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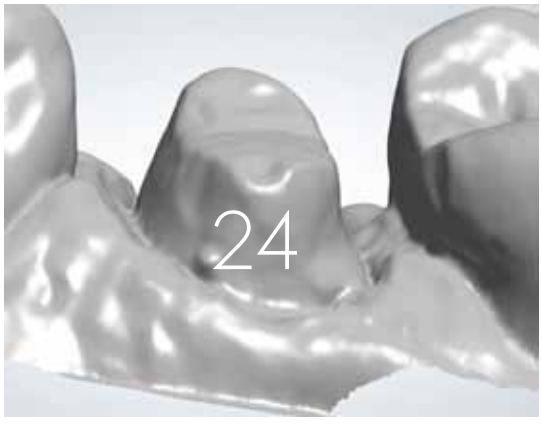

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Changes and Challenges

by Alexander Wünsche, CDT, ZT
FDLA President

Aren't we all happy 2020 finally ended? It was quite a year with the pandemic, recession and election. We were faced with a lot of challenges and most of us were forced to change our lifestyles, work modes and our businesses.

What I like about change is that we are forced to have a realistic view on our past, present and future.

Change is not always negative; I always try to pull the positive out of every situation. What I like about change is that we are forced to have a realistic view on our past, present and future. It's a chance to review what we did wrong, see what helped us through certain situations and consider where we want to be. These are the main questions I ask myself when I am confronted with changes.

If I look back at the last few decades in our industry, we were faced with constant changes. The last 12 months, however, brought some of the most drastic situations which changed and challenged our businesses. Even the simple daily schedule was affected by new and/or stronger disinfecting rituals, the way visitors entered our business property, and even the way we received shipments. It is not as it used to be, and maybe never will be.

Changes, nevertheless, deliver new opportunities. Change can separate us from our competitors and even help to develop additional products. I believe another very interesting change will occur with future dental conferences. We will get together, but in different ways than we used to. As for me, I'm anxious to attend and/or speak at a dental conference and socialize, network with colleagues and just have a good time. This is the one thing that I am most excited for, and I can't wait to see everybody at the 2021 Southern States Symposium & Expo. Online education is great and it helped us get through 2020, but it cannot replace "The Real Deal" of personally attending an education event.

I wish all of you the best as we dive into 2021 and continue our efforts to successfully fight the pandemic and take advantage of the changing dental world.

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By Gary Morgan, CDT

INFECTION CONTROL IN THE "New Normal"

"A new virus has changed the way dental laboratories will operate from this date forward. It will become the normal approach to infection control and will play a much more important role in the everyday activities of the lab in order to help prevent transmission of this serious and deadly disease."

I made this statement in one of my first presentations on infection control to dental laboratory technicians. The year was 1991 and the virus was HIV and the disease was AIDS. The "normal" referred to the infection control policies and protocols that OSHA required in the new Bloodborne Pathogens Standard and it definitely had a huge impact on the ways in which dental laboratories would be required to protect workers from all bloodborne pathogens and other potentially infectious materials.

Now a new virus has emerged and impacted all of our lives in ways we could not have imagined. The virus is SARS-CoV-2 and the disease is COVID-19.

In order to better understand why this virus has dictated a "new normal" in infection control, it is important to understand how it does what it does and what measures are required to protect dental laboratory personnel.

SARS-CoV-2 belongs to a family of viruses called human coronaviruses that can cause some of the most common respiratory infections, including the common cold. The family also includes some of the more serious respiratory diseases such as Sudden Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS) and now COVID-19.

Microorganisms including bacteria and viruses can be pathogenic, or disease causing, once they enter the human body. Bacteria usually damage the host cells directly and can cause endotoxins that damage or destroy cells as they replicate in the body. Viruses differ from bacteria in that they are not living organisms and cannot replicate without a host cell.

Diseases caused by bacteria include tuberculosis, pneumonia, strep infections, staph infections, tetanus, and meningitis. Viral diseases include influenza, hepatitis, AIDS, measles, chicken pox, colds, and SARS.

Many bacterial diseases can be treated with antibiotics or other drugs that mitigate their activity. Viruses do not react to antibiotics and must be treated through antiviral drugs, treating the symptoms, or allowed to run their course. Vaccinations can be developed that can prevent the contraction of the disease, however, they are not 100 percent effective.

Many diseases are bloodborne, meaning they are transferred by the sharing of body fluids such as blood and those that may contain blood. HIV caused the development and enactment of OSHA's Bloodborne Pathogen (BBP) Standard, even though everyone in dentistry had been potentially facing exposure to other serious diseases, especially hepatitis. COVID-19 is a droplet or airborne transmissible disease transmitted by the host expelling the virus by coughing, sneezing, and even talking. This is the same transmission mode as colds, influenza, tuberculosis and measles. It is this transmission mode that has created the need for a new normal in infection control policies and procedures in the dental laboratory to protect everyone.

OSHA's BBP Standard established some basic requirements for protecting workers from exposure to all diseases that could be transmitted through contact with blood or other potentially infectious material, which included saliva in dental procedures. Since it takes a very long time to change, amend or create OSHA standards, specific COVID-19 requirements may never be enacted as a regulation from a federal standpoint. Florida operates under the federal OSHA plans. State-run OSHA programs are much more likely to enact specific requirements for COVID-19 protection for workers. Several states already have.

While the BBP established some basic methodologies for protection, the actual procedures for infection control for dental healthcare facilities were published by the Centers for Disease Control and Prevention (CDC) in 2003. They were reviewed and updated recommendations were published in 2016. Interim guidelines have been published and continue to be updated specific to the COVID-19 pandemic. OSHA can use these guidelines to determine if an employer has tried to protect workers from exposure while at work.

The guiding principle behind good infection control for a dental laboratory has not changed for COVID-19. If the chain of infection can be broken, then disease is not transmitted. This chain is based upon the presumption that a pathogen exists (SARS-COV-2), that there is a source (person), there is a mode of transmission (body fluid), a portal of entry into another person is available (mucous membranes), and that there is a susceptible host (lab personnel). Breaking the chain at any point will prevent transmission. Disinfection can eliminate the pathogen, isolating the source can remove the risk, controlling the source or mode of transmission by wearing masks, physical distancing, and disinfecting surfaces can prevent spreading the pathogen, and protecting the portals of entry with PPE can protect the wearer from exposure. A vaccine would break the chain at the beginning so there is no susceptible host.

OSHA and the CDC have worked closely during the pandemic to promote safety in the workplace. OSHA has required that dental laboratories have a written Exposure

Control Plan (ECP) since 1992 for bloodborne pathogen exposures. The agency is recommending that businesses have an Infectious Disease Preparedness & Response Plan (IDER) for COVID-19 and other emerging diseases. While this is only a recommendation, a plan in place can be seen as evidence of a lab's approach to protect workers from COVID-19. As mentioned earlier in this article, several states have already enacted specific requirements for this type of plan.

The combination of the ECP and the IDER together can provide a "new normal" program of infection control for the laboratory. The plans should include basic infection control prevention measures including frequent hand hygiene, encouraging sick employees to stay at home, physical distancing in the workplace and employee and visitor symptom and exposure screening. Installing engineering controls such as barriers, HEPA air filtration systems, and UV light disinfection should be considered. Source control by wearing masks has been proven to be effective in preventing the spread of COVID-19.

Disinfection protocols in the receiving area of the lab may be enhanced for COVID-19. We are learning more each day about this disease, including how long it may exist in the air and on surfaces, so the approach to disinfecting may change. Currently, following the CDC guidelines, it is recommended that items and surfaces that may be contaminated with the virus should be decontaminated by cleaning to remove the virus and then disinfected with a product that has shown effectiveness against human coronaviruses. This should be on the label of the product. If the label does not make the statement, then the product should be found on the EPA's list of products effective against emerging pathogens found on the EPA website. The standard for timing of the disinfection process has been based in the past upon the amount of time the product took to kill the tuberculosis bacteria, which can range from 30 minutes down to one minute. It may take the same product a different amount of time to be effective at inactivating the SARS-CoV-2 virus, so the longer timing must be observed.

Because this disease can be airborne, the choice of respiratory and eye protection is very important.

The PPE that is chosen for protection from COVID-19 may also be different and based not only upon the level of protection, but also the availability of the PPE due to shortages caused by the pandemic. Because this disease can be airborne, the choice of respiratory and eye protection is very important. Eye protection should be goggles or a face shield. Goggles will seal up around the eyes and offer better protection than regular glasses or even safety glasses. A face shield that fits to the forehead and extends below the chin would be a good choice. Surgical masks provide protection from splash and spatter, so should be used for disinfection procedures. An N95 respirator offers the best protection for the wearer, but if the employer requires the use of a respirator, then there must be a Respiratory Protection Plan in place that requires medical qualification to wear one and then fit testing to ensure a tight seal. Voluntary use of a respirator does not require the plan or fit testing. A protective garment should be worn to protect the worker's clothes from exposure as well as the arms, so it should be long-sleeved and extend to knee length. It can be disposable or launderable. If the garment is to be laundered, it must be laundered at the lab or laundered by a professional service. Any glove that provides a barrier is acceptable. Nitrile or latex gloves are preferable due to their tight fit and flexibility.

Masks or face coverings used for source control are not considered PPE. Any acceptable covering will work in the lab as long as it can contain the user's coughs or sneezes. If face coverings are required as part of the IDER, then the employer should provide them. If they are not part of the IDER but are mandated by state or local regulations, then the employee must provide the covering or mask.

Workers who may encounter a risk of exposure due to their job requirements that are outside of the dental lab, such as drivers, sales personnel and those who perform consultation services or chairside services, may require PPE specific to the risk.

Training is a fundamental requirement and specific for each OSHA standard. This includes training on the infection control procedures, hazardous materials training, proper use of the PPE and respiratory protection. All training should be documented.

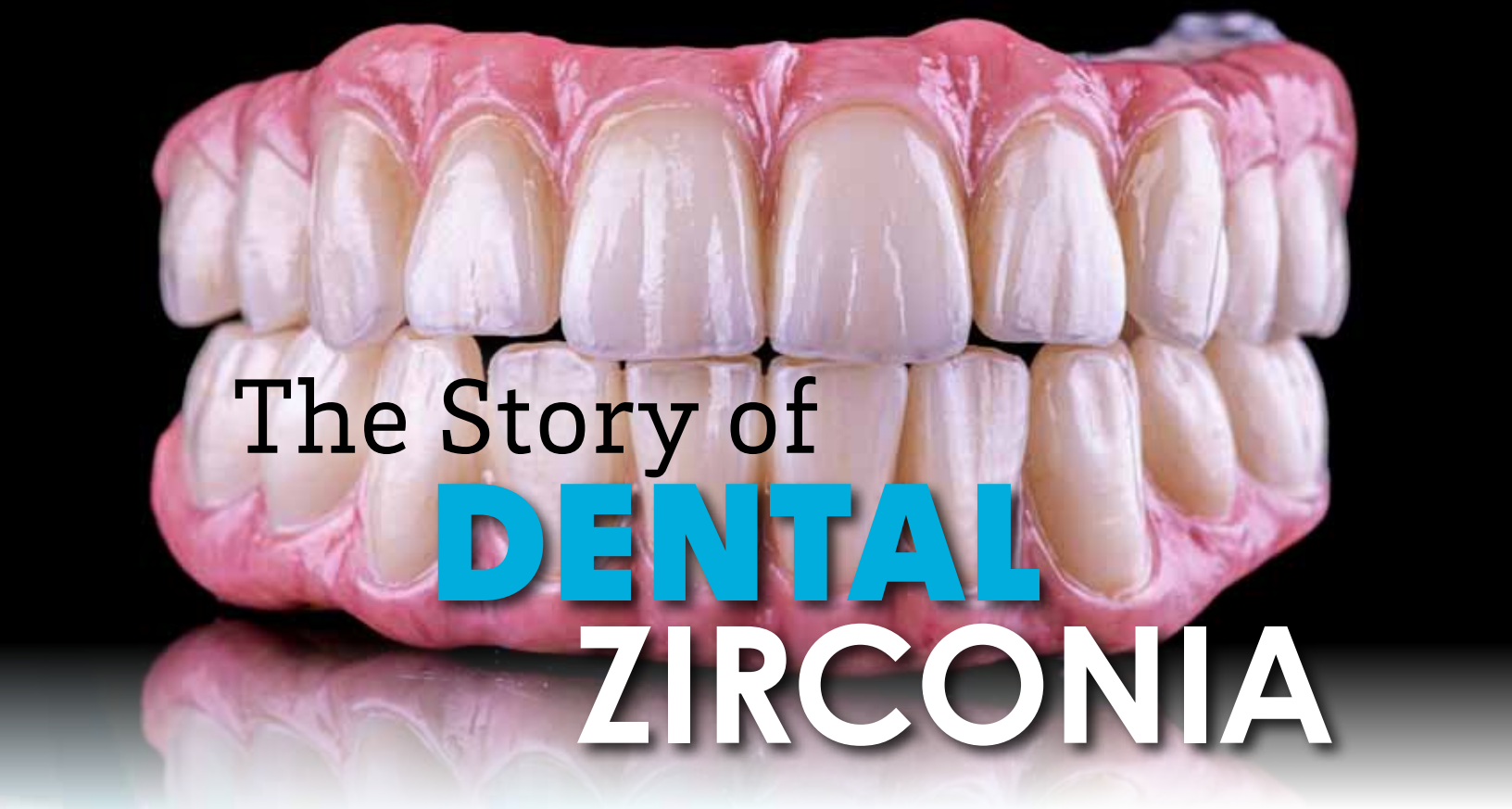
COVID-19 may be with us for the foreseeable future as an ongoing risk to everyone's health just as the other diseases mentioned in this article, so we need to remain vigilant and ensure that our new normal for infection control becomes just normal.

About the Author

Gary Morgan, CDT, CQA/ASQ, is the Vice President and Senior Consultant with SafeLink Consulting. Gary guides businesses in implementing employee health and safety programs and quality systems. Gary is an Authorized Trainer under OSHA's Outreach Program, a Certified Quality Auditor and a Certified Dental Technician. His experience as a dental laboratory owner has provided a unique understanding that enables him to help companies integrate compliance in a way that not only mitigates risk but also benefits the business. He performs safety and quality audits throughout the U.S. and internationally.

Jack Marrano, CDT, Director of Absolute Dental Services Signature Prosthetics Division
Dr. James Pizzo
Made with ArgenZ HT+ Multilayer

By Paul Cascone, BE MetE, MS



The Story of DENTAL ZIRCONIA

This is not a historical review of the substitution of zirconia in place of porcelain-fused-to-metal, but rather a description of what zirconia is, how it is made, the different types of dental zirconia and the properties of zirconia, both good and troublesome, that affect its use as a dental restorative material.

WHAT IS ZIRCONIA?

Zirconia is a crystalline ceramic made from the mineral zircon. Crystalline means that it is not a glass, like dental porcelain, but closer to metals with grains and grain boundaries. We will discuss the implications of this below. Ceramic means that the material is a combination of a metal with, in this case, oxygen. When metals combine with elements like oxygen, the result is a new material having its own set of properties (chemical, physical, biological, etc.). Just as the metal aluminum combines with oxygen to form the ceramic alumina, the metal zirconium combines with oxygen to form the ceramic zirconia.

Zirconia is a crystalline showing grains and grain boundaries while the dental porcelain has no structure since it is a glass. The grains provide strength but also result in fracture if abused.

Table 1 Composition of zircon

MATERIAL	WEIGHT %	RADIO-ACTIVITY
$ZrO_2 + HfO_2$	~ 67	
SiO_2	~32	
Al_2O_3	~ 0.3	
Th	190 - 230 ppm	0.8 – 0.9 Bq/g
U	220 - 260 ppm	2.7 – 3.2 Bq/g
Others	< 0.5	

HOW IS DENTAL ZIRCONIA MADE?

The mineral zircon is one of the oldest minerals in existence. It was one of the first materials formed in the earth's crust over three billion years ago. The mineral consists of zirconia silicate with radioactive elements. **Table**

1 shows a typical composition of the mined mineral from southwest Australia, which is the world's largest commercial mine for zircon.

Dissolving the zircon in acid removes the silica, trace and radioactive elements. This results in the formation of zirconium oxychloride octahydrate ($ZrOCl_2 * 8 H_2O$), which is the feedstock for the production of dental zirconia. This is a critical juncture for dental zirconia since the next steps will determine the optical and physical properties of the final material.

The best process to date for both optical and physical properties is to add yttrium chloride YCl_2 into the feedstock. By adding the yttrium in this way, the zirconia and yttria become more intimately connected producing a more translucent, yet strong dental zirconia. The soup of $ZrOCl_2 + YCl_2 + H_2O$ is then processed to produce a single material ZrO_2 Y_2O_3.

WHAT IS THE COMPOSITION OF DENTAL ZIRCONIA?

Dental zirconia needs to be very pure and has a simple composition as shown in **Table 2**.

Several comments are in order regarding the composition. First, the yttria (Y_2O_3) content is a controlling factor for strength and translucency. Second, the component hafnia (HfO_2) is a sister element to zirconia. Nature sometimes does not allow a material to be 100 percent pure and this is the case with zirconia. There will always be some hafnia present, typically less than five weight percent. For this reason, the combination of ZrO_2+HfO_2 is usually shown. Hafnia, however, is benign, which means that it has no effect on the material's physical or optical properties. Lastly, the alumina content (Al_2O_3) plays a very big role in keeping the dental zirconia in one piece.

Unlike metals, the grain boundaries of zirconia are very weak. It was found that water can seep into the grain boundaries causing the grains to separate, destroying the structural integrity of the object. This phenomenon is called 'hydrothermal aging' and can take place at body temperature. It was found that by adding only one-quarter weight percent alumina, the water was kept out of the grain boundaries and the material remained intact. The problem with this solution was that the material became chalk white. The alumina refracted the light, substantially reducing the translucency of the zirconia. This is why the original dental zirconia was white and required porcelain application in order to be used as a restorative material. As the zirconia development advanced, it was found that the aging could be prevented with smaller and smaller amounts of alumina additions. Most modern monolithic dental zirconia has less than one tenth weight percent of alumina, allowing for improved translucency while maintaining aging resistance.

Table 2 The composition of dental zirconia

$ZrO_2 + HfO_2 + Y_2O_3$	>99 WT%	
Y_2O_3 (Yttria)	5 - 10 wt%	Determines most properties
HfO_2 (Hafnia)	< 5 wt%	Benign sister material
Al_2O_3 (Alumina)	< 0.25 wt%	Added to prevent 'aging'

ZIRCONIA IS A **CRYSTALLINE SHOWING GRAINS AND GRAIN BOUNDARIES** WHILE THE DENTAL PORCELAIN HAS NO STRUCTURE SINCE IT IS A GLASS.

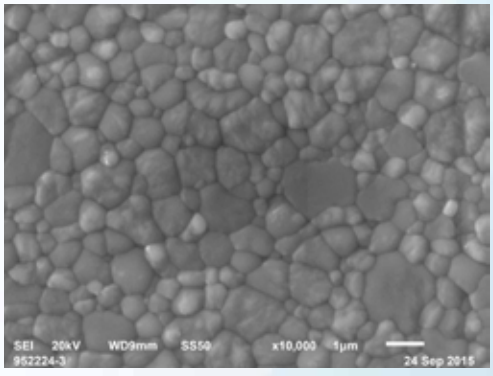


Figure 1a
Dental zirconia
Photo credit: The Argen Corporation

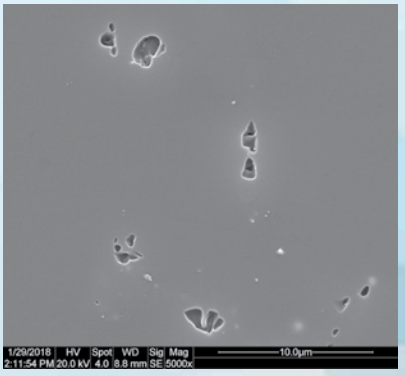


Figure 1b
Dental porcelain
Photo courtesy of Dentsply Sirona

Table 3 Possible material modifications showing zirconia is limited to mostly processing changes whereas the alloys and porcelain can be modified by changing the materials composition.

	ALLOYS	PORCELAIN	ZIRCONIA
Composition	Au, Pt, Pd, Ag, Cu, Ga, In, Sn, Co, Zn *Changes affect all properties.*	Na_2O, K_2O, Al_2O_3, CaO, LiO_2, SiO_2 *Changes affect all properties.*	Y_2O_3
Processing	Grain refining. *Increases the strength and tarnish resistance of the alloy*.	Slow Cooling. *Increases the thermal expansion coefficient*	Quantity of yttria, Chemical addition, Mechanical milling, Mixing method, Drying method, Disc fabrication *Determine optical and mechanical properties.*

USING **PRE-SHADED ZIRCONIA** RESULTED IN A HIGHER INVENTORY COST BUT THE BENEFIT OUTWEIGHED THE COST.

The material development of dental zirconia is very different from the other materials used for prosthetics. As shown in **Table 3**, modifying the properties of zirconia must be done in the initial processing stage, involving thousands of pounds of zirconia, in comparison to alloys or porcelain, where the composition modifications can be made with a few pounds for porcelain or a few ounces for alloys.

WHAT ARE THE TYPES OF DENTAL ZIRCONIA?

As shown in Table 3, the yttria content is the only compositional element that can be used (so far) to produce different variants of monolithic zirconia. This has resulted in a classification system that is based on the amount of yttria in the material. Examples are shown in **Table 4**.

Table 4 Shows the different types of dental zirconia sorted by yttria amount.

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WEIGHT %	MOLE %	EXAMPLE PRODUCTS
~ 5.5%	3% or 3Y	ArgenZ® Ultra, 3M™ Lava™, Cercon®
		ArgenZ® Esthetic, BruxZir®, NexxZr®
~ 6.9%	4% or 4Y	ArgenZ® HT+
~ 9.2%	5% or 5Y	ArgenZ® Anterior, BruxZir® Anterior, KATANA™ STML

The amount of a given element in a ceramic cannot be controlled as tightly as that for an alloy. The amount of yttria is an approximate value as shown in the first column for weight percent. To address this issue, most ceramists use the mole percent rather than the weight percent. The second column shows the two ways of stipulating the mole percent as an actual percentage or with the abbreviated 3Y, 4Y or 5Y and the last column shows some examples of zirconia and its mole percentages.

WHAT ARE THE PROPERTIES OF THE DIFFERENT TYPES OF ZIRCONIA?

There are only two properties in dental restorative material that we have an interest in: translucency and strength. For example, **Table 5** shows the product offerings from The Argen Corporation.

As seen, the yttria content alone does not indicate the strength of the material. There are critical processing parameters that can produce both strength and translucency. Although the 5Y materials have the best translucency, the strength of the materials limits their use to single crowns and short span bridges. The 3Y material's low translucency makes it difficult to reproduce the effects of dental porcelain. The introduction of 4Y materials bridges the gap by providing higher

Table 5 Shows the properties of several dental zirconia materials and their applications.

WT % YTTRIA		BRAND	STRENGTH	TRANSLUCENCY	APPLICATION	# UNITS
5.5 % Y2O3	3Y	Ultra	1400 MPa	almost opaque	PFZ	14
5.5 % Y2O3	3Y	Esthetic	1100 MPa	40%	monolithic	14
6.9 % Y2O3	4Y	HT+	1250 MPa	45%	monolithic	14
6.9% Y2O3	4Y	HTML	1250 MPa	45%	monolithic	14
9.3 % Y2O3	5Y	Anterior	765 MPa	50%	monolithic	3
9.3 % Y2O3	5Y	ST ML	850 MPa	50%	monolithic	3

translucency than the 3Y without any loss in strength. Thus, bridges as shown in **Figures 2a-b** are possible.

HOW IS ZIRCONIA SHADED?

The development of color in zirconia has steadily improved and we now have three basic methods:

1. Dipping: white zirconia is shaded by dipping the milled units in a coloring liquid.
2. Monolithic pre-shaded zirconia. The color is consistent throughout the unit.
3. Multilayer pre-shaded: The color is transitional from incisal to gingival.

Each method has advantages and disadvantages.

Dipping in coloring liquids:

The introduction of water-based coloring liquids simplified their use but there always remained a problem of reproducibility. The coloring liquids contained metal salts that were absorbed by the porous zirconia units. Upon heating, the metal ions became part of the zirconia structure and reflected light depending upon their chemistry. For example, iron reflected yellow and erbium pink. The problem was that the length of time in the liquid and concentration of the metal salts in the liquid

Figures 2a-b
ArgenZ HT+ zirconia. Photos courtesy of Dentsprosth, Sunrise, Fla.

changed the shade or intensity of color; the concentration of the metal salts changed just by leaving the lid open on the shelf. Pontics especially caused variation in shade within the same bridge since they absorbed more of the liquid. The dipping method, however, provides the most control allowing for excellent results as shown in **Figure 3**.

Pre-shaded dental zirconia

Using metal oxides added to the zirconia, companies introduced pre-shaded zirconia starting with a value system and eventually offered all 16 VITA classical shades and three bleach shades. Since the entire disc was one shade, the problem with pontics and reproducibility was solved. **Figure 4** shows a typical result.

Using pre-shaded zirconia resulted in a higher inventory cost but the benefit outweighed the cost. The issue that remained was the entire unit was monochromatic with no natural transitional effect.

Multilayer pre-shaded zirconia

The solution to developing a transitional effect in a pre-shaded zirconia was to fabricate the zirconia disc in layers. Each layer had an increased amount of coloring oxides going from incisal to gingival. The units need to be nested properly in the disc to obtain the proper degree of translucency on the incisal and the proper degree of chroma on the gingival.

Figure 5 shows the most advanced multilayer system varies the layer thickness dependent upon the disc thickness in order to achieve that goal.

Figure 3 This is a custom shade, modified incisal, longer 'enamel' layer and intrinsic characterization. The unit was glazed only with no external stain.

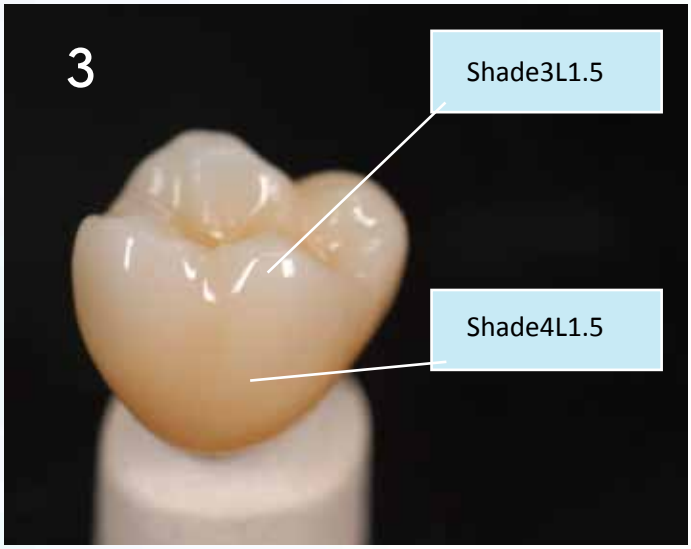
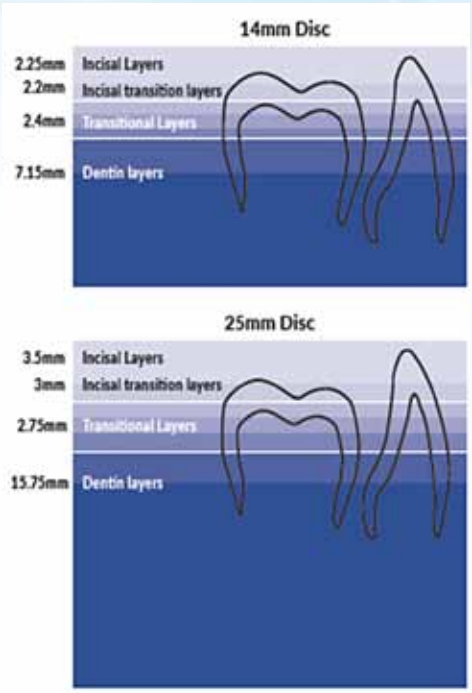


Figure 4

Pre-shaded zirconia helps control the chroma level across a bridge with thin abutments.

Figure 5
Multilayer zirconia disc showing the nesting guidance for ArgenZ HTML. Note that the layer thicknesses are dependent upon the disc thickness.



FINALE

So there you have it, the story of dental zirconia from the mineral mined from the ground through to the remarkable prosthetics that can be fabricated from the dental material. Learn more about dental zirconia from Argen Education.

About the Author

Paul Cascone, BE MetE, MS, is Senior Vice President of Research & Development at The Argen Corporation. He's developed numerous dental alloy products and applied dental metallurgy to the laser-selective-melting process, enabling alloys to be a part of the digital world. He holds patents on dental alloys, materials and processes and has published articles on alloy development, metal-ceramic bonding, computer modeling of material systems and computer simulation material processes.

Figure 6
Shows that ice has a larger volume than the original liquid water just as in zirconia when the tetragonal phase changes to the monoclinic phase.

The Troublesome Features of Dental Zirconia

(and how to handle them)

As we discussed, dental zirconia makes an excellent prosthetic material, however, there are some features that can make using it difficult. These are:

- Yttria is added to zirconia to stabilize the strong form of the material. This causes the structure to be strained since the material would prefer to be in a different form that is larger in size. The situation is similar to water freezing. The ice is larger in size than the original liquid volume as seen in **Figure 6**.

  These lead to fracture during rapid cooling after sintering: adjusting sintered units without using water and using hard tools like carbides and diamond discs on sintered zirconia.
- Bridges or large implant units must be slow cooled, both in the sintering and glaze cycles.
- Use tools especially made for zirconia. They are designed to dissipate the heat.
- Constantly inform your clients to use copious amounts of water when adjusting the sintered zirconia units.
- Zirconia is very inert so it cannot be etched or repaired. Any crack, no matter how small, will NOT heal.
- Zirconia cannot tolerate any tensile force, so bridge connectors must be larger, especially in the vertical dimension, than what was used for PFM connectors.

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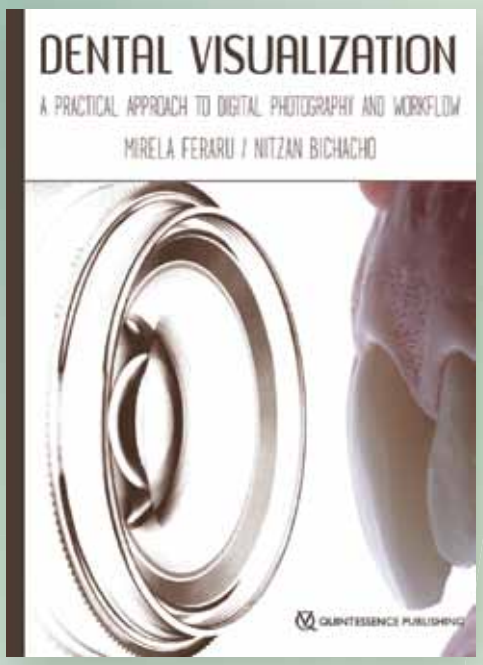

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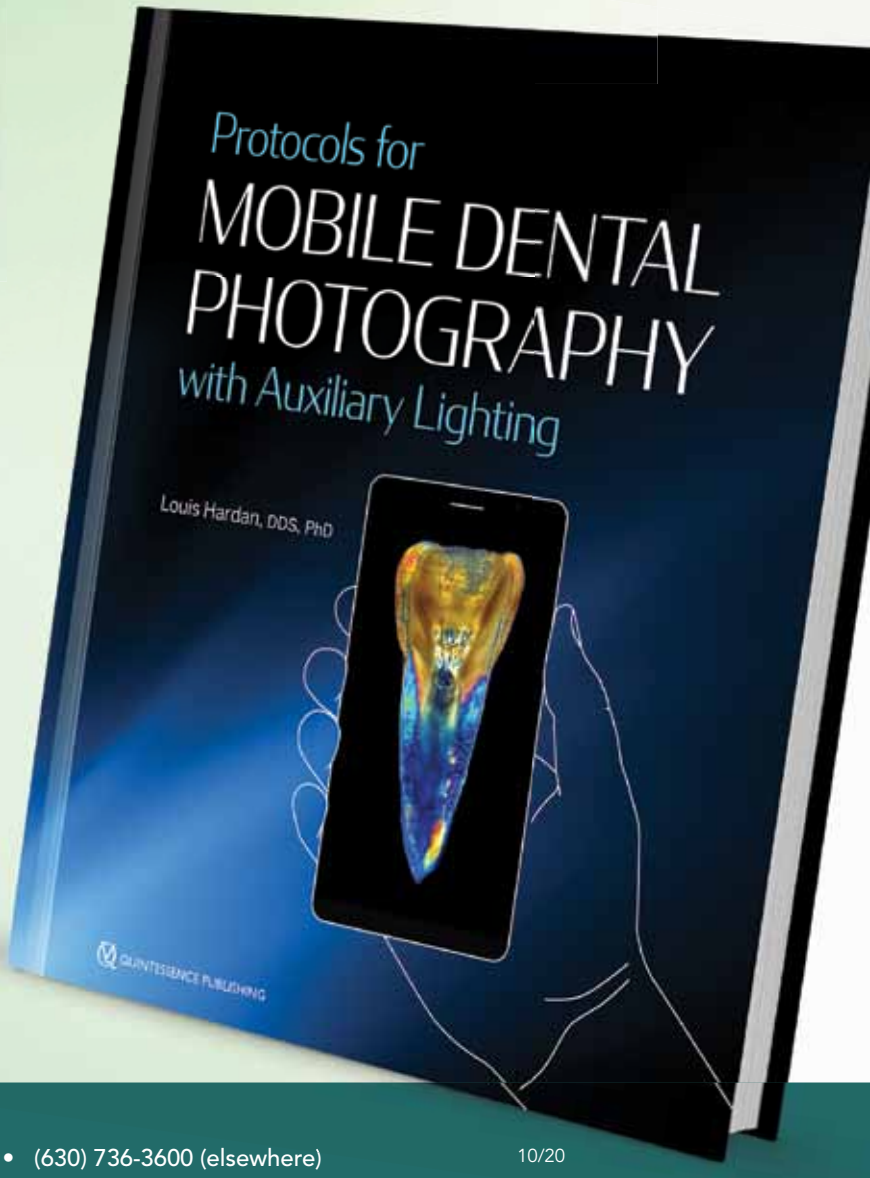

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By Jessica Birrell, MOM, CDT, MUA

AN EXPLORATION:
The Magic and Science in Restorative Dentistry, Simplifying and Enhancing Natural Aesthetics VOL. 1

Natural Dentition

"In all things of nature there is something of the marvelous."
— Aristotle

Reproduction of nature is a combination of magic and science, producing the illusion of mimicked nature and symmetry in an often less than ideal environment. As nature cannot be exactly replicated, a technician's ability to understand the science and create the illusion of mimicked nature is critical.

1. MAGIC AND THE BRAIN'S PERCEPTION

Magic is defined as one of the oldest performing arts in the world, in which tricks and illusions of seemingly impossible or supernatural feats are accomplished using natural means. These feats are called magic tricks, effects, and illusions.

Sight is the most important sense, creating approximately 75 percent of what the brain receives. We can argue that colors are not real; they are "synthesized" by our brain to distinguish light with different wavelengths. While rods give us the ability to detect the presence and intensity of light (and thus allow our brain to construct the picture of

Figure 1: How the Brain Perceives Colors? by Viatcheslav Wlassoff, PhD

the world around us), specific detection of different wavelengths through independent channels gives our view of the world additional high resolution. Humans with three color photoreceptors can see and analyze only a small portion of the visual information available to other creatures. The mantis shrimp, for instance, has 12 different types of photoreceptors. The common bluebottle butterfly has even more, with 15 receptors (**Fig. 1**).

In the optical illusion in **Figure 2**, a horizontal gray bar in a single shade of gray is placed in front of a gradient background. Suddenly, the bar also appears as a gradient, getting darker from left to right. The optical illusion is known as the Bezold effect, and was named after a German professor of meteorology, Wilhelm von Bezold (1837–1907), who discovered that a color may appear different depending on its relation to adjacent colors. **Figure 3** is another example of color as it may appear different depending on its relation to adjacent colors. These dogs are identical color but appear different due to the gradient background.

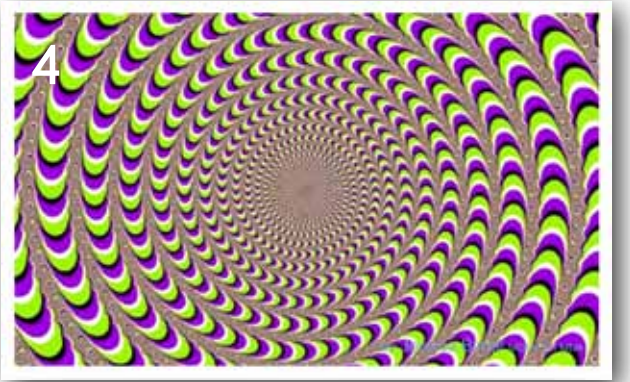
In our decade-long attempt to discern how color influences perceptions of other properties in objects, we have considered a number of novel illusions; many created by us. They have helped us understand how the neural processing of color results in emergent properties of shape and boundary.

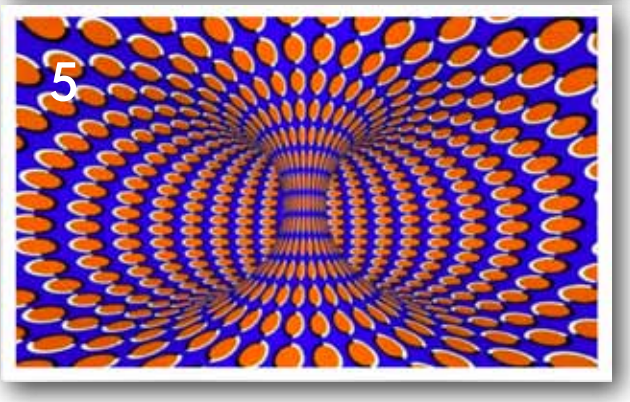
Illusions

Visual perception begins with the absorption of light. There are many types of illusions including the watercolor effect, radial effect (**Figs. 4-5**) and the Bezold effect, as stated previously.

"When you change the way you look at things, the things you look at change."

— Dr. Wayne Dyer





Figures 4-5
Radial Lines
The length, width, number and contrast of the radial lines determine the strength of this phenomenon

Figure 6
The color guide pictured in Figure 6 was designed to build an understanding of the colors needed to create translucency and chrome in relation to the corresponding shade tab.

Figure 7
Flourapatite (Dakota Matrix Minerals)
Apatite Glass-Ceramics: A Review by Tomas Duminis*, Saroash Shahid and Robert Graham Hill https://www.frontiersin.org/articles/10.3389/fmats.2016.00059/full

What role does color perception and illusions play on the fabrication of dental restorations you may ask? Consider what shade translucency appears to be. It includes variations of blue, violet and gray. Brighter shades such as bleach, A1, B1, OM1, 2, and 3, contain a stronger blue chroma, graying as we move down the Vita Classic shade guide. The Vita Toothguide 3D-Master shade guide contains blue chroma on the lighter shades, moving into violet and ending with mahogany (red-brown). Knowing that blue is associated with translucency, and opacity ranges in hues of yellow, lighter shades with more cream and darker shades increasing in yellow, orange (copper) and mahogany, we can now create illusions.

Illusion of depth

To increase depth, we can increase the intensity of the translucent chroma, blue, violet and gray, but this can appear stagnant as strong color pigments are opacious and reduce light absorption. To add chroma, you are increasing opacity, so when moderately increasing translucency or chroma, it is best to do so with layering, cutting back the surface and adding the chroma internally with the addition of topical translucency. Modern materials provide a mix of translucency and gradient chroma, allowing easier shading for enhanced natural aesthetics with little to no layering. Complex colors create better light absorption compared to one single color, allowing a softer transition into depth and translucency (**Fig. 6** - See Key Colors on IPS Ivocolor image guide for complex color recipes). Apply translucency in thin layers with multiple bakes if moderate translucency is needed.

Illusions of depth can also be increased by creating stronger lines of blue next to opacious variations of yellow (tooth chroma). This illusion allows you to manipulate the size and shape of the tooth as translucency creates depth, controlling the edge of the tooth, and increased value creates the illusion of elevation, controlling appearance. Translucency absorbs light and value reflects light, allowing color to control how much light is reflected and absorbed and its intensity.

2. NATURE VS. MAN-MADE

Fluorapatite glass, light reflection and absorption

Fluorapatite glass is used in many forms for dental ceramics. Höland et al. (2000) suggest that the morphology of the needle-like apatite is comparable to that of the apatite in natural teeth, therefore, such needle-like FAp morphology imparts the restoration with exceptional esthetics (**Fig. 7**).

The addition of fluorescence and opalescence allows light to refract and reflect, similar to that of natural dentition. Without this, man-made materials appear stagnant, with little to no light movement. Natural teeth can shift color, light absorption and reflection, which is why teeth can look different depending on the lighting environment (**Figs. 8-9**). Applying a fluorescing glaze aids in light refraction; applying this internally will optimize natural aesthetics as natural fluorescence comes from within dentin.

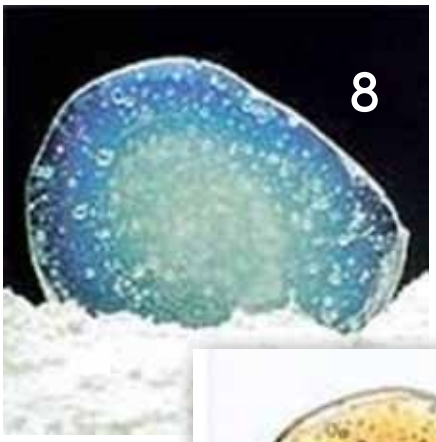


Figure 8 Opalescence: the material assumes a bluish tinge against incident light

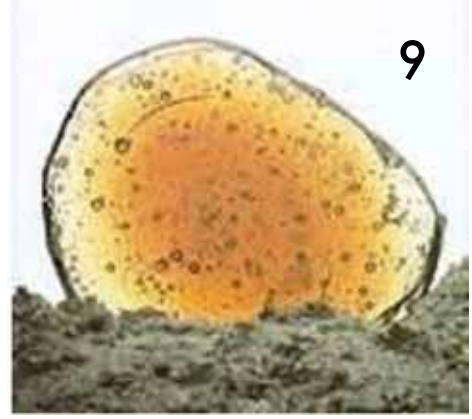


Figure 9 Opalescence: the material assumes an orangish-red hue under UV light

3. THE SCIENCE OF MATERIALS

Restorations can be shaped with many types of materials; it's the mastery and the knowledge of the material itself that brings them to life.

Many materials use a variety of flourapatite glass. This includes a material I loved years ago, IPS d.SIGN, a fluorapatite glass-ceramic which contained fluoride ions that provided the material with a very high chemical resistance. It demonstrated exceptional optical properties as a type of glass-ceramic material and offered brightness, brilliance and true-to-nature fluorescence.

Optical effects, such as opalescence, brightness, opacity and translucency, can be adjusted in a targeted fashion with materials such as IPS e.max Ceram, a modern material utilized for layering over IPS e.max and IPS e.max Prime zirconia. Due to the light scattering effect produced by the differently sized fluorapatite crystals, these crystals and the range in size allow a variation of light refraction and scattering mimicking similar characteristics of natural teeth (**Figs 10-13**).

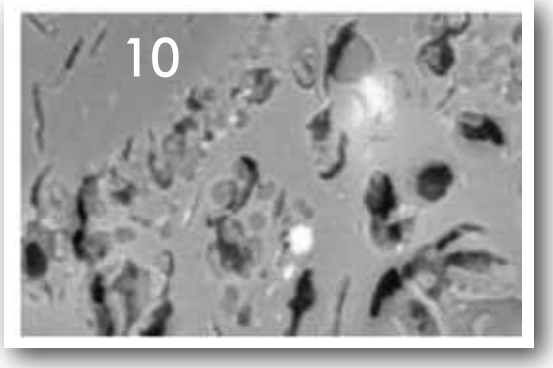


Figure 10 SEM – Conventional feldspar ceramic

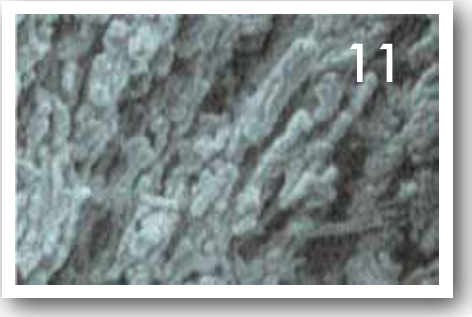


Figure 11 SEM – Natural tooth

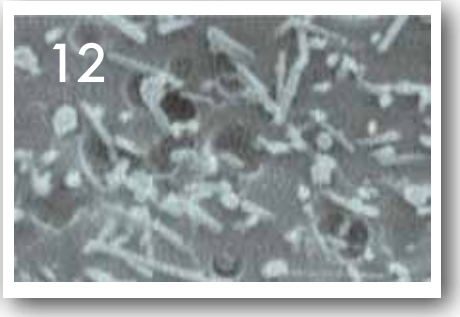


Figure 12 The nanoscale fluorapatite crystals are responsible for the material's opalescence and thereby decisively contribute to its aesthetic properties. The material's opacity (level of transparency) is mainly determined by the larger fluorapatite crystals.

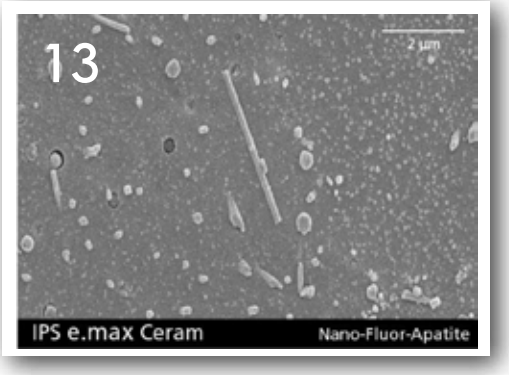


Figure 13 Microstructure of IPS e.max Ceram (SEM fluorapatite crystals)

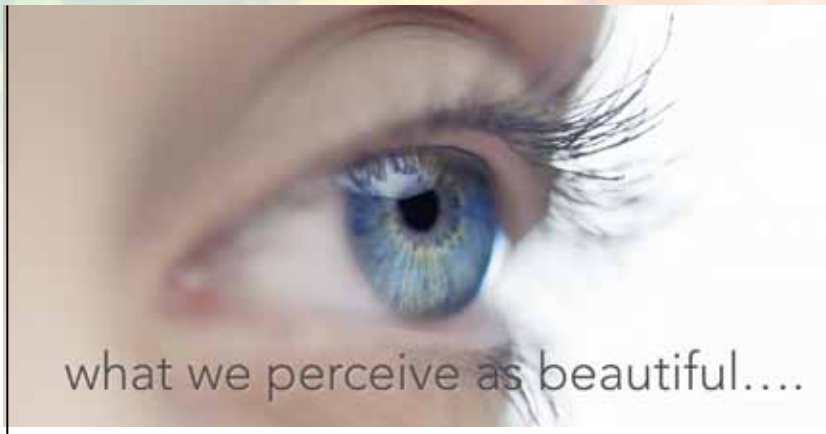
Summary

To enhance natural beauty with restorative materials, color illusions are critical. Sometimes this requires thin layers with multiple applications, and complex colors with multiple shade compositions to create the appearance of depth and control shape and size. The addition of fluorescence and opalescence allows light to bend, refract, reflect and come to life. Most often a topical application of fluorescence is not enough and should be applied internally. As materials evolve, the goal is to create milled, pressed and printed materials with built-in fluorescence, allowing minimal topical application with internal light, and lifelike vitally as to that of natural teeth. In our next article, we will study the characteristics of shape and form that enhance internal and external natural beauty as we increase our knowledge of nature's anatomy.

Look forward to Volume 2 *of An Exploration: The Magic and Science in Restorative Dentistry, Simplifying and Enhancing Natural Aesthetics.*

About the Author

Jessica Birrell, MOM, CDT, MUA, CEO and Owner of Capture Dental Arts, brings genuine passion, imagination, natural inspiration, and heart to the dental industry with her extremely creative touch. With over 22 years in the dental industry and 12 years of laboratory ownership, Jessica's portfolio includes educational dental books, publications, courses, and lectures, dental photography, makeup artistry, and product research, advancing the study of aesthetics and dental anatomy. Jessica serves on the advisory board for *Spectrum Dialogue* magazine, *IDT* magazine, and *JDT* magazine and is a Certified Dental Technician, and Certified Makeup Artist with her most cherished title held, MOM.



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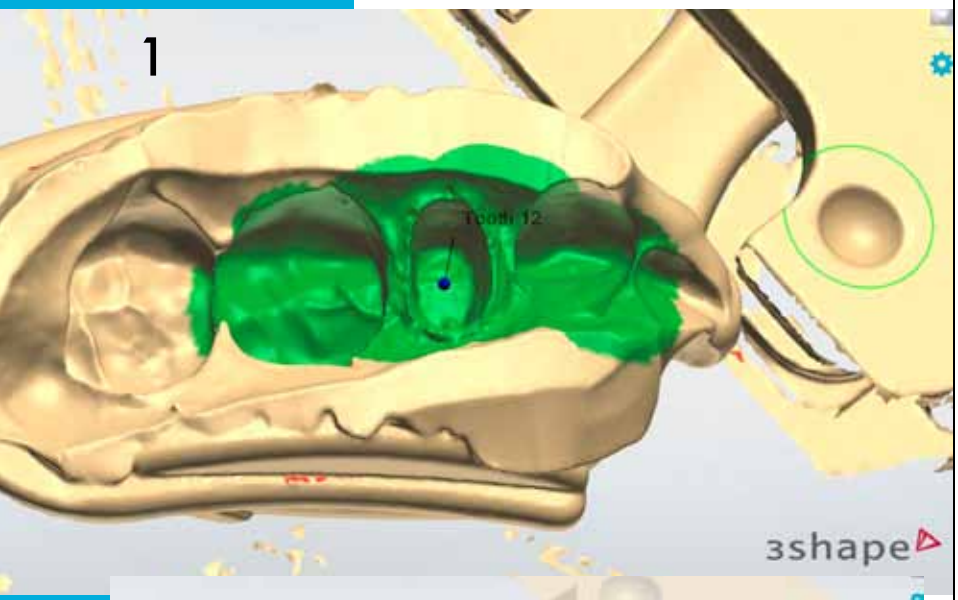
By Chris Peterson, CDT

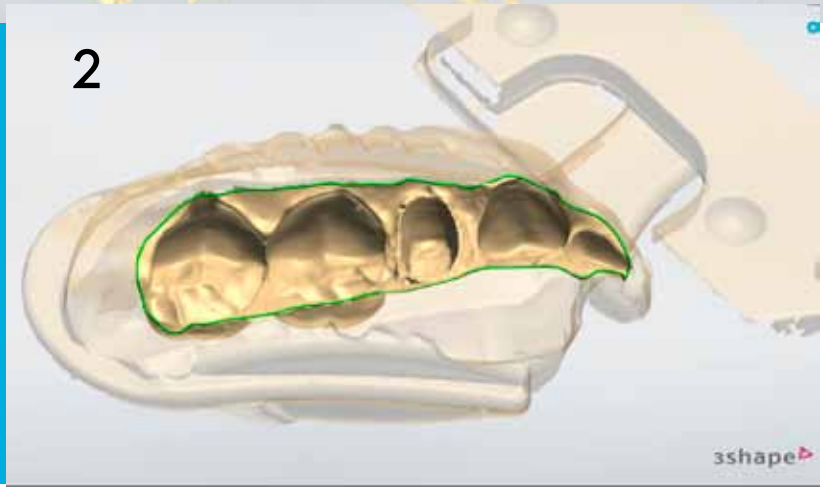
THINK ANALOG Work Digital

Scanning dental impressions in the lab is not yet mainstream. Scanning manufacturers say they can do it, but at this point it's not done by many labs. Why is this? In my discussions with other lab owners, many have tried but claim the scanners are just not there yet. I would challenge this statement and say, "'It's not the arrow,' said the Indian."

Gypsum is cheap, but skilled workers are not.

At our lab, we began testing this process in mid-2019. Today, we are scanning 92.5 percent of our crown and bridge cases between one-to-four units. We identified five key areas to consider if you are going to take this journey away from dirty and dusty gypsum toward freedom.





- Pouring versus Scanning
- Model Adjusting versus Digital Cutting
- Hand Articulator and Virtual Articulation
- Preparing Cast Discrepancies
- Gypsum Expansion versus CAD Settings

Pouring versus Scanning

Think of all the processes that go into an accurate poured model: impression trimming, de-bubblizer, stone/water ratio, mixing time, humidity, calibration of a smart stone dispensing box and most importantly, the skilled hands that complete this task. Consider when scanning your impression to not only highlight the preparation but also the adjacent teeth. Let's not forget about trimming our impression. The scanner works on a line of sight, so if it can't read something, then consider if clinically trimming that area would be acceptable (**Fig. 1**).

Model Adjusting versus Digital Cutting

Gypsum is cheap, but skilled workers are not. If technicians are waiting for cases to load because the server is slow, it is not equitable and can also cause stress when deadlines need to be met (**Fig. 2**).

Hand Articulator and Virtual Articulation

There are three basic areas to understand about the 3Shape Virtual Articulator: modifica-

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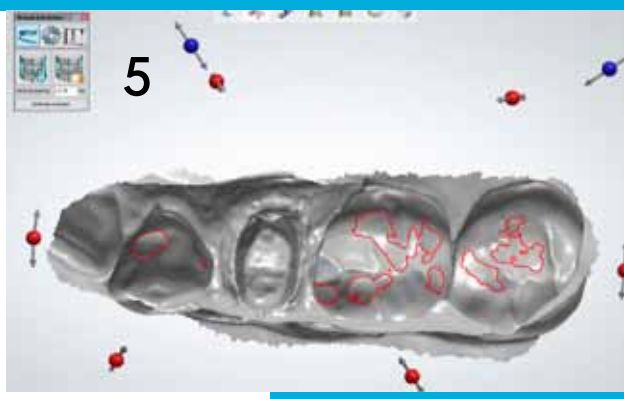

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tion to the static occlusion (this is just light hand articulating and a workaround for equilibrations), articulator parameters (these are the settings on a fully adjustable articulator), and the tools to elevate and adapt the design (protrusive, retrusion, and left and right lateral movements) (**Figs. 3-5**).

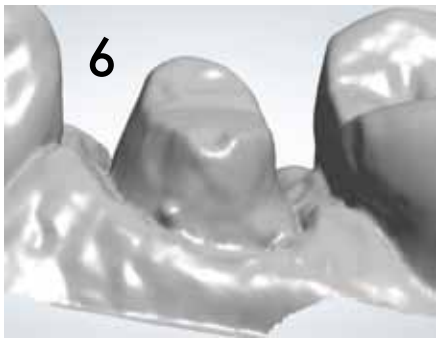
To start, the most important thing is no different than hand articulation. Try to match up both models in MIP (maximum cuspation) while observing wear facets. The majority of the triple trays our lab sees have to be slightly realigned. After this procedure, we move next to "virtual equilibration." It's not like real equilibration where we are removing all incline interferences and allowing cusp tips to totally occlude.

Preparing Cast Discrepancies Before Die Trimming

We all do it to some degree. We all try to go the extra mile and stretch a questionable or downright horrible die into a work of art. While it is not a great idea to go too far, there are some simple digital tools that are just like the analog ones we utilize. This slight positive bulge on the mesial of the prep would normally be removed with a scalpel or rubber wheel. With a simple wisp of the wax knife (smooth tool) and a steady hand, it is removed (**Figs. 6-7**).

Gypsum Expansion versus CAD Settings

Expanding die stone counteracts the shrinkage of the intraoral impression material and



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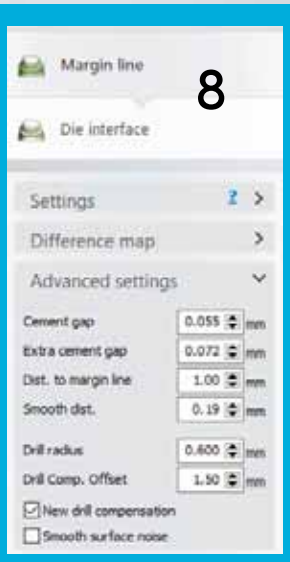
the inherent inaccuracies of traditional impressions. If labs are changing from a die stone process to a digital impression scanning process, they need to take this into account. If they don't, the result will be crowns that fit great on the printed model, but fit tight clinically. Most low expanding die stone are between .11-.15 percent expansion rates. At our lab, we typically use a .045mm die spacer and .060 extra cement spacer for traditional model scanning. When we scan an impression, we up the spacer by .010-.012 mm in both areas. There are other factors that go into play in order to make this tap dance work such as: regular mill calibrations, milling all crowns on the same type of mill with the same exact templates, quality zirconia, calibrated sintering furnaces, and consistent printing, washing and curing techniques (**Fig. 8**).



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About the Author

Chris Peterson, CDT, is vice president and co-owner of Peterson Dental Laboratory, DAMAS. Chris has been with Peterson Dental for 12 years and is a current FDLA executive board member.

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UDI & Surgical Guides

By Eric Thorn, Esq.

One question that has recently arisen is how UDI labeling requirements apply to dental laboratories making surgical guides.

Recent FDA guidance regarding dental laboratories printing surgical guides (NDP), is that dental laboratories that render such a service on the orders of a dentist would retain their FDA registration and listing exemption under 21 CFR 807.65(i)*. Thus, dental labs that print surgical guides do not solely on that basis need to register with FDA as a device manufacturer or list as a manufacturer of NDP.

Now to look at how UDI requirements may apply. It is important to remember that since dental laboratories operate within a specific exemption from FDA registration and listing requirements, the application of some FDA rules to dental laboratories may be different than for suppliers and the manufacturers of the vast majority of other medical devices.

If a dental laboratory were conducting other activities which had required a lab to register with FDA, and they chose to list the manufacture of surgical guides (NDP), they would be subject to UDI labeling requirements. However, since the manufacture of surgical guides (NDP) by a dental laboratory is within the FDA registration and listing exemption, the dental laboratory would not be required to list the manufacture of surgical guides (NDP)

Establishing a UDI is cumbersome and costly so this is good news that it is not necessary for compliance. As always, it is best to consult with a regulatory compliance expert to make sure you fully understand how regulatory requirements apply to your specific activities.

** Dental laboratories manufacturing surgical guides (NDP) under the dental laboratory exemption are still required to comply with good manufacturing practices per 21 CFR 820, including required process controls and process validation per 21 CFR 820.70 and 21 CFR 820.75, as well as manufacturer's indications for use.*

Foundation for Dental Laboratory Technology Launches Workplace Safety Grant

The Foundation
For Dental Laboratory Technology

With COVID-19 impacting how dental laboratories operate on a daily basis, the Foundation launched the Workplace Safety Grant in an effort to ensure safety amongst all dental laboratory employees. Offered on a first-come, first-served basis, the Foundation will provide up to $500 per dental laboratory to assist with implementing corrective action as indicated by OSHA's voluntary on-site safety consultation.

IMPORTANT: Unlike an actual OSHA safety inspection, this free, voluntary, and confidential safety consultation can't result in fines or citations, and the consultant can't report possible violations to OSHA. The consultant's purpose is to help businesses identify safety hazards and provide recommendations about how to improve safety.

Visit www.dentallabfoundation.org/workplace-safety-grant for more information and to apply today!

In Memorium

Bill Parker, CDT, past president of the Florida Dental Laboratory Association, recently passed away. He will be missed.

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CDT HARDSHIP GRANT

Are you a CDT that suffered loss of income as a result of COVID-19? If so, this grant is for you!

The Foundation for Dental Laboratory Technology wants to be sure the impacts of COVID-19 do not hinder the importance of maintaining the CDT designation. As part of the CDT Hardship Grant, the Foundation will cover the annual CDT renewal fee of $170 for a selected group of CDTs.

This grant will be offered four times during 2021 – once for each CDT renewal cycle. The application deadlines are as follows:

- Feb. 28, 2021 for March CDT renewals
- May 31, 2021 for June CDT renewals
- Aug. 31, 2021 for September CDT renewals
- Nov. 30, 2021 for December CDT renewals

With this grant covering CDT renewal fees and the Foundation Learning Library (www.dentallabfoundation.org/courses) offering CE free of charge, the Foundation is your one stop resource to meeting your annual CDT requirements.

We've said it before and we'll say it again – *the Foundation has your back!*

Learn more and apply today at www.dentallabfoundation.org/cdt-hardship-grant.

The Foundation for Dental Laboratory Technology

325 John Knox Rd Ste L103, Tallahassee, FL 32303 | (866) 627-3990 | www.dentallabfoundation.org

Overcoming New Challenges

Greg Martin, CDT, TE, *National Director of Sales, USA & Canada Renfert USA, Inc., located in St. Charles, Ill., shared his thoughts on how businesses can survive in 2021.*

What measures has Renfert taken in order to overcome the challenges from COVID-19? Did your business strategies change?

2020 and COVID-19 presented myriad challenges for us as a company. We needed to be able to continue to service our dealer partners and customers (end users), make sure our inventory supply was stable, be financially responsible to the company, etc., all at the same time. Plus, there was the fact we were facing so many unknowns. We had excellent leadership from all levels, from our CEO in Germany to our General Manager here in the U.S., who encouraged us to be forward thinking and really plan for the worst. We reduced travel to a minimum, but pivoted to virtual connectivity via video conferencing (Skype), increased webinar activity, and creation of our Renfert-On-the-Go Video Learning series, etc. Our team, on a global scale, really pulled together to face the challenges head-on and with a "stronger together" mentality. It really was great to see. I think it made us a better company having faced these challenges.

Be available, be flexible, and be open to new technology and processes.

Where do you see the industry headed in the next five years?

The industry will continue its shift to more digital processes, both with better technology and communication tools (vital to dentist/lab communication), such as our EASYview 3D, as well as new materials for both milling (such as high performance polymers and next generation zirconia) and 3D printing (resins and new materials for final restorations). As the 3D printing technology becomes more mainstream, you will see a huge increase in the offerings available and will drive new innovations for dentistry. With new materials, there will be new finishing techniques and subsequently more new materials needed. We want to be able to meet those needs for our customers.

What advice would you give to laboratory owners to survive and thrive in today's environment?

Stay on top of technology. Be aware of trends and new materials via dental journals such as FDLA's *focus* and NADL's JDT, and through dental forums and groups. Most important, and I can't stress this enough, is to make sure you have open lines of communication and use the tools available to communicate with your doctors. Be available, be flexible, and be open to new technology and processes.

Why is being an FDLA Business Partner valuable to you?

Being an FDLA Business Partner is valuable to us because FDLA really provides a touchstone for information, trends in the industry, and insight into what is really going on out there in the "real world." The FDLA has many members who are trendsetters and industry leaders, and it is vital that we as a company look to them for advice on how to make better products for their daily work processes and to increase our ability to "Make Work Easy."

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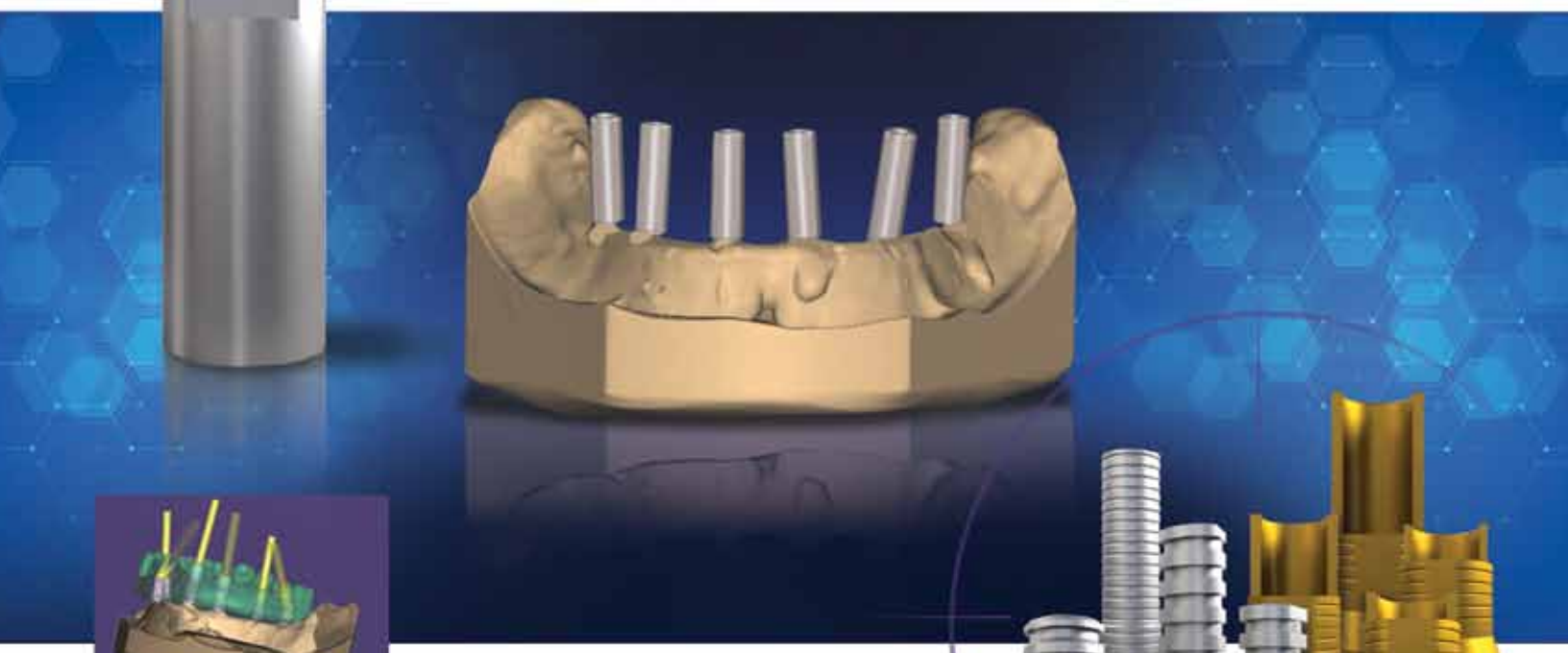

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