RESTORATIVE DENTAL MATERIALS
Options and considerations for this new frontier

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Advances in materials science over the past two decades have proven to be a hotbed of innovation resulting in robust levels of restorative options. But the increased number of options for restoring compromised teeth has also fostered confusion among dental professionals in terms of the proper indications, hardness measures, case development, adhesion, and preparation design for each of these new materials. Driven in large part by the introduction of automated production processes, each new material brought to market offers slight variations for best-use indications and inherent mechanical properties. As both the clinical and laboratory constituents of the restorative dental team grapple with attaining the appropriate knowledge on the science behind each of these materials, there is a tremendous level of required collaboration between the two disciplines to unite and learn together to achieve the best results for their patients.

Computerized systems have significantly
changed chairside and laboratory workflows as well as restorative protocols for both dentists and technicians, according to Gregg Helvey, DDS, MAGD, CDT, private practitioner and Associate Professor, Virginia Commonwealth University School of Dentistry. The CAD/CAM process has spurred an influx of new materials that are not only strong but also aesthetic. The question plaguing many professionals is how does one determine which material is the best choice for a particular case?

Bill Baum, MDT, CDT, owner of Baum Dental Studio and Instructor at New York University College of Dentistry, believes the answer lies in greater collaboration between dentists and technicians.

“The technology we utilize today provides us with many more materials than we had during the days of gold, porcelain-fused-to-metal, and acrylics,” Baum says. “I think dentists have their hands full and have much to learn. It would behoove them to rely on others to consult with, including their trusted technicians who can impart their knowledge.” This collaborative synergy can help provide a true restorative dental team approach that would greatly benefit and elevate all involved.

Oftentimes, the dentist cedes material choice to the laboratory, relying on them to provide a material that spells success for the restoration, according to Robert C. Margeas, DDS, a private practitioner in Des Moines, Iowa, and Editor-in-Chief of Inside Dentistry.

“Sometimes confusing is determining which materials would be ideal and which would require different treatment approaches and preparations,” he says, “as well as whether the dentist wants to bond or cement, where in the oral environment the restoration is being placed, and what kind of forces the material needs to withstand.” These are the primary questions dentists are pondering as they plan treatment for each individual patient.

“In a perfect world, the laboratory technologist shouldn’t be making the decision on which material to use,” Baum says. “That decision actually lies in the hands of the dentist. However, technicians should absolutely be involved in the discussions because they bring a level of expertise and perspective that is unique to the equation.”

**Materials Science**

When contemplating materials science to select the appropriate material for a case, there are several considerations one must contemplate to determine the best course of action. First among them is understanding a material’s flexural and compressive hardness, which are both vitally important, as well as where in the oral cavity this material is intended to function. According to Matt Roberts, CDT, AAACD, owner of CMR Dental Lab and Instructor at The Pankey Institute, material selection is not easy in a field flooded with proprietary formulations that vary only slightly.

“If you look at zirconia alone, it is no longer one material, but rather it is 10 different materials with four different uses in different places within the oral environment,” Roberts says. Each of these zirconia variations has different indications that are dependent on the microstructure of the material and the added fillers, which necessitates keen knowledge and understanding when selecting a material for a case.

For example, the flexural hardness of zirconia ranges from 550 MPa to 1500 MPa. The first iterations of this material were white and opaque, and the milled restoration required full-coverage porcelain overlay to achieve the desired esthetics. However, once an overlay porcelain was applied, the flexural hardness of the overlay material was only 80 MPa to 110 MPa, significantly reducing the hardness of the material in functioning areas from 1200 MPa to a median of 90 MPa.

To add to material selection confusion, today’s more esthetic monolithic zirconia has spurred development of new translucent varieties that both exhibit a flexural hardness in the range of 550 MPa and esthetically resemble lithium disilicate. Zirconia manufacturers provide slight differences in their proprietary formulations, which produce varying hardness and translucency.

“Many times, dentists want to prescribe zirconia, but really need to understand and look at the many variables to select the appropriate zirconia for the specific indication and esthetic value desired,” Roberts says.

Now that we have the more translucent zirconia, Helvey is concerned that the material may be incorrectly prescribed. “This is not your father’s zirconia,” he says. “By manipulating the formulations, technology and materials science have enhanced zirconia by changing a microstructure that offered good mechanical properties, such as wear behavior, to one that offered acceptable esthetics.”

The structural nuances of different zirconia materials as well as other new indirect materials on the market require an in-depth understanding of their indications and uses.

“Dentists are well studied in resins and composites,” Helvey says. “But in terms of indirect materials, most dental schools don’t teach much
on the subject and the materials science behind them, so dentists need to find information on their own through lectures, literature, and conversations with their laboratory. The onslaught of materials can be overwhelming at times and it is."

The most important considerations before material selection is decided should be not only the desired outcome from the aesthetics standpoint, but also the ultimate end goal and the overall health of the supporting preparation, the bone, the occlusion, and how the use of implants will integrate.

"Restorative materials are only a part of the thought process for treatment planning," says Steven McGowen, CDT, owner of ARCUS Laboratory in Kenmore, Washington. "The materials must support the overall dental health of the patient. The material choice should complement the overall treatment plan. There is not one material for everything."

Establishing the Proper Restorative Material

Selecting the appropriate material to restore an individual case is specific to each patient. The preferred mode of action is to work up the case diagnostically. The advent of CAD/CAM technologies has made this process significantly easier and more consistent. It is now possible to upload all the digital information and present it as a virtual patient.

This is a protocol that Roberts uses with all his clientele. "The success or failure of these restorations is already ordained before a bur touches the tooth," he says. Communication platforms and treatment planning couldn’t be more seamless with photographs, videos, face-to-face conferencing, and CAD/CAM cloud-based software.

"Basically, a virtual patient is sitting in front of me and I am creating a smile design while we are talking," Roberts says. "I am looking at the facial landmarks and position of the incisal edges and we are tracking where tooth structure was and where it needs to be. By doing so, we can give the dentist a blueprint or 3-dimensional plan of how to prepare the case so it’s done appropriately. This provides the dentist with not only the proposed outcome, but also the information needed to
guide material selection as it relates to tooth margins and preparations."

Material decisions are often based not only on preparation and margin designs, but also on the familiarity and comfort level of the dentist with adhesive protocols. “For preparations where you have a lot of retention you can cement the restoration; if you do not have enough retention, you are better off bonding the restoration to acquire that retention,” Margeas says.

This reality often sways the decision on which restorative material the dentist selects. “Preparation design is dependent on the underlying tooth structure,” Roberts says. “Zirconia requires a more conservative prep than traditional porcelain-fused-to-metal because it needs less preparation in order to achieve esthetic results.”

Another consideration impacting material selection is the fact that all-ceramic materials formulated with glass components in the matrix can either be cemented or etched and bonded. Zirconia does not contain glass in its formulation and therefore can only be cemented.

“If I need to decide between lithium disilicate or a zirconia crown, then my adhesion or cohesion preference will also help in deciding between the two materials,” Helvey says. Bonding is a more complicated and sensitive process that some dentists are less inclined to choose.

“In order to bond, you need to isolate the tooth well,” Margeas says. “If you cannot isolate well, then you would be inclined to cement. An important consideration to understand is that dentists like to do things the way they’ve always done them and don’t want to have to change their process to fit the materials. Cementing is a simple process that dentists have become very comfortable implementing, since it is identical to what they’ve done for years with porcelain-fused-to-metal restorations.”

Restorative material selection also is impacted by the stump color of the tooth and how that underlying color will ultimately affect the shade of the final restoration. A tooth that has darkened over the years due to trauma or root canal therapy must be considered because it will ultimately impact the end result, particularly if a translucent material is selected.

“For natural teeth, we want to preserve as much as we can,” Roberts says. “If the preparation is very subgingival or dark and needs to be covered up, then we start looking at different materials including zirconia.”

Roberts shares a unique solution that he has been using when faced with a dark preparation but the dentist prefers to use a translucent material such as lithium disilicate: “Ivoclar Vivadent provides a workflow whereby the laboratory can design and mill a zirconia coping to mask the underlying tooth structure and then design and mill an IPS e.max restoration and then fuse the two components together during the crystallization process.”

Restoring multiple teeth with varying indications collectively often presents a material selection dilemma. Under these circumstances it is important to understand how each of the materials behaves individually and in conjunction.

“When selecting materials, particularly for teeth that are adjacent to one another, it is suggested to always use the same material to restore if at all possible,” Helvey says. “Different materials have different reflective or refraction indexes, and even though the shade may be on point, the restorations will look dissimilar because of how they individually reflect light.

**Finishing the Restorative Dental Materials**

Occlusal design and schematics are also critically important when contemplating which material is optimal for restoring fit and function. Restorative
materials typically don’t fail if used appropriately and within the proper occlusal functioning envelope. Both the dentist and laboratory need to pay close attention to the entire functioning oral environment. What is the occlusion like? Do we have cuspid guidance? Group function? Any prematurity with occlusal contacts or other factors that would cause an issue?

“The restorative team—the dentist and the technician—really needs to understand occlusion to appropriately design and plan for proper restorative materials,” Baum says. Every case, small or large, should be designed with proper anterior guided occlusion with just centric occlusal contacts. In the posterior region, you should have six balancing contacts that only occlude in centric to eliminate any destructive gliding forces during function. Roberts supports this philosophy and works out much of these potential pitfalls in the diagnostic phase by providing his dentist clients with a PMMA (polymethyl methacrylate) overlay to assess the design, both esthetically and functionally, before committing to a restorative material and moving forward with preparing the teeth.

Once the finished case is delivered to the practice, clinicians must be cautious about making any adjustments, if required, in order to not compromise the material and ultimately the long-term success of the restoration. Lithium disilicate requires low torque and a wet environment when selectively grinding a restoration. Zirconia presents a more involved final abrading protocol and should be avoided if possible.

“Zirconia, if polished, does not cause any wear on natural teeth,” Helvey says. “However, if the restoration is adjusted and not polished, it in essence introduces a sandpaper-like quality to the restoration that would aggressively wear anything opposing it.”

Helvey also cautions that adjusting zirconia without polishing afterward could cause the tetragonal phase to turn into a monoclinic phase. It significantly weakens the restoration simply because abrading removes the structural toughness from the zirconia matrix; unpolished occlusal adjustments may have more of an impact on zirconia surfaces than other restorative
materials. Porcelain restorations should also be polished after occlusal adjustments to minimize the inherent surface flaws created.

On the Horizon
A multitude of new materials that offer the opportunity to restore complex cases are being brought onto the market and gaining in popularity. Nanoceramics are among those that demonstrate promise as further improvements have been made.

“These materials are ceramic particles held together with other particles in a resin matrix,” Helvey says. “The resin matrix offers the dentist a level of familiarity in use and the ability to make adjustments, as necessary, chairside without the need to send the restoration back to the laboratory.”

The one downside, Helvey points out, is that they do not maintain their luster and are subject to toothbrush abrasion that removes the esthetic stains and glaze. However, the upside is that the restoration can be restored to its original luster chairside.

The recent introduction of high-impact polymers has been an exciting innovation, especially for implant-bar-supported restorations. Although there are some studies available, mainly in Europe, use of the material has seen an upswing in the US.

“PEEK (polyether ether ketone) and PEKK (polyether ketone ketone) have very low elastic modulus, even lower than dentin, which makes them soft,” McGowan says. “Unfortunately, laboratories are putting high elastic modulus lithium disilicate and zirconia restorations over the top of the high impact polymers, which could potentially be a problem if the bonding is not properly done.”

If executed properly, however, this type of complex restorative solution provides the patients with a non-metal, lightweight substructure that is particularly effective at absorbing mastication forces in implant-supported cases.

New material innovations for both subtractive and additive technologies have been the driving force behind the increased traction of digital denture workflows and protocols. PMMA is offered in puck form for CAD/CAM production and liquid form for 3D-printing technology. The materials exhibit homogenous physical properties and a significantly better density composition, which provides for a stronger denture base material with limited fluid absorption. As this technology develops, we will surely see greater advances in materials science to assist and elevate the necessary indications.

Conclusion
Materials science is not the mundane chemistry of yesterday. In fact, those who actively engage in learning about the subject see tremendous benefits and control over their material selection decisions and use of restorative materials. “It is critically important to attend continuing education events and talk with your colleagues about their experiences,” Margeas says. “Manufacturers will share what is available on the market, but those materials may not always be right for your practice.” Helvey believes that the best source of information comes from accredited journals. “I learn a great deal from those journals,” Helvey says. McGowan similarly uses the PubMed database and has alerts set with key words to notify him of new developments, research, and articles featuring materials science. Regardless of how one gains this knowledge, it is vitally important to keep abreast of the science behind these new materials in order to make the best educated and informed material selection for the patient.