (milled) denture base resin had comparable results to the same teeth connected with heat-polymerized denture base resin. Prpić et al. [24] compared the shear bond strength values of different types of artificial teeth (acrylic, nanohybrid composite, and cross-linked) attached to CAD/CAM (milled) denture base resin. Similarly, Han et al. [26] examined shear bond strength values between CAD/CAM (milled) denture base resins and composites with fillers and cross-linked teeth. Both studies used bonding agents for attaching teeth to milled denture base material and had a control group with heat-polymerized resin. Contrary to these studies by Prpić et al. [24] and Han et al. [26], Helal et al. [4] reported higher shear bond strength values between CAD/CAM (milled) denture base resin and two types of denture teeth (acrylic and composite) when compared to conventional heat-polymerized acrylics. This can be interpreted by the volumetric shrinkage reported in heat-polymerized acrylics, which could decrease shear bond strength values [4]. Still, the determined results of studies agree that the use of a bonding agent is at least comparable to the conventional method (compression moulding technique).

As follows from the previous paragraph, two studies [24][26] indicated that no statistical differences were observed between heat-polymerized and CAD/CAM (milled) denture base materials when attached to different types of artificial teeth, and one study showed higher values for CAD/CAM (milled) denture base materials [4]. Conventional hot water/bath polymerization represents the most effective and eligible procedure for denture fabrication as well as for bonding artificial

teeth to denture base material [43]. Considering this fact, shear bond strength values between CAD/CAM (milled) denture base materials and denture teeth comparable to the conventional method can be considered a success. In other words, currently available bonding agents used to achieve optimal bonding between CAD/CAM (milled) denture base materials and artificial teeth demonstrate high shear bond strength values, equivalent to the bonding values between conventional denture base materials and artificial teeth [24].

Traditional fabrication techniques for removable dental prostheses are well known and are still frequently used in clinical practice today. These traditional complete denture protocols require multiple patient visits as well as extensive chairside and laboratory time [44]. Recent advancements have made it possible to incorporate computer-aided design and manufacturing (CAD/CAM) technologies into the complete denture manufacturing process. The constant evolution and improvement of technology has resulted in an exponential increase in the number of providers and systems available on the market today [44]. Some studies indicate that complete dentures produced using CAD/CAM (milled) technologies are as accurate as, or better than, conventionally produced dentures and have better material properties [45][46][47]. Moreover, high levels of patient satisfaction with digitally produced dentures have been reported [48][49]. To conclude, stomatognathic system harmony and overall health can efficiently be re-established with complete dentures, [23] and it is expected that digital technologies will provide even more efficient therapy in the future.

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