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Review Article

Direct bonded fixed partial denture with an artificial denture tooth as a pontic

Naomi Tanoue[a,*], Yoshimasa Takeuchi[b], Mika Furuchi[b], Tetsuo Yamamori[c], Shuji Ohkawa[d]

[a] Division of Pediatric Dentistry, Nagasaki University Graduate School of Biomedical Sciences, 1-7-1 Sakamoto, Nagasaki 852-8588, Japan
[b] Department of Comprehensive Dentistry and Clinical Education, Nihon University School of Dentistry, 1-8-13 Kanda-Surugadai, Chiyoda-Ku, Tokyo 101-8310, Japan
[c] Department of Prosthetic Dentistry, Ohu University School of Dentistry, 31-1 Misumido, Tomita, Koriyama, Fukushima 963-9361, Japan
[d] Division of Removable Prosthodontics, Department of Restorative and Biomaterials Sciences, Meikai University School of Dentistry, 1-1 Keyakidai, Sakado, Saitama 350-0283, Japan

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ABSTRACT

Background: The present review aimed to investigate the feasibility and clinical effectiveness of a direct bonded fixed partial denture (DBFPD) based on available literature. The efficiency of a DBFPD is mainly affected by the type of artificial denture tooth, the type of luting agent, and the adhesive preparation.
Methods: The parameters were reviewed based on the *in vitro* and *in vivo* studies conducted. An acrylic resin tooth or a composite resin tooth for removable dentures should be used as the artificial tooth for the pontic.
Results: Considering the luting agent, a methyl methacrylate-based resin luting agent, which has low mechanical strength but is capable of plastic deformation and could sustain for a long time, should be used. Appropriate pre-adhesive treatment should be performed on both the artificial and abutment teeth. The cases in which a DBFPD can be applied are limited to one missing anterior tooth, as long as it is not overstressed. Patient cooperation in cases of occlusion seems to be another prerequisite.
Conclusion: Knowledge and selection of the material and case indications are essential, and patient cooperation is pertinent in studying the long-term prognosis of a DBFPD.

1. Introduction

The definitive prosthodontic method for a fixed partial denture based on the concept of minimal intervention (MI) may be a direct bonded fixed partial denture (DBFPD) using an artificial denture tooth as the pontic. The DBFPD is a technique in which an artificial denture tooth is directly bonded to an intact abutment tooth, which serves as a pontic, using an adhesive resin luting agent. It is a fairly simple prosthodontic technique without cumbersome steps, such as local anesthesia, tooth preparation, and impression, and the entire prosthetic treatment could be completed in a single day.

It is presumed that the mechanical strength of a DBFPD as a fixed prosthesis for long-term use is not adequate. Consequently, a DBFPD is currently adopted mainly as a temporary prosthesis in clinical practice. However, it has not been clarified whether the strength of a DBFPD is clinically insufficient. Therefore, if appropriate materials and methods can be selected, a DBFPD may be clinically applicable.

This scholarly review aimed to investigate the feasibility and clinical effectiveness of a DBFPD based on available literature. The results of this review are meant to provide useful information to determine if a DBFPD can be applied clinically.

2. Materials and methods

To evaluate the clinical performance of a DBFPD, an electronic search of the literature prior to December 2020 was performed to identify all articles related to DBFPDs. The search was conducted in the National Library of Medicine (MEDLINE) database accessed through PubMed with no date restriction. The following terms were used for the initial search: bridge OR fixed partial denture OR fixed prosthesis OR fixed prostheses AND resin bonded AND denture

* Corresponding author.
E-mail address: t-naomi@nagasaki-u.ac.jp (N. Tanoue).

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tooth AND direct. Furthermore, the "Related articles" feature on PubMed was used to identify further publications of interest within the primary search. The titles and abstracts of all identified articles were screened to eliminate any that clearly failed to meet the inclusion and exclusion criteria. After the first screening phase, the full texts of the articles were assessed for eligibility. The final decision regarding the inclusion of articles was reached after full-text analysis.

2.1. Inclusion criteria

Clinical performance of DBFPDs was evaluated using articles in which a denture artificial tooth or an extracted tooth was used in place of a missing tooth, and both adjacent teeth had sufficient enamel substance. Case reports were included. Articles written in English and Japanese were selected.

2.2. Exclusion criteria

Cases with two or more missing teeth and cantilever-type prostheses were excluded. Studies focusing on implants and other surgical procedures were not included in this study. *In vitro* studies were excluded because they have limitations of experimental objects and methods. In addition, studies on deciduous dentition and mixed dentition, animal studies, and studies with insufficient documentation of materials were also excluded.

3. Results and discussion

The number of potential relevant article identified was 47. Of these, 12 studies remained after screening the titles and abstracts. The articles that fulfilled the inclusion and exclusion criteria were selected after full-text screening, and only three articles were electronically selected for the evaluation of the clinical performance of DBFPDs. After further hand search was conducted, seven studies with different survival and observation periods were finally selected (Table 1).

References were searched for each of the factors presumed to be related to clinical outcomes.

3.1. Selection of an artificial tooth

For provisional rehabilitation of function and esthetics, the method of bonding the extracted natural tooth directly to the adjacent teeth as a pontic has been performed for a very long time [1–8]. Moreover, in order to ensure prolonged function of the extracted tooth pontic, other methods for reinforcing the extracted tooth with a cast metal framework have been introduced [9–11]. These methods could be easily applied due to their simplicity and usefulness; however, they are not applicable when the tooth substance or prosthesis of the extracted tooth is fractured.

Another simpler method using an artificial tooth for removable denture has been proposed, namely a DBFPD. Artificial teeth are roughly classified into metal, ceramic, and polymer teeth; polymer teeth are further classified into composite resin and acrylic resin teeth. A metal tooth cannot be used in a DBFPD because of its unsatisfactory esthetics. A ceramic tooth is also not applicable due to the lower bond strength to resin material [12] and the complicated pretreatment procedures.

Composite resin teeth present the advantage of being easily available since they are frequently utilized as artificial teeth in removable dentures. They have been used as a DBFPD pontic material [11,13] and are reportedly able to function for a long time [13]. A composite resin tooth contains inorganic and/or organic fillers, and pretreatments, such as silane coupling, are indispensable in order to maintain good adhesive strength, as in the case of ceramic teeth. Nakajima et al. [14] reported that it was necessary to reinforce the adhesive interface of the composite resin tooth chemically and mechanically for sufficient durability. A composite resin tooth is considered advantageous for abrasion since it is harder than an acrylic resin tooth due to the incorporation of fillers. Nevertheless, there is no doubt that the composite resin would be abraded [15]. To facilitate long-term use, occlusion must be regularly checked for wear.

Acrylic resin teeth have been used as DBFPD pontics for nearly 50 years [1,2,16–22]. The unfilled structure enables the convenient use of an acrylic teeth, but their inferior mechanical properties result in an increased tendency for abrasion than composite resin teeth [23]. Many of the reported cases therefore involved short-term obser-

Table 1
Clinical performance of direct bonded fixed partial denture (DBFPD).

Missing tooth	Pontic	Enamel surface treatment	Adhesive material	Duration	Ref.
11	Natural tooth + cavities	Cavities + 35% phosphoric acid for 30 s	Prisma Universal Bond (Caulk/Dentsply, Milford, CT, USA.) +light-cured composite resin	5 months	[5]
31	Natural tooth	37% phosphoric acid for 30 s	low-viscosity composite resin (Tetric Flow, Ivoclar Vivadent, Schaan, Liechtenstein)	2 years	[6]
42	Natural tooth	65% phosphoric acid for 30 s	TBB resin (Super-Bond Quick, Sun Medical Co., Ltd., Moriyama, Japan)	11 years	[8]
44	Composite resin tooth (Endura M30, Shofu Inc., Kyoto, Japan) + screw posts (Dentatus Classic Surtex Dental Posts, Dentatus, Spånga Sweden)	Groove + 40% phosphoric acid for 30 s	TBB resin (Super-Bond, Sun Medical Co., Ltd.)	20 years	[13]
Maxillary and mandibular anterior teeth except canines	Acrylic resin tooth + cavities	30% phosphoric acid for 60 s	Bis-GMA bonding resin (Concise Enamel Bond, 3 M Co., St. Paul, MN, USA) + two composite materials mixed (Centrix, Centrix Inc., Shelton, CT, USA)	1.3 years[a]	[19]
Anterior or molar teeth	Acrylic resin tooth (Wearless, GC Corp., Tokyo, Japan)	Phosphoric acid[b]	TBB resin (Super-Bond C&B Clear, Sun Medical Co., Ltd.)	About 4-–5 years[c]	[21]
34	Acrylic resin tooth (Wearless, GC Corp.)	65% phosphoric acid for 30 s	TBB resin (Super-Bond C&B Clear, Sun Medical Co., Ltd.)	6 months[d]	[22]

[a] Mean duration of 33 cases (15 cases lasting more than 1 year).
[b] Under the manufacturer"s instructions.
[c] Under good conditions.
[d] Six months after bonding the acrylic resin pontic, the second-stage prosthetic treatment was undertaken.

Table 2
Resin luting agent classification.

Classification	Category
Curing mode[a]	Self-cured (class 1)
	Light-cured (class 2)
	Dual-cured (class 3)
Adhesive technique [36]	Total etch (acid + adhesive + luting agent)
	One step (acid/adhesive + luting agent)
	Self-etching (luting agent)
Composition	Composite resin luting agent
	MMA[b]-based resin luting agent

[a] International Organization for Standardization (ISO) specification 4049 (2009).
[b] Methyl methacrylate.

vations for several weeks, and the restorations were considered provisional. Grajower et al. [24] compared the bonding properties of artificial teeth *in vitro* and reported that composite resin teeth were superior to acrylic teeth. Nevertheless, Terao et al. [25] stated that the acrylic resin was more suitable as a pontic when considering the bond strength. No additional steps are required to bond an acrylic resin tooth; however, surface grinding enables a bond approximately two times stronger than that of the intact surface [21].

Previous reports have not provided clear selection criteria for artificial teeth. Piemjai et al. [26] reported good clinical results of more than 10 years regardless of the material used. The bonding durability between the pontic and luting agent may be more important than the mechanical properties of the pontic itself for the functioning of the DBFPD for a long period. Instead, it is important to appropriately modify the surface and mechanically reinforce it with pins and fibers to improve retention [13,27]. Jordan et al. [19] reported that acid etching was sufficient for a single missing anterior tooth; however, further mechanical reinforcement of the luting agent was necessary for long-term survival.

3.2. Selection of luting agent

Considering the luting agent, a material with high mechanical properties and sufficient adhesive strength to the artificial tooth and the enamel should be selected. There are many types of luting agents, but an adhesive resin luting agent containing adhesive functional monomers may be optimal for a DBFPD, which is based on adhesion.

Based on their composition, adhesive resin luting agents are classified into composite resin luting agents containing polyfunctional methacrylate and fillers and methyl methacrylate (MMA)-based unfilled resin luting agents containing MMA as the main component (Table 2). Composite resin luting agents, which have superior mechanical properties to the MMA-based ones, are widely used clinically, including for DBFPDs [1–3,17]. However, the higher elastic modulus of composite resin luting agents could cause brittle fractures resulting from stress by rapid crack propagation. On the other hand, an MMA-based resin luting agent has a low elastic modulus, permitting elastic and plastic deformation [28].

MMA-based luting agents are classified as chemically-cured based on the curing mode (Table 1) and further classified into two types according to the curing initiation system: luting agents using a dibenzoyl peroxide (BPO)/ /tertiary aromatic amine initiation system and those using a tri-*n*–*n*-butyl borane (TBB) system. MMA-based luting agents using the BPO/ /amine initiation system reportedly possess low color stability and bonding durability, probably due to the presence of amines [29,30]. On the other hand, an MMA-based resin luting agent initiated by TBB, such as 4-methacryloyloxylethyl trimellitate anhydride (4-META)/ /MMA-TBB resin luting agent (SuperBond; Sun Medical Co., Ltd. Moriyama, Japan), is known to possess higher bonding ability to human enamel [31–34] and has been often applied to DBFPDs [11,13,21,22,26,27]. Damage to the tooth substance may occur during detachment due to its high bond strength to enamel; however, innovative methods for luting agent removal have been recently devised [35]. Similar to the selection criteria of the artificial tooth, low mechanical properties may not be a serious problem clinically if excessive stress is avoided. Conversely, plastic deformations of the MMA-based resin luting agents may favor and propagate improved durability of the DBFPDs.

3.3. Selection of indication

Case selection is essential for the long-term functioning of a DBFPD. The DBFPD should be applied where the space between the abutment teeth is sufficiently narrow [20], such as a single anterior missing tooth. Given that a narrow space should be desirable, the mandibular anterior missing tooth is more suitable for a DBFPD than the maxillary anterior tooth. However, the evidence could not be obtained exactly from the studies that could be searched. Instead, Jordan et al. [19] further stated the following indications:

- Sufficient occlusal equilibration (especially for protrusive and lateral movements)
- Patient cooperation (optimal control of occlusal factors)
- Adequate posterior occlusal support

Patient cooperation in occlusion seems to be an essential prerequSisite for stability; hence, a DBFPD cannot be used in patients who cannot control the occlusal force by themselves. Choosing the appropriate indication appears to have a significant impact on the prognosis of a DBFPD. Table 2 shows the clinical performance of a DBFPD as assessed in previous reports.

3.4. Clinical significance

In recent years, there has been significant development in adhesive materials and techniques in dentistry. Dental conservative restorations and fixed prostheses have conventionally been carried out mainly by mechanical retention and interlocking forces. Nowadays, chemical adhesion can be widely applied with the aid of more conservative prosthetic techniques that can minimize the amount of tooth structure reduction, facilitating the MI paradigm increasingly common in dentistry.

Resin-bonded fixed partial prosthesis is a prosthetic method representative of MI, which has succeeded in significantly reducing the amount of tooth substance removal by applying adhesive techniques. In dentitions with one or two missing teeth and intact bilateral teeth, prosthodontists often select a resin-bonded fixed partial prosthesis. Dental implants are another choice for such cases; however, implants are not feasible in many patients due to systemic diseases, anatomical factors, economic reasons, and other factors.

The resin-bonded fixed partial prosthesis also has certain disadvantages. For example, it is necessary to remove some tooth substance, even if in small amounts. Furthermore, it requires at least two appointments for placement because a resin-bonded fixed partial prosthesis is an indirect restoration. Easier and simpler methods have been eagerly awaited by patients who have difficulty in attending multiple visits. A DBFPD is one of the methods that can overcome such problems.

4. Conclusion

A DBFPD as a prosthetic technique has been practiced for a very long time. It is based on the concept of MI and enables one-day

treatment. For long-term use, it is critical to appropriately select both the artificial tooth and luting agent and to perform reliable adhesive treatment. The selection of appropriate indications and the application of advanced adhesive technology can help promote a DBFPD to the status of non-provisional prosthesis.

Declaration of Competing Interest

The authors report no declarations of interest.

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