Management of Provisional Restorations' Deficiencies: A Literature Review

MICHAEL PATRAS, CDT, DDS*, **OLGA NAKA**, DDS, PhD†, **SPYRIDON DOUKOUDAKIS**, DDS, MSc, PhD‡, **ARGIRIS PISSIOTIS**, DDS, MSc, PhD§

ABSTRACT

Provisional restorations are designed in order to protect oral structures and promote function and esthetics for a limited period of time, after which they are to be replaced by a definite prosthesis. They play a particular role in diagnostic procedures and continued evaluation of the treatment plan, as they should resemble the form and function of the definite rehabilitation that they precede. Therefore, interim treatment should satisfy the criteria of marginal adaptation, strength, and longevity. In complicated treatment plans that intend to last for extended periods of time, the function of provisional prostheses involves the possibility of relining, modification, or repair. These adjustments raise considerations regarding the strength of the resultant bond. Chemical composition of the base and repair material, surface characteristics of fracture parts, and time elapsed since the initial set of the rehabilitation should be considered in the decision of the appropriate repair material and technique. Proper pretreatment of the provisional components' surfaces is essential to ensure bonding as well.

The purpose of this article is to illustrate the management of provisional restorations' deficiencies. This article highlights possible failures of custom-fabricated provisional restorations, describes methods to prevent their occurrence, and discusses clinical techniques for their management. Finally, the proper combination of materials and surface preparation to achieve the optimum treatment outcomes are presented.

CLINICAL SIGNIFICANCE

Provisional restorations' failures and other deficiencies are encountered by clinicians on a daily basis. Adequate laboratory techniques and material combinations presented herein may contribute to their efficient and predictable modifications and repairs.
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INTRODUCTION

According to the Glossary of Prosthodontic Terms,[1] "provisional or interim prosthesis or restoration is a fixed or removable dental or maxillofacial prosthesis designed to enhance esthetics, stabilization and/or function for a limited period of time, after which it is to be replaced by a definitive dental or maxillofacial prosthesis."

The interim treatment focuses on protecting pulpal and periodontal health, promoting guided tissue healing in order to achieve an acceptable emergence profile, evaluating hygiene procedures, preventing migration of the abutments, providing adequate occlusal scheme, and evaluating maxillomandibular relationships.[2–6] From the clinician's standpoint, provisional restorations play a key role in the diagnostic procedures and continued evaluation of the treatment plan, as they must resemble

*Postgraduate Student, Department of Prosthodontics, University of Athens, Athens, Greece
†Lecturer, Department of Prosthodontics, Division of Removable Prosthodontics, Aristotle University of Thessaloniki, Thessaloniki, Greece
‡Assistant Professor, Department of Operative Dentistry, University of Athens, Athens, Greece
§Professor, Department of Prosthodontics, Division of Removable Prosthodontics, Aristotle University of Thessaloniki, Thessaloniki, Greece

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the form and function of the definitive rehabilitation that they precede.[7,8] Provisional treatment can also provide an important tool for the psychological management of patients, whereas a mutual understanding of treatment outcome and limitations of treatment can be identified.[9] It is therefore comprehensible that the realization of this essential step and the quality of the provisional restorations can be the difference between overall treatment success or failure.[2,6,10,11]

Provisional material selection should be based on how their mechanical, physical, and handling properties fulfill specific requirements for any clinical case. Other factors to be considered are biocompatibility and complications from intraoral use, such as chemical injury from the presence of monomer residue and thermal injury from an exothermic polymerization reaction.[12] Nonirritating reaction to the dental pulp and gingival tissues, appropriate marginal adaptation, great tensile strength, dimensional stability, esthetically acceptable shade selection, ease of contour, and repair are extremely important parameters to the success of provisional treatment.[2,3,5,13–16] The most common materials used for custom interim-fixed restorations are several types of acrylic resins such as (1) polymethyl methacrylate (PMMA) resin, (2) polyethyl methacrylate (PEMA) resin, (3) polyvinyl methacrylate resin, (4) bis-acryl composite resin, and (5) visible light-cured urethane dimethacrylates.[3,5,17–19]

Direct, indirect, or combination technique, and custom fabrication or fabrication with preformed materials are well documented in the literature. The selection of the appropriate technique for the corresponding adjustment involves factors such as the strength of the bond, the working and setting time of the material, the ease of handling, and the cost. One should consider the advantages of saving time and low cost, along with the disadvantages of the presence of saliva, reduced visibility, and access in direct techniques.[20] On the other hand, the ease of manipulation, the superiority of the mechanical properties, combined with the disadvantages of increased cost, the need of special equipment, and the extended time for fabrication should be taken into consideration in indirect techniques.[20] The main goal should be the construction of properly contoured and well-fitting provisional restorations that maintain their integrity throughout the reasonable time from tooth preparation to completion of definitive treatment.[21]

However, the Muse of interim prostheses in complicated rehabilitations for extended periods of time involves the possibility of relining, modification, or repair. It also raises considerations regarding failures as a direct reflection of the physical properties of the provisional material.

The purpose of this article is to illustrate the management of provisional restorations' deficiencies. This approach intends to highlight the possible failures of the custom-fabricated provisional restorations, display their prevention of occurrence, and demonstrate their inevitable rehabilitation as well. The combination of materials and preparation of the restorations' surfaces in order to achieve the optimum treatment outcome are emphasized.

DEFICIENCIES AND THEIR HANDLING

Marginal Inaccuracy

Provisional restorations should exhibit accurate marginal adaptation to the finish line of the prepared tooth in order to protect the pulp from thermal, bacterial, and chemical insults.[22] Intrasulcular extension of the preparation requires additional support for the free gingival margin to provide the appropriate emergence profile.[23] Deficiencies can occur when autopolymerizing acrylic resin is used, due to dimensional contraction because of the difference in density between the polymer and the monomer. It has been stated that volumetric polymerization shrinkage for PMMA is 6% compared with 1 to 4% for composite materials.[24] The longer the

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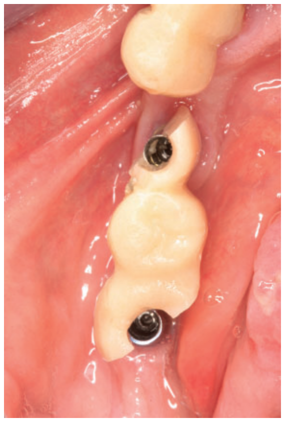

FIGURE 1. Fracture of an implant-supported provisional restoration due to parafunctional activity.

FIGURE 2. Fracture of an acrylic resin interim prosthesis at the connector's site.

span of the prosthesis, the greater the shrinkage and distortion are, resulting in less satisfactory adaptation over the abutments.[25,26]

Additionally, marginal defects are closely related to the direct or indirect technique chosen. Indirect fabrication provides significant improvements in marginal fit relative to direct methods when polymethyl (PMMA) or polyethyl (PEMA) methacrylate resins are used,[27,28] as the acrylic resin polymerizes in an undisturbed manner.[29]
Direct fabrication is usually carried out by successive removals and repositioning of the material over the prepared teeth or bench polymerization after initial set in order to avoid pulp damage.[16] The time of the removal plays a crucial role in limiting the material's distortion.[30]

Other causes of defective marginal fit regard provisional restorations that fall short in length, either during construction or after the removal of the marginal flash.[25,31] The moisture of the oral cavity, temperature changes, and occlusal forces after prolonged intraoral service also affect the fit of provisional restorations.[23,32–36] Furthermore, recementations during various stages of a treatment plan require the removal of temporary cement, followed by inevitable trimming of their intaglio surface, in a way that progressively compromises the initial marginal accuracy.[25,29] Finally, the fit and marginal integrity of an existing provisional restoration can be compromised when an alteration of the taper or marginal configuration of the prepared tooth occurs.

In these instances, the resulting marginal gaps may be minimized by relining the restorations. The addition of provisional material allows closer adaptation to the finish line of the prepared teeth.[23] Relining has been recommended at the time of fabrication[25,37] in order to compensate for the polymerization shrinkage of the resin[4,25] and to improve the initial retention.[38] Likewise, the smaller the marginal gap, the less is the dissolution of temporary luting cements and plaque accumulation.[23]

Fractures

Fracture of provisional restorations may occur upon removal from the mouth, during construction, trimming, or function.[21,39] This failure often occurs as a result of a crack propagating from a surface flaw,[40] inadequate transverse strength, impact strength, or fatigue resistance.[41,42] Stress concentration during functional or parafunctional activities often leads to fractures (Figure 1), especially in a connector's area of a long-span interim restoration[14,43] or where voids have occurred during fabrication.[44] Additionally, the minimal preparation of a tooth results in a thin interim restoration that is more subject to fracture, particularly in the cervical region.[44] Fractured connectors (Figure 2) and missing margins can compromise function, jeopardize tooth and soft tissues' structures, and cause embarrassment and discomfort to the patient.[14,45]

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The best method to reduce the likelihood of fracture is to select the appropriate material based on its behavior in the oral environment when it will be subject to aging, fatigue, water sorption, and wear processes.[35,36,46] Hence, it is important to know the flexural strength of various types of resins for provisional restorations, as most of them are brittle.[47] Despite conflicting reports in the literature, it is generally accepted that PMMAs exhibit higher fracture toughness than bisphenol A glycidyl methacrylate (bis-GMA) resins.[48–50] Recently, the resins have become more widely used even though they are more prone to fractures when used in long-span bridges. As heat-polymerized acrylic resin materials are denser, stronger, and more resistant to fracture than their auto-polymerized[20,40,51] and light-polymerized counterparts,[52] they should be considered for use when provisional treatment for prolonged time or additional strength are required.

Metal castings and swaged metal substructures, in combination with resinous materials, have been reported as especially useful with long-term or long-span interim treatment.[2] When utilized, care must be exercised to prevent violation of the physiologic contours of the provisionals, given the additional thickness of the reinforcing substrate.[53]

Attempts have been made to strengthen provisional dental resins by the application of fibers. Compared with metals, fiber reinforcement possesses superior mechanical, esthetic, and cohesive characteristics and has the advantage of being a lighter-weight composite.[54] Materials used for fiber reinforcement have included glass, carbon graphite, sapphire, polyester, and rigid polyethylene.[40,55–57] Most of these materials have had little or no success in increasing the resulting tensile strength of the overall restoration.[52,55] The fiber quantity and the reinforcement location rather than the length affect the strengthening efficiency.[54,58,59] Preimpregnation of the fibers using the polymer–monomer mix for methacrylates and a bonding agent for bis-acryl resins provides optimal adhesion between the fibers and the polymer matrix,[49] upgrading the strengthening effect.[60]

Nonintegrity of the External Contour

Adding material to achieve the desired morphology and proper contacts with opposing or adjacent teeth is often necessary.[38] The correct shaping of the external contours provides proximal and occlusal stability, and maintains tooth positions while the restorative plan is executed. Moreover, it enables the patient to self-evaluate the appearance, especially in the esthetic region, and provides a blueprint for the definitive restoration.[26] Alterations to the external contour of a provisional restoration may also be required after tooth extraction(s) or surgical alteration(s). The shape of an unfavorable residual ridge[61] may be transformed by the gradual addition of material to create pressure, resulting in a more favorable tissue configuration (site conditioning).[62]

MATERIALS AVAILABLE AND BONDING STRENGTHS CONCERNING RELINING, MODIFICATION, OR REPAIRS

Making additions to remedy many of the deficiencies cited above may require the use of the same material or the combination of different materials.[63] Compatibility issues may arise affecting the overall success of bonding between the provisional base material and the correcting material. In that instance, it seems that the most critical step is the appropriate surface treatment before the bonding between the two materials is attempted.[39]

In general, the chemical similarity of the materials seems to be of great importance in polymer repair.[39] Using provisional base and repair resins with similar chemical skeletons seems to provide greater bond strengths compared with using dissimilar ones.[39]

Among the materials used for these instances, *self-cured acrylic resins* have the ability to easily reconstruct the shape defects, allowing simple and quick manipulation. Unfortunately, the use of this material is also associated with unpleasant odor, significant shrinkage, short working time, and a pronounced exothermic setting reaction.[16,39] Moreover, residual methacrylate monomer

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FIGURE 3. Patient presented with a fractured provisional restoration in the region between #25 and #26.

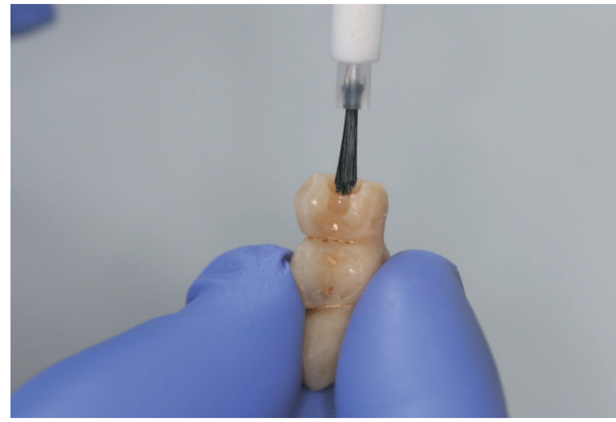

FIGURE 4. The application of methacrylate monomer activates the polymer chains of the substrate matrix and enhances bonding of the repair material.

demonstrates cytotoxicity and potential allergic reactions.[64,65] Heat-cured acrylic resins have lower repair strength compared with self-cured PMMA resin maybe due to fewer free carbon double bonds available for reaction with the PMMA repair resin.[57,64] The surface design seems to be an important issue in the strength of the repair; however, the mechanical retention of the rough, untreated PMMA surface does not provide a strong enough bond between the repair surfaces and the self-cured resin.[66] Wetting the repair surfaces with methyl methacrylate monomer or acetone[67] has been suggested to dissolve the PMMA, permit the diffusion of added acrylic resin, and ensure a good bond,[66,68] especially in aged restorations,[21] due to the formation of new polymer chains[66] (Figures 3–5).

Bis-acryl resin composites have become extremely popular during the past decade due to ease of use, minimal shrinkage, and low exothermic reaction.[30,31,69] A more accurate mixing, due to the cartridge dispensing system, may contribute to improved marginal fit. Many authors report that the use of methacrylate resins to repair bis-acryl provisional restorations results in a weaker bond between the two materials due to incompatibility.[5,14,39,44,70] More recently, *light-cured flowable resin composites* have been suggested for the intraoral repair of bis-acryl resin composite provisional restorations.[21,44,63] Light-cured flowable resin materials offer various advantages including availability in numerous shades and viscosities, ease of application and

FIGURE 5. View of the provisional prosthesis after the repair process.

manipulation, adequate working time, minimal odor, low polymerization shrinkage, and increased marginal accuracy.[39,63] The shear bond strength between them and bis-acryl resins has been shown to be effective and durable,[44] although the resistance to fracture of this approach remains questionable.[39]

Attempting to bond newly polymerized composite to aged composite raises concerns about the predictability of adhesion. It has been stated that the primary interfacial bonding between layers of composites decreases as the original layer sets,[71] perhaps because the number of unreacted methacrylate groups decreases during polymerization.[72] As polymerization proceeds, the solubility and permeability of the polymer decrease,

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thereby reducing the extent of primary and secondary bonding of new composite to the aged composite surface.[71] The composition of the base material, the composition and viscosity of the repair material, the repair liquid, and the surface texture seem to have an influence on the bond strength. It has been found that the increased surface roughness can promote mechanical interlocking, and the coating of composite substrate with unfilled resin bonding agents (bis-GMA/triethyleneglycol dimethacrylate (TEGDMA)) can advance surface wetting and chemical bonding.[44,71–76] The viscosity of light-cured resins may have certain effects on the repair strength as far as their penetration in the interface is concerned,[73] and low viscosity repair composite material leads to better adaptation.[71] Furthermore, a combination of air abrasion and a bonding agent seems to be the most effective protocol for composite-to-composite repairs.[75,77]

Light-cured flowable resin materials can also be incorporated into freshly prepared provisional restorations fabricated from PMMA in order to improve their esthetic appearance, contour, and marginal adaptation.[78,79] The bond strength between PMMA and flowable composite resin can be increased by first wetting the surface with a bonding agent in order to promote a more effective chemical bond between the surfaces.[77,80]

Alternative indirect or direct procedures for fabricating multiple-unit provisional restorations suggested the use of a light-cured composite as a shell, and a combination of self-cured bis-acryl composite and flowable light-cured composite to improve marginal adaptation.[81]

Specific Clinical Procedures

Relining

Self-cured acrylic materials[23,70] or light-cured flowable composite resin materials[63] may be used to reline a provisional restoration. Special attention is required as it has been reported that a majority of restorations are not fully seated to their original position following the reline procedure due to the interference of hydrostatic pressure[25] caused by the additional resin. This problem can be solved to a great degree by venting prior to relining.[25,26] Alternatively, the removal of part of the internal layer of the provisional restoration is recommended prior to adding the material to allow sufficient space for the new resin addition, reduce hydrostatic pressure, and permit complete seating.[23,26,34] Trimming of cement remnants and roughening of the external surface of the margins prior to relining are also critical to ensure good adhesion of the new resin to the aged restoration (**Figure 6**).

FIGURE 6. Roughening of the cervical areas prior to relining.

Additional preparatory steps are recommended according to the chemical composition of the materials involved. A fresh wash of acrylic resin may be added with a "salt and pepper" technique or can lightly be adapted over the margins with a fine brush[38] (**Figures 7 and 8**). Immediately, strong finger pressure[38] or a repositioning key[81,82] is applied to ensure proper seating. The potential trauma from excess monomer and the heat generated by the exothermic reaction, although limited to the low volume of the reline material,[26,81] may be reduced by lightly spraying water over the area during active polymerization.[29,38,83,84]

The difficulty of achieving satisfactory intrasulcular adaptation[28] could be overcome by the placement of a retraction cord and by subsequent exposure of the margins during direct fabrication.[4]

Repairs

Repair may often be preferred to refabrication due to better efficiency, reduced cost, and time savings.[21,39]

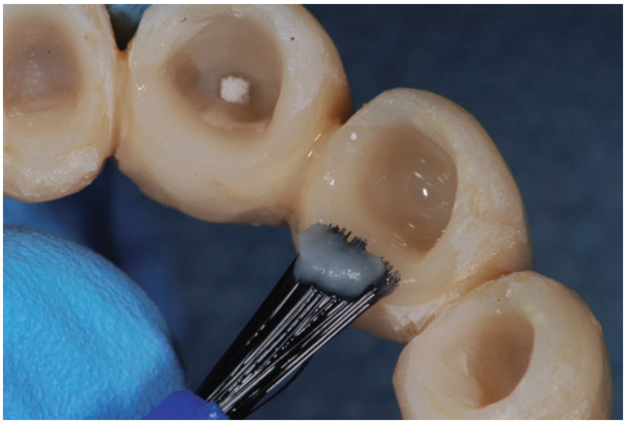

FIGURE 7. Addition of the new layer utilizing the bead-brush technique.

FIGURE 8. View of the margins after the intraoral reline.

FIGURE 9. Roughening of the fractured parts removes the contaminated surface layers and the preparation of the proximal boxes (marked in pencil) increases the macro-retention thus creating more surface area for bonding.

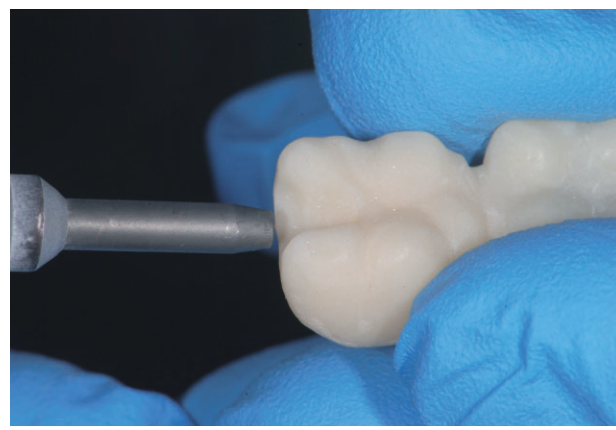

FIGURE 10. Sandblasting enhances overall roughness and micro-mechanical retention.

However, the decision to repair or fabricate a new provisional construction should be taken individually according to the requirements of the case and always considering that the repaired provisional's strength is inferior to the new ones.[14,85] It is well documented that the repair of aged restorations is less structurally effective than that of freshly fabricated provisional restorations.[71,72,86] This is due to the fact that aged restoration has a reduced number of free radicals[87] and has absorbed water from saliva and other fluids into its surface.[88]

Attainment of the appropriate chemical bonding requires the repair surfaces to be free of contamination.[66] Therefore, it is critical to remove a surface layer prior to the addition step, thus providing additional mechanical roughness that facilitates mechanical interlocking.[89] Common methods for the provisional component's adjustment include pretreatment of their surfaces in a 45-degree bevel and rounded surface design,[90] roughening with a rotary cutting instrument,[89] open proximal boxes[45] (Figure 9), or air abrasion (micro-etching with aluminum oxide powder) (Figures 10 and 11) with or without intermediate bonding resin.[44]

External Modification

For minor modifications, the previously mentioned technique of adding wash of acrylic resin with a brush allows easy and quick adjustment of the external

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FIGURE 11. View of the repaired interim prosthesis.

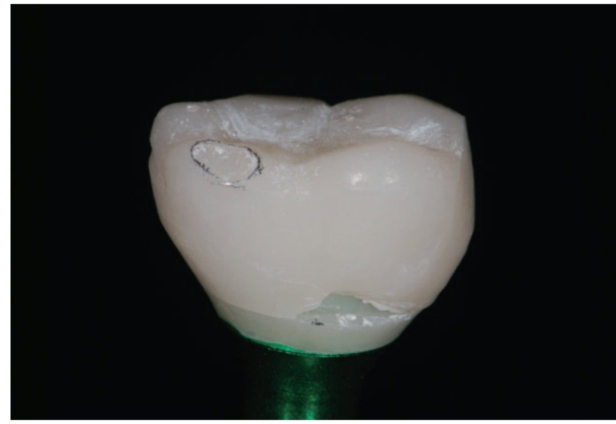

FIGURE 12. During intraoral fabrication, voids (marked in pencil) or marginal gaps may occur due to air entrapment or insufficient volume of the material.

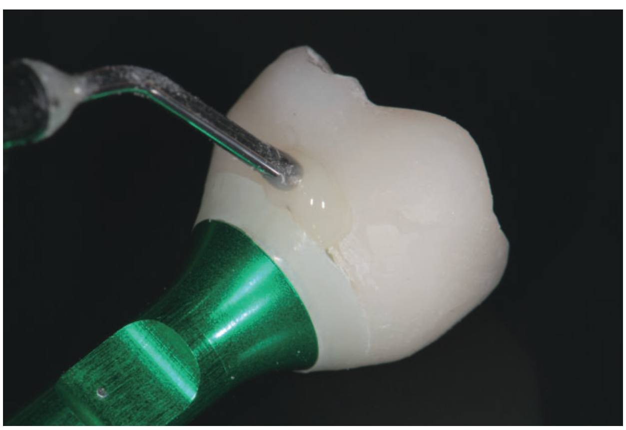

FIGURE 13. Addition of flowable composite resin in newly fabricated provisionals corrects the deficiencies without the need of conditioning with a bonding agent.

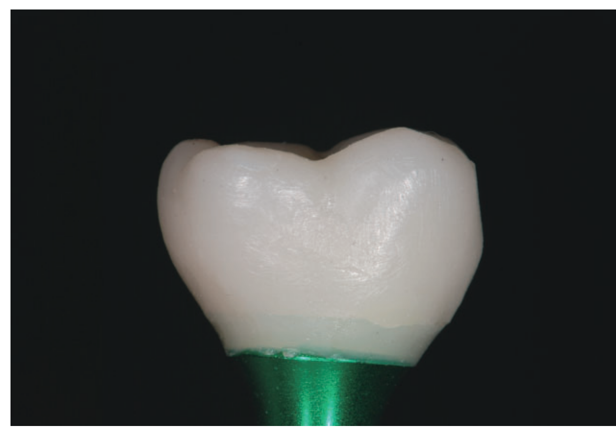

FIGURE 14. Minor repairs and modifications may enhance the contours and the emergence profile of the prosthesis.

contours[26,38,91] in order to correct a marginal gap, the emergence profile, or proximal and occlusal contacts of the provisionals (Figures 12–14). Surface treatment and conditioning seem to be mandatory depending on the combination of the materials as mentioned above, especially in aged restorations. Although effective, this technique is time consuming,[21] and the limited working time of these materials adds a hurdle in accurate modification, especially when the process includes multiple teeth and extended prostheses.[39,42]
The use of flowable composite resin is effective in this case too.[21,63]

In order to improve underlying tissue contour, adding a new layer of acrylic or composite resin has been a valuable management strategy to enhance the tissue conditioning. The amount of resin to be added is judged through an analysis of the shape of the tissue and esthetics.[92]

DISCUSSION

By definition, provisional restorations are an indispensable and demanding step in prosthodontic treatment. Provisional treatment focuses on protecting oral structures and promoting function and esthetics. In complex cases, interim treatment is critical and must satisfy the criteria of marginal adaptation, strength, and longevity. Limitations due to mechanical properties of

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the materials used, as well as defects due to technical procedures, involve the possibility of relining, modification, or repair of interim prostheses. Relining may be necessary to maintain the accurate fit of provisional restorations due to distortion during setting or function. Modifications allow the development of the provisionals' contour which mimics the proper anatomy (size and shape) of the teeth. When interim rehabilitation is intended to function for extended periods of time or extends over long-span edentulous spaces, deformation or fracture may occur during chewing or attempted removal by the dentist. All of the above compose a challenging task from a material or clinical perspective.

Thus, it is important to be aware of the behavior of each material in the oral environment, as there is an association between their physical properties and clinical performance. None of the available provisional materials meet the requisite standards or covers the wide range of the clinical cases.[39] Even among different brands, the materials' properties and clinical performance may vary considerably.[14] As physical properties are material specific, clinicians should be familiar with the essential characteristics and follow manufacturers' instructions.

If a deficiency occurs, its management should be based on information gathered from a research of the current literature. The practitioner should be mindful that reviewed studies often constitute laboratory findings only and may not reflect intraoral conditions. The information derived from in vitro studies is helpful nevertheless, as it is established under controlled situations and therefore a useful predictor of clinical performance, although not a guarantee.

Several parameters should be considered in the decision of the appropriate repair material and technique, including the chemical similarities or discrepancies between the base and repair material, the surface characteristics of fractured parts, and time elapsed since the initial set of the rehabilitation. Proper pretreatment of the provisional components' surfaces seems to be essential to ensure bonding. Moreover, aged provisional restorations require a different approach due to the limited number of free radicals and the absorption of oral fluids.[72] Repair of fractured, aged restorations needs sufficient surface preparation by means of mechanical roughening or air abrasion. Roughening seems to provide mechanical retention for the repair resin, thus increasing the cohesive strength. An increase in the cross-sectional diameter of the connector where the tensile stress occurs, combined with a reduction in depth and sharpness of the embrasures, is also suggested, considering at the same time the preservation of oral hygiene.[26] Finally, as the bond is mostly chemical, it is important that it not be contaminated by residual cement or other substances.[66] All the above parameters serve as important guidelines to be considered before initiating a repair process (Table 1).

TABLE 1. Key points for achieving successful repairs

Suitable material choice (compatibility)
Removal of a surface layer of appropriate thickness
Rational use of pretreatment procedures
Adequate viscosity and volume of repair material improves fracture strength
In aged restorations the repairability may be compromised and less predictable
Identification and elimination of causative factors to reduce the risk for additional fractures

Nevertheless, the resultant bond is weak. This raises concerns about the benefit to carry out a process with a possible short longevity or to fabricate a new interim restoration. In that case, the existing conditions and the cost/benefit ratio in terms of the requisite cost and time to repair or to remake should be taken into account.

Among the materials outlined above, weak bonds in modification areas are reported regarding heat-polymerized resins,[39,64] leading to adhesive failures. Instead, auto-polymerized resins are the material of choice as they show residual carbon bonds able to obtain chemical connection to repair resins with similar chemical structures.[39,64,65] The use of flowable composite

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TABLE 2. Material combinations and suggested surface treatment for effective and durable bonds

Provisional substrate material	Repair material Self-cured acrylic resin	Bis-acryl composite resin	Light-cured flowable resin
Self-cured acrylic resin	roughening, sandblasting + monomer (MMA)[39,86]	low shear bond strengths[39] (not recommended)	roughening, sandblasting + monomer (MMA) + bonding agent[39,77,80] (material specific)
Heat-cured acrylic resin	roughening, sandblasting + monomer (MMA)[39,80]	low shear bond strengths[39] (not recommended)	roughening, sandblasting + bonding agent[80]
Bis-acryl composite resin	low shear bond strengths[39,44] (not recommended)	roughening when newly fabricated[39,44,63,86] (not recommended in aged restorations[14,86])	roughening,[21,44] sandblasting + bonding agent[39,63] (material specific)
Light-cured composite resin (material-specific)	roughening + bonding agent when newly fabricated[39] (low shear bond strengths in aged restorations)	roughening + bonding agent when newly fabricated[39] (low shear bond strengths in aged restorations)	roughening, sandblasting + bonding agent[39,76,77,85]

MMA = methyl methacrylate monomer.

resins, which can be placed, contoured, and cured on command and are compatible to bis-acrylic and PMMA resins,[39] make the adjustments more time- and cost-effective as the materials required are used in routine remedial rehabilitations. This in turn eliminates the unpleasant odor and tissue irritation of the PMMA monomer, reduces clinical time, increases the productivity in the dental office, and differentiates the cost of the repair process.

In the authors' experience, Table 2 provides the adequate sequence of steps along with recommendations for reliable repairs in a simplified way. It should be noted, though, that most of the in vitro studies provide results regarding newly fabricated specimens. Also, different brands present materials with different chemical compositions. Consequently, the suggested combinations of treatments may not be applicable to aged restorations and to all combinations of substrate and repair materials; therefore, the fracture resistance at the repaired joints may vary. Because there is usually a lack of residual monomers in aged composite resins, and hence the likelihood of a weakened chemical bond for future repairs, micromechanical features should always be included as part of the repair process.

CONCLUSIONS

Marginal adaptation and durability are of high clinical relevance in provisional treatment. As the direct method of fabrication continues to be popular because of time- and financial-related advantages, modifications will be common procedures during a treatment period. Those adjustments require additional chair-time, proper materials' combination, surface preparation, and adjustment prior to bonding. The use of practical methods and efficient techniques enhances the longevity of provisional restorations, maintains or restores the health and contour of the underlying and surrounding tissues, and ensures the patient's comfort and satisfaction. Precise knowledge of available materials and techniques enables the clinician to reline, modify, or repair these restorations through a simple and reliable process.

DISCLOSURE

The authors have no financial interest in any of the companies whose products are mentioned in this article.

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Reprint requests: Olga Naka, DDS, PhD, 176 K. Karamanli Str, 54248 Thessaloniki, Greece; email: naka@dent.auth.gr

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