A review of selected dental literature on contemporary provisional fixed prosthodontic treatment: Report of the Committee on Research in Fixed Prosthodontics of the Academy of Fixed Prosthodontics

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One goal of the American Academy of Fixed Prosthodontics is regularly to publish comprehensive literature reviews on selected topics germane to the discipline of fixed prosthodontics. The following report is the result of this goal and focuses on provisional fixed prosthodontic treatment. Major subtopics include materials science and clinical considerations involving natural teeth and dental implants. The interrelationship between provisional and definitive fixed prosthodontic treatment is multifaceted and significant. Provisional therapy involves numerous materials and techniques that require special knowledge and technical experience. In this analysis, technical, clinical, and investigational articles are detailed and presented as a comprehensive literature review to provide contemporary guidelines. Referenced publications were found by conducting a Medline search and were limited to peer-reviewed, English-language articles published from 1970 to the present. Materials used with provisional treatment are discussed in terms of clinical selection and the influence of their physical properties on treatment outcome. Specific product names and manufacturers are included in this report only when they are cited in the original referenced publications. (J Prosthet Dent 2003;90:474-97.)

Fixed prosthodontic treatment, whether involving complete or partial coverage and natural tooth or dental implant abutments, commonly relies on indirect fabrication of definitive prostheses in the dental laboratory. Historically, the necessity for provisional treatment has been primarily derived from this methodologic process. The importance of interim treatment, however, is more far-reaching than is portrayed by this procedural necessity, and the requirements for satisfactory provisional restorations differ only slightly from the definitive treatment they precede.[1] Vahidi[2] and others[3-7] identified multiple areas of critical concern with provisional restorations including esthetics, comfort, speech and function, periodontal health, maxillomandibular relationships, and continued evaluation of the fixed prosthodontic treatment plan. Biologically acceptable fixed prosthodontic treatment demands that prepared teeth be protected and stabilized with provisional restorations that resemble the form and function of the planned definitive treatment.[8] They can assist in the maintenance of periodontal health[2] and promote guided tissue healing by providing a matrix for surrounding gingival tissues.[9] This is especially useful with treatment involving highly esthetic areas. The rationale for provisional treatment is shown in Table I.[5,10]

Besides the immediate protective, functional, and stabilizing value, interim restorations are useful for diagnostic purposes where the functional, occlusal, and esthetic parameters are developed to identify an optimum treatment outcome before the completion of definitive procedures.[9,11] A provisional fixed restoration will provide a template for defining tooth contour, esthetics, proximal contacts and occlusion,[12] and for evaluating the potential consequences from an alteration in the vertical dimension of occlusion.[2] Provisional treatment can also provide an important tool for the psychological management of patients where a mutual understanding

Table I. Rationale for provisional treatment

Protect pulpal tissue and sedate prepared abutments
Protect teeth from dental caries
Provide comfort and function
Evaluate parallelism of abutments
Provide method for immediately replacing missing teeth
Prevent migration of abutments
Improve esthetics
Provide an environment conductive to periodontal health
Evaluate and reinforce the patient's oral home care
Assist with periodontal therapy by providing visibility and access to surgical sites when removed
Provide a matrix for the retention of periodontal surgical dressings
Stabilize mobile teeth during periodontal therapy and evaluation
Provide anchorage for orthodontic brackets during tooth movement
Aid in developing and evaluating an occlusal scheme before definitive treatment
Allow evaluation of vertical dimension, phonetics, and masticatory function
Assist in determining the prognosis of questionable abutments during prosthodontic treatment planning

Modified from Federick[5] and Krug.[10]

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of treatment outcome and limitations of treatment can be identified.[12]

The use of provisional restorations relies on a reasonable turnaround time from tooth preparation to completion of definitive treatment. Provisional treatment is usually well tolerated when this occurs. Longer time periods of use can promote tooth sensitivity and potential pulp damage.[13] Occasionally, however, interim treatment has to function for extended intervals and provide long-term tooth protection and stability while adjunctive treatment is accomplished.[14,15] These procedures can be especially useful while the periodontal health status of an abutment tooth over an extended period of time is evaluated.[2] Long-term provisional treatment also allows for improved interproximal access during periodontal therapy.[15] The maintenance of long-term provisional treatment in concert with procedures such as alveoloplasty, tissue augmentation, dental implant placement, endodontic therapy, and orthodontics is frequently useful.[14]

It can be challenging for practitioners to justify the use of provisional treatment because of its "temporary" nature, especially when the time required to produce a suitable interim restoration equals that spent for tooth preparation and impression making.[16] However, the exclusion of this essential step and the quality of the provisional restoration can be the difference between overall treatment success and failure.[3-5,17,18] The terms *provisional*, *interim*, or *transitional* have been routinely used interchangeably in the literature. The use of the term *temporary*, however, is controversial and is considered inappropriate by some because provisional restorations serve many functions, and "temporary" treatment may be interpreted as one of lesser importance or value.[5,12,19] Provisional restorations should be the same as definitive restorations in all aspects, except for the material from which they are fabricated.[4,20-22] Provisional treatment as an adjunct to some procedures such as porcelain veneers or implant prosthodontics may be occasionally unnecessary.[23,24]

The purpose of this article is to review provisional fixed prosthodontic treatment. The literature was searched using Medline, and references were limited to peer-reviewed, English-language publications from 1970 to the present.

MATERIAL FOR PROVISIONAL RESTORATIONS

Interim treatment promotes numerous adjunct benefits to definitive prosthodontic treatment. The materials and techniques used for these purposes must reflect these variable treatment demands and requirements. Consistent with nearly all areas of dental management where material science plays such a significant role, there is presently no ideal provisional material suitable for all clinical conditions, however, there are many materials that have been used successfully for this purpose.[25] The requirements needed for provisional materials are shown in Table II. Many of these requirements such as appropriate marginal adaptation, low thermal conductivity, non-irritating reaction to the dental pulp and gingival tissues, ease of cleaning, ease of contour, and ease of alterability and repair are extremely important to the success or failure of treatment outcomes.[2]

Table II. Requirements for provisional restorations

Good marginal adaptation; adapts well to a tooth and matrix surface
Adequate retention and resistance to dislodgment during normal masticatory function
Strong, durable, and hard
Nonirritating to pulp and other tissues; low exothermicity
Nonporous and dimensionally stable
Comfortable
Esthetically acceptable shade selection; translucent tooth-like appearance
Color stable
Physiologic contours and embrasures
Easy to mix and load in the matrix, fabricate, reline, and repair; relatively short setting time
Physiologic occlusion
Conductive to routine oral home-care cleaning procedures
Finishes to a highly polished, plaque- and stain-resistant surface
Easy to remove and re-cement by the dentist
Relatively inexpensive
Low incidence of localized allergic reactions

Modified from Federick[5] and Krug.[10]

For others, specific clinical treatments have a variety of mandates for these materials and the importance of these requirements vary accordingly. For instance, anterior provisional restorations usually have higher esthetic demands than those needed for the posterior region.[26] Long-span fixed partial denture (FPD) treatment requires provisional materials and techniques that provide greater tensile strength relative to single-unit restorations.[27] Long-term use of provisional restorations requires materials that are more durable because of their longer period of service.[16,28]

Provisional material selection should be based on the strengths and weaknesses of a given material relative to the clinical mandates for specific treatments.[25] Differing clinical techniques, such as indirect interim fabrication,[2] may be required to accommodate certain situations.[16] Finally, among differing proprietary material brands exhibiting similar chemical composition and physical properties, experience and personal preference is an important consideration in material selection.[25]

Mechanical, physical, and handling properties, as well as biocompatibility, will influence material selection in fabricating provisional restorations.[29] A material should be easy to handle, provide adequate working time, and

Table III. Comparison of physical properties for fixed provisional resin restorations

Desired physical properties	Methyl methacrylate	Ethyl methacrylate	Bis-GMA composite	Visible light-polymerized composite
Minimal temperature change during polymerization	√√	√√√	√√√√	√
Surface hardness	√√√	√	√√	√√√√
Marginal fit	√√√	√√	√√√√	√
Wear resistance	√	√√√	√√√√	√√√√
Transverse strength	√√√√	No value—too rubbery	√√√√	√√√√
Transverse repair strength	√√√√	√	√√	√√√√
Surface roughness and polishability	√√√	√√√√	√√	√√
Color stability	√√	√	√√√	√√√√
Stain resistance	√√√	√√√√	√	√

Modified from Wang et al.[25]
√√√√, Most desirable comparative value; √, Least desirable comparative value.

be nontoxic. Treatment complications such as chemical injury from the presence of monomer residue, thermal injury from an exothermic polymerization reaction, and mechanical injury resulting from polymerization shrinkage must be considered.[30] Likewise, after fabrication, considerations such as preventing repairs and remakes often continue to be a direct reflection of the physical properties of a provisional material.[29] Interim restorations are generally fabricated using 1 of 2 techniques: (1) custom fabrication; or (2) fabrication with preformed materials. Additionally both of these procedures can be accomplished with direct clinical, indirect laboratory, or direct/indirect combination techniques.[2] Indirect techniques may result in an increased cost of fabrication and may require special equipment and increased nonclinical time for fabrication.[31]

Custom-fabricated materials

Custom fabrication represents one of the best choices for provisional restorative treatment.[32] The technique allows for intimate contact between a provisional restoration and prepared tooth. It provides a continuous mechanism for a variety of alterations during treatment such as marginal adaptation, contour change, shade adjustment, occlusal modification, and repair.

Provisional materials have been divided into the following categories based on how they are converted from plastic to solid-elastic masses: (1) chemically activated autopolymerizing acrylic resins; (2) heat activated acrylic resins; (3) light-activated acrylic resins; (4) "dual" light and chemically activated acrylic resins; and (5) others (alloys).[2] The most common materials used for custom interim fixed restorations are acrylic resins.[13,33] Generally, acrylic resins used for provisional restorations are brittle,[34] but their great advantage is the ease with which they can be altered by additions and subtractions.[2,15] Several types of acrylic resin materials are available for interim restorative treatment[2,32,35]: (1) polymethyl methacrylate resins; (2) polyethyl methacrylate resins; (3) other types or combinations of unfilled methacrylate resins; and (4) composites. A comparison of physical properties associated with a variety of provisional materials is presented in Table III. [25] Comparative advantages and disadvantages of provisional materials are listed in Table IV.[2,3,9,10,14,19,25,27,32,34,36-57]

Methacrylate resins

Autopolymerizing polymethyl methacrylate (PMMA) first appeared around 1940[45] and remains the most frequently used material for fabrication of interim restorations.[3,13,29,48] Plant et al[58] found that the intrapulpal temperature rise associated with the polymerization of methyl methacrylate materials could be up to 5 times that associated with the normal consumption of thermally hot liquid. The literature indicates that polymethyl methacrylate is the preferred material when provisional restorations are made using indirect techniques.[3,39]

As seen in Table IV, ethyl methacrylate, introduced in the 1960s,[44] has a number of advantages and disadvantages relative to methyl methacrylate. One study,[59] however, showed the highest value of fracture resistance with an ethyl methacrylate material relative to methyl methacrylate and bis-acryl materials. Ethyl methacrylate may be a better selection for direct interim prosthesis fabrication[2] and is best suited for short-term use relative to methyl methacrylate.[10,32] Two other chemically similar materials, vinyl-ethyl and butyl methacrylate, display comparable clinical behavior to polyethyl methacrylate. Commercially available unfilled methacrylate materials are listed in Table V.

Composite

Composite provisional materials encompass a fairly variable category by virtue of the fact that they are chemically comprised of a combination of 2 or more types of material. Most of these materials use bis-acryl resin, a hydrophobic material that is similar to bis-GMA. When

Table IV. Reported clinical advantages and disadvantages for custom provisional materials

Material type	Clinical advantages	Clinical disadvantages
Methyl methacrylate	Durability[2,25,32,27,42] (controversial) Color stability and esthetics[32,37] Good marginal adaptation[2,25] Capable of high polish[2,25] Relatively inexpensive[2,14]	Poor durability[44,48] (controversial) Exothermic polymerization[2,14,19,38,39] Polymerization shrinkage[9,14,22,32] Poor wear resistance[25] Pulpal irritation associated with excess free monomer[2,14,40,41,45] Strong odor[10,45]
Ethyl methacrylate	Lower exothermic reaction[2,14,19,42] Low polymerization shrinkage[2,14,42] Good handling characteristics[14] Good polishability[25] Good stain resistance[25] Less pungent odor[10] Good toughness[14]	Low tensile strength[14,25,43] Poor surface hardness[25] Poor wear resistance[2,25] Poor durability[2,25] Poorer color stability[2,3,25,36,46]
Bis-GMA composite	Good surface hardness[47] (controversial) Easy to use[14] Low exothermic reaction[14,25,38] Low polymerization shrinkage[14] Good marginal adaptation[25,50,51] Good wear resistance[25] Good color stability[25] (controversial) Minimal pulpal irritation[49]	Poor surface hardness[25] (controversial) Expensive[14] Brittle[2,59] Alterations and repairs are difficult[2,27] Poor stain resistance[25] Less polishability[14] Poor handling characteristics[3,52] Poor color stability[41] (controversial)
Visible light-polymerized composite	Low temperature change[25] (controversial) Good color stability[25] (controversial) Controllable working time[54] Good surface hardness[25] Good wear resistance[25] Good transverse strength[25,34]	Poor marginal fit[25] High temperature change[25] (controversial) Poor color stability[57] (controversial) Poor stain resistance[25] Limited shade availability[54] Relatively expensive[56] Brittle[55]

Table V. Unfilled methacrylate materials and manufacturers for custom fabricated provisional fixed prosthodontic restorations

Material classification	Product name	Manufacturer
Methyl methacrylate	Alike	GC America, Alsip, Ill.
	Coldpac	Motloid, Chicago, Ill.
	Duralay	Reliance Dental, Worth, Ill.
	Jet	Lang Dental, Wheeling, Ill.
	Temporary Bridge Resin	L.D. Caulk, Milford, Del.
	Trim Plus	Harry J. Bosworth, Skokie, Ill.
	True Kit	Harry J. Bosworth, Skokie, Ill.
	Unifast LC	GC America, Alsip, Ill.
Ethyl methacrylate	Splintline	Lang Dental, Wheeling, Ill.
Vinyl ethyl methacrylate	Snap	Parkell, Farmington, NY
	Trim	Harry J. Bosworth, Skokie, Ill.
	Trim II	Harry J. Bosworth, Skokie, Ill.
Butyl methacrylate	Temp Plus	Ellman Int, Hewlett, NY

this resin is mixed with inorganic, radiopaque filler it combines to provide an interim treatment material that is similar to composite restorative materials. Typically these materials use a variety of multifunctional acrylic resin monomers that produce high-density cross linkages during polymerization. Consequently they exhibit a unique rubbery stage during the polymerization process.[14] These materials are available as autopolymerized,

Table VI. Composite materials and manufacturers for custom fabricated provisional fixed prosthodontic restorations

Material classification	Product name	Manufacturer
Bis-acryl composites (Auto-polymerized)	Bis Jet	Lang Dental, Wheeling, Ill.
	Integrity	L.D. Caulk, Milford, Del.
	Luxatemp	Zenith/DMG, Englewood, NJ
	Protemp II	ESPE, Plymouth Meeting, Pa.
	Protemp Garant	ESPE, Plymouth Meeting, Pa.
	Provitec	GC America, Alsip, Ill.
	SmarTemp	Parkell, Farmington, NY
	Temphase	Kerr Dental, Orange, Calif.
	Turbo Temp	Danville Materials, San Ramon, Calif.
	Ultra Trim	Harry J. Bosworth, Skokie, Ill.
Bis-acryl composite (Dual-polymerized)	Iso Temp	3M Dental, St. Paul, Minn.
	Luxatemp Solar	Zenith/DMG, Englewood, NJ
	Luxa-Flow (repair material)	Zenith/DMG, Englewood, NJ
	Provipont DC	Ivoclar/Vivadent, Amherst, NY
Urethane dimethacrylate composite (Visible light-polymerized)	Triad	Dentsply Int, York, Pa.

dual- (auto/visible light) polymerized, or visible light-polymerized forms.

Most of the composite materials are now available with an auto-mix delivery system similar to polyvinylsiloxane impression materials. This makes them quick and easy to use, but expensive.[14] Diaz-Arnold et al[47] showed a general decrease in hardness over time for 2 out of 3 composite materials tested. This is consistent with Ireland et al[60] who showed that the bis-acryl materials exhibited higher flexural elastic moduli and moduli of rupture values at 24 hours but exhibited the greatest decrease in these values over time.

Varnish materials designed to coat provisional restorations and produce a smoother surface are commercially available but are not advisable.[61] Bis-acryl materials are compatible with other composite materials, but alterations for repairs and addition are difficult.[2,27] In fact, Koumjian and Nimmo[27] showed an 85% decrease in transverse strength after repair of a bis-acryl material. They suggested that it might be more advantageous to make a new provisional restoration than repair this material.[27] Young et al[50] compared bis-acryl and polymethyl methacrylate materials in terms of occlusion, contour, marginal fidelity, and finish. For both anterior and posterior teeth, they found the bis-acryl materials significantly superior to PMMA in all categories. Another report makes similar comments.[62]

Some practitioners find bis-acryl materials difficult to manipulate before setting because of difficult handling properties.[1,3,35,52,53] Conversely, it has also been reported that dual-polymerized materials provide a more rigid rubbery stage where considerable adjustment and evaluation can be made before the final photopolymerization.[29]

Two other studies have discouraged the use of dual-polymerizing materials because of technique sensitivity.[1,51] Luthardt et al[1] compared the clinical performance of autopolymerizing, dual-polymerizing, and visible light-polymerizing bis-acryl materials. They concluded that the light- and dual-polymerizing materials did not offer a clinical benefit relative to autopolymerizing. Reduced flexibility of the partially polymerized materials made them difficult to handle, which lead to complications with the integrity of provisional restorations. Tjan et al[51] stated that handling techniques might contribute to problems with marginal accuracy.

Visible light-polymerized resin

The visible light polymerized (VLC) materials, first introduced in the 1980s,[44] require the addition of urethane dimethacrylate, a resin whose polymerization is catalyzed with visible light energy and a camphoroquinone/amine photo initiator.[34,55,60] These materials usually incorporate a filler such as microfine silica to improve physical properties such as reduced polymerization shrinkage.[53] Unlike methacrylate resins, they do not produce residual free monomers after polymerization, which explains why they exhibit significantly decreased tissue toxicity relative to methacrylate resins.[63] Haddix[54] indicated that VLC materials could produce provisional restorations with quality similar to heat-polymerized, laboratory-processed restorations, but with less time and expense. Dual-polymerizing composite materials generally incorporate both chemically polymerized bis-acryl and light-polymerized urethane dimethacrylate resins in variable product-specific combinations. Commercially available composite materials are listed in Table VI.

Table VII. Preformed materials and manufacturers for provisional fixed prosthodontic restorations

Material classification	Product name	Manufacturer
Polycarbonate resin	B-Crowns	Harry J. Bosworth, Skokie, Ill.
	Polycarbonate Crowns	3M Dental, St. Paul, Minn.
Polycarbonate resin	Molar B-Crowns	Harry J. Bosworth, Skokie, Ill.
Nylon fiber reinforced metal	Iso-Form Crowns (tin/silver alloy)	3M Dental, St. Paul, Minn.
	Gold Anodized Crowns (gold anodized aluminum)	3M Dental, St. Paul, Minn.
	Stainless Steel Crowns (nickel chrome)	3M Dental, St. Paul, Minn.

Preformed materials

Preformed provisional crowns or matrices usually consist of tooth-shaped shells of plastic, cellulose acetate, or metal. They are commonly relined with acrylic resin to provide a more custom fit before cementation, but the plastic and metal crown shells can also be cemented directly onto prepared teeth using a stiff luting material following adjustment.[14] They are commercially available in various tooth sizes and are usually selected for a particular tooth anatomy. Nonetheless, available sizes and contours are finite which makes the selection process important for clinical success. Compared with custom fabricated restorations, this treatment method is quick to perform but is more subject to abuse and inadequate treatment outcome. This can result in improper fit, contour, or occlusal contact for a provisional restoration.[32]

Polycarbonate resin

Polycarbonate resin is commonly used for preformed crowns and possesses a number of superior properties relative to polymethyl methacrylate materials.[5,64] These crowns combine microglass fibers with a polycarbonate plastic material.[14] Practitioners commonly use polycarbonate resin shell crowns as a matrix material around a prepared tooth that is relined with acrylic resin to customize the fit.[5] This material possesses high impact strength, abrasion resistance, hardness, and a good bond with methyl-methacrylate resin.[64]

Metal

Metal provisional materials are generally esthetically limited to posterior restorations. Aluminum shells provide quick tooth adaptation due to the softness and ductility of the material, but this same positive quality can also promote rapid wear that results in perforation in function and/or extrusion of teeth.[14] An unpleasant taste is sometimes associated with aluminum materials.[14] Iso-Form Crowns (3M Dental Products, St. Paul, Minn) are manufactured with high-purity tin-silver and tin-bismuth alloys. Like aluminum, they possess reasonable ductility and can be contoured quickly, but the occlusal table is reinforced so they are more resistant to wear related failure.[14] For longer-term use, nickel chrome and stainless steel crowns are available but may be more difficult to adapt to a prepared tooth.[14] Commercially available preformed materials are listed in Table VII.

INFLUENCE OF MATERIAL PROPERTIES ON TREATMENT OUTCOME

Marginal accuracy

Accurate marginal adaptation of resinous provisional restorations to the finish line of a prepared tooth assists in protecting the pulp from thermal, bacterial, and chemical insults.[65] Barghi and Simmons[66] indicated that from their qualitative assessment, autopolymerizing acrylic resin provisional restorations routinely did not have adequate marginal adaptation. The accuracy could be significantly improved by relining the restoration after the initial polymerization. Furthermore, they found that because of hydraulic pressure, 80% of restorations did not fully reseat after the reline procedure. They suggested that this problem could be improved by venting a provisional restoration before reline.

Crispin et al[67] evaluated marginal accuracy with direct and indirect techniques. They reported that indirect fabrication provided significant improvements in marginal fit relative to direct methods when methyl and vinyl ethyl methacrylate resins are used. They demonstrated that the marginal fit of polymethyl methacrylate restorations could be improved by up to 70% with an indirect technique. Other reports showed similar results.[56,68]

A number of studies have focused on the effects of thermocycling on provisional crown margins.[69-73] They reported that (1) acrylic resin provisional crowns demonstrated dimensional degeneration and enlarged marginal gaps resulting from thermocycling and occlusal loading; (2) marginal gap changes were greater after hot thermocycling than cold thermocycling; (3) improved marginal accuracy of PMMA provisional restorations occurred when a shoulder finish line was used compared with a chamfer marginal design; (4) in addition to improved initial accuracy, provisional resin restorations that were relined had smaller marginal changes after thermocycling and occlusal loading; and (5) light-polymerized materials provided significantly improved marginal accuracy relative to autopolymerizing PMMA resin after thermocycling. In contrast, Keyf and Anil[74] concluded that the marginal discrepancy found with bis-acryl resin was significantly greater with a shoulder finish line after 1 week relative to a chamfer design.

Koumjian and Holmes[75] examined a variety of resinous provisional materials and reported that they all demonstrated continued polymerization shrinkage after storage in air for 1 week. When stored in water for 1 week, water absorption compensated for polymerization shrinkage in all of the materials except for polyvinylethyl methacrylate and bis-acryl materials. The water storage environment was the most clinically relevant in this study and produced significantly lower marginal discrepancies with the PMMA and ethyl methacrylate materials.

Lepe et al[68] reported that polymerization shrinkage of acrylic resin would play an important role in the fit of provisional restorations. Volumetric polymerization shrinkage for polymethyl methacrylate is 6% compared with 1% to 2% for composite materials. They speculated that composite materials would provide a better marginal fit relative to unfilled polymethyl methacrylate because of less polymerization contraction, but the authors also pointed out that marginal fit is not the only factor affecting the overall retentive quality of provisional restorations. They found a nearly 20% improvement in the retention of interim crowns made with polymethyl methacrylate compared to those fabricated with composite materials. They concluded that polymerization shrinkage occurring with the polymethyl methacrylate material might have allowed for a tighter fit of the restoration on the prepared tooth, which had a direct influence on improved retentive quality.

Color stability

In esthetically critical areas it is desirable for provisional restorations to provide an initial accurate color shade match and then to remain color-stable over the course of provisional treatment.[26] Discoloration of provisional materials can produce serious esthetic complications, especially when long-term provisional treatment is required. Modern provisional materials use stabilizers that decrease chemically induced color changes, but these materials are susceptible to other factors that will promote staining.[36,37,76] Most provisional materials are subject to sorption, a process of absorption and adsorption of liquids that occurs relative to environmental conditions.[26,36] When provisional materials contact pigmented solutions such as coffee or tea, discoloration is possible.[37,76] Porosity and surface quality of provisional restorations,[36,74,77] as well as oral hygiene habits,[26] can also influence color changes.

Crispin and Caputo[36] studied the color stability of provisional materials. They found that methyl methacrylate materials exhibited the least darkening, followed by ethyl methacrylate and vinyl-ethyl methacrylate materials. They also reported that increases in surface roughness induced increases in material darkening and pressure polymerizing did not influence discoloration relative to air polymerizing. Koumjian et al[57] included a visible light-polymerized material in their investigation. They placed test materials into the flanges of complete dentures and concluded that for short time periods of 5 weeks or less, all materials demonstrated acceptable color stability. They stated, however, that the Triad VLC material exhibited more adverse color change relative to other materials at the end of 9 weeks.

Yannikakis et al[37] immersed provisional materials in various staining solutions for up to 1 month. They reported that all materials showed perceptible color changes after 1 week. After 1 month, the methyl methacrylate materials exhibited the best color stability and bis-acryl materials the worst.

Robinson et al[78] reported on the effect of vital tooth bleaching on provisional restorative materials. They prepared disks of polymethyl, polyethyl, polybutyl methacrylate, and bis-acryl composite materials. Polycarbonate crowns were also studied. Specimens of each type of provisional material were placed into a variety of proprietary dental bleaching agents and soaked for up to 14 days. They concluded that an orange discoloration occurred throughout the specimens representing all methacrylate materials. The bis-acryl and polycarbonate crowns showed no difference relative to the control group. Another study confirmed the color stability of composite materials during vital bleaching treatment.[79] Monaghan et al[80] found that vital bleaching produced visibly lighter composite restorations. They reported that in some situations composite restorations might lighten along with natural teeth that are simultaneously bleached.

Gingival response

Inflammation and recession of the free gingival margin associated with provisional treatment is a common occurrence.[81-84] Donaldson[81] reported the following observations regarding gingival recession: (1) the presence of a provisional restoration lead to at least some recession at about 80% of the free gingival margin sites evaluated; (2) the degree of recession was time dependant; (3) placement of the definitive treatment commonly lead to gingival recovery; (4) 10% of subjects demonstrated recession in excess of 1 mm; and (5) in the presence of gingival recession, only one third of subjects demonstrated complete gingival recovery.

In a separate report, Donaldson[82] indicated that the occurrence of gingival recession before provisional treatment was directly linked to further recession observed after the completion of definitive prosthodontic treatment. A history of bone loss and subsequent gingival recession would suggest that a patient would have an adverse reaction to provisional fixed prosthodontic treatment. He also found a direct relation between the degree of pressure applied by a provisional restoration and gingival recession. An anatomically contoured provisional restoration caused less recession than did a nonanatomically contoured one.

In contrast, MacEntee et al,[85] in a histologic evaluation of tissue response, reported no detectable change in gingival tissue associated with provisional restorative treatment over a 3 week period. Waerhaug and Zander[83] found that in the presence of mechanical irritation such as poor restorative contours, provisional treatment did not negatively alter gingival tissue response. Rather, they implicated the presence and accumulation of necrotic tissue and plaque material in areas associated with poor marginal adaptation and surface roughness of interim restorations as a constant source of inflammation to the gingival tissues leading to diminished gingival health. Garvin et al[84] concluded that periodontal inflammation associated with provisional treatment could be expected to be a reversible process provided that the amount of gingival irritation is minimal and provisional treatment occurs over a short time span.

Pulpal response

Dental pulp inflammation can be caused by either thermal or chemical insult resulting from materials used to produce direct provisional restorations.[38,49,86,87] Tjan et al[86] studied the dental pulp chamber temperature rise associated with the direct fabrication of provisional restorations. In this in vitro study, a thermocouple probe was placed into the pulp chamber of specimen teeth to measure the exothermic reaction associated with the direct contact polymerization of methyl methacrylate, ethyl methacrylate, vinylethyl methacrylate, and bis-acryl materials. Although the bis-acryl material produced the lowest temperature increase, no significant differences were found among the 4 types of materials tested. The results of this study suggest the possibility of thermal damage to dental pulp tissue and odontoblasts during direct provisional fabrication, but the authors also indicated that actual damage could only be accurately assessed by use of histologic studies. They suggested that by use of air and water coolants, as well as by use of a matrix material, that can dissipate heat rapidly, the pulp temperature rise might be reduced. Additionally, the amount of heat rise is dependent on the quantity of provisional restorative material used.

Other studies have found comparable results with similar methods.[38,87] Moulding and Teplitsky[38] reported that intrapulpal temperature rise was dependent on the type of acrylic resin, and the type of matrix used to retain the material on the tooth during polymerization. Temperature rise was greatest with polymethyl methacrylate and vacuum adapted templates; least with bis-acryl and relined resin shells; and intermediate temperature increases were recorded with polyethyl methacrylate materials and either irreversible hydrocolloid or polyvinylsiloxane impression materials used as a matrix for holding acrylic resin provisional material against a tooth. The authors also identified that fixed partial denture provisional restorations produced a greater temperature rise than did single-unit provisional restorations.

Grajower et al[87] showed that faster polymerizing acrylic resin materials could generate higher temperatures than slower polymerizing resins. They indicated that external heat dissipation might be enhanced with a water spray or by polymerization of restorations in silicone impressions. Additionally, this external heat dissipation caused retardation in the polymerization, which further decreased heat production. The retardation resulted from the cooling effect of the spray and not the water itself, since moisture quickens the polymerization of autopolymerizing acrylic resins that contain tertiary amine accelerators. The authors concluded that (1) provisional acrylic resin restorations might be fully polymerized on prepared teeth by appropriate methods such as in impressions or with external cooling, without causing excessive heating of the dental pulp; (2) removal of a provisional restoration before complete polymerization, leading to potential deformation of the acrylic resin material, is therefore unnecessary; and (3) a thin insulating layer should be applied to a prepared tooth before contact with nonpolymerized acrylic resin to avoid chemical injury.

Hypersensitivity

Hypersensitivity from provisional materials has been reported but appears to be rare.[88-90] Autopolymerizing methacrylate materials have greater potential for producing allergic contact stomatitis than similar heat-polymerized materials.[90] The residual monomer in the material has been implicated as the causative factor.[90] One report showed that the residual monomer content in heat-polymerized acrylic resin ranges from 0.045% to 0.103%. Autopolymerized acrylic resin has a residual monomer content of 0.185%. Over time residual monomer is gradually leached out, leaving a fraction that is tightly bound to the resin material.[88]

Allergic reaction to provisional materials will demonstrate the following features: (1) the patient has had previous exposure to the provisional material; (2) the reaction conforms to a known allergic pattern, such as redness, necrosis, or ulceration; (3) the reaction resolves when a provisional restoration is removed; 4) reaction recurs when a provisional restoration is replaced; and 5) a patch test for the material is positive.[90] Patch testing has demonstrated less response with light-polymerized materials relative to autopolymerizing acrylic resin.[89] Indirect material processing methods are recommended for individuals showing evidence of hypersensitivity.[89,91] After complete polymerization, the polymerized acrylic resin usually does not induce allergic reactions. Unpolymerized monomer can be substantially removed by placing an autopolymerized provisional restoration in a pressure pot with warm water for 20 minutes.[89]

Strengthening provisional materials

The literature clearly favors acrylic resin as the material of choice for provisional restorations.[33] Most resins used for provisional restorations are brittle.[34] Repairing and replacing fractured provisional restorations is a concern for both clinician and patient because of additional cost and time associated with these complications.[33] Failure often occurs suddenly and probably as a result of a crack propagating from a surface flaw.[34] The strength and serviceability of any acrylic resin, especially in long-span interim restorations, is determined by the material's resistance to crack propagation.[43,92,93] Crack propagation and fracture failure may occur with these materials because of inadequate transverse strength, impact strength, or fatigue resistance.[48]

Physical properties of strength, density, and hardness may predict the longevity of provisional restorations. Donovan et al[92] examined methods to improve the longevity of these restorations using variable indirect polymerization techniques. They compared methyl methacrylate material strength, porosity and hardness under the following polymerization conditions: (1) in air; (2) under water; (3) under air pressure; and (4) under water and air pressure. They found that polymerization with a pressure vessel with air and water had the greatest influence on increasing strength and reducing porosity. There was no difference in hardness for the 4 conditions tested. A similar study, however, evaluated the fracture toughness of provisional resins and found that the use of a pressure vessel during polymerization did not significantly increase the fracture toughness for the resins tested.[43] Covey et al[94] found that oven heat treatments at 120°C for 7 minutes could significantly increase the tensile strength for both chemical and light-polymerized composite materials.

Heat-polymerization of acrylic resin materials can be used when provisional restorative treatment will be required for extended periods of time or when additional strength is required. This indirect laboratory process results in materials that are denser, stronger, more wear resistant, more color stable, and more resistant to fracture than their autopolymerizing counterparts.[3,95] Metal castings and swaged metal substructures in combination with resin materials have been incorporated into provisional restorations and have been reported as especially useful with long-term or long-span interim treatment.[5,95,96] Both heat-polymerized acrylic resin and metal provisional restorations should last longer than autopolymerized restoration, but the expense and time required for indirect fabrication can make them less cost effective for routine use.[97]

Reinforcing frameworks reduce flexure, increase retention,[95] and increase structural integrity.[98] Attempts have been made to strengthen acrylic resin materials by reinforcement with either chemical modification with grafted co-polymers and stronger cross linkage or by inclusion of various organic and inorganic reinforcing fibers.[48] Materials used for fiber reinforcement have included metal, glass, carbon graphite,[99,100] sapphire, Kevlar (Du Pont, Wilmington, Del),[101] polyester, and rigid polyethylene.[48] Most of these materials have had little or no success in increasing resin strength.[99]

Investigations on fiber reinforcement have favored the use of long continuous fibers, with strand alignment placed perpendicular to the direction of applied loads.[102] Samadzadeh et al[102] studied the effects of plasma-treated woven polyethylene fiber (Ribbond Inc, Seattle, Wash) on the fracture strength of methyl methacrylate and bis-acryl materials. Fracture strength was increased for the bis-acryl material. Ribbond fibers did not increase the fracture strength of PMMA prostheses, but complete catastrophic fracture was avoided. Powell et al[28] compared Kevlar 49 polyaramid fiber (Du Pont) with stainless steel wire as a way of reinforcing provisional fixed partial dentures made with methyl methacrylate resin. They found that the wire configuration produced a superior stiffness and toughness.

Zuccari et al[103,104] studied methods to promote a stronger resin matrix by decreasing crack propagation. They reported that when admixed zirconium oxide powders were added to unfilled methylmethacrylate resin, the resultant composite material exhibited significant improvements in the modulus of elasticity, transverse strength, toughness, and hardness, even though water sorption over time had a negative influence on mechanical properties.

Emtiaz and Tarnow,[44] Davidoff,[31] Caputi et al,[98] and others[8,12,16,17,55,96,105,106] have described various methods of adding metal reinforcing structures to acrylic resin provisional restorations; castings, spot welded stainless steel matrix bands, and precut stainless mesh have been used. Generally margins are not reproduced in the cast alloy. Yuodelis and Faucher[17] described using stainless steel wire material while Hazelton and Brudvik[105] reported the benefits of stainless steel orthodontic band material adapted around abutment teeth, removed, welded, and fitted inside acrylic resin shell crowns to reinforce autopolymerizing acrylic resin materials. Similarly, Greenburg[107] recommended ultra-thin stainless steel bands. Spot-welded stainless steel band–reinforced acrylic resin provisional restorations are stiffer and more resistant to cement degradation and loss of cement seal from deformation.[33] Fabrication of a reinforcing metal framework is guided by a diagnostic wax-up that generates the desired contours for the finished provisional.[95]

In a study describing a negative influence on the strength of provisional materials, Chee et al[108] studied the effect of chilled monomer on the working time for 3 autopolymerizing acrylic resins. They found that the working and setting times increased by up to 4 minutes when chilled monomer was used, but the transverse strength for the materials were decreased by 17%.

Provisional luting materials

Provisional luting agents should possess good mechanical properties, low solubility, and tooth adhesion to resist bacterial and molecular penetration.[11] The most important function of these materials is to provide an adequate seal between the provisional restoration and prepared tooth.[68] This is necessary to prevent marginal leakage and pulpal irritation.[11,68] There are a variety of luting materials used for interim purposes. The most common include (1) calcium hydroxide; (2) zinc-oxide and eugenol; and (3) noneugenol materials.[11] Generally, all of these possess poor mechanical properties that likely worsen over time. This can have a negative influence on marginal leakage but also provides an advantage by allowing easier dislodgment and removal of provisional restorations from teeth.[11]

The retentive requirements for provisional luting materials are that they be strong enough to retain a provisional restoration during the course of treatment but allow easy restoration removal when required.[68] This paradoxical necessity for good retentive and sealing quality and easy restoration retrieval may lead to a compromise in material behavior, particularly regarding mechanical properties.[11] Baldissara et al[11] recommended that interim restorations be frequently evaluated and used for only short periods of time. Literature reports advise that if provisional treatment is required over a protracted time period, it is best to remove and replace the provisional luting agent on a regular basis.[11,21]

Some of the most commonly used cements with provisional prostheses are those containing zinc-oxide and eugenol.[11] They provide sedative effects that reduce dentin hypersensitivity and possess antibacterial properties.[11] Unfortunately, free radical production necessary for polymerization of methacrylate materials can be significantly hampered by the presence of eugenol found in eugenol based provisional luting materials.[14] This can interfere with the acrylic resin polymerization and hardening process.[109] They can also be incompatible with some resin-based definitive luting agents for the same reason.[11]

Eugenol-free provisional luting materials are commercially available and have gained popularity due to the absence of resin-softening characteristics.[109] Gegauff and Rosenstiel,[110] however, reported that Temp-Bond (Kerr Dental, Orange, Calif) a zinc-oxide and eugenol–based cement did not appear to have a significant adverse effect on the polymerization of acrylic resins. They postulated that the softening effect of eugenol on acrylic resin is dependent on the presence of unreacted eugenol, which may be minimal in Temp-Bond cement.

CLINICAL CONSIDERATIONS FOR PROVISIONAL TREATMENT INVOLVING NATURAL TEETH

The literature describing the fabrication of provisional restorations is extensive but largely anecdotal. Virtually all teeth receiving cast restorations require provisional restorations. Properly executed provisional restorative treatment rarely fails and dislodgment or fracture usually indicates that their form is unacceptable or that a tooth preparation is inadequate. Provisional restorations should be smooth, highly polished, and alterable and for this reason custom made provisional restorations most consistently meet the biological, functional, and esthetic needs of a patient.[2] The brand of provisional material and method of fabrication are not as important as the devotion, skill, and attention to detail of the dentist.[22]

Provisional restorations as part of comprehensive treatment

Provisional restorations are not devoid of interactions with other modes of therapy. Patients often have periodontal, endodontic, orthodontic, or surgical needs in conjunction with their prosthodontic treatment. Provisional restorations produce outcomes that range from microscopic tissue effects to psychological factors that change a patient's behavior.[111] Provisional restorations can provide patients with an increased confidence in treatment.[4,111]

Diagnostic provisional treatment

In the simplest situations, complete oral and extraoral clinical examinations, as well as radiographic evaluation, may be all that is necessary before commencing prosthodontic treatment. In more complex treatments, however, provisional restorations provide a means of designing, improving, and assessing the occlusion, esthetics, and contours for definitive restorations, as well as to determine their effects on gingival health, phonetics, and patient adaptability before the initiation of the definitive treatment.[6,12,112-114] Provisional restorations fit into 2 categories: (1) those that fit within an arch of fundamentally intact teeth that provide reference for their occlusion, contours, and esthetics; and (2) those that become the reference for the entire prosthesis.[115,116] Provisional treatment for patients with more complex prosthodontic needs demands fabrication and articulation of diagnostic casts and completion of a diagnostic wax-up in the maxillomandibular relationship in which definitive treatment is to be performed.[2,30,117]

Occlusal diagnosis and treatment

Casts of provisional restorations mounted opposite definitive casts transfer contours, clinical crown dimensions, and maxillomandibular relationships from a patient to a dental laboratory for developing occlusal factors, especially anterior guidance, for fixed prosthodontic treatment.[2,4,5,118] Sometimes treatment feasibility can only be tested via full-arch provisional restorations and occlusal problems are best diagnosed during a functional testing period with provisional treatment.[15]

Esthetic and phonetic diagnosis and treatment

Provisional restorations assist development and assessment of esthetic and phonetic values of the planned fixed prosthesis.[2,12,39,115,117,119] Zinner et al[12] proposed use of guidelines to test anterior contours. They recommended that the maxillary anterior incisal edges follow the contour of the lower lip, the "smile line," and all 6 maxillary anterior teeth should be in contact with their antagonists in maximum intercuspation. Evaluation of labiodental ("F" and "V") and sibilant ("S" and "CH") sounds are useful methods of ascertaining the lengths of maxillary incisors.[39] Matrixes created from a diagnostic waxing or from casts of provisional restorations are useful tools for producing specific contours in a definitive prosthesis or communicating those concepts to the dental laboratory.[118-122] In certain situations phonetics and esthetics of a planned prosthesis can be assessed before tooth preparation by use of vacuum or pressure-formed matrixes that hold autopolymerizing acrylic resin between unprepared teeth and proposed tooth contours to provide intraoral treatment simulation.[117]

Periodontal treatment and maintenance

Periodontal treatment is commonly part of comprehensive prosthodontic care. These provisional restorations provide a matrix against which the tissue heals, guiding the generation of correct soft tissue architecture.[123] According to Shavell,[22] tooth preparations and provisional restorations should be completed with retraction cord in place. Patients should be seen weekly for evaluation and the provisional restorations are judged successful only when the gingival tissue reflects good general health. It has been recommended that when the duration of the periodontal treatment is less than 6 months, the use of acrylic resin provisional restorations should be adequate.[17] For longer treatment periods, gold-band-and-acrylic-resin restorations are more appropriate.[13,17] A provisional restoration also guides preparation of teeth that require periodontal surgery.[20] Poorly fabricated provisional restorations have consequences for fixed prosthodontic treatment including: gingival recession[2]; difficulty making impressions; difficulty fitting the definitive restorations[9]; soft tissue damage; and inefficient use of time at prosthesis insertion.[3] Provisional restorations play a role in long-term periodontal therapy as well.[15] Chlorhexidine used in conjunction with provisional treatment has been shown to reduce plaque levels and improve gingival indexes.[124]

Slightly convex facial and lingual contours of provisional restorations and a flat emergence profile are effective in promoting gingival health.[30] Good periodontal health can be created by developing the appropriate contour and good gingival adaptation and embrasure space of the prosthesis for the particular situation. Embrasure spaces that are too broad can cause food impaction and blunting of the papilla.[2]

Orthodontic conjoint treatment

It is generally better to avoid crown preparation before orthodontic treatment because after tooth movement; a tooth may be incorrectly prepared. However, in conjunction with tooth movement procedures, carefully planned provisional restorations can (1) replace hopeless or missing teeth to improve esthetics; (2) achieve occlusal stability with missing posterior teeth and maintain vertical dimension of occlusion; (3) retain teeth in proper position; (4) allow maturation of investing tissues; (5) allow evaluation of questionable teeth; and (6) provide anchorage where only a few teeth remain.[125]

Provisional fixed prosthesis fabrication

General concepts. According to Kopp[126] provisional fabrication involves 2 segments: (1)"supragingival construction," the basic form providing abutment protection, stabilization, and function; and (2)"intrasulcular extension," marginal fit and correct contours to promote soft tissue health. Central to this is the use of a matrix to produce the external form and adaptation of material replicating the contour of the prepared tooth or teeth. Provisional restorations are often made clinically though they may also be fabricated indirectly in the laboratory. In contemporary practice, the majority of provisional restorations are made wholly or in part with autopolymerizing acrylic resin.[3,13,29,48] Lubricants applied to teeth or a cast with indirect methodology are often recommended during fabrication of provisional restorations. The published preferences for lubricant materials used for these purposes are shown in Figure 1.

Adaptation to a prepared tooth. Adaptation is done either directly on a tooth or indirectly on a plaster, stone,

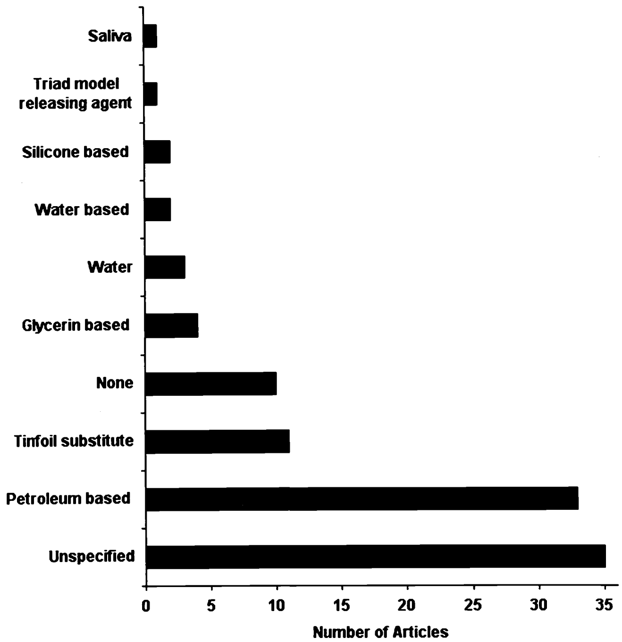

Fig. 1. Prevalence in literature of lubricant materials for tooth-borne provisional restorations.

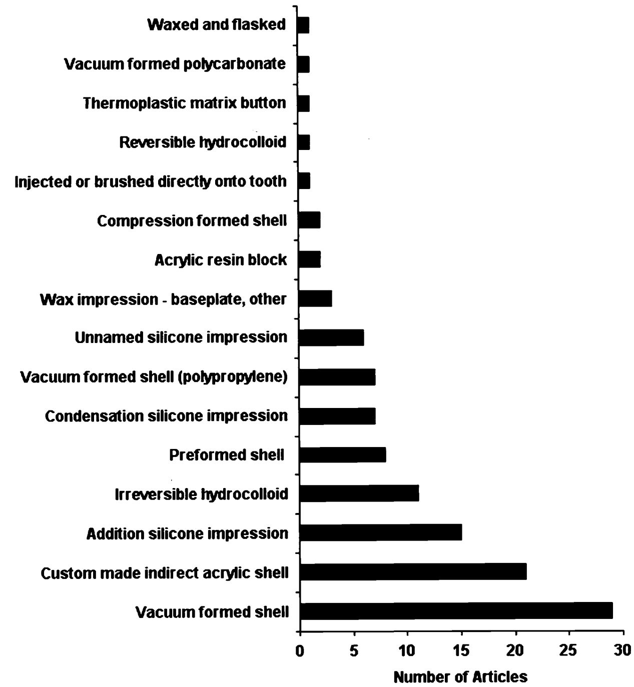

Fig. 2. Prevalence in literature of clinical fabrication methods for tooth-borne provisional restorations.

polyvinylsiloxane, or other replica of a prepared tooth.[3,5,127] Representation of the internal surface adaptation, or intaglio, is typically accomplished by adapting a plastic material such as acrylic resin or occasionally a cement, such as zinc oxide and eugenol to a tooth or tooth replica with an external shell or custom-made matrix. The internal surface adaptation is evaluated much like the surface of an impression.[3,9]

Cavosurface adaptation. Provisional restorations must be made of a material, which is alterable[2] and can be precisely adapted to prevent excessive cement film thickness.[30] A marginal gap usually exists at the interface between tooth, provisional restoration, and cement allowing plaque to accumulate and compromise cementation.[30,128] Relining provisional restoration margins produces the best adaptation as long as potential trauma from monomer and the exothermic heat of reaction is controlled with methods such as external water spray.[129-131] Exposure of margins by placement of retraction cord, not by electrosurgery,[126] is recommended during fabrication directly on the teeth.[9,22,53,126] Burnished copper or gold bands adapted to the cervical one third of a prepared tooth and incorporated into a provisional restoration are reported to improve margin adaptation, physiological contours, and hygiene,[125,132,133] however, at least 1 report asserts that acrylic resin margins can be as good as metal band margins.[15]

Posterior crown preparations can expose 1-2 million dentinal tubules if all the enamel is removed.[134] Dentin conditioners used with dentin bonding systems have been shown to increase fluid flow through the dentin.[134] Although dentin-sealing agents have demonstrated a reduction in dentin tubule fluid flow, numerous sealants have a significant film thickness at the margin area, some as thick as 263 μm.[134]

Form. Provisional restorations should have cervical concavities and proper emergence profile.[22] It has been suggested that pontics should be designed for hygiene on the mandibular arch and hygiene and esthetics on the maxillary arch. The convex, "bullet-shaped," pontic has been suggested to be the easiest to keep clean.[3]

Liebenberg[130] advocated avoiding splinted acrylic resin restorations whenever possible to promote better hygiene, cement removal, and reuse. Others advocate splinting adjacent provisional restorations together even if the definitive treatment plan calls for individual definitive restorations.[9] Burnished metal bands incorporated in the provisional reportedly improve contours.[125,132]

Clinical methods

Matrices. Numerous references have appeared in the literature since 1970 describing clinical fabrication methods and the prevalence of these methods is shown in Figure 2. A matrix planned for provisional fabrication may copy existing tooth contours from the mouth with a diagnostic cast[119] or reproduce customized contours created by a diagnostic waxing.[16] It is further suggested that, when possible, this matrix should extend onto at least 1 tooth adjacent to teeth being restored.[53] The addition of acrylic resin, VLC resin, or even elastomeric impression materials can add contour to select areas of casts to correct extensively damaged teeth before making the matrix.[135,136]

Transparent thermoplastic materials may be vacuum[8,10,14,55,65,137-139] or pressure[117,140] adapted to a dental stone cast creating a matrix or external surface form. Transparent matrices can be used for provisional fabrication, to guide tooth preparation,[53] as a laboratory aid, and can become a part of the patient records.[139]

Impression materials are useful for provisional matrices. Polyvinylsiloxane and irreversible hydrocolloid matrices serve functions other than providing an external surface form for the provisional restorations in that they can limit thermal insults to pulpal tissues.[38,87,141] A disadvantage of polyvinylsiloxane as a matrix material is its high cost.[35] Other materials such as baseplate wax have also been used for matrices.[142,143]

Direct fabrication. For select patients, a denture tooth secured in position with typical class III composite restorations and orthodontic wire may be a suitable provisional restoration for a missing mandibular incisor.[144] For urgent situations, in the absence of any matrix or opportunity to create a matrix, a provisional restoration can be fabricated by adapting a block of freshly mixed acrylic resin directly to a tooth. After the acrylic resin block has polymerized, the tooth contours can be carved with acrylic resin burs of choice and the restorative margins perfected intraorally.[131]

Most patients, however, require a more conventional approach. Fabricating provisional restorations directly on teeth using the "direct method" is suitable for single units and up to 4-unit fixed partial denture provisional restorations, according to 1 report.[126] Three techniques encompass virtually all of the literature on direct provisional restorations: (1) use of a premanufactured provisional shell[3,145-150]; (2) use of an impression material,[14,17,52,130,151-157] or pressure or vacuum formed translucent matrix[140,148]; and (3) use of a custom, prefabricated acrylic resin shell.[8,14,55,105,151,157-161]

Prefabricated shell crowns are constructed from a variety of materials including aluminum, silver-tin, tin-bismuth, polycarbonate resin, celluloid, stainless steel, and nickel-chrome and can be used as matrices for direct fabrication.[3,14,147]

Much more common in the literature is the use of impression materials or thermoplastic materials as shell matrices. Direct provisional restorations made particularly of PMMA and, to a lesser degree, polyethyl methacrylate (PEMA) must be cooled if the material is allowed to polymerize completely on a tooth; polymethyl methacrylate can increase pulpal temperatures as much as 7°C.[141] Cooling the material during polymerization by its removal at initial polymerization and allowing complete polymerization to be completed while it is off the tooth, cooling with air-water spray, periodic removal, and flushing with water and use of a "heat sink" matrix material such as alginate will limit temperature increases to less than 4°C, minimizing the exothermic risk.[162] Larger masses of exothermic materials such as with FPD provisional restorations produce greater pulpal temperature increases.[162]

Visible light polymerized materials produce smaller pulpal temperature increases and have extended working time compared with PMMA or PEMA.[38,141] One author[55] recommended softening Triad material in 120°F to 150°F water, creating a "hollow" in the center of the softened material mass with a blunt instrument before seating and lubricating the tooth as a method for reducing the viscosity of the material and promoting tooth adaptation. The adaptation was then evaluated extraorally before polymerization.[53] External colorants can be applied either as autopolymerizing pigments or as suspensions within light polymerized unfilled acrylic resins.[53] A number of reports[30,163,164] have recommended hybrid visible light-polymerized composite/PMMA direct provisional restorations. Fehling[163] stated that this combination decreased occlusal and proximal wear and recommended placing 3 coats of copal cavity varnish to protect the tooth from "deleterious effects of free monomer."

Indirect fabrication. The indirect method has been indicated to fabricate multiple unit provisional restorations to[126] (1) avoid exposure of a patient to adverse properties of provisional acrylic resins; (2) optimize the properties of provisional acrylic resins; (3) allow the use of materials that are difficult to polymerize intraorally; (4) make significant contour or occlusal changes; and (5) provide for the fabrication of hybrid provisional restorations. A variety of methods of creating an acrylic resin shell customized for a patient's occlusion or contours have been published.[8,55,65,158,160,161] Many authors describe indirect methods.[18,31,35,44,96,98,121,127,135,156,165-168] Indirect techniques generally use either approximate tooth preparations made on a duplicate cast or a cast of the actual tooth preparations made after the clinical procedure has been accomplished. A matrix made from a diagnostic wax-up of planned treatment tooth contours can be placed over the tooth preparations on the cast. Autopolymerizing acrylic resin can be packed into a matrix and fitted over the prepared tooth cast or a diagnostic wax-up can be invested and boiled out so that tooth-colored, heat-polymerized acrylic resin can be packed and processed.[2,31] One advantage of the indirect technique is that it can be allocated to auxiliary personnel.[35]

Fabricating a provisional restoration wholly or in part using an indirect method reduces exposure of oral tissues to monomer, heat, shrinkage,[121,169] and reduces the volume of volatile hydrocarbons inhaled by a patient. Creating an indirect acrylic resin shell of an unprepared tooth that is later relined intraorally is one method

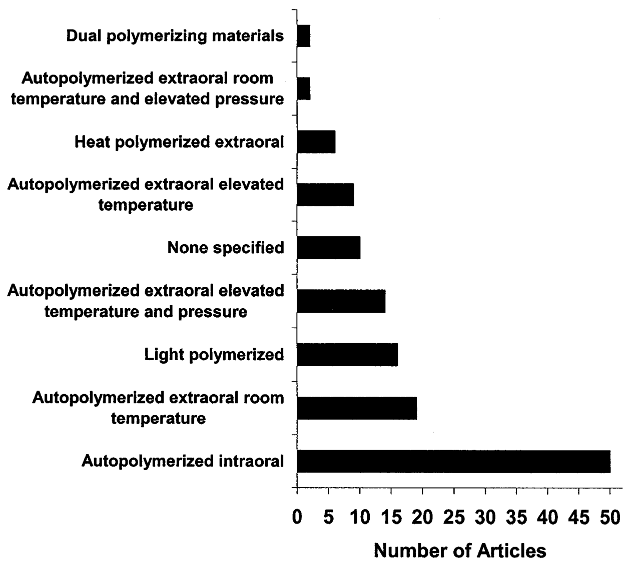

Fig. 3. Prevalence in literature of polymerizing methods for tooth-borne provisional restoration materials.

of reducing patient exposure.[157,161] Extensive shell matrices designed for adaptation and margin relining in the mouth can be initially fabricated of polycarbonate or visible light polymerized polymers.[55,64]

It has been reported that provisional restorations fabricated indirectly have superior margins to those from direct techniques because the acrylic resin polymerizes in an undisturbed manner.[127,169] Polymerizing autopolymerizing acrylic resin under heat and pressure improves the physical properties of the material. Reinforcing the vacuum or pressure formed matrix allows it to be secured to the cast on which the provisional shell is polymerized.[8,156,170]

The prevalence in the literature on polymerizing methods for tooth supported provisional restoration materials is shown in Figure 3. The intraoral autopolymerizing method is considerably more prominent in the literature relative to other, particularly extraoral, methods.

Provisional treatment for all ceramic veneer restorations

All-ceramic restorations including laminate veneers have become a large part of dental practice. Most of what has been published regarding provisional treatment for veneers has focused on technical procedures. Provisional veneers are indicated when (1) esthetics and intelligible speech are important; (2) mandibular incisors are veneered; (3) dentin is exposed; (4) proximal contacts are broken; (5) maxillary teeth are inverted lingually and the veneer surface affects occlusion; (6) the preparation margin invades the gingival sulcus; and (7) the final veneer is dependent on patient approval of form, color, contour, and position.[171] Sheets[172] stated that patients were happier with provisional veneers but recommended that provisional restorations not be luted. Provisional restorations allow patients to have a trial period for making notes about esthetics so that their desires can be taken into account with the definitive veneer treatment.[151] Provisional veneers may be cemented,[151,173,174] bonded,[23,151,171,174-176] or left unluted.[24,172]

In contrast to preparations for conventional cast restorations, preparations for porcelain veneers may not have mechanical retentive features and thus one concern regarding a provisional restoration is tooth attachment while avoiding irreversible contamination or alteration of the luting surface of a prepared tooth. Elledge[174] advocated placing 2 small dimples on opposing surfaces of the preparation to provide mechanical retention for the provisional veneer that is luted with a cement of the clinician's choice. One method that avoids excess cement while sealing the margin area is the "peripheral seal technique" that uses a 3-second etch of the preparation periphery and then bonding a provisional restoration primarily at the etched periphery.[171] Similarly, a colored luting resin may facilitate removal of excess resin and reduce contamination of a tooth surface. After a provisional restoration is removed, 1 report indicated that a tooth could be satisfactorily cleaned of all residues with a microetcher (Danville Engineering, San Ramon, Calif).[177]

Another technique known as the "spot etch" method incorporates provisional restorations that are luted with light polymerized acrylic resin to an etched spot near the center of the preparation.[175] In an in vitro study of surface contamination associated with provisional bonding, a polyurethane isocyanate surface treatment left the cleanest tooth structure whereas a noneugenol provisional cement left significant but removable residue; a dual polymerizing resin cement left tenacious residue that could only be removed with a bur.[124]

A variety of methods for fabrication of veneer provisional restorations have been reported and are not unlike the methods advocated for conventional provisional restorations including, a removable "splint,"[24] with handformed visible light-polymerized materials,[23] polycarbonate provisional crowns,[173] acrylic resin shells,[151] and splinting together adjacent provisional veneers.[176]

Esthetics

Patients may be highly motivated by esthetics and instant improvement can be achieved through provisional restorations.[15] Custom colored provisional restorations made with mixtures of acrylic resin powders creating an incisal polymer, a body polymer, and a cervical blend are easier to fabricate with an indirect method.[156] Esthetically enhanced provisional restorations can be

Table VIII. Interim treatment options for an implant prosthodontic patient

Treatment protocol	Clinical conditions			
No interim prosthesis required	Esthetics not a concern to a patient		Implants placed in posterior region	
Removable interim prosthesis	Before first-stage surgery; eliminated after first-stage surgery with implant-supported provisional	Before or just after first-stage surgery; eliminated after second-stage surgery with implant supported provisional	Before or just after first stage surgery, maintained until completion of definitive treatment[196,200–202]	
Fixed interim prosthesis	Resin bonded using clinical crown of extracted tooth or denture tooth[203,204]	Resin bonded pontic prosthesis[186,189,208]	Provisional fixed partial denture with adjacent abutment teeth[205–208]	Transitional implants/fixed prosthesis implant retained[214]
	Natural tooth abutment-retained cantilever fixed provisional[209]	Transitional implants/fixed prosthesis implant tooth abutment retained	Provisional placed at or shortly after first-stage surgery implant retained[187,188,190–195,197–199]	Fixed implant retained provisional placed after second-stage surgery/no removable prosthesis[210,213]

fabricated with visible light-polymerized labial veneers or denture tooth facings in conjunction with acrylic resin.[5,44,138]

Gingival architecture and tissue contour are among the many factors other than materials that influence esthetics. Anterior provisional restorations should provide the following esthetic benefits: (1) optimum periodontal health; (2) visualization of the anticipated esthetic outcome; (3) ability to test the incisal edge position and cervical emergence; (4) development of appropriate anterior guidance; and (5) determination of the need for periodontal surgery.[117]

Methods for improving or customizing colors also include coloring provisional luting cements[178] and coloring a provisional restoration with porcelain stains and visible light-polymerized acrylic resin.[172] Custom color guides for provisional restorations have also been recommended.[179-181]

CLINICAL CONSIDERATIONS FOR PROVISIONAL TREATMENT INVOLVING DENTAL IMPLANTS

Provisional prosthesis designs for dental implant patients can vary widely, ranging from a removable acrylic resin complete denture, to an implant supported fixed prosthesis with several different potential designs that promote esthetics, convenience, the loading of implants, tissue contour control, material strength, and interim prosthesis durability. Although several removable prosthodontic provisional treatment modalities are available in conjunction with implant treatment, this discussion is primarily limited to fixed provisional prosthodontic treatment and specific materials. Manufacturers are indicated when available in the original reference. Generally, the literature related to implant provisionalization is dominated by anecdotal information and clinical observation. Information related to implant fixed provisionalization is therefore limited and is generally a carryover from natural tooth provisional treatment techniques.

A provisional restoration in combination with an implant-retained restoration provides many of the same benefits derived when treating non-implant retained fixed restorations. However, implant-retained treatment can require an extended period of time and provisional treatment can present a challenge. When the implant-retained prosthesis is located in an esthetic region, the need and desire for an interim prosthesis increases. In this respect, the transition from tooth-related fixed prosthodontics to implant-retained prosthodontic treatment has evolved from experience with conventional treatment.[182,183] Restorative techniques are often the same, and management of a patient can simulate conventional fixed prosthodontic treatment. Nonetheless, the significance of provisionalization with implant prosthodontics cannot be overstated.[184,185]

Table VIII[186-214] lists provisional fixed prosthodontic treatment options for an implant patient that may vary depending on (1) the number, position, or location of the implants; (2) the number of natural teeth remaining in a treatment arch; (3) opposing occlusion; (4) whether teeth adjacent to the implant site(s) can serve as abutment teeth for a provisional restoration; and (5) the desired protocol for provisional treatment at either first- or second-stage surgery.

Historically, most endosseous implant systems have used a 2-stage surgical procedure. The surgical stages were separated by a 4- to 6-month period to allow for tissue integration. When necessary, a removable interim prosthesis was used. This protocol evolved from treatment of an edentulous patient to treating a partially edentulous patient. The use of a removable provisional prosthesis, however, in some situations has been less popular when treating a partially edentulous patient. Several factors have been proposed suggesting why this protocol has been challenged. When treating a partially edentulous patient, acceptance of a removable interim prosthesis may be objectionable and great lengths may be taken to fabricate a fixed provisional restoration to transition a patient through the implant integration period.[215]

A reduction of micro-movement of an implant due to the potential stability obtained from adjacent teeth as well as a rigid implant connection when treating both partially and completely edentulous patients may lead to successes when providing provisional treatment at first-stage surgery.[187] As a result, early or rapid loading of several implant systems has been tested, however, routine immediate or rapid loading of dental implants is still controversial. The use of transitional implants has also been explored for support of a fixed implant-retained provisional prosthesis. Of course when the adjacent teeth can be used as abutments supporting a fixed interim restoration this treatment option may be more easily accommodated throughout the implant integration time period.[186]

Single-tooth, implant provisional treatment

One of the most challenging restorative treatment scenarios involves restoration of a single tooth implant.[216] The demand for optimal esthetics and a natural appearance to a definitive restoration dictates a comprehensive diagnosis and treatment plan. Depending on the location of an implant, an interim prosthesis may or may not be necessary. For example, providing a provisional restoration in the posterior region during the implant integration period may be avoided if esthetic demands from the patient are low. On the other hand, in an esthetic region, great lengths may be taken to replace the edentulous area with a provisional restoration thereby providing a more socially acceptable interim treatment before a definitive restoration.

Techniques related to replacing a single tooth with an implant prosthesis embrace both first and second stage surgical protocols. Provisional treatment options are also related to treatment history of the adjacent abutment teeth.[189,192]

Provisional treatment at first-stage surgery: single-tooth, implant-retained

The placement of interim implant-retained fixed restorations at first-stage surgery provides benefits related to the time involved and the multi-step process in dental implant therapy,[187] as a result, provisional fixed implant-supported restorations have gained in popularity. Fixed implant-retained provisional treatment at first-stage surgery eliminates a removable interim prosthesis and the need to involve adjacent natural teeth. Although many reports advocate or explore this protocol, implant provisionalization techniques are, in most respects, a carryover from conventional natural tooth provisionalization. The literature is comprised of technique information with little or no scientific or evidence-based information presented.

Several studies have questioned or evaluated the potential to restore an implant fixed prosthesis using earlier or more rapid occlusal loading, thereby incorporating a fixed provisional restoration early in the implant restorative procedure.[190,191] Kupeyan and May[191] described a technique in which the 2-stage Brånemark implant system (Nobel Biocare, Yorba Linda, Calif) was used in a 1-stage, nonsubmerged surgical procedure with placement of an interim fixed single crown restoration at stage-1 surgery. The authors modified Brånemark healing abutments (5.5 or 7.5 mm in length) in the laboratory before the surgical date for the fabrication of provisional restorations. The authors also fabricated acrylic resin copings to fit the modified healing abutments, with an autopolymerizing acrylic resin (Jet Acrylic, Lang Dental Mfg. Co, Chicago, Ill) in the appropriate patient shade. A provisional crown was fabricated from either a polycarboxylate material or a polystyrene preformed provisional shell that was filled with autopolymerizing methylmethacrylate also of an appropriate shade. After surgical implant placement, an interim restoration was fabricated by fitting the resin coping to the modified implant healing abutment and uniting the crown to the coping with a small amount of autopolymerizing resin. The final finishing of the margins of the provisional was accomplished extraorally. The provisional restoration was luted with a provisional cement (TempBond; Kerr Mfg Co, Romulus, Mich).

Chee and Donovan[192] also described provisional restorative treatment of a single implant-retained crown at both first- and second-stage surgery. At second-stage surgery, the authors advocated recontouring the soft tissue cuff with a coarse diamond and placement of a provisional restoration with ideal axial contours. They also described fabrication of a provisional crown before second-stage surgery with the technique described by Hochwald[217] in which an impression is made at first-stage surgery by use of the surgical guide. The resultant cast allowed fabrication of a provisional restoration before uncovering the implant.

A technique for fabricating a provisional, screw-retained restoration for immediate loading of single implants was presented by Proussaefs and Lozada.[218] A provisional restoration was fabricated for a maxillary first premolar extraorally during the surgical appointment. The usual preparatory phase of treatment was done before the surgical procedure: (1) diagnostic casts; (2) diagnostic waxing (Sculpturing Wax; Williams Co, Amherst, Mass); (3) duplication of the diagnostic waxing with an impression (Coe Alginate; GC America Inc, Alsip, Ill); and (4) generation of a gypsum cast (Microstone; Whip Mix Corp, Louisville, Ky). A vacuum-formed matrix (Ultradent Products Inc, South Jordan, Utah) was also fabricated. The authors fabricated a light-polymerized acrylic resin template (Triad; Dentsply International, York, Pa) on the duplicate cast that was used as a surgical guide during implant placement and also registered the implant position at time of surgery by applying autopolymerizing resin between the access hole of the template and the implant (Pattern Resin; GC Co, Tokyo, Japan). After polymerization, the template was removed, an implant analog was attached to the guide, and the template was positioned on the original diagnostic cast that had been modified to allow placement of the implant analog. The analog was incorporated into the cast with autopolymerizing acrylic resin (Pattern Resin; GC America). A "temporary" hexed abutment (Replace; Nobel Biocare) was placed on the implant analog and, after verifying the appropriate occlusal height and position of the abutment with a clear vacuum formed matrix, a screw-retained provisional was fabricated with the matrix and autopolymerizing acrylic resin (Alike; GC America). The provisional restoration was trimmed in the laboratory and adjusted intraorally. Gomes et al[219] also described this technique in which the provisional restoration was fabricated in the laboratory before the surgical placement of the implant.

Provisional treatment at first-stage surgery: partially edentulous and edentulous, implant retained

Published reports have advocated immediate loading of multiple implants in an edentulous or partially edentulous patient to avoid a removable interim prosthesis.[193-197] In most articles, authors did not describe the material and methods involved with provisional fabrication therefore details are limited.

Horiuchi et al[193] reported the immediate loading of Brånemark implants after placement in edentulous patients and treatment with fixed interim restorations. The authors fabricated heat-polymerized acrylic resin provisional restorations reinforced with chromium-cobalt castings. At the time of stage-1 surgery, implants were immediately loaded and incorporated within the provisional restoration using "temporary" cylinders. Jaffin et al[195] also evaluated the immediate loading of implants in partially and completely edentulous patients. Rigid fixation and the use of a metal-reinforced, passively fitting provisional restoration were factors proposed for successful use of this protocol.

Kinsel and Lamb[198] described gingival esthetics related to treatment of an edentulous patient with an immediately loaded single-stage, implant-supported fixed prosthesis. The authors fabricated heat-polymerized acrylic resin provisional restorations from diagnostic casts. These provisional restorations were relined intraorally at the time of implant placement. The authors also described treatment in which retention from sufficient teeth to support a transitional fixed prosthesis and ovate pontics were created within the extraction sites to be used to maintain facial prominence and interdental papillae surrounding the extracted teeth. After implant integration, the remaining abutment teeth were extracted, and the provisional prosthesis was converted to a solely implant-supported provisional prosthesis.

In a preliminary report, Balshi and Wolfinger[199] evaluated the immediate loading of Brånemark implants placed in the mandibular arches of 10 edentulous patients. The design involved 4 widely distributed implants that were immediately loaded with an interim, fixed, implant-retained prosthesis at first-stage surgery. The authors used additional implants in a conventional manner to provide sufficient support for a definitive fixed prosthesis, even if all the immediately loaded implants failed.

The use of 2-stage threaded implants to support an immediate, fixed, interim prosthesis was also outlined by Schnitmann et al.[197] The authors converted a previously fabricated complete denture into a fixed-retained provisional partial denture by incorporating gold cylinders (Nobelpharma USA, Inc, Chicago, Ill) in the complete denture with autopolymerizing acrylic resin (Jet Acrylic; Lang Dental Mfg). The complete denture containing the gold cylinders (1 anterior, 2 posterior) was recontoured into a fixed partial denture by removal of the flanges and reduction of the distal extension to within 2 mm of the posterior screw holes. After securing to the abutments with gold screws (Nobelpharma, USA, Inc), the screw channels were filled with cotton pellets and Cavit (ESPE, Bad Seefeld, Germany).

Balshi and Wolfinger[200] also described the "conversion prosthesis," one that at second-stage surgery was converted from a complete denture to a fixed, interim prosthesis. The technique involved incorporation of modified screw-retained impression copings (as opposed to more costly gold cylinders) within a wire-reinforced complete denture. Advantages suggested by the authors were as follow: (1) a fixed prosthesis with improved function, stability, and distribution of load was provided immediately following second-stage surgery; (2) the prosthesis protected the mucosa; (3) it served as a prototype for a definitive prosthesis; (4) it could be used as a verification jig; (5) the original vertical dimension of occlusion was preserved; (6) the provisional restoration aided in obtaining and transferring interocclusal records; and (7) it assisted long-term patient maintenance and reduced the number of treatment visits.

Cibirka and Linebaugh[201] described modification of an existing conventional complete denture to a fixed/detachable interim prosthesis 10 to 14 days after second-stage surgery. The authors modified an existing mandibular complete denture by attaching Brånemark "temporary" cylinders (Nobel Biocare) with an autopolymerizing acrylic resin using a closed-mouth technique. Once polymerization was complete and the fit verified, the denture base flanges were modified with the provisional prosthesis removed to resemble the definitive prosthesis. After polishing, the prosthesis was attached to the transmucosal abutments and the screw access holes were sealed with Cavit (ESPE). The authors suggested advantages of this interim treatment technique stating that the procedure was accomplished in 1 appointment, it was convenient for a patient, and the prosthesis served as a template for a definitive prosthesis. Berglin[202] also presented conversion of a patient's existing complete denture by fitting gold cylinders to a prosthesis (DCA-072 or 073; Nobelpharma USA, Inc) with acrylic resin (Coe-rect; Coe Laboratories).

Aparicio[220] outlined the importance of passively fitting provisional implant-retained prostheses in a technical report. He emphasized that interim treatment offers the possibility of evaluating or creating the following: (1) a proper emergence profile; (2) peri-implant health; (3) occlusion; and (4) esthetics, phonetics, and hygiene. This also facilitates progressive loading of implants during the bone maturation period. Modified gold cylinders for EsthetiCone abutments (Nobel Biocare) were used so that a provisional prosthesis could be luted to the cylinders in the mouth with a provisional luting cement (Kulzer Microfilm Pontic Cement; Heraeus Kulzer, Wehrheim, Germany). This provided a circumferential fit between the prosthesis and gold cylinders and easy retrievability.

Tooth-retained provisional treatment at or before first-stage surgery

When teeth adjacent to an implant are not to be restored with a fixed prosthesis, a resin-bonded fixed partial denture (RBFPD) may provide an interim treatment option, avoiding or eliminating a removable prosthesis.[203] Breeding and Dixon[189] described the fabrication and use of a resin-bonded prosthesis with orthodontic retainers (Bond-A-Splint; TP Orthodontics, Inc, La Port, Ind) and a light-polymerizing restorative material (Triad VLC Provisional Material; Dentsply). After surgery, the interim prosthesis is bonded to adjacent natural teeth.

Hannon et al[204] described bonding an extracted or denture tooth to adjacent natural teeth as a means of providing provisional treatment for an edentulous space. This technique offers fixed reversible provisional treatment ultimately leading to an implant-supported restoration.

Zinner et al[186] presented 2 RBFPD techniques as a means of eliminating a removable provisional prosthesis in a partially edentulous patient. Both used cast metal frameworks with denture teeth processed to the framework before cementation, but only 1 method involved longer spans requiring preparation of abutment teeth.

A provisional fixed prosthesis can be placed before or at the time of implant placement surgery when the adjacent teeth either need full coverage restorations or might be extracted after integration of the implants.[205] The advantages of this treatment compared to a provisional removable prosthesis have been described.[206,207] Winkelman[207] described a provisional prosthesis supported by a combination of implant and natural tooth abutments. Treatment involved transitioning a patient requiring multiple implant surgeries through long-term treatment, leading to a maxillary complete arch, implant-supported, fixed prosthesis, with a heat-polymerized acrylic resin provisional restoration supported by natural teeth slated for extraction. Binon[208] also described a combination implant/natural tooth abutment, provisional restoration.

A multifunctional provisional implant-retained FPD described by Tung et al[206] was a modification of a previously reported metal-reinforced FPD.[44] The authors incorporated matrix-patrix plastic patterns as an integral part of the metal framework (Rexillium III; Jeneric/Pentron Inc, Wallingford, Conn). The patrix was fabricated as part of a cast metal framework and the cast matrix was later incorporated into the removable pontic section. The pontic section was initially used as a radiographic and surgical guide and was subsequently modified and provisionally cemented (Temp-Bond; Kerr Corp) until second-stage surgery when the pontic section was again modified and cemented as an implant-supported prosthesis. A disadvantage noted by the authors was cost; however, they stated that the long-term cost-effectiveness and benefit of the prosthesis outweighed the disadvantage of increased cost.

Zinner et al[209] advocated use of a cantilever provisional restoration when no maxillary molars and posterior implants are planned. If the premolar(s) are to be restored with complete crowns, 1- or 2-unit, metal-reinforced, acrylic resin cantilever provisional pontics may meet the esthetic requirements of a patient; the pontics are left out of occlusion to reduce torquing forces applied to the provisional prosthesis and abutment teeth. After implant integration, a screw retained acrylic resin provisional can be fabricated with titanium provisional abutments (Implant Innovations, Inc, West Palm Beach, Fla). The authors supported the advantages of second-stage provisional treatment by citing anecdotal references involving incremental and progressive loading and clinical criteria related to the control of occlusal and restorative contours.

Implant-retained provisional treatment at second-stage surgery

Several advantages have been purportedly related to fixed provisional restorations after second-stage surgery: (1) improved tissue contours related to emergence profile; (2) development of an inter-dental or inter-implant papillae; (3) potential avoidance of a third surgical operation; (4) fixation of the prosthesis; and (5) customization during the healing process to form an esthetically contoured prosthesis.[210,211,221]

Dumbrigue et al[211] described options for fabrication of provisional restorations for an ITI solid abutment (Straumann USA, Cambridge, Mass). The use of an ITI plastic (burn-out) coping, fabrication of an acrylic resin coping on a brass ITI practice solid abutment, with the ITI impression cap for the solid abutment as a core, and fabrication a provisional restoration with the ITI cementable Protictiv Cap were presented.[222]

Techniques for incremental loading can be employed either directly or indirectly after second-stage surgery.[208,222] Others have described similar techniques involving tissue contour development and esthetic concerns.[217,223-225]

Saba[212] described placement of a prefabricated interim restoration shortly after second-stage surgery to mold the soft tissue and allow healing around the anatomically shaped restoration and likened it an "ovate pontic" procedure as outlined by Garber and Rosenberg.[226] Hinds[227] explained the use of a custom impression coping modified with acrylic resin for registration of the healed tissue associated with the implant site. He promoted the value of this technique in transferring information to the laboratory when designing a definitive prosthesis.

The use of interim restorations to influence or maintain soft tissue contours before fabrication of a definitive prosthesis has been suggested as a key function of an interim implant restoration.[210,211,228-230] Boston and Boberick[231] described a technique for fabrication of a single-tooth implant provisional restoration for the ITI system (Straumann USA) with a laboratory shoulder analog that functions as a die. Marginal adaptation is enhanced by extraoral fabrication, and the contours and emergence profile are completed intraorally controlling esthetics and soft tissue contours. Kaiser and Jones[232] outlined a technique for a cementable single implant provisional restoration.

Jemt[233] reported that although provisional crowns may accelerate soft tissue contour development compared with healing abutments, the papillae adjacent to single implant definitive restorations developed similar tissue volume in both modalities after 2 years in function. The author recommended the need for more scientific data to evaluate different clinical procedures for optimizing esthetic results in implant dentistry. Drago[234] provided an overview of surgical indexing at stage-1 surgery describing both clinical and laboratory procedures involved with this process.

Stein and Nevins[235] outlined the relationship of the guided gingival contour to a provisional crown for a single implant restoration. Submergence profile (the vertical discrepancy between an implant platform and an adjacent tooth's cementoenamel junction), the potential guided gingival growth, and the relationship of titanium provisional abutment gingival surfaces to the healing tissue were explained. The authors propose that the greater this discrepancy, the more unpredictable the guided gingival growth. Other aspects of guided gingival growth include (1) keratinized gingival tissues; (2) titanium provisional abutments; (3) a nontraumatic provisional treatment; and (4) a goal of achieving a realistic 1 mm to 4 mm increase in gingival growth. Although these techniques and guidelines may lead to successful treatment, no scientific data were presented. Biggs and Litvak[236] advocated making impressions at first-stage surgery to fabricate casts incorporating implant analogs for single-tooth replacement. They used interim cylinders (Implant Innovations Inc.) to fabricate autopolymerized, screw-retained, acrylic resin provisional restorations that were placed at second-stage surgery. The authors recommended screw-retained provisional restorations suggesting that elimination of cement aided tissue healing, that the highly polished surface of the abutment would not be damaged by cement removal, and the ability to remove a provisional restoration helped facilitate adjustments to perfect contours of both the provisional restoration and soft tissues.

In a clinical report describing the adverse axial inclination of a single tooth implant, Daoudi[213] used a single interim abutment (Nobel Biocare) to provide a matrix for a provisional restoration. The abutment was evaluated so that the portion that protruded beyond the proposed provisional crown contour was marked. The abutment was removed from the implant, adjusted extraorally to create the proper profile, reinserted, and an acrylic resin provisional restoration (Myerson acrylic resin; Nobelpharma USA Inc) was fabricated directly by use of a vacuum-formed matrix. The desired emergence profile was created extraorally and the provisional restoration was luted with provisional cement (Temp-Bond; Kerr Mfg. Co). The provisional restoration could also be screw retained.

The immediate fixed transitional restoration

Another means of eliminating a potentially unstable removable provisional prosthesis that might interfere with soft tissue healing was proposed that used immediate transitional implants supporting a fixed provisional prosthesis at, or just after, first-stage surgery.[214]

Dental implant provisional treatment: material and methods

Several methods of implant provisional restoration fabrication have been described in the literature.[211,222,237-239] Chaimattayompol[237] described the use of square impression copings for wide diameter implants at the implant level when fabricating a provisional implant supported prosthesis, advocating improved precision of fit, healthier peri-implant tissue because of the high polished metal surface, and cost-effectiveness of the procedure.

Fabrication of an autopolymerizing acrylic resin cylinder was also described and advantages such as simplicity, lack of special equipment required, improved resin bonding, ease of modification, and potential color improvement were noted.[240] Anglis[238] suggested that as with any fixed restoration, a provisional restoration tests esthetics and comfort of the dental treatment before completion, stating that an acrylic resin provisional restoration is a 3-dimensional model of a definitive prosthesis. He advocated the use of abutments designed to allow cementation of a provisional restoration, not screw retained, stressing that when treating in this manner, the successive steps proceed in a manner similar to conventional fixed prosthodontic treatment.

Balshi and Wolfinger[241] presented a technique for fabricating auto-polymerizing acrylic resin copings for CeraOne abutments (Nobel Biocare). Jet Acrylic (Lang Dental Mfg) was allowed to flow onto the lubricated abutment and was manually adapted as it polymerized. After polymerization of the resin, the coping was removed, trimmed, and polished. The acrylic resin coping could then be placed on the abutment at time of connection and a polycarbonate resin provisional tooth form (Ion; 3M Dental Products) was relined onto the coping. The authors pointed out that this procedure provided a chemical bond of resin to resin which they explained was lacking when a manufactured healing coping or the provisional coping components were used. Other benefits included increased patient satisfaction and reduced chair time for repairs.

Smalley and Blanco[242] described implant provisionalization when implants were used for anchorage in combination with orthodontic tooth movement. A technique outlining indirect placement of orthodontic brackets on screw retained acrylic resin provisional crowns was presented.

Another use for the fixed interim partial denture in the preliminary phase of implant treatment was presented by Stellino et al[243] A dual-purpose implant guide was described where the authors fabricated an abutment-retained FPD incorporating gutta-percha in locations where implant placement was desired. The cemented provisional restoration, therefore, served as a radiographic guide and was also used later as a surgical guide. After implant placement, the gutta-percha was replaced with autopolymerizing acrylic resin.

Material strength and provisional prosthesis durability in relation to dental implants

The necessity for longer-term provisional treatment of an implant-restored patient follows provisional techniques used in traditional fixed restorative treatment. Longer spans, longer treatment times, and the necessity for addressing tissue contour issues before definitive treatment dictate techniques that would provide more durability. Management involving indirect fabrication of acrylic resin provisional restorations for increased polymerization and reinforcement with assorted types of methods and materials has been described.

Fabrication of a heat-polymerized provisional implant-supported fixed partial denture was advocated by AlZallal and Morgano.[244] The authors sighted increased resin strength and durability as advantages when longer healing times are necessary for the patient treated with implants. Saba[245] also described a cast-bar reinforced provisional restoration used when treating an implant patient.

SUMMARY

The topic of provisional fixed prosthodontic treatment involves a multifaceted array of clinical activities, special knowledge, material selection, and management. Contemporary treatment incorporates both natural teeth and dental implants. This literature review provides a comprehensive summary of published reports on this topic. It characterizes clinical methods and provides clinicians with an understanding of the nature of materials used with this clinical activity.

Dentistry continues to struggle with the limitations of existing materials available for fixed prosthodontic provisional treatment. Clinical techniques and indications are reasonably well characterized, but future research activities will need to focus on technological advancements to provide improved materials that demonstrate improved biocompatibility, ease of use and modification, and physical properties.

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