With continuous developments in material science and technology, dentistry keeps evolving and embracing innovative ways to ensure patients receive the best in oral healthcare. In the process, some professionals may bid farewell to the methods and materials that have been the traditional “go to” choices. In recent years, the treatment modality falling repeatedly to the wayside is the traditional porcelain-fused-to-metal (PFM) restoration.

In a 2013 survey conducted by Lab Management Today, 40% of respondents reported a decline in PFM fabrications, although fewer than 10 years earlier, respondents noted that nearly 85% of all crown and bridge work completed was metal-based. Perhaps directly related, 60% of these same survey participants reported a significant increase in the use of pressable lithium disilicate (IPS e.max®, Ivoclar Vivadent, www.ivoclarvivadent.com) over the past 2 years, and nearly 50% reported an increase in the use of zirconia layering ceramic.¹

Additionally, approximately 15% of all dentists today have a CAD/CAM system within the practice. According to Michael Augins, president of Sirona Dental, Inc., when in-office CAD/CAM is used, all the materials available for those systems are metal-free ceramics. Therefore, 15% of dental restorations will be non-PFM and metal-free based on in-office CAD/CAM usage. “But the truth is, about 70% of all laboratories fabricate restorations through CAD/CAM,” he adds.
RELEVANT OR RELIC?

IF CURRENT TRENDS HOLD, PFMS MAY BECOME OBSOLETE

If the PFM market is waning and patient concerns about and desires for esthetic restorations are answered with easier, quicker fabrication methods (e.g., in-office and/or laboratory/milling center CAD/CAM systems), then dental teams and laboratories alike must be prepared to adopt new approaches for delivering case-specific treatments.

“As we move from analog to digital, from metal to metal-free, and from handmade to industrial processes, those dentists and laboratory technicians who are able to transition from analog to digital will be very successful, but those who remain anchored in the analog world will have great difficulty surviving,” predicts Jonathan L. Ference, DDS, clinical professor of prosthodontics and occlusion in the department of advanced education in prosthodontics at the New York University College of Dentistry. “People who see themselves as waxers or as ceramists will not succeed unless they begin to think of themselves as experts in tooth design, including morphology, esthetics, and occlusion,” he says. “It is the knowledge and expertise of the technician that really counts, not the choice of materials or the methods of fabrication.”

Evolution of Non-Metal Materials

Indirect restoratives such as dental ceramics have been used since the 18th century, when the first complete dentures were fabricated using porcelain. It wasn’t until the 1800s, when Logan introduced the Richmond crown system—a ceramic crown fused to a platinum post—that the foundation for future restorative materials was laid. In the
The introduction of zirconia-based ceramics and CAD/CAM led to further changes. This material is composed primarily of 95% to 98% zirconium oxide, with small amounts of titanium dioxide, silicon oxide, and iron oxide. However, the material requires stabilization, which is achieved by adding yttrium or cerium. It can be CAD/CAM milled to oversized single- or multi-unit substructures, which compensate for overall volumetric shrinkage caused by sintering.

Lithium disilicate, however, has since enabled restoration fabrication through either press or CAD/CAM methods. This material consists of lithium disilicate, potassium oxide, silica, alumina, and phosphorous pentoxide melted together, then cooled. It is then heated to achieve the necessary crystalline growth that maximizes the material's strength, after which it is pulverized into a powder that is pressed into ingots or blocks.

“Now, between zirconia and lithium disilicate, we can basically replace metal in 98% of all metal indications for fixed crowns and bridges,” Culp says.

Of the characteristics of available metal-free materials that dictate the selection of a PFM alternative involve esthetics, durability, and fracture toughness, explains J. Robert Kelly, DDS, MS, DMSc, professor of graduate prosthodontics and biomaterials and director of the Center for Advanced Technology Integration at the University of Connecticut Health Center. Because almost any of the available all-ceramic systems will be successful for restoring an anterior tooth in terms of strength and fracture toughness, the characteristics that will be very relevant to choosing a material will be opacity and translucency, he says.

“Clinicians need to choose the system that will best match the Munsell value, that is the ‘translucency or opacity, of the case they’re trying to restore, and there is a good, wide range of materials available,’” Dr. Kelly elaborates. “For a young patient with fairly opaque teeth, veneered zirconia would work well. For an older patient with fairly translucent teeth, a more translucent lithium disilicate material would be easy to match.”

Then, good clinical data about a material’s fracture toughness—which indicates how easily the material will break and/or its likelihood for fracture—will determine its appropriateness for use as a single molar or multi-unit restoration, Dr. Kelly adds.

Is the PFM Option Still Relevant?

A survey conducted by Glidewell Laboratories in 2013 revealed that only 10% of their crown fabrications were PFM, down from 65% in 2007. Yet they also reported that the number of lithium disilicate crowns was steadily increasing, making up nearly half of all their anterior restorations. The characteristics of these monolithic restorations compared to traditional bilayered restorations were cited as the reason for the switch, as dentists and ceramists alike felt more confident about the stability of lithium disilicate crowns.

Although not all laboratories or dental practices may experience the same phenomenon, it is worth noting that new materials have brought...
the discussion about the relevancy of PFMs to the forefront. While many laboratories still see their crown and bridge production equally split between PFM and all-ceramic restorations, the cost of precious metals has been steadily rising, leading many dental professionals to search for an acceptable, cost-effective alternative that still offers patients an aesthetic, durable solution for their dental needs.

“Accuracy and strength are the greatest issues we have with all-ceramic restorations, as well as keeping the costs down by moving away from noble metals,” says Dr. Gettleman, noting that the price of gold has soared to approximately $1,200 per ounce. “That’s a reason not to use metals except in cases where strength is needed. However, the current research is trending toward ceramic materials and polymeric materials to replace the metals that we have traditionally used in dentistry.”

Culp reflects on the parallels between finding new ways to fabricate restorations and today’s economy, noting that for the first time in 20 years, dental laboratories have felt the economic pressure from dentists, who are feeling the pressure from patients looking for something less expensive. With traditional analog, as opposed to digital processes, dentistry really couldn’t provide better, faster, or possibly less expensive restorations, he adds.

“CAD/CAM-manufactured restorations are more economical and less expensive than a PFM,” says Augins. “So economics certainly come into play—especially in the laboratory—but you also have the other real advantages of strength, esthetics, and ease of manufacturing driving dentistry toward the continued adoption of CAD/CAM and all ceramics.”

Esthetic demands are also driving the trends. PFM restorations can often exhibit a dull appearance, especially when compared to an all-ceramic restoration. The metal PFM substructure is often visible.

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**TABLE 1**

**Which Material for What Indication?**

<table>
<thead>
<tr>
<th>SINGLE ANTERIOR CROWN OR BICUSPID</th>
<th>Multilayered, etched and individually bonded&lt;br&gt;Layered CAD/CAM ceramics, etched and individually bonded&lt;br&gt;Leucite-reinforced glass ceramic, etched and individually bonded&lt;br&gt;Alumina-based ceramics, individually bonded or conventionally cemented</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTERIOR 3-UNIT</td>
<td>Full-contour, monolithic lithium disilicate (not veneered), etched and individually bonded</td>
</tr>
<tr>
<td>POSTERIOR 3-UNIT WITH MOLAR ABUTMENT</td>
<td>Full-contour, monolithic lithium disilicate (not veneered), etched and individually or conventionally bonded&lt;br&gt;Zirconia, either veneered or not veneered</td>
</tr>
<tr>
<td>4 OR MORE UNITS</td>
<td>PFMs and possibly zirconia</td>
</tr>
</tbody>
</table>
usually appearing as a thin gray line at the crown margin. When presented with the alternative of highly esthetic all-ceramic restorations, patients may jump at the opportunity, especially if they experience tissue sensitivity with traditional PFM restorations.

“In our practice, monolithic lithium disilicate full-contour restorations have been highly successful, very predictable, and we rarely veneer them anymore,” comments Dr. Ferencz. “We’ve learned to achieve the color match required—even for matching a single anterior tooth—using a monolithic material and customizing it with stains.”

Although there are some very high-end laboratory technicians and ceramists who can achieve excellent results with PFM restorations, most cannot create the esthetics that are possible with an all-ceramic restoration, Dr. Kelly says. However, PFM will probably always remain more robust than all-ceramics in terms of their fracture resistance, but zirconia substructures or veneered zirconia restorations will perform well, he adds (Table 1).

“Researchers are still investigating all-ceramic and CAD/CAM ceramic materials, and most of them are quite well. They are very esthetic and translucent, whereas metal, of course, is opaque and must be masked to simulate natural tooth structures,” notes Dr. Gettlemann. “However, all metal restorations are still okay for use, especially in cases where the patient demonstrates a lot of force against the teeth, such as grinding and bruxing, which makes an all-metal restoration probably the better choice.”

Unfortunately, bite force variations from one patient to the next as a deciding factor in material selection is difficult to predict, explains Dr. Ferencz. “We have patients who have broken nearly any restorative material we’ve provided them, and others who’ve never broken even the weakest ceramics we’ve used,” he recalls. “I would advise clinicians to examine their patients, see what they are doing to their own teeth, and other restorations, and if they see a lot of wear, tooth fractures, and ceramic chipping, I would be much more likely to recommend zirconia.”

Technological Advances Mean More Options

While advances in material science cannot be discounted as a substantial reason for the shift away from PFM restorations, technological developments are equally significant. CAD/CAM and digital systems, once relegated to dental laboratories, are now infiltrating dental practices and enabling clinicians to take digital impressions, design the ideal restoration, and mill it immediately—without the patient needing a second appointment. The digital workflow helps to ensure accuracy, and the software accompanying these systems accounts for important factors such as occlusion, fit, and esthetics, so operators are guided in their efforts to create a patientspecific restoration.

“There are many factors that have funneled our profession toward digital dentistry,” explains Gary Severance, DDS, chief marketing officer for 3M E4D Technologies. “These include, but are not limited to, economic factors, quality with efficiency, increasing delegation to a competent team, and improved and open technology” (Table 2). This digital dentistry workflow is also simultaneously changing the dental laboratory industry and allowing it to respond to the ongoing decline of skilled and talented technicians entering the profession, says Culp. The population of laboratory technicians is aging, and theoretically, there could be a serious shortage of technicians in 10 years.

“Digital laboratory processes allow me to train technicians easier and faster, since the most labor-intensive processes—such as creating the proper tooth shape framework and layering porcelain—are now performed digitally and with milling,” Culp elaborates. “However, digital technology is not a substitute for training in function or esthetics—such as working with color, chroma, and value—but it does allow individual technicians productivity to double, at a minimum.”

Use of digital systems also invariably leads to increased use of the all-ceramic and indirect composite materials that these systems are designed to process and mill, whether in the dental practice or the laboratory. “The introduction of products like IPS emax and full-contour zirconia in a millable form dramatically increased the acceptance of products for both chairside and laboratory indications,” Dr. Severance observes. “In 2013, 3M introduced a resin nanoceramic (Leva™ Ultimate, 3M ESPE, www.3mespe.com) in a millable form and, at the same time, effectively worked to change the insurance codes to include ‘predominantly ceramic materials.’ This opened up a whole new set of materials for insurance reimbursement.”

According to Dr. Severance, more CAD/CAM companies are designing open technology and processes to eliminate as many human variables as possible, minimizing processing errors and empowering the team—all of which transform the economic reality to the benefit of clinicians and patients alike.

| TABLE 2 |
| Factors Driving Dentistry Toward CAD/CAM |

<table>
<thead>
<tr>
<th>Economy</th>
<th>Quality with efficiency</th>
<th>Increasing delegation to a competent team</th>
<th>Improved and open technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>The rise of corporate dentistry, increasing PPO plans, decreasing insurance reimbursement, decreasing patient spending</td>
<td>Dental professionals, both laboratories and clinicians, looking for more efficient techniques that provide quality results without compromise, so they can work smarter, not harder</td>
<td>Expanding role of dental assistants, and assisting curriculums that include digital dentistry</td>
<td>More quality digital systems that allow clinicians and laboratories the ability to share files, gain consensus among specialties, and be more flexible with treatment options</td>
</tr>
</tbody>
</table>
Conclusion

It may still be too soon to determine if the days of PFM restorations are numbered. While dentist and laboratory perspectives suggest that PFM restorations are headed for extinction, there are those who feel that PFM restorations will always have a place in dentistry.

“The rise of non-metal restorations is occurring because they are easier and faster to produce using CAD/CAM technology; they can be as strong or stronger than metals, with very good esthetics and better fit; and people in general prefer not to use metal restorations,” Augins observes. “This all leads to the decline of PFM and the rise of all-ceramic restorations.”

Therefore, given the ever-changing dental material and technology landscape, it is likely that advancements in these areas will continue to shift the paradigm away from conventional practices. According to Dr. Pencin, “I think in fixed prosthodontics—both for natural teeth and for implants—there’s a ceramic material that can be used for virtually every metal indication.”

References