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Resin-Bonded Fixed Partial Dentures (Maryland Bridges): Modern Bonding Protocols and their Impact on Longevity

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Abstract
Replacement of missing anterior teeth is essential for restoring function, esthetics, and psychological well-being of patients. Among the available treatment options, resin-bonded fixed partial dentures (RBFPDS), commonly known as Maryland bridges, have emerged as a conservative and minimally invasive approach. Unlike conventional fixed partial dentures, RBFPDS require minimal tooth preparation and preserve the majority of the healthy tooth structure of abutment teeth.

This review discusses the evolution of bonding protocols, materials, and clinical techniques that have enhanced the effectiveness of Maryland bridges over time. Early designs introduced in the 1970s demonstrated limited success due to weak bonding and frequent debonding. However, advances in adhesive dentistry—including improved enamel etching techniques, tribochemical silica coating, MDP-containing primers, and modern resin-based luting cements—have significantly improved bonding strength and clinical outcomes.

Additionally, the development of advanced restorative materials such as zirconia, lithium disilicate (e.max), and fibre-reinforced composites, along with digital technologies like CAD/CAM systems and 3D printing, has enhanced the esthetics, precision, and durability of RBFPDS. These innovations have contributed to better marginal adaptation and reduced mechanical failure rates.

Longevity of Maryland bridges has improved considerably with modern materials and bonding systems. Traditional designs demonstrated survival rates of approximately 50–60% at 10 years, primarily due to debonding. In contrast, contemporary adhesive systems and improved prosthetic materials have increased survival rates to 90–95% at 5 years and around 80–88% at 10 years. Proper case selection, adequate enamel bonding surface, favourable occlusion, and meticulous bonding protocols remain essential factors influencing long-term success.

Keywords: Resin bonded fixed partial dentures, Maryland bridge, bonding system, advanced restorative material, Zirconia, adhesive

Introduction

Spacing in anterior region of the dental arch can occur due to various reasons like trauma and congenitally missing teeth. The loss of anterior teeth causes not only functional impairment but also significant psychological effects, particularly in young patients. (1) Traumatic dental injuries are a frequent clinical issue, with numerous studies reporting prevalence rates ranging from 4% to 19.5%. (2) Various treatment modalities are available for the restoration of missing anterior teeth. These include implants, removable partial dentures and fixed partial dentures.(1) Implants are one of the best treatment options for the same. However, its placement depends on various factors like condition of bone and surrounding tissues, financial aspect of the patient, etc. Removable dentures offer poor long term results as they lead to problems like bone resorption. A conventional fixed partial denture may offer a good solution however, in young patients, excessive tooth preparation is required of the abutment teeth which might not be fruitful in the long run.(3) For such cases, a minimally invasive fixed restorative treatment modality is resin-bonded fixed partial dentures. (1)

Resin-bonded fixed partial dentures (RBFPD) were initially introduced in 1970s, but they had a poor success rate. Due to continuous development and advances of design and materials, the success rate of these appliances increased to nearly 88% and continues to increase till date. (3) Furthermore, considerable advancements like minimally invasive tooth preparation using micro abrasion and lasers, usage of materials like zirconia and Fibre reinforced composites, enhanced bonding protocols like CoJet systems and self adhesive cements have been made in the worlds of RBFPDs. Digital technologies like CAD/CAM, Robotics, 3D printing have further increased the longevity of fixed prosthesis. (4)

Evolution Of Bonding Protocol

1. Traditional methods

Buonocore introduced the concept of bonding in 1955 which opened a wide network of possibilities in dentistry. (5) Rochette in 1973 splinted mandibular anterior teeth using cast gold bar bonded lingually to adjacent teeth. The splint had perforations which provided a mechanical interlocking while the cement used provided a chemical bond. (5) In 1980, Livaditis introduced adhesive retained fixed partial denture. This gave rise to a new era of conservative tooth replacement. He introduced the concept of Maryland bridge. Initially it was a porcelain fused to metal pontic attached to two metal wings which were cemented on the lingual surfaces of adjacent teeth. (6) Maryland bridges reduced the need for the preparation of adjacent teeth drastically but early designs failed due to loss of adhesion. Maryland bridge also had esthetics limitations because the dark shadow of the metal gave a grey appearance to the prosthesis. (6) Since then, a variety of variations of the traditional Maryland bridge concept have developed.

2. Contemporary methods

RBFPDs conserve the majority of healthy tooth structure, shortens chair side time, and delivers superior esthetic results. These advantages hold particular value for young patients or cases where implants are not viable. (7) Despite these advantages, these bridges have not been universally accepted due to long term retention concerns. (7)

Few of the advances in RBFPDs made to combat these issues are discussed below.

- **Tooth preparation**

The necessity of tooth preparation for resin-bonded bridges (RBBs) remains a topic of debate. While earlier approaches employed more extensive preparations to enhance retention, contemporary practice favors minimal enamel-depth preparation or none at all.(8)Typically, preparation is confined to the lingual enamel of abutment teeth, extending 1 mm proximal to the contact area and incisal edge with a shoulder finish line. These bridges are commonly made from non precious alloys, which have improved micro-mechanical retention.[8]

Tooth preparation using minimally invasive methods is an effective way to preserve tooth structure of the adjacent teeth. This method preserves the tooth's structural integrity. Moreover, minimally invasive techniques reduce patient discomfort during the procedure and support quicker recovery. [9] Techniques like micro abrasion, laser assisted tooth preparation and digital methods can be used to provide precise tooth cutting.

Micro abrasion combined with cementation with a high strength cement is a good combination to improve the longevity of prosthesis. [9]

Dental lasers provide minimally invasive and precise treatment option for various procedures including tooth preparation. [9]

Digital dentistry and 3D printing integration unlock promising opportunities for minimally invasive prosthodontics. Combining CAD/CAM systems with 3D printing allows precise restoration fabrication, boosting accuracy, efficiency, and patient-specific customization. [9]

- **Material used for prosthesis**

Traditional porcelain fused to metal had disadvantages like de bonding and grey appearance. To overcome these, use of different materials came to light.

Material	Description	Key Advantages	Clinical Survival Rates
Porcelain fused to-metal (PFM)	Thin non precious metal wings (e.g., NiCr or Co-Cr) fused with porcelain pontics; electrochemically etched for retention.	Cost-effective, durable under load, proven micro mechanical bonding via etching/air abrasion, natural esthetics with porcelain	80-90% at 10 years with rebonding, debonding main failure (20%)
Zirconia	High-strength monolithic or layered zirconia frameworks with optional veneering; CAD/CAM fabricated.	Superior fracture resistance, metal-free biocompatibility, excellent esthetics in translucent grades, precise fit from digital workflows	85-95% at 5 years
e.max (Lithium Disilicate)	Glass-ceramic ($Li_2Si_2O_5$, 360400 MPa) for retainers/pontics; etchable with HF acid, silane-coupled.	High translucency for natural anterior esthetics, conservative thickness (1-1.5 mm)	88-92% at 5 years; ideal for esthetics over strength.
Fiber Reinforced Composite	Polyethylene/glass fibers embedded in PMMA or bisGMA resin matrix; chair side or lab-formed wings.	Minimally invasive, lightweight/flexible, easy intraoral repair, low cost, enamel-only bonding.	65-80% at 3-5 years; best for interim/adolescent use.

Table no. 1, Comparison of materials used for prosthesis, ref [7,8,10,11]

- **Luting cements**

Early RBFPDs used conventional water-based cements like zinc phosphate (introduced 1878: mechanical retention only, 25 µm film, soluble in fluids) or zinc polycarboxylate (1968: chemical adhesion to Ca, biocompatible but deforms under load). These offered 50-60% 10-year survival but failed via hydrolysis/debonding without adhesion to dentin/metals [12,13]

Modern resin-based/self-adhesive cements dominate, providing chemical/micro-mechanical bonds (20-50 MPa tensile), low solubility, and fluoride release. Self-etch (e.g., RelyX Unicem) and MDP-types (Panavia F: bonds oxides sans etching) yield 90-97% 5- year survival. [14,15]

TYPE	EXAMPLES	KEY PROPERTY	SURVIVAL/ ADVANTAGES	LIMITATIONS
Traditional (water based)	Zinc phosphate, Polycarboxylate	Mechanical/ Chemical adhesion	65-75% 5 years; stable long term if dry	No dentin bond, soluble, high acidity
RMGIC	Fuji plus	Fluoride release , dual set	80-88% 5 years, moisture tolerant	Hygroscopic expansion, HEMA Allergy risk
Resin (Total-etch)	RelyX ARC	Etch enamel / dentin	Superior bond ; low microleakage	Technique sensitive, shrinkage
Self adhesive resin	RelyX Unicem	Self etch, bioactive	87-92% 5 years, humid stable	Weaker bond, viscosity varies
Flowable composite	Filtek Ultimate flow	High viscosity, low shrinkage	>87% , caries resistant	Polymerization dependent

Table no. 2, Comparison of luting cements, ref [16,17]

Advancements in bonding for Maryland bridges have dramatically improved retention and longevity, shifting from basic resin cements to sophisticated adhesive systems and surface treatments. Some of these include the following.

- Tribochemical Silica Coating: Rocatec or CoJet systems deposit silica particles (110 µm) on metal/zirconia via high-pressure alumina, enabling silane coupling for chemical bonds; reduces debonding by 60-70% vs. traditional etching.[18]
- -MDP-Containing Universal Primers: Monomer like 10-MDP (e.g., Z-Prime Plus, Clearfil Ceramic Primer) forms covalent bonds with zirconia/metal oxides; achieves shear strengths >30 MPa, stable in humid oral environments.[7]
- -Bioactive and Self-Adhesive Cements: RelyX Unicem 2.0 or Duo-Link Universal release ions for remineralization, minimizing micro-leakage; light cured opaques mask metal shine while enhancing retention (90%+ 5-year survival) [8]

Advancement	Mechanism	Longevity
Silica Coating (Rocatec)	Micro-mechanical + silane	Debonding ↓ from 38% to 12% at 5 years
MDP Primers	Chemical phosphate bonds	85-95% survival at 10 years
Ribbond Fibers	Plasma-treated UHMWPE weave	61-80% at 5 years, interim use

Universal Cements	Self-etch + bioactive	92% retention post-recementation

Table no.2, Comparison of bonding protocol, ref – [7,8]

Impact On Longevity

Advances described above have made a significant increase in the survival of RBFPDs.

Protocol Type	5-Year Survival	10-Year Survival	Key Factors
Traditional (1980s)	65-75%	50-60%	Debonding from hydrolysis
Modern Adhesive (post-2010)	90-95%	80-88%	Silica coating, universal primers
Digital/CAD-CAM Enhanced	92-97%	85-92%	Precise fit, graphene/PEKK frameworks

Table no.3, Impact on longevity, Ref [10]

Case Selection

RBFPDs can be given in the following cases.

INDICATIONS	CONTRAINDICATIONS
- Replacement of one missing teeth in anterior region	-Presence of unfavorable occlusal pattern
-Splinting of periodontally compromised teeth	-Abutment teeth that are extensively restored
-Provision of fixed retention after completion of orthodontic therapy	- Abutment teeth exhibiting mobility
-Presence of sound teeth adjacent to the edentulous space	-Requirement of a diastema between the abutment and the pontic
-Ability to achieve excellent moisture control	-Allergy to metals

Table no. 4, Indications and contraindications of RBFPDs, ref[5]

Complications

Maryland bridges, or resin-bonded fixed partial dentures, can encounter several clinical issues despite their conservative design. Common problems include debonding, discoloration of abutment teeth, and secondary caries.[10,20]

Primary Complications: Debonding stands out as the most frequent issue, affecting about 21% of cases and often requiring rebonding or replacement, particularly on posterior teeth. Tooth discoloration occurs in around 18% of patients due to resin cement staining the enamel.[10,19,20]

Other Risks: Secondary caries develop in roughly 7% of instances, often under faulty retainers if oral hygiene falters.[10] Less common concerns involve porcelain or framework fractures (around 3%), periodontal changes like increased plaque or gingival inflammation, and endodontic issues in abutments.[19,20,21]

Debonding Challenges: Debonding remains the predominant complication, occurring in up to 21% of restorations, especially in posterior regions where occlusal forces are higher. This often stems from inadequate enamel etching, poor moisture control during bonding, or heavy functional loads that stress the adhesive interface. When it happens, the bridge may need simple rebonding if the framework is intact, but repeated failures can necessitate a full remake.[19,20]

Esthetic and Caries Issues: Abutment tooth discoloration affects approximately 18% of cases, typically from resin cement leakage or staining over time, which compromises the natural appearance. Secondary caries arise in about 7% of patients, frequently beneath defective retainers if plaque accumulates due to suboptimal oral hygiene. These risks underscore the need for supra-gingival margins and rigorous patient education on brushing and flossing around the bridge.[10,21]

Structural and Periodontal Risks: Framework or porcelain fractures occur in roughly 3% of instances, often linked to design flaws like overly thin metal wings or parafunctional habits such as bruxism. Periodontal complications, including plaque retention, gingival inflammation, or pocket formation, can develop if the bridge fit is imprecise, altering the emergence profile.

Endodontic problems in abutment teeth, though rarer (around 5%), may arise from pulpal irritation during preparation or undetected pre-existing pathology.[19,20,21]

Long-Term Considerations: Over the years, cumulative failures can reach 19.32% at 5 years, influenced by factors like span length, occlusion, and patient compliance. Preventive strategies include using high-bond strength cements, precise framework design, and regular follow-ups to monitor for early debonding or caries.[20]

Future Direction

Emerging developments in Maryland bridges (resin-bonded fixed partial dentures) focus on boosting durability, esthetics, and precision through innovative materials and techniques. These advancements aim to expand their use beyond temporary anterior fixes to more reliable long-term options.[22]

Material Innovations: Zirconia frameworks show promise with up to 98% survival rates over 10 years, offering superior strength over traditional metal alloys and better esthetic integration. Flexible resins and high-strength composites enhance micro-mechanical retention and reduce debonding risks, while CAD/CAM fabrication ensures precise fits and reproducibility. [8] Design Enhancements: Cantilever contact-point designs improve stability for anterior congenital missing teeth, demonstrating zero failures in early trials up to 5 years, calling for broader long-term studies. Reinforced wings and optimized preparation protocols target posterior applications, countering past limitations from occlusal stress.[22]

Technological Advances: Digital workflows with intraoral scans and 3D printing streamline production, minimizing errors and chair time. Future research emphasizes extended clinical trials on these hybrids to validate survival under varied loads and habits.[8]

Conclusion

The Maryland bridge offers a minimally invasive way to replace a single missing front tooth, using adhesive wings bonded to the backs of adjacent healthy teeth instead of grinding them down like traditional bridges do. This preserves natural tooth structure, making it a prime example of conservative dentistry that prioritizes tooth health over aggressive preparation.Success depends on careful patient selection, such as ensuring stable bite alignment, enough enamel on neighboring teeth for strong bonding, and steering clear of areas with heavy chewing forces.Dentists also rely on precise lab fabrication—often with advanced materials like zirconia-reinforced metal or fiber composites—and expert cementation techniques using high-strength resin cements to lock it in place securely. Recent material upgrades, including all-ceramic frameworks and bioactive cements, have improved its strength, natural appearance, and longevity, with survival rates often reaching 5-10 years or more in the front of the mouth. This positions it well as a reversible, cost-effective interim option before implants or for patients avoiding surgery.When chosen correctly, the Maryland bridge strikes an ideal balance of restoring function, matching esthetics seamlessly, and conserving teeth, outperforming more invasive alternatives in suitable cases.

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