Technical fixed prosthodontics: time to change the status quo?

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CPD: 1 hour

Educational aims and objectives

The aim of this article is to explain the current methods in the US to accomplish fixed prosthodontic procedures.

Anticipated outcomes

- Be able to assess and evaluate their prosthodontic procedures
- Learn about the products used in conventional techniques and new digital methods
- Follow the suggestions from the authors about the benefits of various products.

Technical fixed prosthodontics: time to change the status quo?

Gordon J Christensen DDS, MSD, PhD, and **Paul L Child Jr** DMD, CDT discuss the current methods to accomplish fixed prosthodontic procedures and look at the products used in conventional techniques as well as in the constantly evolving and improving digital methods to produce restorations

INTRODUCTION

Fixed prosthodontic procedures comprise a major part of the services provided by general dentists in the United States. It has been estimated by the National Association of Dental Laboratories that there were about 36 million units, most of which were single crowns, placed in the United States during 2010 (Bennett Napier, co-executive director, personal communication, January 2011). Assuming that there were about 140,000 practicing general dentists in the United States and roughly 3,500 prosthodontists, it appears that each general dentist placed more than 20 units of crowns or multiunit fixed prostheses per month in 2010. There is significant revenue produced by fixed prosthodontic procedures, but practitioners and dental assistants must be highly organized and efficient to make this dental laboratory dependent side of dentistry profitable. All dentists using conventional procedures and/or in-office CADCAM milling devices have to be organised and time efficient to ensure an adequate return on their major investment for any technologies purchased.

In this article, we will discuss the current methods to accomplish fixed prosthodontic procedures and look at the products used in conventional techniques as well as in the constantly evolving and improving digital methods to produce restorations. We will emphasise the most commonly accomplished procedure, the single crown. The purpose of this article is to motivate practitioners to evaluate their personal fixed prosthodontic procedures, thus allowing them to make logical decisions about any potential desirable changes toward digital concepts in their clinical fixed prosthodontic techniques.

Figure 1: Brux Zir (Glidewell Laboratory)

CONVENTIONAL TECHNIQUES

Experienced dentists are very familiar with conventional fixed prosthodontic procedures. However, some practitioners could increase their efficiency and clinical predictability by using products different from those that they have currently in use. We will make suggestions based on Clinicians report (CR) (formerly named CRA) and other international research as well as our own personal experience relative to the most efficient, popular, and effective clinical procedures.

For more than 50 years, PFM restorations have dominated procedures involving single crowns. That day is rapidly passing. According to data from Glidewell Laboratories, one of the largest dental laboratories in the United States, during 2010 about one half of the indirect restorations were all-ceramic, and other half were the other types of crowns, including PFM (Jim Shuck, sales executive at Glidewell Laboratories, personal communication, January 2011). It has been our observation from speaking with thousands of dentists that this is the case regardless of what dental laboratory they are using. Milling of monolithic restorations in dental laboratories is beginning to dominate crown fabrication in many labs because of the ease of fabrication when using the milling procedure and the lower amount of labour required to hand-invest wax patterns, cast metals, and layer porcelain. From our observations and reports from laboratories full-zirconia crowns are among the fastest growing crown types in the history of dentistry. BruxZir from Glidewell Laboratories, was the first brand to begin this movement and there are now many more brands being marketed. PFM restorations, and now all-ceramic

restorations, are the most commonly placed indirect restorations in the United States. In spite of the frustration expressed by many experienced dentists, full-gold alloy restorations are significantly reduced in use, and infrequently offered as a treatment option to patients.

The typical US dentist is using conventional fixed prosthodontic techniques and materials, although this long-proven, successful orientation is changing rapidly. We suggest in this article many successful devices, materials, and techniques that have been identified from research by CR, reports from hundreds of CR product evaluators, and from our own personal experience.

The following are categories of activity in the fixed prosthodontic procedure, with accompanying successful products that are well known to allow optimum speed and efficiency.

TOOTH PREPARATIONS

A very small percentage of the restorations placed in 2010, about 2%, were inlays and onlays (Limoli and Associates, personal communication, January 2011). Both authors are known to encourage use of these conservative restorations (when indicated), particularly when the facial and lingual portions of teeth are intact and the intracoronal portion of the teeth is either destroyed by dental caries or has a previously placed defective restoration. Most of these types of restorations are placed by those practitioners using CEREC from Sirona Dental Systems (Patterson Dental) and E4D from D4D (Henry Schein) in-office milling devices to be discussed later in this article. However, we encourage more dentists who do not use CADCAM devices to provide onlays, because of their simplicity and conservative nature.

In spite of our desire for more onlays and the resultant less tooth reduction, the easiest indirect tooth restoration is reported by experienced practitioners to be the full-crown. However, these restorations are the most aggressive. The full-crown preparation concept is changing, as full-zirconia restorations are becoming more popular. Full-zirconia restorations do not require deep preparations as with PFM or the popular all-ceramic options. Because many dentists purposely or inadvertently prepare teeth to a minimal degree, the acceptability of these minimally prepared teeth may be one of the reasons for the growing popularity of the full-zirconia restoration.

Figure 2: Tooth preparations - CEREC (Sirona Dental Systems)

Figure 3: E4D (D4D Technologies)

Figure 4: Neo Diamond (Microscopy)

Figure 5: Diamond Burs (Spring Heath)

DIAMOND ROTARY INSTRUMENTS

These instruments significantly vary in price from just more than one dollar (for the so-called single use diamonds) to 10 times that cost (for diamonds intended to be used many times). Our research has shown that some low-cost brands of diamond instruments prepare teeth very similarly to higher cost instruments. Two well-proven, low-cost diamond brands are NeoDiamond (Microcopy) and Diamond Burs (Spring Health). Nevertheless, some dentists prefer to use the more expensive multiple-use diamonds that are also effective and may provide more options. Example companies include: Axis Dental, Brasseler USA, KOMET USA, Premier Dental Products, SS White Burs, and others. CR works with all of these companies and has found many different diamonds to be successful.

TISSUE MANAGEMENT

Gingival retraction cords are used by most dentists, and are claimed by many dental laboratory technicians to be the most adequate of tissue management techniques (as observed in impressions from their dentists). The double-cord technique is the most reliable cord technique, since usually it reduces bleeding significantly more when compared to the previously taught one-cord procedure. Two popular and effective cord examples are Ultrapak (Ultradent Products) and Stay-Put (Roeko). The Stay-Put cord contains a small copper wire for stability, and it does stay in place most of the time. Both options are cost-effective and provide excellent choices for quick and easy tissue management.

Some dentists strongly prefer to

Figure 6: Ultrapak (Ultradent Products)

Figure 7: Stay-put (Rokeo)

Figure 8: Odyssey Navigator (Ivoclar Vivadent)

Figure 9: NV Microlaser (Discus Dental)

Figure 10: ezlase 940 (BIOLASE Technologies)

Figure 11: Picasso (AMD LASERS)

avoid cords. Diode lasers have become increasingly popular in the past few years, primarily due to their decrease in cost. When used properly, they provide excellent hemostasis and can assist in tissue management for difficult situations. One of the most popular diode lasers has been the Odyssey Navigator (Ivoclar Vivadent). However, with the introduction of newer lasers at more affordable costs, other brands are becoming more popular. These include the cordless NV Microlaser (Discus Dental), the ezlase 940 (BIOLASE Technology), and the low-cost Picasso (AMD LASERS). A low-cost alternative to a diode laser technology is electrosurgery. One of the most popular electrosurgery units is the Sensimatic 700SE Electrosurg (Parkell).

Styptic-containing clay products have gained popularity and can provide great retraction, but at a higher cost per crown. Expasyl (Kerr) and Traxodent (Premier Dental Products) are very viable alternatives.

It is important to note that at this time, excellent tissue management is necessary for taking either conventional impressions or digital impressions. For some intraoral imaging systems, tissue management is even more essential, due to the longer amount of time required for scanning when compared to injecting conventional impression material. There are possibilities in the developmental stages that may change the concept in the near future, and tissue management may not be as important as it is currently.

Because of the high cost of digital devices for impressions, dentist conversion will be slower

IMPRESSION MATERIALS

Typical elastomer impression materials are being challenged for accuracy by digital impressions (to be discussed later), but conventional impressions are still by far the most popular procedure. Vinyl polysiloxane (VPS) has the majority of the US market, while polyether is still used by many practitioners. Two of the most popular and well-proven premium brands of VPS material are Aquasil Ultra Monophase (DENTSPLY Caulk) and Imprint 3 VPS (3M ESPE). Impregum (3M ESPE) dominates the polyether market. Either type of material (used properly) provides extremely accurate impressions. For those practitioners who have significant financial constraints, lower cost, proven brands are available from example companies such as Parkell, Pentron Clinical, and others.

Elastomer impression materials may have reached their optimum potential. Most elastomer materials used with excellent techniques can result in impressions that are not only accurate, but are also easily used by dental laboratory technicians. In contrast, digital intraoral scanning technology is just beginning to realise its potential. Continued improvement in digital scanning equipment and manufacturer investment in this technology will probably produce impressions that surpass the desirability of conventional elastomer materials. However, because of the high cost of digital devices for impressions, many years will probably be required before the majority of dentists to change to digital impressions.

Some practitioners do not realise the relatively high cost of elastomer impressions, which can cost £20-£30 for a full-arch impression in a stock tray. The cumulative impression material and accessory cost of conventional impression techniques compared to the initial and

Figure 12: Sensimatic 700 SE Electrosurg (Parkell)

Figure 13: Expasyl (Kerr)

Figure 14: Traxodent (Premier Dental Products)

Figure 15: Aquasil Ultra Monophase (DENTSPLY Caulk)

Figure 16: Imprint 3VPS (3M ESPE)

Figure 17: Impregum (3M ESPE)

ongoing cost of digital impression devices will be important as dentists determine their predicted return on investment for digital devices for impressions.

PROVISIONAL RESTORATIONS

These restorations are a negative factor in the conventional procedure that has been overcome by the one appointment in-office milling technique. In the conventional procedure, the patient must go home with a provisional restoration for an average of two or three weeks in most practices.

Bis-acryl resin, some of the most popular brands of which are ProTemp 3 Garant (3M ESPE), Luxatemp (DMG America), and Integrity (DENTSPLY Caulk), have become the most used materials for provisional restorations. Their low exotherm, moderate strength, and good color are a welcome relief when compared to the methyl and ethyl methacrylates, which were the most popular materials until just a few years ago. However, the popular bis-acryl category of provisional restorations comes at a significantly higher cost than previous materials. Both eugenol-containing and noneugenol provisional cements are popular, with TempBond (Kerr), with and without eugenol, being the most used provisional cement in the marketplace. Newer dual-cured resin-based provisional cements have been introduced that provide increased strength for tooth preparations with less retention.

THE RESTORATION

At this point in the conventional procedure, the dental laboratory team takes over from the dentist and fabricates the restoration. As stated previously, PFM and all-ceramic restorations each have about one half of the market.

CEMENTATION

Without any doubt, resin-modified glass ionomer (RMGI) cement, FujiCEM (GC America) and RelyX Luting Plus (3M ESPE), have the majority of the market. These moderate-strength, fluoride-releasing, self-bonding, no-sensitivity cements have proven themselves over a long period of time.

A growing category of cements, resin with an incorporated self-etching primer (such as RelyX Unicem 2 [3M ESPE] and Maxcem Elite [Kerr]) are proven cements in this new category amid a multitude of clones. These resin cement formulations have increased strength over RMGI, decreased sensitivity when compared to some other formulations of resin cement, and still retain the strength that is well-known for resin cement. Conventional resin cements such as Panavia F2.0 (Kuraray) or the newer Clearfil Esthetic Cement (Kuraray), Multilink Automix (Ivoclar Vivadent), and Duolink SE (Bisco) are growing in use due to the increased application of all-ceramic restorations.

DIGITAL IMPRESSIONS

What are the differences in clinical techniques when a dentist decides to make digital impressions instead of using conventional impression materials and techniques?

- Tooth preparation techniques are the same. However, many dentists who have changed to intraoral imaging have noted that their tooth preparations are improved because of their observations of the enlarged immediate images on a monitor.
- Tissue management is the same as for conventional impressions. However, some digital impression users have adopted diode lasers for tissue management.
- A digital device makes the impression with your help. Among the digital impression systems available, there are four devices that are most popular; CEREC (Sirona Dental Systems), E4D (D4D), iTero (Cadent: Align Technology), and LAVA Chairside Oral Scanner (C.O.S.) (3M ESPE).

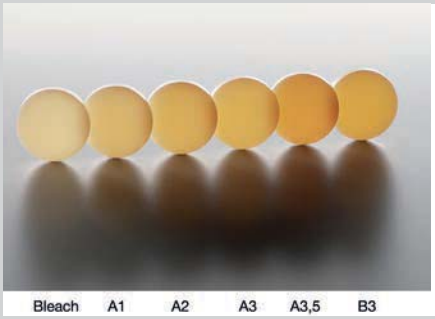

Figure 18: ProTemp 3 Garant (3M ESPE)

Figure 19: Luxtemp (DMG America)

Figure 20: Integrity (DENTSPLY Caulk)

Figure 21: TempBond (Kerr)

Figure 22: FujiCEM (GC America)

Figure 23: RelyX Luting Plus (3M ESPE)

Each of these devices costs from about £10,000 to £30,000. Other systems are being introduced that provide digital intraoral imaging, and they may become more popular with time. The significant cost for these machines could pay for many conventional impressions. However, it is not the comparative cost of using the two concepts that is most important; it is the convenience and lack of discomfort for patients that is provided by the digital concept that makes this procedure desirable. Many studies, including those published by CR, have demonstrated that the accuracy of the impressions made by these digital systems for one to three units (restorations) is equal to, or better than, conventional methods. Current studies are underway to evaluate the adequacy of these devices for patients requiring more than one to three units. We predict that the proven reliability and predictability of digital impressions will gradually help this concept become the most popular method for making impressions during the next several years.

• Level of difficulty for making digital impressions. Making an impression by conventional methods requires variable times to master. Similarly, making an impression with one of the four different digital systems requires a learning time. Some clinicians are able to master digital impressions rapidly and others require several months.

• A provisional restoration is still required when using digital impressions alone without in-office milling. As with conventional impressions, the patient is required to come back to the office a few weeks after the tooth preparation appointment for seating the restoration. If the clinician elects to upgrade the CEREC or E4D from just impression taking to an in-office milling system, the restorations can be seated in just one appointment. Occasionally, even with the in-office milling concept, the more difficult cases may require the dentist to opt for more than one appointment, still requiring a provisional restoration.

The proven reliability and predictability of digital impressions will help it become the most popular

• Making the restoration. Digital impression devices allow fabrication of any type of crown you prefer from their authorised laboratories, just as with conventional impressions. Most intraoral impression systems now offer the capability of a milled model or a resin-cured stereolithographic model that the dental laboratory team can use in place of a conventional stone cast for fabricating the restorations. Initial studies have demonstrated these models to be equal to or superior to conventional stone casts.

• Cementation is the same as for restorations made in a conventional manner.

IN-SURGERY MILLING

When using CEREC and E4D, clinicians can fabricate their own restorations chairside. This capability can be an advantage in most cases; however, excellent patient scheduling is needed, and the dentist or staff person is required to take the total responsibility for the restoration fabrication. Clinicians state that all current dental CADCAM systems can be improved, including both the chairside and laboratory aspects of the process. The level of consistency and accuracy of restorations can occasionally be less than acceptable and can require extra time if the restoration proposals are not adequate for quick and simple modification. We are told by CADCAM mechanical engineers that the current level of accuracy and consistency for CADCAM systems in dentistry is

Figure 24: RelyX Unichem 2 (3M ESPE)

Figure 25: MaxCem Elite (Kerr)

Figure 26: Clearfil Esthetic Cement (Kuraray)

Figure 27: Multilink Automix (Ivoclar Vivadent)

Figure 28: Duolink SE (Bisco)

Figure 29: iTero (Cadent Align Technologies)

Figure 30: Lava COS (3M ESPE)

below that of some other industries, such as medical, electronic, automotive, machining, etc. Despite this limitation, the current dental systems have proven to be clinically acceptable in most situations when attention to detail is provided by the clinician.

Currently, there are about 12,000 in-office milling devices in the US, the majority of which are CEREC systems and a growing number are E4D systems. Although there is the expected competition and marketing claims from both companies, CR has demonstrated that both systems can provide an excellent restoration. Both devices have advantages over their competitor and both have areas of improvement. We expect many new and exciting innovations as the technology continues to evolve.

What are the differences in clinical techniques when a dentist decides to use digital impressions and in-office milling instead of conventional techniques? The following steps show that there can be significant differences in the clinical procedure. Steps 3 to 8 can be legally accomplished by staff persons in most states:

1. Seat the patient, select the colour of the restoration, and anesthetize the patient.
2. Make the tooth preparation to a specified design, which may be slightly different depending on the type of ceramic or composite used for the restoration.
3. Place reflective powder if required. CEREC requires a thin dusting of powder, while E4D does not require the use of powder. (Sometimes a liquid contrast agent on enamel or metal restorations is needed with the E4D.) Both pre-impression techniques are minimal and require little time and effort.
4. Make a digital impression of the tooth preparation. The length of impression time varies by system.
5. Design the restoration using the computer program. This task can require from a few minutes to 20 minutes, related to the quality of the impression, the accuracy need of the proposed restoration, and the number of changes the clinician desires.
6. Mill the restoration from standardized blocks. There are a variety of materials from which to choose, with most materials coming from Vident, Ivoclar Vivadent, or 3M ESPE. The introduction of IPS e.max CAD (Ivoclar Vivadent) for chairside milling has allowed the clinician to provide a stronger restoration, but requires a furnace to fully crystallise (bake) the material.
7. Adjust the restoration clinically.
8. Characterise and/or stain the restoration as desired or needed. Several furnaces are available with one of the most popular

being the Programat CS (Ivoclar Vivadent).
9. Cement the restoration (resin cement is the most commonly used for these mostly ceramic or polymer restorations). Most clinicians are using either a self-adhesive (such as RelyX Unicem 2 or Maxcem Elite, or separate self-etching resin cement (such as Multilink Automix).
10. Evaluate and adjust the occlusion with fine diamonds and porcelain polishing instruments (such as Brasseler USA or KOMET).
11. Finish and polish the restoration where adjustments were made with porcelain polishing paste (such as Diashine by VH Technologies).

CR research has shown for more than nearly 25 years that the quality of restorations made from digital impressions and milled in-office are the same as or better than restorations made in the conventional manner when strict attention to the protocol is provided. Digital impressions and chairside milling should not be considered to allow less attention to detail or require less clinical expertise.

Figure 31: Vita (Vident)

Figure 32: IPS e.max CAD (Ivoclar Vivadent)

Figure 33: Programat CS (Ivoclar Vivadent)

Figure 34: Diashine (VH Technologies)

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Dr Child is the CEO of CR Foundation, a nonprofit educational and research institute (formerly CRA). He conducts extensive research in all areas of dentistry and directs the publication of the Gordon J. Christensen CLINICIANS REPORT, and other publications. Dr. Child graduated from Case Western Reserve University School of Dentistry, completed a prosthodontic residency at Louisiana State University, and maintains a private practice at the CR Dental Health Clinic in Provo, Utah. He is also a certified dental technician through National Board of Certification in Dental Lab Technology.

When those using these concepts follow the manufacturers' instructions and develop excellent clinical skills, these chairside digital devices can deliver a great restoration.

How soon this concept will become commonplace in dentistry is unknown. We appear to be somewhat behind other areas in adapting to this popular and growing concept. More innovative planning and development requiring more manufacturer investment is suggested to make the systems more accurate, faster, easier, and definitely less expensive. For some dental practices, the move to in-office milling can be efficient, predictable, and profitable.

SUMMARY

The majority of indirect restorations placed in the United States are currently made by conventional procedures in two or more appointments, including standard impressions using VPS or polyether, use of dental laboratory technicians to make the restorations, and conventional cementation procedures. The likelihood of rapid change to digital impressions and/or in-surgery milling is not predicted. However, some dentists have changed to making digital impressions and sending the information to specific dental laboratories to have the crowns fabricated. In general, they are satisfied with the concept and the restorations thus produced. It is anticipated that digital impressions will slowly continue to grow until the concept eventually dominates the market.

In-surgery milling of restorations by CEREC or E4D is now a reliable clinical process in spite of an arduous and long period of development. It is anticipated that this concept will continue to grow.

At this time, any of the three concepts discussed in this article — conventional procedures, digital impressions sent to a laboratory, or digital impressions followed by in-office milling — are acceptable depending on the preferences of practitioners. **CPD**