



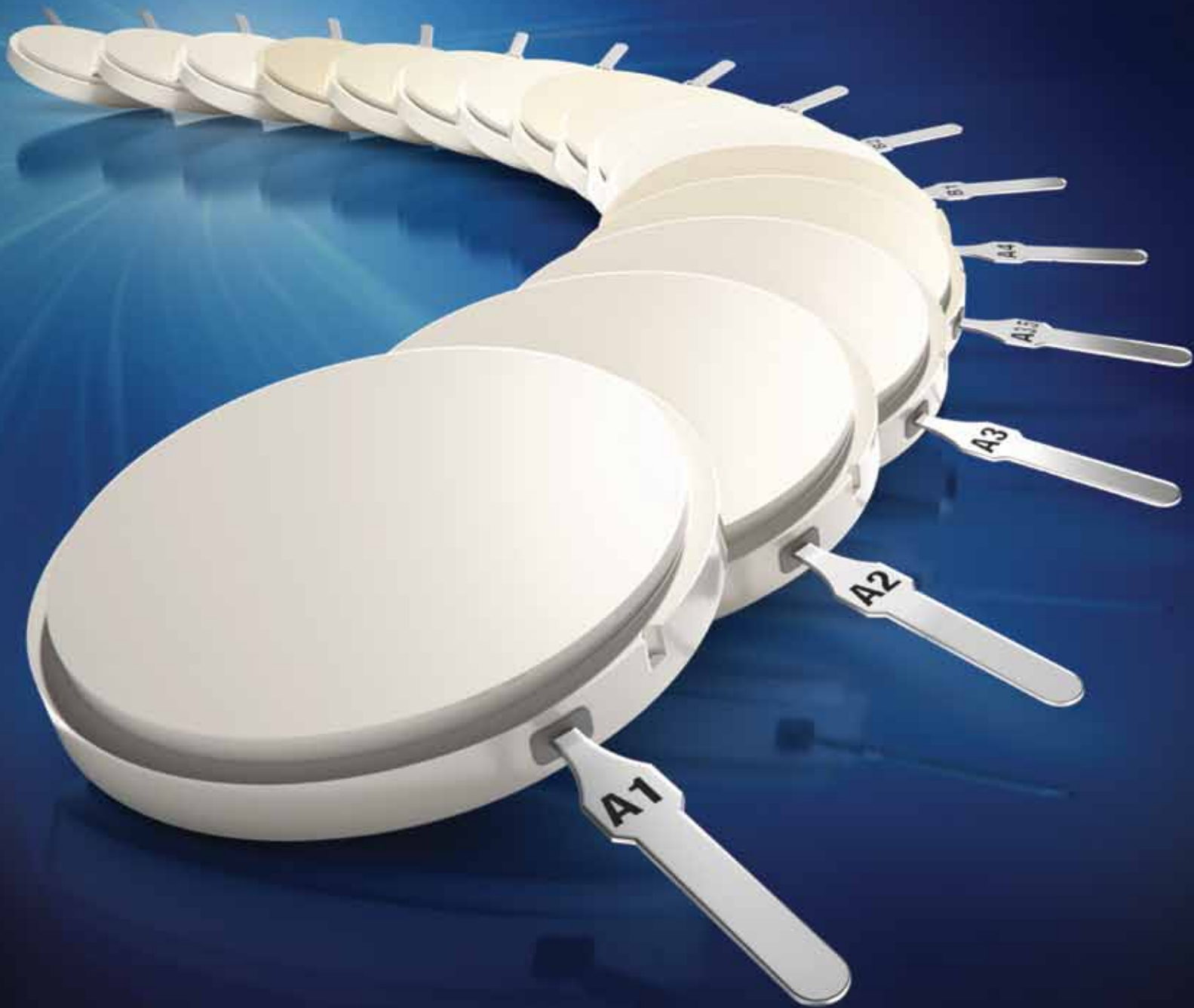
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## 3D PRINTING and Dental Implants

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# Living in a Digital World

**T**here's no question that we live in a digital world—personally and professionally.

According to the National Association of Dental Laboratories' 2015 Materials and Equipment Survey:

- 54% of dental labs design their own custom mill abutments
- 53% of dental labs own their own CAD/CAM systems
- 48% of dental labs own at least two CAD/CAM systems
- 36% of dental labs use a CAD/CAM digital communication network and say it has improved their business
- 40% of dental labs use a standalone scanner
- 16% of dental labs use a 3D printer
- 14% of dental labs use a digital impression system
- 51% of dental labs use digital design software to fabricate restorations




FDLA President Fernando De Leon

Digital laboratory technology has helped to improve how we communicate with our dentist clients, our productivity and our remake rates. All of this is good. However, we have to remember that digital technology is just one of our tools, not the solution to every problem.

*"Digital technology is just one of our tools, not the solution to every problem."*

Don't take this to mean I don't believe in digital technology. I do. I have some digital technology in the lab and it has changed some of our everyday processes and helped to streamline our production. It helps if you have the dental knowledge to use the digital technology correctly so you get the benefits and have fewer remakes. Once you conquer the digital technology learning curve and use your dental knowledge, it really does help speed up the work.

However, like every other tool, digital technology is only as good as the technician who wields it. We must remember that every technician, whether he or she is a waxer to a CAD/CAM specialist, must know at least the basics of tooth morphology, occlusion and restoration design. It's difficult finding technicians who know of those right out of the gate, so we have to invest in training. That's where FDLA comes in. With the Southern States Symposium & Expo, as well as the very affordable FDLA District Workshops, we can help our technicians gain the knowledge they need. In addition, there are online courses (check out the Foundation for Dental Laboratory Technology's online course finder) that can help newer technicians master the basics and more knowledgeable technicians conquer the new technology.

No matter how digital the world becomes, dental technology will always require a human touch. 



**By Fernando De Leon**  
FDLA president

### FDLA Mission

Serving Florida's dental technology professionals as a valued part of the dental team enhancing oral health care.

### FDLA Vision

Advancing the individual and collective success of Florida's dental technology professionals in a changing environment.

### Values Statement

FDLA's board of directors and professional staff are guided by these principles:

- Integrity
- Leadership
- Recognition
- Safety
- Acceptance
- Innovation

## focus

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Web site: www.fdla.net

Published quarterly by the  
Florida Dental Laboratory  
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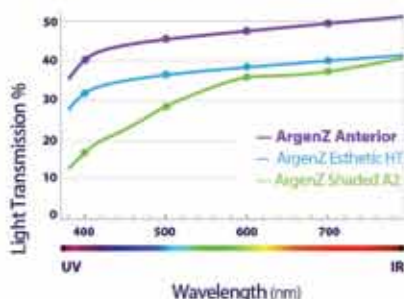
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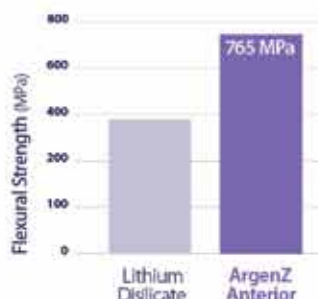


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## Southern States Symposium & Expo a Success!

**T**he 2016 Southern States Symposium & Expo was held May 5-7 at the Renaissance Orlando Resort at SeaWorld and was a great success. The symposium and expo is the largest dental laboratory industry meeting in the country run by a nonprofit association. The educational sessions and expo provided dental technicians, laboratory owners, laboratory managers and dentists with beneficial information on the latest trends and technology updates. Here's a look at some of the great moments from the Symposium & Expo.



*Friday Night Reception*



*Expo Hall Ribbon Cutting*



*Expo Hall buzz*



*Tony Circelli, Heraeus Kulzer, with Shawn Nowak, Nowak Dental Supplies, at the golf tournament*



*Golf Tournament winning foursome*



*Von Grow Hands-On Workshop*





*Gail Perricone, FDLA president, with Clark Viexama, McFatter Technical College*



*Al Fillastre, III, CDT, FDLA board member, with Gail Perricone, FDLA president*



*Fernando De Leon, incoming FDLA president, presents 2015-2016 FDLA President Gail Perricone with the gavel plaque for her service*



*Dena Lanier, NADL president, (left) with 35 year CDT milestone recipients*



*Dena Lanier, NADL president, (left) and FDLA Past President Morris Fucarino, CDT, (right) present 25 year CDT milestone to Barry Singer, CDT.*



*Dena Lanier, NADL president, (left) presents 40 year CDT milestones to (from left to right) Lenny Herrera, CDT; Mark Devery, CDT; Gary Gann, CDT; and Morris Fucarino, CDT.*





*Expo Hall Buzz*



*2016 Best of Show – Argen Corporation*



*Tim Stevenson, CDT, FDLA board member, and Fernando De Leon, FDLA president, present sponsor ribbon to GC America*



*Pat Taylor, CDT, Ivoclar Vivadent, Inc., (right) with FDLA member*



*Argen table clinic in Expo Hall*



*Affordable Dentures booth*



*Expo Hall buzz*



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BE SOCIAL WITH US:  

By Daniel Alter MSc, MDT, CDT

# 3D PRINTING and Dental Implants

**D**ental implantology offers a conservative approach to dental treatments for fully or partially edentulous patients. Placing implants successfully requires a specialized set of skills and expertise to ensure their viability. Digital technology and 3D printing have significantly elevated the rate of success and transformed the workflow and practice of dental implant standards of care. Forward-thinking clinicians and dental laboratories are harnessing the benefits of digital technology to attain the best outcome for their patients, while providing the needed versatility, cost and time savings. Dental professionals can create guides for dental implants like this one more efficiently and cost-effectively using 3D printing.



**Figure 1**

*Dental professionals can create guides for dental implants like this one more efficiently and cost-effectively using 3D printing.*

Dental patients are searching for options to maintain their oral health's longevity. Implants are a viable solution to replace missing teeth without the need to destroy neighboring healthy dentition. Traditionally, replacing a missing tooth required the patient to undergo a series of preparations on two or more healthy teeth adjacent to the missing tooth to construct a bridge. Although this process satisfied the requirement to replace a tooth, the treatment also cut away tooth structures of the healthy adjacent teeth. Dental implants remove that requirement and are a more conservative approach in replacing the missing tooth. A clinician can place an implant into the site without affecting or damaging the adjacent healthy teeth.

Special consideration is needed prior to placing any dental implants. The location, angulation and size of the implant need to be appropriate and specific to the site, and the clinician should consider the biomechanics of the patient's bone density, sinuses and nerves. Traditionally, surgery was either done by hand, or surgical guides were fabricated on solid stone (gypsum) models or laboratory-fabricated dentures, and holes were



pre-drilled to guide the dental surgeon's handpiece. With the advancement of digitization and cone beam computed tomography – also called CBCT – scanning, true guided surgery can be performed.

The first step in guided implant surgery is to run a cone beam scan on the patient, which provides a wealth of information on the bone, bone density, soft tissue, location and nerves. The DICOM file, or rendering of the patient's anatomy, is integrated into a guided surgery software program. There, the clinician and/or dental technician can virtually place an implant and run a series of tests to ensure its best location outcomes. An impression of the patient's mouth is captured, either digitally with an intraoral scanner or with the analog PVS method, from which a model is created and scanned. This creates an optical scan that provides an STL file that can quickly and simply be overlaid onto the DICOM (cone beam) file and provide a comprehensive STL file to be imported in to the guided surgery software.

In the guided surgery software, the clinician chooses the type of implant system and the implant size. The software automatically generates the implant and allows the clinician to virtually position the implant in the bone. Once the implant and its location are lined up, together with the intraoral scan or optically scanned model, they are integrated and overlaid to become one open-source concise STL file. This comprehensive file can now be manipulated and a surgical guide can be designed.

Designing the surgical guide in the software provides the clinician with the freedom to achieve the optimal results and best treatment protocols, elevating the standard of care. It is fast and easy to plot the location and borders of the guide. Once the plot is selected and all involved areas are considered, the software virtually generates a hole where the drill guide sleeve can be attached.

"The 3D printed surgical guide technology allows me to gain the best aspect of every single guide out there—we can now do more," said Dr. Richard Nejat, DDS, a diplomat at the American Board of Periodontology and a periodontist in New York. "This technology provides us with the freedom to do anything possible; if it's possible, we can do it."

Once the implant surgery guide is designed, it is simple to export the comprehensive STL file to a 3D printer to provide a quick and seamless surgical guide. The guide is printed in the Stratasys® bio-



**Figure 2** An intraoral scanner captures an impression of a patient's mouth.

compatible (MED610) material, which is certified for contact with the oral environment for a short duration. Specifically, the material is approved for short-term mucosal- membrane contact of up to 24 hours. The hole accepts either a metal sleeve that is glued into the guide, or a predetermined hole is 3D printed and used with a drill-guided sleeve that fits on the dental drill and guides the clinician to the location and depth of the desired implant placement.

Dr. Nejat follows the same work flow mentioned above, and broadened his restorative protocol with the use of dual scans. The dual scans provide an additional level of treatment—the patient is scanned while wearing a denture and then again without wearing the denture (this can also be achieved digitally). The dual scans provide more information on guided surgery, because now the data of the patient's teeth or desired future teeth placement is included in the treatment plan and not just bone and site considerations.

Guides are printed in the bio-compatible material—a PolyJet™ material—that is deposited in 28-micron layers and built up to full geometry with support material. The support material is later removed, leaving an accurate, clear surgery guide with a hole to guide the drill. These guides can be printed on an as-needed basis or be bundled and printed in batches of seven surgical guides in a seven-hour print cycle. The print time depends on the height of the surgical guide; the higher the guide, the more passes the print head needs to make and the longer the print job will take.

## A Statistical Look at THE DIGITAL LABORATORY

Among laboratories without a **3D PRINTER**, 74.4% do not plan to acquire a 3D printer, 8.1% plan to acquire one within 1 year, 7% plan to acquire one within 2 years, and 10.4% plan to acquire one within 5 years.

With respect to **CAD/CAM SYSTEMS**, 53.2% of laboratories own, 4.3% lease, and 42.5% do not have one.

Among laboratories that have **CAD/CAM SYSTEMS**, 52.6% have only one, 23.2% have two, 10.9% have three, 3.6% have four, and 9.6% have five or more.

Compared to traditionally manufactured restorations, 44% of **CAD/CAM USERS** feel their systems produce restorations of higher quality, 42.7% feel the quality is equal, and 13.3% feel CAD/CAM restorations are of lower quality.

Source: National Association of Dental Laboratories

## A Statistical Look at THE DIGITAL LABORATORY

➡ Sixteen percent of laboratories surveyed have a **3D PRINTER** and the remaining 84% do not.

➡ In terms of **CAD/CAM RESTORATIONS** by type of block, the percentage breakdown is as follows: 58.3% are zirconia, 14.8% are porcelain, 11.2% are wax, 3.6% are acrylic, and the remaining 12.1% are unknown.

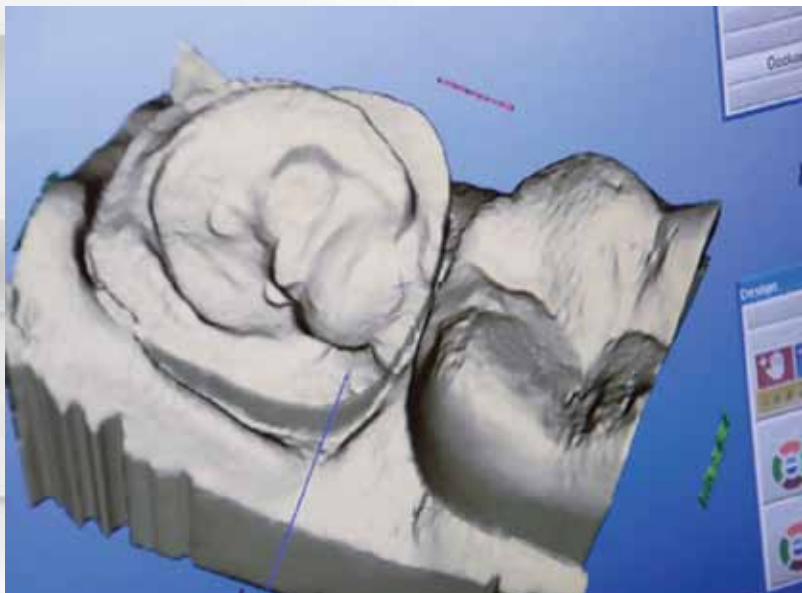
➡ Forty percent of laboratories surveyed have **STANDALONE SCANNERS** (with no internal milling system) and the remaining 60% do not.

➡ Among laboratories that have **STANDALONE SCANNERS**, 59.1% have only one, 21.7% have two, 6.4% have three, 3.4% have four, and 9.4% have five or more.

Source: National Association of Dental Laboratories

**Figure 3**

The scan data is processed into an STL file.



There are multiple benefits in 3D printing surgical guides in clinical environments. Dr. Nejat says there are three key benefits, with the first being complete customizable control of the surgical guide and treatment protocol.

"I can use any implant system and customize the guides to the way I want them to be and as I see it best suits for my patient's needs and their desired outcomes," he said.

This was not the case before he could 3D print his own surgical guides. All too often, using an outside vendor to manufacture these guides impeded the process, like the limited options for specific diameters, positioning and support. The main limitation with outside vendors was turnaround time and cost. It typically took two weeks to receive guides, which ranged in cost from \$300 to \$500 each. With 3D printing, Dr. Nejat now captures the desired attributes from multiple surgical guide vendors and incorporates them into his own 3D printed surgical guide.

The second benefit of digital dentistry Dr. Nejat highlights is a significantly faster treatment protocol and patient turnaround time. A patient can come in, be assessed and both begin and complete treatment in a considerably shortened time period. This enhances the patient's dental experience, and provides a quicker and better outcome. Lastly, an in-house 3D printer generating these surgical guides provides a significant cost savings: Dr. Nejat estimated a robust average cost savings of 50 percent to 85 percent from previously outsourced surgical guide options.

**Figure 4**

This implant surgery guide was 3D printed in the bio-compatible material.



Dental professionals are constantly seeking to improve and elevate the standards of care for their patients. Digital technology and 3D printing make this goal easier to attain. Forward-thinking professionals are using these technological solutions to obtain diverse treatments and services for their existing and future clientele.

This technological solution provides a business model for practitioners and dental laboratories that is cost-effective, enhances precision and significantly elevates dental treatments. This results in a better dental experience for the patient and increased longevity and viability of the implant-supported restoration. ①

## ACKNOWLEDGMENT:

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## ABOUT THE AUTHOR

Daniel Alter's experience and repertoire is comprised of more than 20 years in the dental profession. He has 10 years of experience owning and operating a successful mid-sized dental laboratory.

In addition, he earned a master's degree in business management and organizational leadership, the designation of Master Dental Technologist and two certifications. He is a professor of restorative dentistry at the City University of New York. He is a recognized published author and presenter on various relevant subjects, and is continually active in learning and sharing his knowledge with like-minded professionals.





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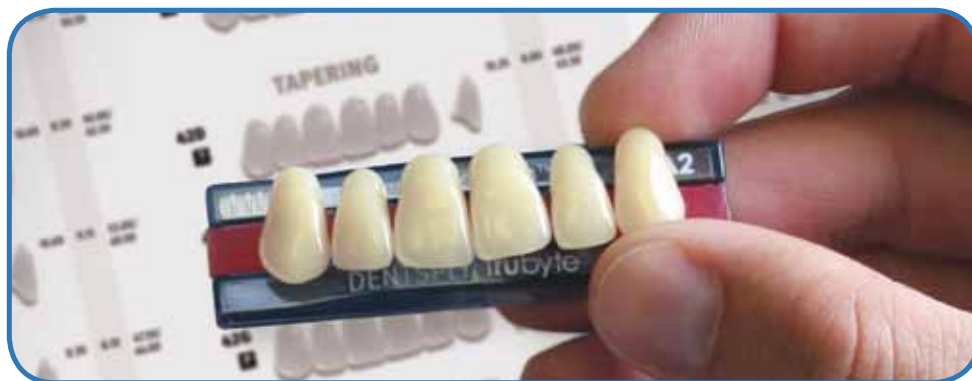
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By Jeremiah Naas, CDT

## Removable Partial Frameworks

**R**emovable partial frameworks are precision appliances that require skill and planning. Ever since the first documented removable partial denture in 1711, technicians have been battling with creating a precise fitting RPD with the materials available to them. As time went on, manufacturers continued to improve the materials that we use. Today's high-quality materials enable technicians the ability to consistently control the variables that might influence the end result.



Jeremiah Naas, CDT  
Owner of Inverness  
Dental Arts

*"The more you  
can consistently  
control every step  
along the way,  
the more you  
will eliminate  
variables  
that create  
inconsistencies."*

At Inverness Dental Arts, we do things in a way that allows us to continually manufacture a precise-fitting framework and wanted to share five tips that will help you achieve this result along with some money saving ideas.

### Tip 1

Find a company that offers a RPD fabrication system. Inverness Dental Arts uses BEGO's RPD system and is an International Wironium Circle "IWC" member. BEGO has spent years developing investments, refractory model investments and metal that all work together. No matter which system you use, I do not recommend mixing and matching manufacturing products.



### Tip 2

Take the time to truly learn the manufacturer's instructions for use. Do not vary from them. The more you can consistently control every step along the way, the more you will eliminate variables that create inconsistencies. BEGO has been nice enough to pre-weigh their investment bags. This does two things:

1. It allows for a consistent mixture without the error of weighing.
2. The 400g bag of Wiroplus® S works perfectly when pouring two refractory models with little to no waste.





## Tip 3

The use of a pressure vessel. I was never a big believer of using a pressure vessel until I tried one. I use BEGO's pressure vessel and I would never be without at least one. Using the Wiroplus® S refractory investment along with the pressure vessel creates a refractory model that is a precise, smooth surface texture and bubble-free. The decision to use the Wiroplus® S pays for itself when you see the post casting results.

## Tip 4

Use silicone duplicating material. I often hear that it is too expensive to use. Wrong. Let me tell you why: a meat grinder. Yes, I said a meat grinder. We take the old duplicates and put them back to use. Chopping up the silicone material to use a filler along with the help from the pressure vessel, our average duplicate consists of as much as 40 percent filler per mold. This has saved us hundreds. Warning! If you're not using a pressure vessel, be very careful adding too much filler as this can cause major flaws in the duplicate. BEGO also offers a pre-formed silicone duplicating flask. These flasks come with tongue/palate spacers. It's worth taking the time to use the proper spacer. Silicone is expensive, so anywhere you can reduce the amount used is money saved.



*"We are able to produce a product that is very predictable and reliable."*



## Tip 5

When we invest the waxed framework, we use a BEGO ring former and WiroVest investment. Here is another money saving tip. Use WiroVest instead of Wiro Plus S for the investment pour. Wirovest is cheaper, but still a high quality product designed to be used with the BEGO system. I get clean castings with the luxury of easy removal during sandblasting.

In conclusion, by using one manufacturer's material, following instructions consistently and utilizing the pressure vessel, we are able to produce a product that is very predictable and reliable. The use of the pressure vessel, along with the repurposing of the old duplicate and using two investments, helps with expenses associated with casting high quality partial ①



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# Why Temperature Control is Critical in Dental Ceramic Firing

A recent LMT survey showed that 66 percent of dentists switch laboratories based on inconsistency in the quality of the finished product. A comprehensive understanding of thermodynamics, controlling temperature accuracy, and the physical characteristics of the materials used will give laboratory owners and technicians the ability to ensure success. So, the implementation of tools to help with consistency in the end product is imperative.

*"We may like to believe in magic, but in firing dental porcelains, there is only physics."*

In the ceramic world, isolating problematic issues generally boils down to two phases. First is the preparatory work done prior to firing the ceramic, and second is the firing process itself. There are so many different things that can go wrong with a case during the preparation and construction phase, and conversely, perfectly prepared cases can be ruined by an unstable firing environment (porcelain furnace). Measuring the critical parameters comprising the ceramic firing process can be challenging and consuming for the dental technician. If the technician can verify the temperature consistency of the furnaces being used, then any further process instability can be addressed simply in terms of preparatory work or mechanical defect.

The following information reviews the importance of temperature control, how to accomplish it, and how to ensure success from conventional ceramic firing to lithium disilicate pressing and/or crystallizing.

## Thermodynamics of the Modern Vacuum Porcelain Furnace

We may like to believe in magic, but in firing dental porcelains, there is only physics. The consistent

measurement of temperature accuracy is a critical part of the process. To appreciate how this process functions, it is first necessary to understand the principles of thermodynamics as they relate to the modern furnace.

The most accurate sensor for high-resolution temperature is the noble metal thermocouple. Thermocouples consist of two dissimilar metals welded together at one end to form a junction known as the bead. When the bead is heated by convection (air currents passing across it) or by radiation (which is the case when the furnace is operated under vacuum), the bead will generate a positive electrical charge on one side and a negative electrical charge on the opposite side. Measuring with a meter will tell us the temperature.

The measurement of the interior muffle temperature in a vacuum porcelain furnace can be more challenging than the simple sensing of temperature around the thermocouple (**Figure 1**). One of the factors is the position of the thermocouple inside the muffle. Most modern vacuum porcelain furnaces have a spiral wound heating element encased in tubular quartz which covers the inside surface of the muffle. The thermocouple projects downward from the roof of



the muffle. Heated air inside the muffle will migrate to the top and force cooler air toward the bottom of the muffle. The difference between the hotter and cooler air depends upon several factors:

- The level of vacuum
- The height of the muffle
- The diameter of the muffle
- The average air temperature.

In addition, the higher the air temperature inside the muffle, the larger the top-to-bottom temperature differential is within the unit.

Besides the physical factors mentioned above, the ability to control and regulate temperature inside the muffle is influenced by the time it takes the thermocouple to sense the current temperature of the muffle. The furnace must decide whether it is too high or too low and by either turning the heater on or off, to reach the desired temperature.

The control circuitry of the furnace must take this thermal time constant (the amount of time it takes to sense the temperature) into consideration, or the muffle temperature may wind up oscillating up and down as it constantly hunts for a stable point.

The muffle cavity itself also influences temperature. The muffle is formed by surrounding the heater coils with an insulating material such as aluminum oxide, which will slow—but not completely stop—the loss of heat from the higher interior temperature to the lower exterior temperature.

The rate of heat loss increases as the difference in temperature between the inside of the muffle and outside increases. The insulation, when exposed to enough heat over a short period of time, can turn into a heat dam, which will not allow the temperature to drop until enough time has elapsed to radiate the migrating heat toward and away from the outside of the muffle chamber. Fortunately, most dental porcelains only require a few minutes of process time at high temperatures and return to

lower temperatures before enough heat can back up in the insulation dam and adversely affect the firing.

The thermocouple bead and the porcelain restoration are each affected by the radiant energy coming from the heater windings. This radiant energy is directly proportional to the surface area of the heater windings facing the porcelain and the thermocouple. It is also proportional, to a lesser degree, by the indirect radiant energy that is reflected off the muffle walls. This energy bounces around the interior of the muffle chamber, until it strikes the porcelain restoration and/or the thermocouple.

How a restoration is affected by this radiant energy depends upon the size of the restoration, the surface area and the amount of time it is exposed to the radiant energy. If the restoration is layered ceramic, the speed at which the porcelain absorbs the heat is affected by the amount of moisture in the porcelain and how close the porcelain particles are to each other. In addition, the speed of absorption will depend upon the overall mass of the restoration. This is the case

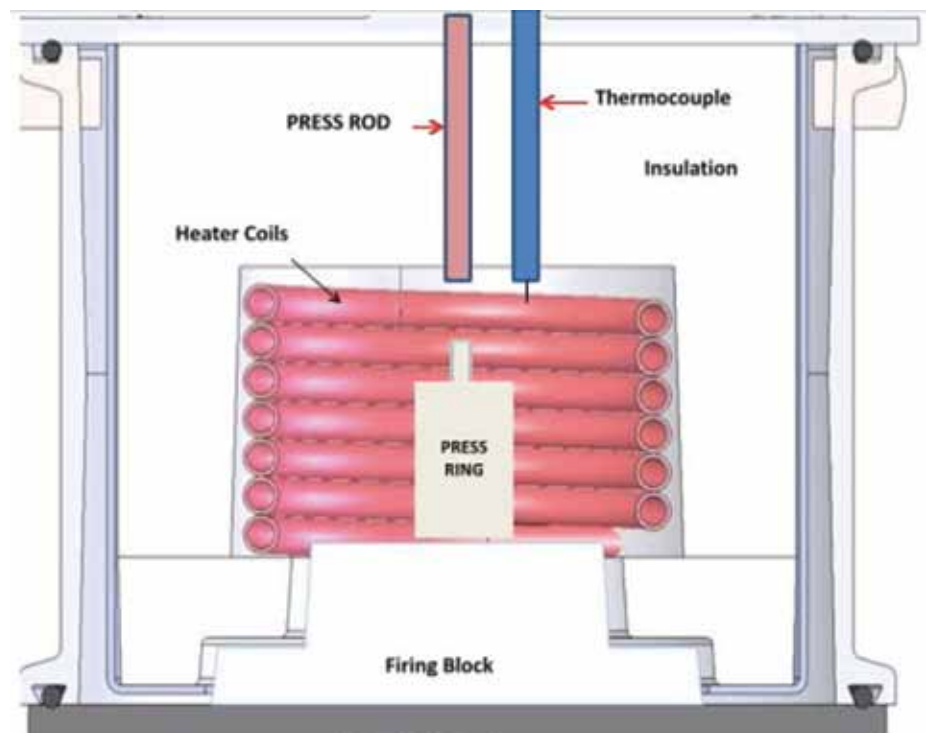
for all ceramic types whether layered, pressed or milled.

Heat (photon density) is subject to the inverse square law which states, “a work piece which is twice as far away from the heat source, receives one quarter of the energy per square millimeter of surface area.”

What this means is that where you place the restorations in the furnace, relative to the center of the muffle and firing tray, will have an effect on the amount of heat energy the restoration will absorb at a given temperature setting. The bottom line is that the closer to the center, the better. Also with a smaller muffle, the heat is increased in the same amount of time it would be in a larger one.

We also find that the firing parameters you employ will be different if you are using a 115 volt furnace versus a 220 volt furnace because the exposed heater coil surface of a 115 volt furnace is less than the 220 volt furnace, which uses the same wattage. Since the photon density is higher in the 220 volt furnace, it would require less hold time to generate

Figure 1



equivalent firings on the same material with the same surface and mass. So published firing parameters will need to be adjusted to accommodate the furnace muffle design you are using.

The wavelength of the photons leaving the muffle coils should be the same to assure a uniform depth of penetration of the ceramic. The physical composition of the muffle coils and the applied voltage determine the spectral heat wavelength. When a muffle coil nears the end of its life, the composition of the wire can change slightly due to boil-off loss of one of the two metals composing the wire. This can cause a slight spectral shift which would suggest a drift in the firing parameters required to generate an equivalent firing on a given material, wetness and mass. This drift is often blamed on the aging thermocouple inside the muffle, but in fact can be due to the aging of the muffle coils.

Some attention should be paid to the quartz tubing and the insulation and their affect on heat exchange. The quartz tubing surrounding the heater coils in the muffle is heated at the primary spectral wavelength by the coils and then re-radiates this energy to the muffle cavity at a spectral wavelength characteristic to the quartz. The same is true about the surrounding alumina fiber insulation. The characteristics of these elements do not vary significantly over time so their effects can largely be ignored. Therefore, the claim of no quartz versus quartz is not a significant issue.

The measured top-to-bottom temperature difference mentioned previously is not of particular concern because the relative vertical position of the ceramic inside the muffle chamber is usually held constant by Saggar trays and points. The midline height of the units or bridge never vary vertically more than a couple of millimeters. The ceramic generally sees the same temperature with each firing.

## Thermodynamics of Modern Vacuum Porcelain Furnaces Used with Pressed Ceramics

The fact that the thermocouple may see a slightly different temperature than the actual work units should not matter since both the restoration plane and the thermocouple plane are simultaneously present in the same place during every firing. The thermocouple helps ensure a preset point of temperature at its location. The ceramic will still need to be inspected visually to ensure that the temperature set point produces the desired effect on the ceramic at the location of the ceramic.

The same is true when using a pressing furnace to press lithium disilicate or other pressable ceramics. There is no thermocouple inside the invested ring to measure the temperature near the pattern molds. Suggested firing parameters are made by the manufacturer of the glass ceramic and in certain cases based on research using their furnace only. Any furnace with the ability to reach and hold an object at the required maturation temperature, whether in one or multiple stages, will be able to properly vitrify any layering/veneering ceramic or pressable material.

A good ceramic technical team should be able to help any furnace user find the best thermal location for their glass. We have covered a lot of technical and physics related issues in this article.

In the end, a porcelain furnace does six things:

1. It encloses the work in a sealed heating chamber
2. It heats up at a specified rate
3. It achieves a vacuum
4. It holds a preset high temperature for a specified amount of time
5. It stops the heating procedure at a specified time or temperature
6. It opens the sealed chamber

So, indeed, there is no magic in firing dental porcelains, just pure science. The

ceramic and its manufacturer control the firing parameters to ensure that the ceramic achieves consistent success.

## The Advantage of Three Point Furnace Calibration

The calibration of ceramic furnaces in the dental laboratory has a long history tied to temple tablets, silver pellets or silver wire. Peering through a window of smoked glass waiting to throw a switch at just the right moment of the melt to set a 1,763°F temperature point has been replaced by modern technological breakthroughs. For many years, we stretched silver wire between two electrodes and plugged it into our ceramic furnace brain, which sent a current of electricity through the wire. When a muffle temperature of 1,763°F was reached, the wire melted and broke the electrical circuit.

This set a temperature reference point. Most of the time, this temperature actually went past the reference point we sought before the set. This happened because the temperature of the furnace continued to rise in the moments before we or the furnace brain threw the switch. Some manufacturers are still using this technology in what are called self-calibrating furnaces.

Accurate measurement is tricky enough at a single temperature, but when pinpoint accuracy is required across a broad range of temperatures, as is used in the process of firing ceramic, it is doubly challenging.

The furnace manufacturer begins the calibration process by using a noble metal thermocouple, which will withstand the high firing temperatures on modern dental ceramics. Each thermocouple has a characteristic response curve unique to the two-metal combination of that thermocouple.

The American Society for Testing and Materials (ASTM) publishes ideal thermocouple performance charts for each thermocouple. The charts list the temperature on one axis of the curve

and millivolts of electricity required to achieve that temperature on the other axis. These charts are programmed into the software of the furnace so that the electronics inside the furnace can accurately convert the incoming millivolts from the thermocouple into degrees of temperature. These control the muffle heating response and are displayed to the furnace user.

Unfortunately, there are no perfect thermocouples. The ASTM typically separates noble metal thermocouples into two grades:

1. Standard grade =  $\pm 0.2\%$  of the actual temperature
2. Special limits grade =  $\pm 0.1\%$  of the actual temperature

What this means to you is that the standard grade thermocouple will be within  $\pm 2.4$  degrees Centigrade at  $1,200^{\circ}\text{C}$  and the special limits grade thermocouple will be within  $\pm 1.2$  degrees Centigrade at  $1,200^{\circ}\text{C}$ . This is at a single set temperature point.

The calibration process of the modern ceramic furnace ( Whip Mix PRO100, PRO200 Series furnaces) takes into account the values of the ASTM standardized thermocouple used in the muffle. Then, a second National Bureau of Standards (NBS) traceable reference thermocouple is placed into the muffle and connected to an accurate laboratory grade temperature meter. As the furnace goes through the temperature parameter changes, the offset differential (the difference between the readings of the two thermocouples) is used to correct the future response to internal furnace temperature measurements. It does this by storing the information in the on-board computer of the furnace. This is a very precise means of correcting for the accuracy of response over a range of temperature values.

With single point temperature calibration, the further you are away from that single point to the cold or hot side (positive or negative), the more temperature inaccuracy you

*"For a ceramic furnace to be a viable asset as we move into the future of dental materials, it will need to be accurate and correctable for the user."*

will encounter. The calibration of the entire range of the desired temperature operation is best accomplished by using multiple temperature check points, instead of just a single one. These temperature points are spaced roughly 30 percent apart.

In Whip Mix furnaces, this translates to  $850^{\circ}\text{C}$ ,  $1,000^{\circ}\text{C}$  and  $1,150^{\circ}\text{C}$ . The temperatures encompass the firing range of most ceramics on the market today. The use of three calibration values is very much like wearing tri-focal lenses instead of single vision lenses. You would have clarity close up, at arm's length and on the horizon. Whip Mix furnaces come to you pre-calibrated using this three-point calibration method.

The use of the second thermocouple with a second meter is much like doing an internal audit of your business. You would never ask your accountant to audit his or her own work. You would always go to a second firm to perform this function. Some of the current furnace manufacturers claim a self calibration feature with a second thermocouple, which remains in the furnace all of the time and is read by the furnace brain. Since this thermocouple is experiencing the same environmental conditions as the first thermocouple, is it then capable of performing an independent audit? With the accuracy of the furnace temperature at stake, is this type of system worth the risk?

### Why Three Point Calibration is Essential for Pressed Ceramics

Some of the modern materials being processed in ceramic furnaces, such as pressable lithium disilicates, have a temperature variance of as little as five

degrees centigrade, which can mean the difference between the ceramic becoming molten enough to be successfully pressed or not. With these types of tight tolerances, it is imperative that the furnace you are using has the ability to be calibrated correctly over the total range of the temperatures used in the parameters for the firing dental ceramics. For a ceramic furnace to be a viable asset as we move into the future of dental materials, it will need to be accurate and correctable for the user. Those furnaces that use the three point calibration system have that ability.

### The ProCal Calibration Device: An Invaluable Tool

Historically, the most universally accepted method of verifying furnace temperature accuracy was by melting a silver wire at the known silver melting point. Unfortunately, this technique can be significantly inconsistent due to human technique factors.

The placement on the posts, the axial orientation and the electrical resistance of the silver wire being used as a fusible link can all contribute to error. In addition, the ramp rate (rate of temperature rise) can also change the point at which the wire breaks. The process can be time consuming, is often subject to trial and error, and must be repeated multiple times if there is any deviation from prior results.

Whip Mix recognized this challenge, so to make and keep its furnaces extremely accurate, it developed the ProCal device. It was conceived to satisfy the need for an efficient, consistent method of checking not only on an individual ceramic furnace, but an array of PRO furnaces. The device had to be



more accurate than the furnace itself, highly portable, rugged, offer an easy application of the information acquired by the instrument and not be subject to human interpretation. Lastly, the investment in dollars, time and the ongoing consumable costs (silver wire) had to be minimal.

There are several off the shelf portable meters used in other industries, so why reinvent the wheel? There are three reasons based on our initial requirements that removed these devices from consideration:

1. The complexity of the operation
2. The combined accuracy of the instruments with their thermocouple
3. Traceability back to the exact same temperature reference standard over a period of years, i.e.; the lifetime of the furnace

Another issue that was critical for this evaluation was to place the second thermocouple into the muffle in a consistent position without dismantling parts of the furnace to access the factory port for the original calibration. Loose

thermocouples are difficult to mount and keep in a stable position during testing. The variations in their height and distance from the muffle center will often cause inconsistent information readings. The decision was made to embed the second thermocouple into a firing tray just like the one which insulates the base of the muffle and forms a platform for the sagger tray. This allows the thermocouple to be at a repeatable position in the muffle and to be removed and replaced consistently with each use. This also overcomes the problem others have with leaving the second thermocouple in the high temperature environment.

As seen in **Figure 2**, wire connections leave the base of the firing block and connect to an instrumentation box, which contains a microprocessor and a system to accurately amplify the low level thermocouple signal with precision.

### So how does it work?

The thermocouple in the special firing block monitors the electrical signal produced by the heating of the muffle and sends it to the instrument box. The

instrument box filters the low voltage electrical noise in the micro- and millivolt-range. The cleaned signal is then sent to a pre-amplifier with a built-in digital filter to further boost the signal and clean it again.

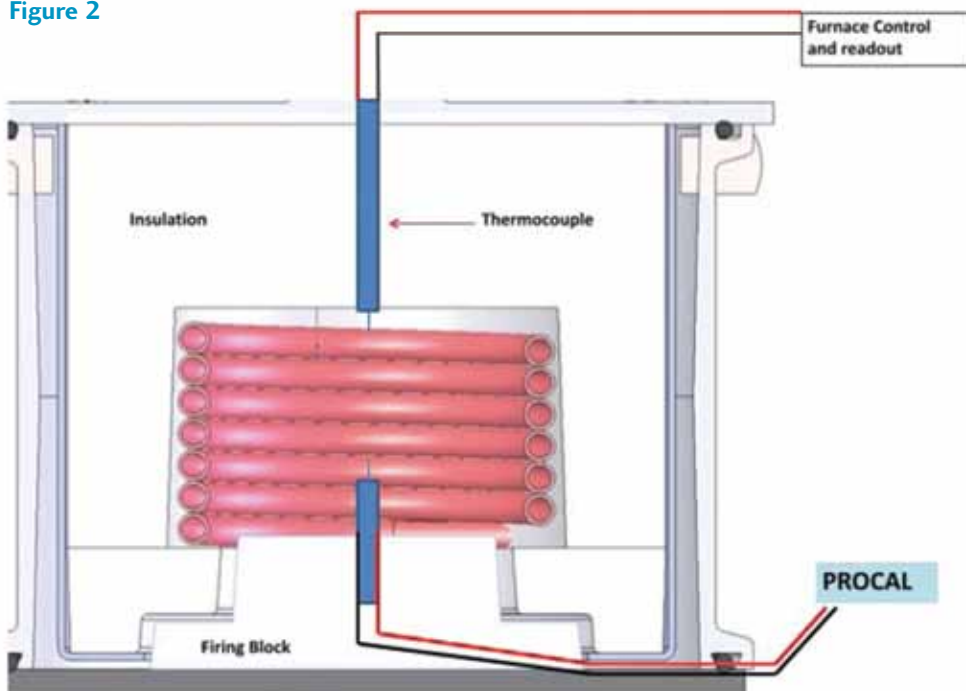
Finally, the cleaned signal is presented to a 24bit analog-to-digital converter for conversion to digital ones and zeros, which are transmitted to the furnace computer. Once the information is received, the temperature value is computed and compared to the value being sent by the furnace-reference thermocouple by the furnace computer and the variance is stored. This variance is the correction value.

With this information, each time the furnace is commanded to a specific temperature in a firing parameter, the furnace looks at that target temperature, determines which calibration value is appropriate for that target value and either adds or subtracts the correlation value to produce the accurate muffle temperature desired in real time.

### Why do furnaces require a periodic temperature recalibration?

Effluents given off by the materials (alloys, ceramics, investments, metal ceramic stains and glazes) fired in the ceramic furnace can deposit on the platinum/palladium thermocouple and in some cases react chemically with the noble metals to affect the temperature sensed. In addition, oxide layers can build up on the thermocouple through many cycles of vacuum and vacuum release exposure to air, causing a chemical change to the thermocouple. Prolonged high heat can cause crystallization of the metals in the thermocouple and inhibit the transmission of the electrical registration signal to the computer. Lastly, the muffle heater wire itself can become brittle and scaly along its surface, especially after extended usage. This can affect the infrared spectrum heater wire and redirect the angle of

**Figure 2**




the emitted photons so that the ones striking the thermocouple are more diffused and create less of a charge on the thermocouple. With a sub-charged thermocouple, the furnace computer may think that the temperature of the muffle is different than the actual temperature.

The goal of this article was to explore the many controllable parameters of heating, pressing and vitrifying dental porcelain materials. Any quality control program has the goal of consistent process results. While the goal is admirable in theory, it is not always efficient in practice. We hope that this article helped you make it more efficient and consistent in your laboratory.

### About The Authors

Craig A. Pickett, CDT, is NBC certified in crown and bridge with technologist designation and is the technical support manager at Whip Mix Corporation.

Before joining Whip Mix, he managed large and small crown and bridge/ceramic laboratories, owned Pickett Fabrication in California, and represented J.F. Jelenko & Co., Whaledent, and Dentsply as a technical sales rep. As a 30-year CDT with over 35 years of crown and bridge, ceramics, and industry experience, Pickett now assists in developing and evaluating new products, overseeing technical support and represents Whip Mix by presenting technical clinics in the U.S. and internationally. He is the recipient of the 2014 NADL Excellence in Education Award.

David Hall is director of engineering for Whip Mix Corporation. He is responsible for all furnace, burnout oven and mechanical equipment design. David has over 30 years engineering experience, 16 years of that at Whip Mix. 

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At the 2016 Southern States Symposium and Expo, FDLA joined together with the Foundation for Dental Laboratory Technology to increase awareness of the opportunities for enhancing education in the industry. Through individual donations and a wine toss fundraiser, FDLA presented FDLT with a check for \$2,345. Thank you to all who participated!

Right: From left to right: FDLA Supplier Representative and FDLT Trustee Nick Azarra, NADL President Dena Lanier, FDLA President Fernando De Leon and FDLA Immediate Past President Gail Perricone.



## Miami Workshop a Success

Zahn-technik, Inc. hosted a hands-on workshop on April 2 in Miami and it was a huge success. We would like to thank Amann Girrbach for sponsoring the session, How to Create Aesthetic Restorations with Monolithic Zirconia, presented by Alexander Wünsche.

Left: Alexander Wünsche (second from left) with a few of the workshop participants.



Johnson



Reyes



Wünsche



Azarra

## Welcome New FDLA Board Members

During the 2016 Southern States Symposium and Expo, the Florida Dental Laboratory Association's newest board members took office. In addition to Fernando De Leon becoming president, the board welcomed four new members into its ranks. Please join us in welcoming directors at large Bryan Johnson, Daniellis Reyes and Alexander Wünsche as well as supplier representative Nick Azarra.



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# Daniellis Reyes

**A**t the Southern States Symposium & Expo, the new Florida Dental Laboratory Board of Directors was installed. One of the newest directors is Daniellis Reyes, the crown and bridge laboratory manager at Signature Dental Lab in Naples. Recently, we sat down with Reyes to find out a little more about her and her perspective on the industry.

*“I want to be motivated and share my knowledge with my fellow technicians.”*

FDLA board member  
Daniellis Reyes

**How did you begin your career in the dental laboratory profession?**

I'm a second generation dental technician. My mom is a dental technician in Cuba and since I was 14 years old, I've been around technicians and prosthodontics who've enriched my knowledge. I came to this country in August 2007. In December of that same year, I started working at Signature Dental Lab where my boss, Daniel McCabe, CDT, gave me the opportunity to grow my skills and be more successful.

**What is it about the dental laboratory industry that you find most interesting?**

I love everything about it—especially when there is a challenging case and we utilize the

planning process to get the best outcome for the patient.

**What are the three most exciting things about the dental laboratory profession right now?**

1. CAD/CAM
2. Material selection
3. New techniques

**Tell us a little about your laboratory.**

We are a four-person, full-service lab in Naples. We're very proud of our high-quality restorations and fast service. Our newest service utilizes CAD technology work flow.

**Why did you decide to volunteer your time by being a part of the FDLA board?**

One day, I was on my second and beautiful job as a mom at the park with my kids and I got a phone call from my friend Nery Paredes, who is a technician in Miami. He asked me if I wanted to be a part of the FDLA board and I said why not? I want to be motivated and share my knowledge with my fellow technicians.

**What is it that makes your FDLA membership valuable?**

FDLA membership brings the opportunity to get high-quality education at an affordable cost to the lab.

**Where do you see the dental laboratory industry headed in Florida?**

This question is open to many directions, but the bottom line is that if we (labs) don't get together as the industry should be, there will be a negative impact to our industry. ❶





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