THE DENTAL CLINICS OF NORTH AMERICA

Dent Clin N Am 48 (2004) 487–497

Interim restorations

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Interim restorations are an essential part of fixed prosthodontic treatment. Patients must be provided with an interim restoration from initial tooth preparation until the definitive prosthesis is placed. An interim prosthesis is defined as ''a fixed or removable prosthesis, designed to enhance esthetics, stabilization or function for a limited period of time, after which it is to be replaced by a definitive prosthesis. Often such prostheses are used to assist in determination of the therapeutic effectiveness of a specific treatment plan or the form and function of the planned definitive prosthesis'' [1]. The term ''provisional'' prosthesis is often used as a synonym for ''interim'' prosthesis [1]. The requirements of an interim restoration are essentially the same as for the definitive restoration, with the exception of longevity and possibly the sophistication of color [2].

Basic requirements of an interim restoration

The requirements of an interim restoration are to provide pulpal protection, positional stability, maintenance of occlusal function, cleansability, strength, retention, and esthetics [3]. These requirements can be subdivided into biologic and biomechanical categories.

Biologic requirements

An interim restoration must maintain the health of the pulpal and periodontal tissues [4]. Once the dentinal tubules are exposed through tooth preparation, the internal adaptation, the marginal integrity of the interim restoration, and the provisional luting agent help protect the pulp from the

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0011-8532/04/$ - see front matter
doi:10.1016/j.cden.2003.12.007

adverse effects of bacterial microleakage and chemical and thermal irritation. For endodontically treated teeth, the interim restoration should help maintain the biologic seal and prevent coronal microleakage that may result in the contamination of the root canal system [5]. Patients undergoing complex fixed prosthodontic treatment over extended periods of time should be provided with properly adapted interim restorations. These interim restorations must be evaluated at regular intervals because provisional luting agents are subject to relatively rapid dissolution [6].

An important role of the interim restoration is to maintain the health of the periodontal tissues. This is accomplished by maintaining marginal integrity and by ensuring that the gingival contours do not impinge on the periodontal tissues and are smooth and highly polished. Proper emergence profiles are essential to maintaining gingival health. Over-extended and over-contoured gingival contours cause gingival irritation and increase plaque retention and may lead to inflammation and subsequent recession of the marginal gingiva [7]. Concerning esthetics, appropriate emergence profiles and proximal contours are essential for maintaining interdental papilla form. When fabricating interim fixed partial dentures, appropriate pontic form is essential in maintaining the health and esthetic contours of the gingival tissues overlying the edentulous ridge.

Biomechanical requirements

Interim restorations must be able to withstand the functional forces of mastication without fracture or displacement. This is particularly true for interim fixed partial dentures. In addition, the interim restoration must maintain the position of the prepared teeth and the stability of inter- and intra-arch relationships through the establishment of optimum proximal and occlusal contacts. Maintenance of these contacts prevents the prepared teeth or opposing teeth from mesial or distal drifting and supraeruption. It is essential that interim fixed partial dentures maintain the interabutment relationship recorded during the final impression procedure until the definitive prosthesis is placed. Anterior interim restorations must maintain the appropriate protrusive and lateral guidance for the patient.

Diagnostic potential of interim restorations

Interim restorations serve as valuable diagnostic tools in fixed prosthodontics. Most practitioners would not attempt to deliver a definitive removable prosthesis without a preliminary evaluation of the prosthesis through a wax try-in. In fixed prosthodontics, the interim restoration serves as a functional and esthetic try-in. Through duplication of the diagnostic wax-up, the interim restoration helps determine if the proposed prosthodontic solution for the presenting condition satisfies the patient's functional requirements and esthetic expectations [2,8]. A properly adapted and contoured interim restoration can serve as a guide to determine if there is adequate retention and resistance form for the functional requirements of the prosthesis and if optimal tooth reduction has been provided to satisfy the biomechanical, physiologic, and esthetic requirements of the planned restoration.

As the complexity of the proposed prosthodontic treatment increases, the importance of the interim restoration as a key diagnostic tool is magnified. Changes in vertical dimension of occlusion, centric occlusal contact relationships, and anterior guidance can most readily be evaluated with properly designed interim restorations. Changes in tooth length, contour, incisal edge position, lip support, occlusal or incisal plane, and tooth color can also be best evaluated with the interim restoration [2,4,9–12].

Interim restorations also aid in adjunctive therapies associated with fixed prosthodontics. This is especially true for periodontal therapy. Removal of the interim restoration enhances access for periodontal control procedures and aids in the diagnosis and decision-making associated with periodontally compromised teeth. Properly designed interim restorations serve as excellent guides to periodontal surgical procedures, such as crown lengthening, ridge augmentation, and pontic site development procedures. Interim restorations may also aid in pre-prosthetic endodontic and orthodontic therapies [13].

Once the dentist and patient are satisfied with the interim prosthesis function, phonetics, and esthetics, a duplicate of the interim restoration serves as a guide for the laboratory technician in the fabrication of the definitive prosthesis. In this way, the interim restoration ensures a predictable, functional, and esthetic definitive prosthesis [2].

Materials for interim restorations

Contemporary materials for the fabrication of single- and multiple-unit interim restorations are for the most part resin based. They differ with regard to method of polymerization, filler composition, and monomer type. They include auto-polymerizing and dual curing resins, such as poly (methyl methacrylate) (PMMA), poly (ethyl methacrylate) (PEMA), polyvinyl (ethyl methacrylate) (PVEMA), bis-GMA resins, bis-acryl resin composites, and visible light cured (VLC) urethane dimethacrylate resins. In selecting a material for an interim restoration, consideration should be given to the physical properties of the material. Clinically relevant physical properties include strength, rigidity, reparability, exothermic reaction, polymerization shrinkage, marginal integrity, and color stability.

Strength and rigidity

One of the limitations of resin-based interim restorations is their relatively poor strength. The flexural strengths of interim restorative materials vary within material chemical classes and between chemical classes of materials; therefore, it is difficult to predict the flexural strength of a provisional material on the basis of generic composition alone [14].

In general, PMMA has been shown to exhibit the greatest strength of the methacrylate acrylic resins [15,16]. The bis-acryl composite resins have been shown to have the highest modulus of rupture and flexural elastic modulus of all provisional material types [17], whereas the PMMA resins have been shown to have higher flexural strength than composite resin [18]. Others researchers have found no significant difference between the strength of PMMA and composite resin provisional materials [16]. Some of this confusion may be due to a lack of standardization of testing methodologies reported in the literature and a lack of correlation between various testing methodologies and the functional strength requirements of interim prostheses in vivo.

The newer bis-acryl resin composite provisional materials seem to exhibit an enhanced microhardness over the traditional PMMA provisional materials, which may be an indicator of their resistance to wear [19].

The fracture toughness, or the resistance to crack propagation, has been shown to be highest for PMMA, followed by bis-GMA composite resin and PEMA [20]. Urethane dimethacrylate resin has also been shown to have high fracture toughness values [21]. The bis-GMA composite resin materials seem to be more brittle than PMMA and therefore more likely to fracture in long-span fixed partial denture applications.

In the event of clinical fracture of an interim fixed prosthesis, an understanding of the strength of the repaired prosthesis is helpful. Unfortunately, the repaired strength of all interim restorative materials is significantly less than the strength of the original unrepaired prosthesis, with the bis-acryl materials demonstrating an 85% decrease in transverse strength after repair [22].

Reinforcement

To enhance the mechanical properties of acrylic resins, various reinforcing techniques have been advocated. These have included glass fibers, nylon fibers, aluminum and sapphire whiskers, polycarbonates, metal strengtheners, and carbon graphite fibers [15,23–26]. The effectiveness of these strengthening mechanisms varies, with the over-riding requirement being adequate bond formation between the reinforcing material and the parent resin. If there is not an adequate bond, the filler may act as an inclusion body and weaken the prosthesis. In addition, although the incorporation of materials such as polyethylene and carbon graphite fibers has been shown to increase the moduli of elasticity of commonly used provisional fixed partial denture materials, technical difficulties and esthetic concerns have prevented their widespread use [15]. If these fiber reinforcements protrude from the interim restoration surface, they may be difficult to polish and can act as a wick, attracting oral bacteria.

Exothermic reaction

For all interim materials, the potential for pulpal injury exists during the fabrication of direct interim crown or fixed partial denture restorations due to the heat generated during the exothermic setting reaction [27]. In vivo investigation has determined that a 10°F (5.6°C) increase in pulpal temperature resulted in a 15% loss of vitality of tested pulps, a 20°F (11.2°C) increase in pulpal temperature resulted in a 60% loss of pulpal vitality, and a 30°F (16.8°C) increase in pulpal temperature resulted in 100% pulpal necrosis [28]. The temperature increase during polymerization of PMMA has been shown to be significantly higher than that for PVEMA, VLC urethane dimethacrylate, and bis-acryl composite resin, with the VLC urethane dimethacrylate exhibiting significantly less polymerization temperature increase than the other resins [29]. In a study that compared two auto-polymerizing bis-acryl resins with three dual-cured bis-acryl resins, the peak polymerization temperature of the auto-polymerizing bis-acryl resins was significantly higher than that of the three dual-cured bis-acryl resins [30]. Peak polymerization temperature increases have been associated with the volume of acrylic resin [31].

Contrary to manufacturer claims, all resin materials used in the fabrication of interim prostheses exhibit an exothermic reaction. In general, PMMA exhibits the greatest exothermic reaction, followed by PVEMA, PEMA, bis-acryl composite, and VLC urethane dimethacrylate resins. In addition to the chemical class of material used, various fabrication techniques have been shown to substantially influence the peak temperature rise during direct fabrication of interim restorations [32–34].

The clinician should limit the thermal insult to the pulp by selecting an appropriate interim material, minimizing the volume of material, and choosing an appropriate fabrication technique.

Color stability

As patients become more esthetically aware and demanding, it is paramount that the clinician provides an esthetically acceptable interim restoration. The shade selected for the interim prosthesis should match the adjacent and opposing teeth and should not exhibit a color shift during the time of provisionalization. Interim restoration color instability may be due to the incomplete polymerization of the material, sorption of oral fluids, surface reactivity, dietary habits, and oral hygiene. Historically, the PMMA provisional materials were found to be more color stable than PEMA and PVEMA provisional materials [35–38]. As with other physical properties, color stability cannot be predicted solely on the chemical classification of the material [39–41]. Surface finish may also contribute to the propensity of provisional materials to stain, with porous unpolished surfaces exhibiting significantly more darkening than highly polished materials [35].

Fabrication techniques

Multiple techniques exist for the fabrication of interim restorations. Essentially, a matrix is required to form the external contours of the interim restoration. The internal adaptation of the interim restoration can be formed directly on the prepared tooth or teeth (the direct technique) or on a stone cast of the prepared tooth or teeth in the dental laboratory (the indirect technique).

Matrices

For either technique, a matrix is required to create the external axial and occlusal contours of the interim restoration. Prefabricated or preformed aluminum, tin, stainless steel, polycarbonate, and cellulose acetate external crown forms are available in various tooth sizes and shapes. They are limited to single-unit restorations and may require substantial adjustment to achieve appropriate proximal contours and occlusion. These crown forms are usually relined directly with a resin-based material to achieve individualized internal adaptation and marginal fit [4].

The use of a custom matrix is preferable for the fabrication of multiple unit and complex interim restorations [42]. These matrices are fabricated from thin vacuum-formed materials or elastomeric impression materials. Whereas a duplicate stone cast of the diagnostic wax-up is required for thermoplastic vacuum-formed materials, a polyvinyl Siloxane putty material is convenient to use and can be adapted directly to the stone cast or the diagnostic wax-up of the proposed restoration, resulting in precise anatomic detail. The use of a polyvinyl siloxane material as the matrix has been shown to significantly reduce peak polymerization temperatures as compared with the use of a vacuum-formed polypropylene matrix material [32,33]. Other materials that have been advocated for use as a custom matrix include wax, thermoplastic resins, and irreversible hydrocolloid impression materials.

Direct technique

The direct technique involves the use of a mold or matrix that is related intraorally to the prepared teeth. The matrix is made from a preoperative diagnostic cast or from a diagnostic wax-up. After tooth preparation, the matrix is trial fitted in the patient's mouth. The prepared teeth are washed, gently dried (not desiccated), and lubricated with petroleum jelly. Any surrounding composite resin restorations should also be lubricated with petroleum jelly. The selected provisional material is mixed according to the manufacturer's instructions and placed into the matrix; care is taken not to incorporate any air bubbles. The matrix with the provisional restorative material is then seated over the prepared teeth and allowed to polymerize. At this point, careful attention must be paid to the working and setting times of the material being used to minimize heat build-up due to the exothermic reaction and to prevent the restoration from becoming locked into any undercuts on the preparation or adjacent gingival embrasures [33]. Using the air water syringe may aid the dissipation of the heat generated. To prevent pulpal damage or locking of the interim restoration on the preparations, some advocate that the interim restoration be removed after the rubbery stage has been reached and allowed complete polymerization outside the mouth. This technique is problematic with PMMA resins due to their polymerization shrinkage. It is more appropriate for the bis acrylics, which have less polymerization shrinkage as compared with PMMA. An "on-off" technique is advocated to prevent locking the interim restoration on to the preparations during polymerization. After the provisional material has reached the rubbery stage, the interim restoration is teased partially off of the preparations and reseated several times throughout the setting reaction while the area is flushed with water as a coolant until polymerization is complete [34]. Unfortunately, this technique has been shown to result in relatively poor marginal integrity [43]. Other researchers advocate letting the restoration achieve final set in situ but emphasize the need to continually flush the area with water to prevent thermal damage to the pulp. This technique is not realistic; the interim prosthesis will likely be difficult to remove due to the presence of interproximal undercuts on the teeth adjacent to the preparations.

The advantage of the direct technique is that it is the most efficient use of time and materials because no intermediate impression or stone cast is required. The disadvantages of the direct technique are that the freshly cut dentin and the vital pulpal tissues are exposed to the heat generated during the exothermic polymerization reaction and to the free monomer or other irritating chemicals present in the unpolymerized interim restorative materials. The direct technique is well suited for single crowns and short-span (up to three units) fixed partial dentures.

Indirect technique

A similar, although more complex, protocol is followed when the indirect technique for interim restoration fabrication is planned. After tooth preparation, an irreversible hydrocolloid impression or a fast setting multipurpose nonaqueous elastomeric impression is made of prepared teeth. The impression is poured in fast setting plaster or stone. The decreased strength of the dental plaster can be helpful when removing the interim restoration from the cast. The matrix is trial fitted to the cast, and modifications are made to the matrix or cast until complete seating of the matrix is achieved. A separating medium (petroleum jelly or tinfoil substitute) is applied liberally to the prepared teeth, adjacent teeth, and tissues on the cast. The desired provisional material is mixed according to the manufacturer's instructions and carefully loaded into the matrix. The matrix is then positioned over and firmly seated onto the cast until complete seating of the matrix is achieved. A gypsum core can be used in conjunction with the matrix to ensure full seating and to optimize the interim restoration's occlusal vertical dimension [42]. The matrix can be stabilized with elastic bands and the cast/matrix assembly placed in warm water in a pressure pot to increase density and to optimize the physical properties of the completely polymerized restoration.

The indirect technique has several advantages over the direct technique for interim restoration fabrication. Because the provisional materials do not polymerize intraorally, the pulpal tissues are not exposed to the exothermic polymerization reaction or to unreacted free monomer or other chemical irritants. Because the amount of heat generated is proportional to the volume of material used, the indirect technique is most often indicated for the fabrication of interim restorations for multiple crowns or complex fixed partial dentures with multiple pontics where the exothermic reaction cannot easily be controlled intraorally. Although the indirect technique has been described as more accurate [44], incomplete capture of preparation margins and polymerization changes may require repair or reline of the restoration intraorally.

The main disadvantage of the indirect technique is that an intermediate impression and stone cast are required to fabricate the interim restoration, resulting in increased time and materials required for fabrication.

Indirect-direct technique

A combination of the two techniques is proposed to provide a relatively atraumatic means to achieve the most accurate fitting interim prosthesis [4]. The technique involves the fabrication of a thin shell indirectly on a minimally reduced cast of the proposed restorations. These shells are relined with the provisional restorative material intraorally. This technique combines the best marginal accuracy with the least potential for thermal damage to the pulpal tissues. However, as with the indirect technique, the indirect-direct technique requires greater time and laboratory support.

Marginal integrity

Regardless of the technique used in fabrication, one of the key requirements of an interim prosthesis is to provide a definitive marginal seal to prevent pulpal sensitivity, provisional cement washout, bacterial ingress, and secondary caries or pulpal necrosis. A definitive marginal seal also promotes optimal periodontal and gingival health and facilitates the impression and cementation procedures and maintenance of the gingival architecture [45]. The specific technique used in the fabrication of an interim restoration has a significant impact on the resultant marginal integrity. Having the material polymerize completely and undisturbed intraorally on the tooth preparation or on a gypsum cast of the preparation provides the most accurate marginal adaptation [43]. However, this method is impractical with the direct technique because leaving the material undisturbed leads to "locking" the interim restoration on to the prepared tooth. Although the indirect technique has been found to produce significantly more accurate marginal integrity than the direct technique, the amount of improvement between the direct and indirect techniques is material specific [43,44]. In addition, for adequate marginal integrity, the indirect technique requires a complete and accurate impression of the preparation finish line. A direct reline procedure seems to improve the marginal integrity of directly and indirectly fabricated interim restorations [46]. It is important to provide adequate internal room for the reline material and to provide an escape vent to optimize marginal adaptation. When comparing the marginal integrity of provisional materials fabricated using the same technique, in vitro results suggest that marginal fidelity is more dependent on the specific product than on the chemical classification of the material [47,48].

Summary

Interim restorations are a critical component of fixed prosthodontic treatment. In addition to their biologic and biomechanical requirements, interim restorations provide the clinician with valuable diagnostic information. They act as a functional and esthetic try-in and serve as a blueprint for the design of the definitive prosthesis. In selecting a material for the fabrication of a single crown or multi-unit interim restoration, the clinician must consider multiple factors, such as physical properties (eg, flexural strength, surface hardness, wear resistance, dimensional stability, polymerization shrinkage, color range and stability, and radiopacity), handling properties (eg, mixing time, working time, predictable and consistent setting time, ease of trimming and polishability, and repairability), patient acceptance (eg, smell and taste), and material cost. There is no one material that meets all requirements [16]. Complicating the clinician's ability to choose a material is the fact that the material classification alone of a given product is not a predictor of clinical performance. However, some clinical trends are noteworthy. For single-unit restorations, the bis-acryl materials offer many desirable properties. They tend to have low exothermic reactions, minimal polymerization shrinkage, minimal odor and objectionable taste, and relatively quick setting reaction and are easy to trim and marginally accurate. In addition, many of the bis-acryl provisional materials offer convenient cartridge delivery systems, which may allow for more consistent mixes [49]. Disadvantages include their brittleness and increased cost, which are not as critical for single-unit interim restorations. For multi-unit, complex, long-term interim fixed prostheses, the PMMA provisional materials remain the material of choice. They have high flexural strength, good reparability, high polishability, acceptable marginal fit, good color stability, excellent esthetics, and cost effectiveness.

The clinician must have a thorough knowledge of the handling characteristics and properties of the interim restoration material selected.

The technique used for fabrication will most likely have a greater effect on the final result than the specific material chosen.

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