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Interim Restorations in Fixed Prosthodontics: A literature review

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Abstract

Background: Interim or transitional restorations have been demonstrated as critical components in different dental treatments, they designed to enhance the esthetics, functions and protect the oral structures for limited period of time. Aims: This review focuses on several important aspects associated with interim restorations including materials, techniques of fabrication, and current trends in the application of interim restorations in fixed prosthodontics. **Conclusions**: Interim fixed restorations play a specific role in the diagnosis and treatment plan of dental procedures. They must resemble the function and form of the definite prostheses. Therefore, interim restorations should satisfy the criteria of longevity, marginal adaptation and strength.

الخلاصة

المقدمة: تم إثبات ان الترميمات المؤقتة أو الانتقالية كمكونات أساسية في علاجات الأسنان المختلفة ، فهي مصممة لتعزيز الجماليات والوظائف وحماية التراكيب الفموية لفترة محدودة من الزمن. الأهداف: تهدف مراجعة المقال إلى التركيز على العديد من الجوانب المهمة المرتبطة بالترميم المؤقت بما في ذلك: المواد ، وتقنيات التصنيع ، والاتجاهات الحديثة في مجال الترميمات المؤقتة في التعويضات السنية الثابتة. **الاستنتاجات**: الترميمات الثابتة المؤقتة لها دورًا مهما في التشخيص وخطة العلاج لإجراءات طب الأسنان ويجب أن تكون مشابهة شكلا ووظيفة التعويضات الاصطناعية لذلك يجب أن تفي الترميمات المؤقتة بمعايير طول العمر وتوافق الحواف والقوة.

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INTRODUCTION

The term fixed interim, temporary, or transitional restorations are dental prostheses designed to promote function, esthetics, and stabilization for a limited time, after that, they are to be replaced by permanent dental prostheses. [1] The importance of interim prostheses becomes critical in full mouth rehabilitation. In these cases, multiple teeth are prepared and interim restorations typically needed for a long period to improve patient comfort and satisfaction. [2] The temporary treatment aids in protecting periodontal and pulpal tissues, preventing migration of the abutment teeth, maintaining the adequate occlusal scheme, and maxilla mandibular relationships. [3]

The interim fixed restorations should satisfy many factors, which can be classified as biological, mechanical, and esthetic. Biological requirements include pulpal and periodontal protection, the interim restorations must seal the prepared tooth surface from the oral environment to prevent sensitivity of the pulp, [4] they must have proper contour, good marginal fitness, and smooth surfaces to facilitate plaque removal, particularly when the restoration margins are placed intra-secularly. [5] The interim restorations must maintain proper contact with adjacent and opposing teeth. Incorrect contact leads to supra-eruption and horizontal movements. In addition, they should provide a highly polished surface and perfect shade match to be pleasing to the patient. These factors are very important for the success of treatments. [6] The most common interim restorative materials are 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. [7] Since the beginnings of interim materials in 1930, they have developed extremely from the first generation of acrylic resins and prefabricated crowns to bis-acryl composite resins and computer-aided design/computer-aided manufacturing (CAD/CAM) restorations. [8,9]

There are several techniques for the fabrication of interim restorations: a direct technique which is performed directly on prepared teeth using a matrix. Indirect technique by making an impression of the prepared abutment teeth. An indirect-direct technique involves the fabrication of a preformed shell that is relined intraorally. [10]

Interim restorations are important components in fixed prosthodontics, they provide a template for permanent restorations, preview future restorations, and promote the health of the periodontium and abutments, therefore this review focuses on several important aspects associated with interim fixed restorations including materials, techniques of fabrication, deficiencies of interim restorations and their management, and current trends in the application of interim restorations in fixed prosthodontics

Materials of interim fixed restorations

There are no temporary restorative materials that can fulfill the requirements for each situation. Practitioners always select their products depending on factors such as marginal adaptability, strength, cost, effectiveness, esthetics, and ease of manipulation. (11) Generally, the choice of materials should be satisfying the requirements for the success of the treatment, as materials with the least polymerization shrinkage should be chosen for a direct technique. Alternatively, in the case of long-span prostheses is being produced, high strength is an important selection standard. However, a major problem still to be solved is dimensional instability during polymerization, which causes marginal discrepancy, especially when the direct procedure is used. (12)

Aluminum, nickel-chromium, tin-silver, and polymethyl methacrylate (PMMA) acrylic resins were the first materials used as temporary crowns and bridges. PMMA is the most common material for both multiple-unit and single-unit interim restorations. They have been used since the 1930s. Their popularity may be due to acceptable esthetics, low cost, and good wear resistance. However, they have certain drawbacks including significant shrinkage, an objectionable odor, discolor over time, and heat generation during polymerization. Polyethyl methacrylate PEMA is another acrylic resin used for interim restorations. Despite its numerous advantages of it such as less shrinkage, low cost, and less heat generation during polymerization than PMMA, they have some disadvantages such as less esthetics than other current resin materials, poor color stability, poor wear resistance, and objectionable odor. Epimines were introduced in 1968, they have relatively low heat generation, polymerization shrinkage, and the lowest pulpal irritability. (6, 13)

Over the last few decades, composite resins are commonly used as temporary restorative material like bis-acryl resin which is a hydrophobic material available as auto-polymerized, photopolymerized and dual polymerized. bis-acryl interim materials represent an improvement over acrylic resins because they generate less heat during polymerization, shrink less, minimize odor, have excellent esthetics, and can be polished on the chairside. Previous studies investigated the flexural strength, microhardness, marginal fit, and occlusion of different interim restorative materials. They found that bis-acryl composite resins were significantly superior to conventional PMMA and other light-cured composite resins owing to the differences in their compositions. Multifunctional monomers of bis-acryl resin (BISGMA or TEGDMA) promote the mechanical characteristics of a resin by cross-linking with other monomers.

Moreover, the inorganic fillers may enhance flexural strength and microhardness. Therefore, they suggested the application of bis-acryl resins when high mechanical strength and long-term use of temporary restorations are required. [11, 14-16]

Luxa-temp materials are interim composite materials available as auto polymerized and photopolymerized systems. Various modifications were made to this new trend: Luxatemp fluorescence, which has excellent esthetics and handling properties, Luxatemp Ultra with superior flexural strength by the addition of nanoparticles, and Luxatemp Solar, which is a photopolymerized material with suitable working time. [17]

Tuff-temp plus is a rubberized resin. It is either an auto polymerized or photopolymerized system. Recently, rubberized urethane has been shown to provide high dimensional stability and impact resistance. This material exhibited little polymerization shrinkage and perfect marginal adaptation. [17, 18]

Types of interim fixed restorations

Interim fixed restorations can be classified according to the fabrication methods as follows:

a- Preformed restorations are commercially preformed crowns that do not satisfy the requirements of the interim restorations because most of them need some modification (occlusal adjustment, axial recontouring, and internal relief). Materials from which performed restorations are made from cellulose acetate, polycarbonate, aluminum, nickel-chromium, and tin-silver (Figure1).

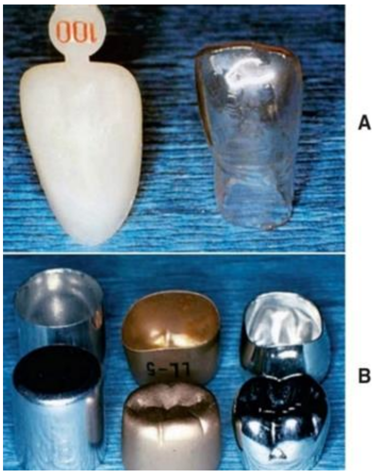

Figure1. A, preformed anterior crowns: (left) polycarbonate and (right) cellulose acetate. **B,** preformed posterior crowns: (left) aluminum non anatomic shell, (middle) aluminum anatomic, and (right) tin-silver anatomic. [6]

Polycarbonate resins are the most commonly used performed restorations. [19] They combine polycarbonate plastic material and micro glass fibers. This material possesses a high wear resistance, impact strength, and hardness. Preformed restorations are limited for use as a single restoration because they are not suitable to use as pontics for fixed partial dentures. [20]

b) Custom-made restorations are a negative reproduction of the patient's teeth before preparation. They can be obtained directly with any impression materials such as irreversible hydrocolloids or silicone. The disadvantages of this method are that it involves additional lab procedures and is time-consuming. [6]

Custom-made interim restorations can be classified based on fabrication techniques into (a) Indirect technique (b) Direct technique (c) Direct – indirect technique. The indirect procedure included taking an impression of the prepared abutment teeth and pouring in quick-setting gypsum products or polyvinyl siloxane. Interim restorations are fabricated outside the patient's mouth (Figure2).

(A) **(B)**

Figure 2. Indirect technique: **A**, an alginate impression is external surface form (ESF); plaster cast, tissue surface form (TSF). **B**, a silicone impression is ESF; a plaster cast, TSF.[6]

This procedure has some advantages superior to the direct technique because there is no touch between the free monomer and the gingiva or prepared abutment teeth, which could cause tissue injury or sensitization. The prepared teeth are not subjected to heat generated from the polymerization of the resins. [21] The marginal fit of indirectly designed interim restorations is significantly better than restorations that have been removed from the patient's mouth before becoming rigid. [22]. The direct procedure includes the use of a mold which is applied intra-orally to the prepared abutment teeth. The interim materials are mixed and filled in to the mold which seated directly over the prepared abutment teeth and allowed to polymerize. After that the mold remove from the patient's mouth and the interim restoration should be well trimmed and polished to avoid any excess. In the direct procedure, the gingival tissues and prepared abutment teeth represent the tissue surface form (TSF). While, external surface form (ESF) may be made from custom or preformed mold (Figure 3).

(A) **(B)**

Figure 3. Direct technique: **A**, a preformed shell is is external surface form (ESF); the patient, tissue surface form (TSF). **B**, a wax impression is ESF; the patient, TSF. [6]

The advantage of direct- technique is that it is the most efficient procedure saving the materials and time by eliminating the transitional labratory steps. The significant disadvantages of direct techniques include tissue trauma from the polymerizing resins, marginal inaccuracy, saliva contamination, and insufficient access and visibility. [6]

In the indirect-direct procedure, the indirect part produces a “custom-made ESF” similar to a preformed polycarbonate crowns. In most situations, the practitioners use a custom-made (ESF) and a diagnostic cast with intentionally underprepared diagnostic preparations as (TSF). A custom-made (ESF) which produced from thermoplastic sheets, that adapted and heated to a stone cast with air pressure or vacuum while the materials are still pliable. This technique produces a transparent ESF with thin walls, which is advantageous in the direct-technique due to its minimum interference with the occlusion. However, the thinness of the material may be a disadvantage in the direct technique, and so care must be taken when remove it from the patient’s mouth. After tooth preparation, the resulting shell is lined with resin (the prepared teeth serving as the TSF). This step is the direct part of the procedure (Figure 4).

(A) **(B)**

Figure 4. In direct- direct technique: **A**, an acetate sheet is external surface form (ESF); the patient, tissue surface form (TSF). **B**, a three-unit fixed prosthesis shell which fabricate indirectly is ESF; the patient, TSF. [6]

This procedure exhibits significant benefits as less chair-side time is required because most of the steps have been fabricated before the patient's visit. Also, it decreases heat generation due to the little number of resins that polymerize in contact with the prepared abutment teeth and contact between the soft tissues and resin monomers is minimized compared with the direct procedures. [6,7]

Deficiencies of Interim Fixed Restorations and their Management

-Marginal Inaccuracy

Interim restorations must have accurate marginal adaptation to the finishing line of the prepared abutment teeth to maintain the pulp from chemical, thermal, and bacterial insults. The most important factor related to the clinical behavior of dental prostheses is the marginal fit. Manufactured imperfections associated with marginal fit may result from bad manufacturing processes and/or the materials of choice. Marginal inaccuracy may create a gap, leading to biological or technical complications. [23, 24] Dimensional shrinkage is the most common cause of marginal inaccuracy. It has been demonstrated that the volumetric polymerization shrinkage for polymethyl methacrylate is 6% compared with 1-4% for composite resins. Also, the marginal discrepancy is associated with the chosen techniques. Indirect procedures provide better improvements in marginal fitness than direct procedures. Other factors affecting the marginal fit are temperature changes, moisture environment of the oral cavity, and occlusal forces during prolonged intraoral use. In this situation, relining is recommended to minimize the resulting marginal gaps and compensate for the polymerization shrinkage of the resin. [25,26]

-Fractures

Fractures of interim restorations may occur during removal from the mouth, construction, trimming, and/or function. [27]

Fractures usually exist as a result of a crack propagating from a surface fault, due to inappropriate impact strength, transverse strength, and/or fatigue resistance. Additionally, fractures are caused by water sorption, solubility, and aging because absorbed water acts as a plasticizer and decreases the strength of the resins.(3,28,29) Stress concentration during parafunctional or functional activities also leads to fractures particularly, in a connector of long-span transitional restorations. Moreover, minimum tooth reduction results in a thin restoration that is mostly exposed to fracture. (30) The best method to minimize the probability of fracture is the selection of appropriate materials depending on their behavior in the oral environment during subject to fatigue, aging, and water sorption. (31)

-Improper External Contour

Adding material to obtain the desired morphology and contact with opposing and adjacent teeth is always necessary. The proper shaping of the external contour provides occlusal and proximal stability until the treatment plan is completed. Alterations to the external contour of interim restorations can also be needed after tooth extractions or surgical alteration. (3,32)

Correction of some deficiencies requires either the use of the same materials or different materials. The compatibility may affect the total success of bonding between the correcting and interim materials. (3) The most common repair materials used are autopolymerized acrylic resins that have the ability to rebuild the defects, providing easy and fast manipulation but, the use of these materials are also related to considerable polymerization shrinkage, short working time, unpleasant odor, and a heat generation during polymerization.(33) Bis-acryl composite resin is a new repair material which becomes significantly popular during the past decade because of its low exothermic reaction, ease of application, and minimal shrinkage. More recently, photopolymerized flowable composite resins have been recommended as intraoral repair materials. These materials display many advantages including, ease of use, availability in different shades, viscosities, easy manipulation, adequate working time, excellent marginal accuracy, and low polymerization shrinkage. (3,34)

Current Trends in Interim Fixed Restorations

Several efforts have been made to progress the mechanical and physical properties of temporary crown and bridge materials. Some studies have recommended the incorporation of fibers into the resins for reinforcement. Other studies reinforced the resins with different metal oxide nanoparticles and the most recent method is the exploitation of (CAD/CAM) technology. [35,36]

-Fiber-reinforced interim fixed restorations

Fiber-reinforced fixed prostheses contain a fiber-reinforced composite substructure veneered with certain composite materials. The substructures provide good mechanical properties such as strength, and the veneers exhibit good physical and esthetic properties. They are considered the best solution when longer-term interim restorations are required due to their good mechanical properties.[3] Fiber-reinforced temporary materials are classified depending on the following characteristics: fiber orientation, type of fibers, and whether the fibers impregnate in the resins. The fiber orientation includes braided, unidirectional, and woven patterns. Different fiber orientations exhibit different mechanical and handling properties. Unidirectional orientated glass fibers exhibit better flexural and handling properties than other fibers. [29,37]

The most common fibers used in dentistry are polyethylene, carbon, and glass fibers. Polyethylene fibers can improve the mechanical properties of PMMA and bis-acrylic interim materials. Ultra-High molecular weight polyethylene fibers exhibit excellent ductility, esthetic, color, and biocompatibility. [38] Carbon fibers effectively enhance transverse strength, fatigue resistance, and impact strength of PMMA resins, but it also shows unsatisfactory aesthetics and toxicity. Impregnation of the fibers using the saline coupling agent for methacrylates and bonding agents for bis-acryl resins provide superior adhesion of the different fibers to the resin matrix. [3,29] Previous studies demonstrated that the fiber-reinforced PMMA and PEMA fixed prostheses with longer spans exhibited excellent reinforcement effects. However, some studies have explained that the addition of fibers to acrylic resins may cause tissue irritation and bad adhesion of the fibers to the resins.[35]

-Nanoparticles Reinforced Interim Fixed Restorations

Nanotechnology which is developed the last time has a distinctive role in the progress of fixed prosthodontics. Nanomaterials such as aluminum oxide, titanium oxide, and zirconium oxide have favorable properties making them acceptable to improve the properties of interim fixed restorations. [9,39-41] Nanoparticles or nanofillers can be added to the resins either as surface-modified or unmodified particles. Although numerous studies have concluded that the modified nanoparticles have favorable effects of a silane coupling agent. [42] other studies have reported that unmodified nanoparticles also significantly improve the characteristics of acrylic resins. Unfortunately, the surface treatment of nanofillers is expensive, requires additional facilities, and is time-consuming. (43)

Currently, nano zirconia (ZrO_2) has been widely used as a nanofiller to reinforce dental materials because it exhibits desirable characteristics such as biocompatibility, and high hardness. The improvement of hardness using ZrO_2 nanofillers may be due to their strong ionic interatomic bonding. The white color of nano zirconia is expected to have a negligible effect on the appearance of dental materials. (35,43) Several researchers studied the effect of different concentrations of zirconium oxide (ZrO_2) on flexural strength, fracture toughness, and the hardness of acrylic resins. They showed that depending on the kind of acrylic resins, the concentration and size of fillers (macro, micro, or nano) used to reinforce the resins, there was either improvement or no remarkable effect on these mechanical properties. (35,42,43)

Today, some techniques were introduced to improve the characteristics of interim materials like mixing of different reinforcing materials by one of the following procedures: incorporation of a mixture of more than one kind of fibers, the addition of different metal oxides and ceramics, combination of ceramic fillers, or incorporation of both fibers and metal oxides to the resins.(44,45) Some researchers proved that the incorporation of nanoZrO_2 and fibers together can improve the impact strength and flexural strength of polymethyl methacrylate compared to incorporating them separately. In addition, they suggested modifying the surface of nanoparticles and fibers with a coupling agent to obtain a superior distribution of particles in the material and improve the adhesion of the fillers to the matrix. (44,46)

Chowdhury et al. in 2021 explained that the addition of titanium oxide and zirconium oxide nanofillers may improve the mechanical properties of PMMA, but also increase surface roughness leading to more sites of microbial adhesion to the restoration. (47)

-Digital interim fixed restorations

Computer-aided design/computer-aided manufacturing (CAD-CAM) is a recent trend in the fabrication of interim fixed restorations which give more attention to anatomic details. These restorations are fabricated from dense block/discs with extremely reduced porosity and shrinkage compared to conventional materials (Figure 5). The potential benefits of CAD/CAM technology have become widely accepted for the generation of promising strategies to treat difficult clinical situations that necessitate the use of temporary restorations, such as the need for large reconstructions, evaluating the problems of occlusion in the presence of a temporomandibular disorder, a planned change in the vertical dimension, and the period of healing of implant or pontic sites. The patient can digitally evaluate appearance, function, and comfort before the fabrication of the definitive restoration.[6,9]

Figure 5. CAD/CAM interim fixed restorations milled from a resin disc. [6]

The tissue surface form (TSF) consists of a three-dimensional virtual image of the prepared tooth, while the external tissue form (ESF) consists of one of the following: a three-dimensional virtual image of the tooth before preparation, a scan of a preoperative diagnostic waxing, or a virtual form proposal generated by computer. The digital information is usually sent to a milling machine during the time of tooth preparation. TSF and ESF were milled from dense discs/blocks of resins. Thus, there is no requirement for analog representations of ESF and TSF. Commonly used materials for CAD/CAM interim fixed restorations include CAD/CAM polymethyl methacrylate (Figure 6) and composite resins. [6]

Figure 6. Maxillary three-unit fixed prosthesis milled from polymethyl methacrylate as an interim restoration. [6]

The CAD/CAM process decreases the patient's exposure to monomers because the commercially available discs from which temporary restorations are milled include only approximately 1%residual monomers. They are more accurate and have better mechanical properties for clinical use than conventional restorations. (48) Digital production of the restorations is that the data files may be used to mill the definitive restorations if the prepared abutments and tissue contours have not been altered. CAD/CAM technologies also allow the production of multiple-unit PMMA or composite prostheses. Diagnostic tooth preparations or diagnostic wax-up are provided to the laboratory, where digital design software is used to virtually prepare the tooth with a margin near the gingival margin or design the external contours, or both. (6, 18,49)

Other benefits related to CAD/CAM interim restorations are no laboratory work needed, efficient, no polymerization shrinkage, can be bonded to the tooth structure, lowest residual monomer, more wear resistance, and no air inhibited layer. Additionally, definitive restorations can be milled exactly in duplicates of interim. The potential disadvantages of CAD/CAM restorations are the internal adjustment that may be required before relining; some blanks are mono-color and digital impressions and in-office mills are required. In-office mills usually require additional software and a modified coolant filler system to avoid blocking of the cooling system caused by ground polymer particles. (6,50)

With the development of dental technology, new materials and techniques have been introduced, one of these techniques is three-dimensional (3D) additive printers.(51-53) This new techniqueallows the gaining of prostheses with different materials at a suitable cost and with no loss of materials linked to the milling process. In resinous materials, this method allows the three-dimensional impression of prostheses as a part of a chair-side concept during the same appointment.(53,54) Revilla-León et al. in 2020 reported that (3D) printing technique manufactured interim restorations have significant chemical composition variations and appropriate mechanical properties for clinical use compared to other traditional interim restorations.(55)

Digital light processing (DLP) is a (3D) printing system that depends on using of a digital light projection source (high-power LED). The layers were illuminated by a light obtained from a digital micro-mirror device. Each mirror identifies a pixel of the projected images, curing the total resin layer at once. (56) DLP technology uses several resin and monomer systems, such as UV-curable hybrid resin or light-curing multi-phase polymers.(53) Some studies have investigated the marginal and internal accuracy of various resin interim fixed partial dentures using (3D) printed (DLP) and milled technology. They denoted that (3D) printed prostheses had smaller internal gaps than the milled prostheses, as well as the marginal accuracy of the (3D), printed resin prostheses was clinically acceptable. Molinero-Mourelle et al. in 2020 assessed the marginal fit of some resin materials for interim three-unit fixed partial dentures. They concluded that methacrylate oligomer phosphine oxide curable resin interim restorations were made using the DLP (3D) printing system provided marginal fitness within the clinically acceptable limits. (53)

CONCLUSION

Interim fixed restorations are critical components of dental treatment. They act as an esthetic and functional try-in and provide the clinicians with valuable diagnostic information. The success of fixed prosthodontics usually depends on the precision with which the interim restorations are designed and fabricated. Although they are usually meant for a short period and then discarded, they should be accurately fabricated using the most current techniques and materials to enhance their longevity and maintain the health of teeth and periodontal tissue.

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