Current Status of the Use of Resin-bonded Attachments for Removable Partial Dentures: A Review of the Literature

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Abstract

Removable partial dentures (RPDs) are effective treatment modalities for patients with reduced dentition. To enhance the retention and stability of RPD, retentive clasps are used to engage the undercuts of the existing teeth. An alternative oral rehabilitation solution that satisfies the functional and aesthetic demands of the patients is the use of extra-coronal attachment-retained or implant-assisted RPD. Moreover, resin-bonded attachments (RBAs) have emerged as a minimally invasive solution with a fail-safe advantage that offers reparability. Despite having several advantages, such as better retention and esthetics, there is no comprehensive review regarding the clinical application of RBA, including the methods, drawbacks, and current research in dental literature. Our narrative review aims to provide a comprehensive synthesis and qualitative analysis of the use of RBAs. We conducted a comprehensive search of databases such as PubMed and Medline from 1990 to 2024. Furthermore, the snowballing method was employed, where one reference led to the identification of additional relevant articles to be included in the review process. This review will serve as a guide for clinicians seeking advanced prosthodontic treatment to meet the functional and esthetic needs of partially edentulous patients.

Keywords: Resin-bonded attachment, Removable partial denture, Extra-coronal attachment, Precision attachment

1. Introduction

Tooth loss is a chronic condition that prevents patients from carrying out functions such as mastication, speech, and aesthetics. Several studies have evaluated and identified the recent advancements in prosthodontic materials and treatment methodologies (1). Among them, removable partial dentures (RPDs) offer an effective treatment modality for patients with fewer teeth, and clinical studies have proven that they have been a successful long-term treatment option for many years (2).

The clasps of conventional RPDs, typically made of cobalt-chrome (CoCr), titanium metal, or plastic, engage the undercuts of the existing teeth, enhancing stability and retention (3, 4). Metal clasps have deformation in the long term, decreased direct retention, fatigue failure, and an unesthetic appearance. Moreover,

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large undercuts are more likely to cause extra stress on the abutment tooth, and the abrasion process takes place due to friction during the insertion and removal of the RPDs. This abrasion to the abutment tooth is more pronounced with stiffer material. Consequently, these disadvantages can cause patients discomfort and potential tooth damage (5, 6).

A recent systematic review reported high satisfaction rates, ranging from 50% to 81%, among RPD wearers. Patients with several missing teeth, particularly in the mandible, reported lower satisfaction, indicating the importance of denture stability and comfort (7). RPDs might appear noticeably unnatural, necessitating a focus on restoring aesthetics in a way that provides long-term benefits (8). An alternative rehabilitation method that satisfies the functional and esthetic demands of the patients is the use of implant-assisted or extra-coronal attachment-retained RPDs (6).

Attachments such as magnetic attachments used in implant-assisted RPDs can improve patient satisfaction, indicating the potential benefits of using advanced prosthodontic techniques (7). Despite having some benefits over conventional RPD, implant treatment is potentially influenced by several systemic diseases and local conditions (9), and the cost of implant-assisted RPD remains substantially higher (10). Therefore, quality of life and expected lifespan are necessary to be considered in the cost-benefit analysis when treating patients with systemic conditions (9).

Precision attachments offer enhanced aesthetics and allow the adjustment of retention, which are advantages over clasp-retained RDPs (6), and a higher level of patient satisfaction is reported for RPD with attachments compared to RPD with conventional clasps (11). However, conventional attachment-retained RPDs attached to the crowns often fail due to abutment tooth fractures, with free-end situations increasing the risk of such fractures (12).

The resin-bonded attachments (RBAs) have been known as a minimally invasive option for RPDs since the mid-1980s (13–16). Unlike conventional RDP attachment methods such as telescopic crowns or precision attachments fixed to conventional crowns, RBAs offer a minimally invasive treatment option if the abutment teeth have enough enamel for optimal bonding (17–20). As the geriatric population grows, the percentage of patients with edentulous or partially edentulous jaws will increase (1). Furthermore, more people are likely to retain their teeth, indicating a growing need for a minimally invasive treatment option for the elderly population. Despite having several advantages, there is no comprehensive review regarding the clinical application of RBA, including the methods, drawbacks, and current research in the dental literature.

Our narrative review aims to provide a comprehensive synthesis and qualitative analysis of the use of RBAs based on literature from 1990–2024. We conducted a comprehensive search of databases such as PubMed and Medline using keywords such as "RBA," "resin-bonded attachment," "precision attachments," and "extra coronal attachment." Relevant studies that meet the goals of the studies were selected. Furthermore, the snowballing method was employed, where one reference led to another article to include more studies in this review. The present narrative review provides an overview of the current state of the art regarding RBAs and RPDs as a long-term treatment option. Our review will serve as a guide for clinicians seeking advanced prosthodontic treatment for partially edentulous patients to meet their functional and aesthetic needs.

2. Preparation Design for RBAs

The clinical workflows of resin-bonded fixed dental prostheses (RBFDPs) and RBAs for RDPs have significant similarities (21). The design of the preparation is based on general preparation guidelines for RBFDPs (11, 16). Typically, a non-retentive tooth preparation is distinguished from a retentive tooth preparation, which involves the use of grooves and pinholes (23).

The retainer wing of the premolar is prepared by extending it from the mesial-vestibular area over the occlusal surface to the lingual side.

The preparation of the canine often involves the entire palatal surface, extending distally into the proximal region. The preparation consists of the creation of a palatal veneer preparation, a fine incisal finishing shoulder, a fine cervical chamfer, and an occlusal rest (23).

A preparation height of 3.5 mm, with the lingual enamel sections rounded and roughened, and retention grooves prepared with a uniform depth of 0.3 mm and a length of 2.5 mm, is recommended (24). The adhesion between the retainer and the abutment tooth is enhanced by creating parallel grooves in the enamel that align with the metal retainer wing (25). However, Brune, Wille, and Kern (24) reported that it is reasonable to keep the number of retention grooves to two rather than four since they are simpler to create but still allow the dentist to securely place the RBA on the abutment tooth during the adhesive luting process. The tooth to serve as an abutment must be sound and free from defects, as this can lead to exclusive fractures of dental tissue during dynamic loading (24). Since this is a relatively new concept, limited studies are available for the tooth preparation designs of RBA. Up until now, the tooth preparation technique for RBA has been confined to only one tooth; further research into the preparation of two teeth as an abutment should be done to increase the longevity of the treatment.

3. Design of the Attachment

The standard design consists of six parts, namely a circular retainer wing, proximal guidance plate, extra-coronal slide attachment, connecting bar, occlusal rest, and convex base surface of the slide attachment (24). The attachment design and connector size are crucial factors for the success of zirconia RBAs (26).

Jagodin et al. (26) investigated the effect of material and attachment design on the retention of RBA. During quasi-static loading, the attachment design does not have a significant difference in the failure load of RBA, regardless of the materials. However, as the oral cavity is a dynamic environment, cyclic loading to mimic the mechanical stress during dynamic loading should be considered.

The modified attachment design with a reinforced shear distributor and an enlarged patrix/matrix, specifically designed for zirconia, has a comparable fracture load to the metal attachment with the standard attachment design. However, during dynamic loading, the standard design using zirconia shows a higher incidence of RBA fractures. Therefore, replacing CoCr alloy with zirconia without changing the design of the resin-bonded attachment is not recommended (26). It is recommended to use a unique modified attachment design for zirconia ceramic and an appropriate connector size (27). A connector height of 3 mm is recommended for the CoCr alloy. However, the connector sizes that are suitable for CoCr alloy may not be sufficient for zirconia ceramics (26) due to the inferior mechanical properties of the zirconia ceramics. Further studies are indicated to investigate the optimum connector size and shapes of zirconia RBA.

Since RPDs usually experience both horizontal and lateral forces, more studies are needed to evaluate the biomechanical behavior of RBAs that reflect real-world scenarios. Additionally, there will likely be a higher demand for periodontal prostheses for abutment teeth with decreased alveolar bone height in elderly populations. The use of RBFDP frameworks in patients with lower alveolar bone levels may increase the risk of debonding and injury to periodontal tissue compared to patients in a healthy state (28). This could be more pronounced in a cantilever situation. Further studies are indicated to optimize the design of the attachment to be more periodontal-friendly.

4. Materials Used for RBAs

Historically, RBFDPs and RBAs had been made using metal-based retainer wings composed of base alloys such as nickel-chromium (NiCr) or cobalt-chromium (CoCr). In modern times, as the desire for enhanced esthetics grows among both patients and professionals, all-ceramic restorations are becoming more common (27). One of the reasons for reduced satisfaction with appearance was the direct display of metal, which generated an effect known as "greying" due to metal shine-through (29)

For lower mandibular premolars using a cobalt-chromium-molybdenum (CoCr-Mo) alloy, the minimum thickness of the retainer depends on the material used. Brune, Wille, and Kern (24) reported that a thicker retainer wing made of CoCr-Mo alloy results in a higher fracture load if two retention groves are used. However, this positive relationship could not be confirmed for preparation designs with no groove, with one groove, or with four grooves. More studies with test designs that can detect the influence of material thickness on the fracture load of RBA are still needed.

Despite being low, the incidence of fracture within the alloy cast of CoCr is 7.6 % as reported by Garling et al. (30). The periodontal-friendly, rigid design of an RBA is crucial for long-term success and can prevent technical failures like RBA fracture due to undersized connector design, requiring dental technicians' expertise (30). Although 3 mol% yttria-stabilized zirconia (3YSZ) zirconia offers a more esthetic and minimally invasive treatment approach, long-term clinical studies to be used as RBAs are still missing (27). Recently, low-yttria-doped zirconia, also known as 1.5 mol% yttria-stabilized zirconia (1.5YSZ), with its high Weibull modulus, fracture toughness, and high aging resistance properties (31) could be a promising alternative to 3YSZ in situations where bending moments are encountered.

5. Bonding Protocol of RBAs

Before the use of airborne-particle abrasion and 10-methacryloxydecyl dihydrogen phosphate (MDP), extra-coronal attachments made of the metal alloy were electrochemically etched to adhesively bond to the tooth structure (11, 25, 26, 26, 27).

A rubber dam to isolate the tooth from moisture is an essential prerequisite for bonding RBAs to the tooth (30). To bond the zirconia and CoCr alloy to enamel, alumina particle air-abrasion at moderate pressure with a luting resin containing a phosphate monomer should be used (35). The increase in surface roughness of the material increases the bond strength by increasing the available surface area and micromechanical retention. In addition to that, the use of 10-MDP-containing primer or cement gives a significant improvement in bond strength to zirconia and CoCr by forming chemical bonds (36, 37).

In the occurrence of RBA debonding, resin cement containing 10-MDP can be used to rebond it, but sufficient enamel should remain to achieve durable bonding. In the instance of dentine exposure, the alternative luting resin cement (38), for example, Panavia V5 (Kuraray Noritake Dental Inc., Tokyo, Japan), which offers better bond strength to dentin, should be used (34). It is important to note that tooth fracture occurs in some studies (18, 20). This phenomenon was also observed in a clinical study by Garlin et al. (30), indicating that the bond strength of the RBA to the tooth could overcome the mechanical properties of the tooth.

Regarding alternative surface treatments, some studies investigated surface treatments such as gas plasma, air abrasion, laser, hot etching, and selective infiltrative etching. Recent network meta-analysis shows that they do not have significant bond strength with each other. However, the tribochemical silica coating has a higher probability of effective surface treatment than the air abrasion method (36) and should be considered in clinical practice. Recently, MDP salts have been introduced to clean the restoration surfaces that have been contaminated during the try-in procedure (39) and enhance priming properties (40). An alternative method, glass-ceramic spray deposition (34, 35), is a potential bonding approach that is a clinically feasible method and should be considered for bonding zirconia ceramic.

6. Clinical Long-term Survivability of RBAs

In a study by Garling et al. (30), 66 out of 205 RBAs fail, including 32.2% technical failures and 42.2% biological failures. Debonding of RBA was the primary cause of all RBA failures, accounting for 50% of all cases of failure, with 33 RBAs placed in 25 patients. As a result, the 10-year success rate was determined to be 58.4%. Nevertheless, if the occurrence of debonding was regarded as a failure, the 15-year survival percentage decreased to 46.2%. Rebonded RBAs demonstrated survival rates of 68.3% and 61% at 10 and 15 years, respectively, if deemed to have survived (30). The survival rate for fifteen years is 61%, which is similar to that of other RPD retentive attachments (43).

RBA offers an alternative method of retention when an existing RPD does not have a sufficient retentive element, thereby lowering the necessity for complete prosthesis replacement and improving the effectiveness of existing RPD (30). For instance, in cases where a telescopic crown is broken and the tooth cannot be restored, it may be feasible to utilize an RBA on a neighboring healthy tooth to retain the RPD (44). There are limited studies regarding the use of RBAs in different clinical situations, such as the free end or bonded saddle and the maxilla or mandible, and their biomechanical considerations could be different from conventional RPDs. Therefore, further studies are indicated to evaluate the use of RBAs in different clinical settings.

7. Complications of RBAs

Regular oral hygiene instructions and follow-up appointments are crucial for minimizing biological complications, whereas the same applies to all other RPD retention elements (45). The percentages of failure due to biological complications such as caries, periodontal disease, and fracture of the tooth are 10.6%, 9.1%, and 22.7%, respectively (30). Regarding technical complications, debonding is the most frequently reported complication, with 50% of all failures; however, it can be rebonded easily. Fractures of the alloy cast of RBA material account for 7.6% of all failures (30). Currently, there is no information regarding the changes in retention and stability over time or the need for replacement of the O-ring. Therefore, further studies are indicated to assess the change in retention and stability of resin-bonded attachments.

8. Conclusion

Resin-bonded attachment is a minimally invasive treatment option for patients who need more esthetic RPD treatment without the clasps. It is a fail-safe option and can easily be rebonded in the event of debonding. Current studies suggest that it has a comparable survival rate to cantilever FDPs, with debonding as a major type of failure. This could potentially be achieved by bonding to additional abutments. Zirconia could offer more aesthetics over Co-Cr with similar failure loads. However, the use of zirconia with a modified design still requires long-term studies to confirm the pre-clinical study results. Further long-term randomized controlled studies are indicated to make scientifically valid conclusions regarding the use of RBA for precision-retained RPDs.

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