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Review

Review of adhesive techniques used in removable prosthodontic practice

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Abstract: There are several benefits in using adhesive technique in removable prosthodontics as well as fixed prosthodontics. Previous studies have examined denture-base surface treatments that improve bond strength between a denture base resin and autopolymerizing repair resin. Dichloromethane and ethyl acetate are organic solvents that swell the denture base surface, thereby permitting diffusion of the acrylic resin. The optimal treatment duration is 5-10 s for dichloromethane and 120 s for ethyl acetate. It was reported that the bond durability of dichloromethane was superior to that of ethyl acetate. Bonding between metal components and the denture base resin has an important role in the longevity of removable prostheses. The combination of metal conditioners and alumina air-abrasion is effective in fabricating and repairing removable dentures. Acidic monomers (4-META and MDP) are appropriate for base metal alloys, including Co-Cr alloy and titanium alloy, while thione monomers (MTU-6 and VBATDT) are suitable for noble metal alloys such as gold alloy and silver-palladium-copper-gold (Ag-Pd-Cu-Au) alloy. As an alternative to conventional restorations, resin-bonded restorations can provide precisely parallel guide planes with well-made rest seats. Careful consideration should be paid to stabilizing loosened teeth by fixing them with resin-bonded splints or fixed partial dentures. (J Oral Sci 54, 205-211, 2012)

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Introduction

Since approximately the year 2000, dental practice in operative dentistry and fixed prosthodontics has dramatically changed due to both the introduction of the concept of minimal intervention (1) in dental tissues and advances in adhesive techniques. These new materials and techniques have led to the popularity of resin-bonded fixed partial dentures (2-4), resin-bonded splints (5), and cementation of ceramic restorations (6,7), porcelain veneers, (8) and zirconia-based restorations (9). Adhesive techniques may also be useful in some aspects of removable prosthodontics, including chemical bonding of denture components. The effect of surface treatments on bond strength between repair or reline acrylic resin and a denture base resin has been evaluated (10-26), and some clinical procedures using these treatments have been reported (27,28). It is well known that significantly greater force is necessary to separate acrylic denture base resin or repair resin from metal frameworks that have been treated with metal conditioners (29-36). In addition, by using adhesive techniques based on the concept of minimum intervention, precise preparation of clasped teeth for removable partial dentures is possible, as in fixed prosthodontics (37-45).

The present article reviews the literature and clinical cases relevant to adhesive techniques used in removable prosthodontic practice. This review consists of three topics: surface treatments for denture base resin, surface treatments for metal components of removable dentures, and precise preparation of clasped teeth.

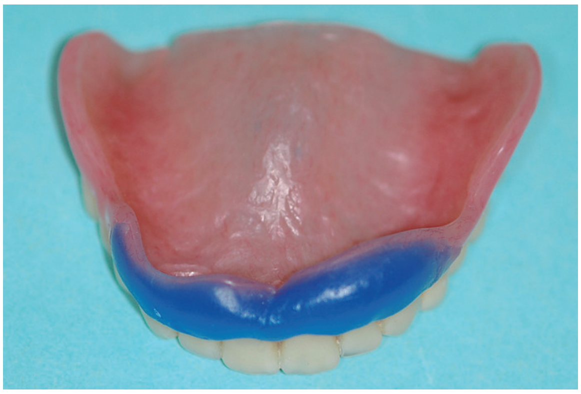

Fig. 1 Completed flange for the anterior gingival region, using softened wax.

Fig. 2 The surface of the region where the softened wax was added is treated with ethyl acetate for 120 s.

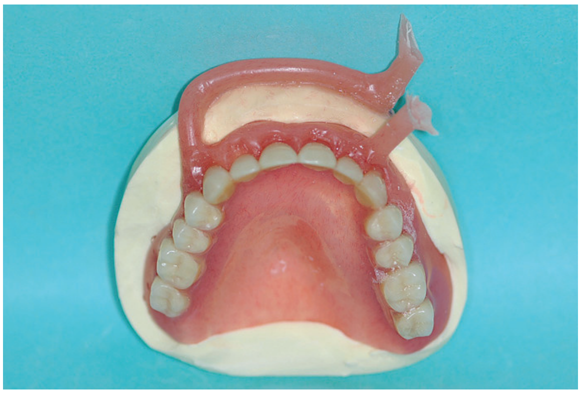

Fig. 3 After polymerization, the silicone mold is removed and the denture is retrieved.

Fig. 4 The final form of the denture is perfected by cutting the sprues and polishing.

Surface treatments for denture base resin

Without any surface treatment, repaired denture bases frequently fracture at the interface of the denture base and the repair materials rather than within these materials. This strongly suggests that there is a poor bond between autopolymerizing repair resins and the denture base resin. Although the mucosal surface of the denture base is quite smooth immediately after a direct reline, the long-term outcomes of partially debonded direct reline materials are occasionally catastrophic. Therefore, some products include an adhesive material to aid in direct relines. The main component of adhesive materials for repair or reline using acrylic resin is usually dichloromethane (i.e., methylene chloride) (10-13,15,18,19,22,23,27) or ethyl acetate (17,20,21,24,28). Both are organic, nonpolymerizable solvents that swell the surface and permit the acrylic resin to diffuse. Chloroform (14), methyl formate, methyl acetate (25), and methyl-methacrylate (14,26) are also occasionally applied.

Dichloromethane has been used in industrial processes, food preparation, and agriculture. However, it has been the subject of toxicological and carcinogenic research and was assumed to be a human carcinogen based on evidence of carcinogenicity in several animal studies (46-50). Therefore, ethyl acetate has recently been viewed as the safer surface preparation.

A suitably treated surface will significantly improve bonding to direct reline resin or autopolymerizing repair resin. There are optimal treatment durations for each material, e.g., 5-10 s for dichloromethane (18). Furthermore, air-abrasion with 50-µm alumina, followed by application of dichloromethane, increases bond strength to a heat-processed denture base resin material when the fracture site is repaired with an autopolymerizing acrylic repair resin (18). It was reported that a 120-s surface application of ethyl acetate enhanced bond strength between autopolymerizing acrylic repair resin and denture base resin (20,21). However, this treatment duration is clinically protracted. In addition, the bond durability of this preparation was inferior to that of conventional dichloromethane application (21). Both dichloromethane and ethyl acetate are available for denture repair (22,27),

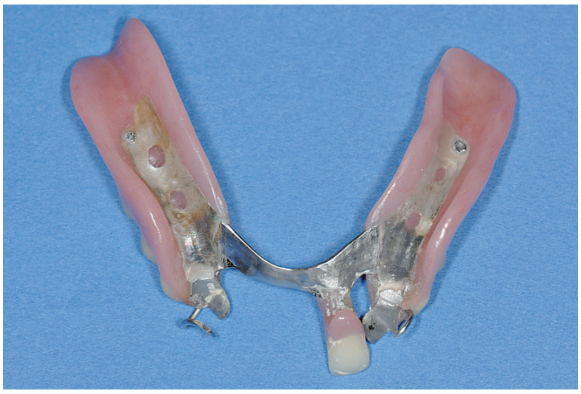

Fig. 5 Lack of bonding at the metal–resin interface resulted in discoloration and staining of margins.

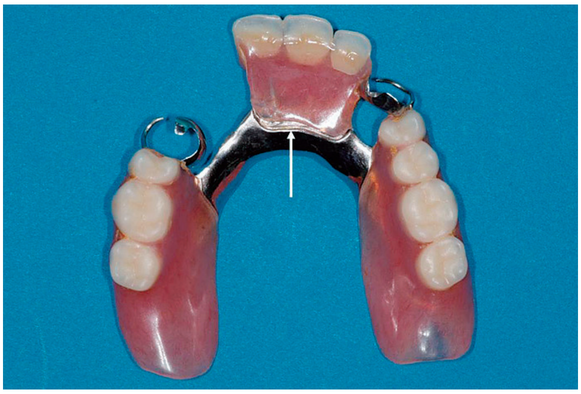

Fig. 6 Lack of bonding at the metal–resin interface in the anterior region resulted in loosening of the denture base from the framework (arrow).

Fig. 7 Lack of bonding at the metal–resin interface resulted in fracture of the denture base.

Fig. 8 For repair of a removable denture, Co–Cr wrought wire was air-abraded with alumina particles, after which a metal conditioner was applied (Alloy Primer, Kuraray Noritake Dental Inc., Tokyo, Japan).

direct or indirect reline (13,16,17,23,24), and build-up of lip support (28) (Figs. 1-4). It is important to remember that when ethyl acetate is used clinically, it must be applied repeatedly for up to 120 s because of its high volatility. Additional in vitro and clinical research is necessary to determine the effects of organic solvents on bonding of repair resin to denture base resin, as a new, more effective treatment would be very beneficial.

Surface treatments for metal components of removable dentures

Microleakage can result from lack of bonding or poor chemical bonding between the denture base resin and the cast metal framework of a removable partial denture or the metal base of a complete denture. This may cause discoloration and staining of the margins at the metal–resin interface (Fig. 5), as well as potential adhesive failure if the resin loosens from the framework (Figs. 6 and 7). Therefore, it is desirable to achieve durable bonding between the metal framework of removable dentures and the denture base resin, autopolymerizing repair resin, and reline resin (in some cases).

Studies have evaluated the bond strength between Co-Cr alloy and denture base resins, including 4-methacryloyloxyethyl trimellitate anhydride (4-META), one of the most well-known functional monomers (29,30). Recently, the bond strength of denture base resin to cast commercially pure titanium (31,36) and titanium alloy (31,32,34) treated with metal conditioners was compared with the strength of the bond to Co-Cr alloy. The application to base metal alloys of metal conditioners containing functional monomers designed for bonding, such as 4-META and 10-methacryloyloxydecyl dihydrogen phosphate (MDP), significantly increased the bond strengths of a denture base resin to the titanium alloys and Co-Cr alloy (Fig. 8). However, the durability of the bond to titanium alloy was inferior to that of Co-Cr alloy (32). This indicates that the bond durability of an autopolymerizing resin to titanium alloy is inferior to that of a composite material designed for fixed prostheses (51), which may

Fig. 9 Casting with a well-made cingulum rest seat and a precise guide plane.

Fig. 10 Stabilizing loosened second premolar by fixation, using resin-bonded fixed partial denture with mesial occlusal rest seat and a surveyed guide plane for a removable partial denture.

be due to differences in their chemical composition, polymerization procedure, and/or mechanical properties.

A previous study reported the bond strengths of denture base resin to modified Au-Pd, Au-Ag-Pd-Cu, and a few other alloys used in fabricating metal frameworks for hybrid implant prostheses (52). However, there is little information on the bonding of the dental gold alloy used in the metal frameworks of removable prostheses to denture base resin with metal conditioners (33,34). Thiol-derivative conditioners, which contain 6-methacryloyloxyhexyl 2-thiouracil-5-carboxylate (MTU-6) or 6-(4-vinylbenzyl-*n*-propyl)amino-1,3,5-triazine-2,4-dithione, -dithiol tautomer (VBATDT), significantly enhance the bond strength of 4-META/MMA-TBB resin to Ag-Pd-Cu-Au alloy (53). The sulfur in thiol-derivative conditioners can improve the bond strength of denture base resin to cast gold alloy (33). The fact that there was no decrease in bond strength when a sulfur-based metal conditioner was used suggests that this type of metal conditioner is appropriate for bonding denture base resin to a cast gold alloy. This conclusion agrees with data from a study in which a resin composite veneering material was bonded to a gold alloy (54).

An effective method for repairing fractured denture base resin involved 1) the use of reinforcement metal air-abraded with 50-µm alumina, followed by application of a metal conditioner designed for bonding dental alloys, and 2) concurrent application of dichloromethane or ethyl acetate to the denture base resin (22). This treatment procedure shows the capacity to synergistically reinforce the metal and surface preparation of the denture base resin. Another study reported a procedure to repair a removable partial denture with a fractured metal major connector, which allowed the repaired denture to be worn using a cast, staple-shaped splint and metal adhesive system including 4-META/MMA-TBB resin (27). This procedure allows patients to retain the function of their current dentures until new dentures are fabricated and does not require a laser welding apparatus. It is a versatile option for the repair of a dental metal prosthesis, such as the metal components of a removable denture, but clinical uptake has been limited due to its high price. However, the adhesive procedure should be restricted to interim treatments during completion of a new denture, since the bond strength of dental alloy to adhesive luting cements, or to denture base resin, is much lower than the tensile strength of removable partial denture alloys (55).

Precise preparation of clasped teeth

Proper rest seats and precisely parallel guide planes should be provided on abutment teeth to supply vertical support and bracing or reciprocal stabilization of removable partial dentures (56). Wong et al. described a technique to adhere lingual rest seats to anterior teeth, using prefabricated stainless steel foil-mesh pads with an orthodontic bracket bonding system (37). However, in removable prosthodontics, the foil-mesh pads do not supply bracing, due to the lack of guide planes. After publication of that study, resin-bonded cingulum rest seats were suggested as an alternative to conventional cast restorations (37-45). An extended follow-up study of electrochemically etched nonprecious metal castings bonded to enamel for use in mouth preparation procedures for removable partial denture placement found that bond strengths were sufficient to support clinical function of the castings and removable partial dentures (41). Recently, some clinical data indicate that the combination of resin-bonded noble metal alloy castings and a noble metal adhesive system was successful for removable prosthodontic treatments (43,45) (Fig. 9). In this procedure, vertical grooves at the proximal planes are necessary for mechanical retention. The lingual rest seat, like the cingulum groove for the canine and the occlusal rest seat for the premolar, must be prepared in order to receive the applied occlusal force. An additional pinhole can be drilled in the lingual ledge for the canine (42).

Alfonso et al. (57) described a technique for using composite resin with a combination of a vacuum-formed template matrix and light-polymerization source to create desirable contours on abutment teeth so as to retain and support removable partial dentures. Another study described using highly filled composite resin partial-coverage restorations in a clinical procedure for abutment preparations of removable partial dentures. The procedure requires minimal intervention and results in favorable esthetics (44).

A troublesome problem in removable partial dentures associated with clasped teeth is pathological mobility of loosened abutment teeth. The most reliable treatment to stabilize loosened teeth is cementing of cast splints comprising multiple full-coverage restorations. However, substantial tooth reduction is necessary if this procedure is to be successful. In such situations, a resin-bonded cast splint is preferable, as it requires minimal intervention in intact teeth. Nevertheless, considerable attention is need in stabilizing loosened teeth by fixing them with resin-bonded splints or fixed partial dentures with rest seats and surveyed guide planes (Fig. 10). The mobility of abutment teeth is a critical factor in the outcome of resin-bonded fixed partial dentures (58). In fact, resin-bonded fixed partial dentures without any retentive preparation form on each abutment tooth resulted in a significantly higher failure rate (59). In summary, the application of a splinting device without tooth preparation appears to be inadequate, although minimal intervention remains an important therapeutic goal. Retentive structures should be used as a last resort to extend the life of the mobile abutment tooth and the service period of the splinting device (42,45).

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