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Bonding Materials

Consider the Patient's Needs to Achieve the Best Restorative Outcome

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Table of Contents

Ask any dentist about the best way to personally bond with their patients, and the answers are universal: trust, professionalism, efficiency and know-how.

Ask any dentist about the best materials that bond restorations to teeth, and the answers are less universal. Successfully bonded restorations require intimate knowledge of tooth surface structure, morphology of bonding agents, clinical applications, etching techniques, primers and esthetic considerations. Mastering these variables in a real-world setting is a life skill that extends well beyond a traditional clinician. And since no two oral cavities are ever the same, protocols for the right approach depend on the needs of the patient, skills of the dentist and a desire to produce the best possible restorative outcome.

BISCO sat down for a detailed discussion with dental experts in four areas of restorative bonding: dentin and enamel, glass ceramics, zirconia, alumina and metal, and composite CAD/CAM blocks. Their input, which represents nearly a century of combined experience, is featured in this resource.

1

SECTION ONE

BONDING TO DENTIN AND ENAMEL

with Dr. Adamo Notarantonio,
Huntington Bay Dental,
Huntington, New York

Dr. Adamo Notarantonio is a graduate of the State University of New York at Stony Brook School of Dental Medicine, where he received honors in both removable and fixed prosthodontics. He completed his residency in the Advanced Education in General Dentistry Program at Stony Brook in 2003, and was chosen by faculty to complete a second year as Chief Resident. Dr. Notarantonio was accredited by the American Academy of Cosmetic Dentistry in 2011, and recently received his Fellowship in the AACD. He is the only Accredited Fellow in New York State, and the 80th person worldwide to achieve this honor.

Dr. Adamo Notarantonio is sensitive to the challenges of bonding to dentin and enamel. As a general dentist in Huntington, N.Y., for the past 16 years, Dr. Notarantonio knows that etching dentin can lead to increased sensitivity.

“My patient pool these days is a lot of surgeries and restorative dentistry, but also lots of cosmetic work and veneers,” he says. “I started using Choice 2 Veneer Cement as a resident, as well as One-Step and All-Bond 3 early in my career.”

A pre-operative photo of teeth in need of restoration.

The most mineralized tissue in the human body, enamel forms a hard, thin, translucent layer of calcified tissue that covers the whole tooth crown. It is enamel's strength that allows teeth to withstand the blunt, heavy forces of chewing. Enamel thickness and color vary from tooth to tooth, and from person to person. More than 95% of enamel is made of calcium and phosphate ions that make up hydroxyapatite crystals, which contain trace minerals such as strontium, magnesium, lead and fluoride. Enamel also consists of water and enamel-specific proteins called enamelins, which are capable of binding hydroxyapatite crystals.

Rubber dam-isolated teeth are prepared for try-in to ensure proper seating.

Each tooth contains millions of carbonated hydroxyapatite crystals arranged in long, thin rods that are roughly 4 micrometers to 8 micrometers in diameter. A protein sheath of enamelins surrounds each rod. The number of rods in each tooth ranges from about 5 million in the lower lateral incisor to about 12 million in the upper first molar. The rods typically extend at right angles from the junction of the enamel and dentin layers to the tooth surface.

Tiny pores exist in spaces where crystals do not form between rods. Pores help make enamel permeable but also cause variations in tooth density and hardness. These variations can create spots prone to the loss of calcium and phosphate ions, when oral pH becomes too acidic and falls below 5.5. In this state, known as demineralization, crystalline structures shrink while pores enlarge. Enamel damaged by injury or decay cannot be restored beyond the normal course of remineralization.

Dr. Michael Buonocore surely had all this in mind while researching ways to improve acrylic resin's ability to bond to an enamel surface. Dr. Buonocore theorized that exposing the underlying enamel and its presence of contaminants and tiny imperfections would increase its surface energy and receptiveness to the adhesion of resins.

His landmark 1955 study published in the *Journal of Dental Research* formed the basis for the three, acid etching techniques still in use today.

At the microscopic level, etching dissolves some of the minerals contained in enamel. This controlled erosion creates tags and tunnels, or microroughness, that can better absorb bonding resin and can chemically lock it into place on the enamel surface. The acid consists of a colored, 35% phosphoric acid gel placed on the tooth for 15 to 30 seconds. The resulting erosion gives the enamel surface a frosty appearance. Bonding material is cured with a special light, then layered with filling material until the filling is built up to its final shape.

Select HV Etch consists of a colored, 35% phosphoric acid gel placed on the tooth for 15 seconds.

With self-etching, the acid and bond material are combined and layered onto the tooth in one step. Phosphoric acid demineralizes the hydroxyapatite in enamel and exposes a honeycomb-etch pattern. The technique is most often indicated for a tooth that is easily expected to retain the new restoration. However, some self-etch adhesives are not acidic enough to create surface texture on enamel. A total-etch procedure involves placing the acid etch material on all enamel surface layers. This technique is most often indicated when a large amount of bonding material will be used, retention is an issue, and if tooth preparation will not be deep or near the nerve. Total-etch systems don't interfere with the polymerization of dual-cure resin products, so they can be used universally. The biggest challenge with total-etch systems is etching the enamel long enough without over-etching the dentin.

Preparations after bonding and light cure of All-Bond Universal, which is compatible with light-, dual- and self-cured materials.

Selective-etch systems call for etching material to be applied only to the enamel surface. This technique is most often indicated for cases that might cause sensitivity in deep areas of a tooth. It's also Dr. Notarantonio's etching method of choice.

"I'm always on the lookout for any procedure that might decrease sensitivity," Dr. Notarantonio explains. "Selective etching gives me the most control. The viscosity of BISCO's Select HV Etch is excellent. It goes exactly where you put it. Other acids are muddy, and you're much more likely to hit dentin."

Veneers are seated with Choice 2 cement and held in place to "tack cure."

Multiple studies have investigated the success of universal bonding agents and resin infiltration on cut and uncut enamel. One study compared three universal adhesives, a conventional two-step adhesive and a conventional single-step self-etch adhesive on human enamel specimens from lower anterior teeth. The study, published in the June 2019 *European Journal of Oral Sciences*, found that all adhesives showed significantly higher shear bond strength values in etch-and-rinse mode compared with self-etch mode, regardless of whether enamel was cut or uncut. Another study published in the April 2011 *Journal of Conservative Dentistry* found that shear bond strength values for etch-and-rinse bonding agents were significantly higher for cut and uncut enamel surfaces compared with the all-in-one bonding agent, while the all-in-one bonding agent produced a higher bond strength on the cut enamel surfaces. A third study published in the September 2000 issue of *Dental Materials* found that the adhesive strength of the resin to the phosphoric acid-etched enamel was mainly attributable to the resin's ability to penetrate between the enamel crystallites and rods.

"Once you etch enamel, there's not a huge difference with the bonding agents you use," Dr. Notarantonio observes. "Where it comes into play for me most is when you talk about bonding to dentin."

Dentin is a hard, light yellow, porous layer of living tissue directly underneath enamel cementum. Harder than bone but softer than enamel, dentin consists mainly of apatite crystals of calcium and phosphate that are capable of regeneration. A layer of dentin-producing cells called odontoblasts lines the pulp cavity of the tooth and sends projections through tubules into the calcified material of the dentin. Nerves also pass through these dentinal tubules, allowing dentin to transmit sensitivity to pain, pressure and temperature. This is why etching dentin must be performed with the utmost care.

Etching with phosphoric acid demineralizes dentin to varying depths while opening dentinal tubules and exposing organic collagen fibers.

The final restorations are color-matched, durable and protected from sensitivity to pressure, pain and temperature.

If dentists don't support this collagen filigree with enough moisture and don't fill the demineralized area of the inorganic dentin with enough adhesive, the restoration could fail. Too much drying of the dentin can lead to collagen fibril collapse, which creates a layer that can prevent diffusion of acrylic monomers into the demineralized layer. Poor diffusion of monomers means poor sealing of the dentinal tubules that were opened during etching. All this leads to hypersensitivity to pain, pressure and temperature.

Early dental adhesives placed directly on dentin smear layers could not form resin tags, and fractures often occurred within the smear layer. A landmark 1982 study published in the *Journal of Biomedical Research* found that resin infiltration of acid-etched dentin transformed the crystalline, acid-sensitive, hydrophilic surface of dentin to an organic, acid-resistant, relatively hydrophobic surface. Since the total-etch technique led to the collapse of the demineralized matrix when it was air-dried, dentists began applying primers to re-expand the matrix before applying a bonding agent. A 1996 study published in the *Journal of the American Dental Association* found that leaving some residual water in the acid-etched dentin could double bonding strength. And so "wet" bonding became a key part of three-step process: etch and rinse, priming and evaporation of solvent, and application of adhesive followed by light curing.

A total-etch technique for bonding dentin requires dentists to etch the whole tooth preparation, enamel and dentin, then rinse thoroughly. Next, a desensitizing agent containing 5% glutaraldehyde and 35% hydroxyethyl methacrylate is used to coagulate the dentin and reduce permeability to the resin. The glutaraldehyde is suctioned off, and a thin layer of resin-modified calcium silicate pulp protectant/liner such as BISCO's TheraCal LC is placed and cured into any deep holes where carious lesions have been removed. The primer and bond are placed, the bond is cured, and the preparation is ready for the restorative resin. The selective-etch technique is similar to total etch, except that dentists selectively etch the enamel only with a gel etching material such as BISCO's Select HV Etch. The tooth structure is rinsed quickly and thoroughly to avoid significant contact of acid residue with the dentin.

> *Etching dentin is very technique sensitive, and I've always been a selective-etch kind of guy. When working with dentin, I use 2 percent Chlorhexidine, then blot dry before applying the bonding agent. This deactivates the MMPs [Matrix Metalloproteinases] which play a major role in degradation of the bond."*
>
> **Dr. Notarantonio**

2

SECTION TWO

BONDING TO GLASS CERAMICS

with Dr. Todd Snyder,
Laguna Nigel, California

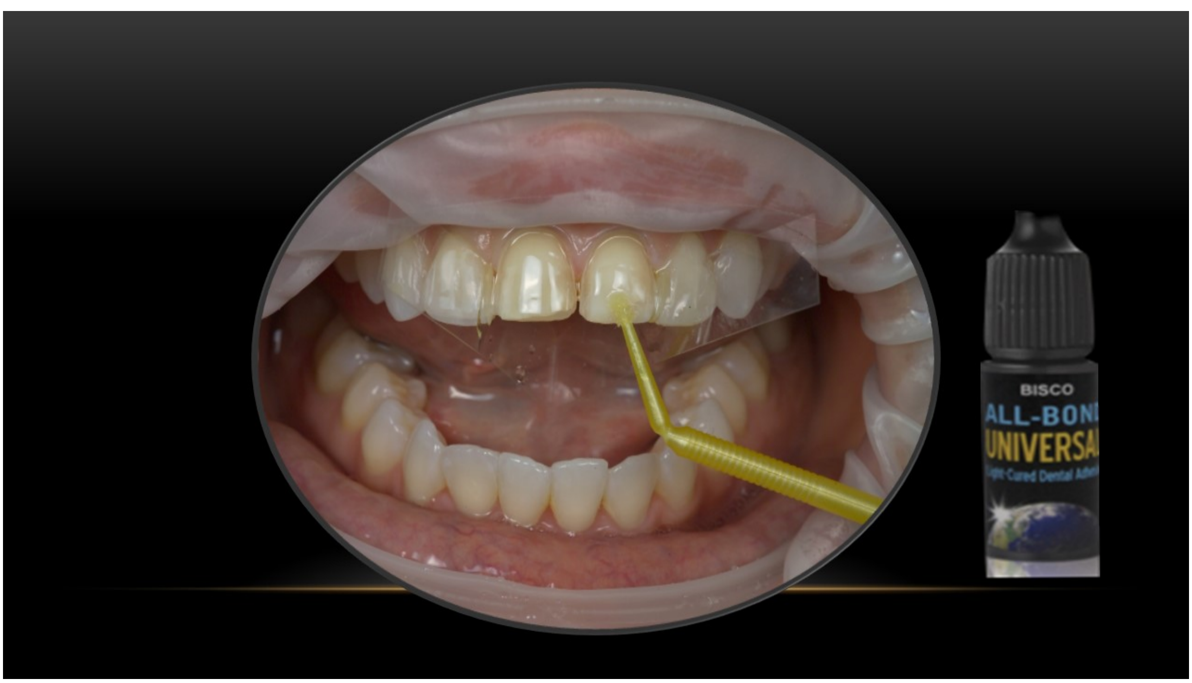
Dr. Todd Snyder, is a cosmetic dentist in Laguna Niguel, Calif. He lectures both nationally and internationally on numerous aspects of dental materials, techniques and equipment. Dr. Snyder received his doctorate in dental surgery at the University of California at Los Angeles School of Dentistry. He is an Accredited Fellow of the American Academy of Cosmetic Dentistry. Furthermore, he has trained at the FACE institute for complex gnathological (functional) and temporomandibular joint disorders. Dr. Snyder has been on the faculty at UCLA and is currently on the faculty at Esthetic Professionals.

The two most popular forms of glass ceramics, lithium disilicate and feldspathic porcelain, have played a prominent role in Dr. Todd Snyder’s practice for the past 26 years. Dr. Snyder, who runs a cosmetic restorative practice in Laguna Niguel, California, says that each agent contains unique properties designed to give clinicians and patients a successful outcome.

Lithium disilicate glass ceramic features a glassy matrix with about 70 percent needle-like crystals of 3 to 6 micrometers in length. Pressable lithium-disilicate restorations, fabricated with a wax hot-press technique, feature a continuous manufacturing process of melting and cooling. The simultaneous nucleation of two different crystals, and the growth of crystals, helps to prevent defects. Dentists dissolve polyvalent ions in the glass to achieve the desired color. The color-controlling ions are homogeneously distributed in the single-phase material, which helps eliminate pigment imperfections. Pressable lithium-disilicate restorations can be finished as thin as 0.3 millimeters, and typically exhibit a flexural strength between 400 megapascals (MPa) to more than 500 MPa.

Machineable lithium disilicate blocks can be fabricated either in the laboratory or chairside using CAD/CAM technology.

The process creates an intermediate crystalline phase, which leads to the formation of lithium metasilicate crystals. These crystals are responsible for the material's processing properties, edge stability and machineability. The microstructure of machineable lithium disilicate consists of about 40 percent platelet-shaped lithium metasilicate crystals embedded in a glassy matrix. The crystals range in length from about 0.2 micrometers to 1 micrometer. The material achieves the desired tooth color when the lithium metasilicate is transformed into lithium disilicate during the post-milling firing process. Milled lithium disilicate restorations exhibit a flexural strength of about 360 MPa.



Isolation and application of BISCO's All-Bond Universal bonding agent to the veneer preparations.

The difference in flexural strength stems from the size and length of the lithium disilicate crystals.

Dr. Snyder says the strength of lithium disilicate makes it a good candidate for restorations that require more changes to tooth structure.

“If I have a patient with sleep apnea, worn teeth, heavy rotation, occlusion, wear and damage, there’s a lot more alteration needed,” he explains. “If I have to lengthen a tooth a couple of millimeters, I’m going to hedge my bet on something that’s four to five times stronger than feldspathic porcelain. I’d just rather not take the chance that it could fail.”

The ceramic veneer is ready for adhesive application and delivery.

Lithium disilicate restorations can be cemented if there's enough retention and thickness of ceramic material. Otherwise, the restorations should be bonded to increase its strength and durability.

After using pumice to clean the preparation(s), the restorations are tried in to check their marginal adaptation, interproximal contacts and occlusion. If one plans to access the shade matching, then a water-soluble, try-in paste should be used to optically connect the tooth to the restoration.

If adjustments to the ceramic are necessary, there are many ceramic adjustment devices on the market. After adjusting and polishing the ceramic, the restoration needs to be cleaned. The crown's interior surface should be cleaned with ZirClean or Ivoclean.

After cleaning the restoration(s), a silane coupling agent should be placed. The use of a pure silane coupling agent with heat eliminates alcohol, water and other by-products from the ceramic surface. Condensation of the silane silanols with other silanols gives a multimolecular structure of crosslinked siloxane on the inorganic surface.

Silane coupling agents attached to the inorganic surface will allow that surface to take on the reactive properties of the organic surface. If you place a lot of all-ceramic restorations, then a pre-hydrolyzed silane in a single bottle (BISCO's Porcelain Primer) is a good choice. If you only place all-ceramic restorations occasionally, then a two-bottle silane (BISCO's Bis-Silane) is a better choice as it offers a longer shelf life.

Crowns received from the dental laboratory for bonding should already have the interior surface etched with hydrofluoric acid. The tooth structure should be cleaned with pumice paste, then isolated to protect adjacent teeth from acid etching. A solution of 37-percent phosphoric acid is then applied for 15-25 seconds to the enamel and for 15 seconds to the dentin.

Adjustment of the ceramic veneer with a medium grit extra-oral grinding wheel.

Dr. Snyder points out that proper etching is key to achieving a good bond. A study published in the November/December 2017 *Operative Dentistry* compared the effect of various concentrations of hydrofluoric acid and etching times on the microshear bonding strength to lithium disilicate. The study of 275 lithium disilicate blocks found that hydrofluoric acid concentrations of 5%, 7.5% and 10% offered significantly higher microshear bonding strength values than concentrations of 1% and 2.5%, regardless of etching times. Etching times of 40 seconds to 120 seconds increased microshear strength for 1% and 2.5% concentrations compared with 20 seconds, but etching periods did not differ within the 5%, 7.5% and 10% groups. A similar study published in the August 2019 issue of *Head & Face Medicine* found that etching with hydrofluoric acid concentrations of 5% or 9% for 15 to 60 seconds would achieve the highest shear bond strength.

All-Bond Universal adhesive should be applied in two separate coats on the tooth structure, scrubbing the preparation with a microbrush for 10-15 seconds per coat. Excess solvent should be air-dried with an air syringe for at least 10 seconds, or until there is no visible movement of the adhesive.

After light curing for 10 seconds, dentists can place the resin luting cement (light-cured BISCO Choice 2 or dual-cured BISCO Duo-Link Universal) and restorative material. Most veneers are cemented with a light-cured resin cement to allow for seating of restorations and when ready to cure they can then utilize a curing light for 20 seconds from facial and lingual. A dual-cured cement is favorable when you have a thick restoration or an opaque restoration where it may be difficult to get complete penetration by a curing light to the dual-cured resin luting cement. The only drawback to using a dual-cured cement for veneers is that the material will start to harden on its own and may create difficulties when trying to cement numerous veneers at the same time.

This photo shows examples of feldspathic and lithium disilicate veneers.

If tooth structure changes are minimal or not needed, and esthetics is the primary desired outcome, feldspathic porcelain is Dr. Snyder’s material of choice.

“If I’m going for beauty on healthy teeth, and there’s lots of tooth structure, feldspathic is more pleasing to the eye than lithium,” Dr. Snyder says. “There’s nuances of translucency there. Some patients come in and want the Hollywood white look, and it can be really obvious with lithium they had work done. With feldspathic, there’s something about them people can’t quite put their finger on, because it looks more like a real tooth. People will never know they had veneers.”

Feldspathic porcelain is most commonly indicated for anterior teeth with a significant portion of remaining enamel. The porcelain is a silica-based ceramic created by layering silicon dioxide powder and liquid materials on a platinum foil or refractory die. Ceramicists use a wet brush and porcelain powder to paint layers onto a model, then bake it in a porcelain oven. Since each porcelain layer is very thin and shrinks when heated, the process is repeated many times to obtain the proper contour. Ceramicists can allow what’s attractive in existing teeth to shine through, then mask flaws and enhance colors without creating a painted-on look.

The glass mainly consists of a three-dimensional network structure of silica (silicon-oxygen) in which each silicon atom is bonded to four oxygen atoms in the form of a tetrahedron. Natural aluminosilicates that contain various amounts of potassium and sodium, called feldspars, can be modified to create glass used for various dental restorations. The resulting porcelain is highly translucent and closely resembles the color and texture of natural teeth. The mean flexural strength of feldspathic porcelain is between 60-100 MPa.

Dr. Snyder maintains that layering by hand allows ceramicists to create veneers that are more natural-looking. Pressed ceramics force technicians to start with a fully contoured surface in a uniform shade, then require cut-back techniques to render the ingot more natural looking. Patients can retain more original tooth structure, rendering the whole process much less invasive.

> *The strength of lithium disilicate makes it a good candidate for restorations that require more changes to tooth structure.*
>
> **Dr. Todd Snyder**

Machineable lithium disilicate blocks can be fabricated either in the laboratory or chairside using CAD/CAM technology. The process creates an intermediate crystalline phase, which leads to the formation of lithium metasilicate crystals.

For feldspathic veneers, the intaglio surface is first etched with a 9.5% concentration of hydrofluoric acid for about 90 seconds. Step two is the application of pure silane primer over the etched surface to increase wettability of the resin cement and to interact chemically with the resin matrix and hydroxylated porcelain surface. For bonding, BISCO's Bis-Silane 2-part porcelain primer can be mixed by dispensing one drop from each of the two bottles into a mixing well and stirring. One or two thin coats are brushed onto the internal surface of the etched porcelain for about 30 seconds. The coats are then dried with a warm air syringe. The restorations are then bonded with an adhesive esthetic resin cement like Choice 2 light-cured veneer cement from BISCO.

Tooth enamel and dentin should be etched with Uni-Etch (32% semi-gel phosphoric acid) for 15 seconds, then rinsed thoroughly for 5 seconds with suction. Selective etching of enamel requires suction prior to rinsing to avoid etchant flowing onto the dentin.

“Many patients love that perfect white look, and others like something more realistic and believable. Because of the variability in desires, it becomes important to have diversity in one’s ceramics and adhesive techniques,” he observes. It really boils down to what patients want, and what a dentist thinks will meet their needs. “Every smile is uniquely different.”

3

SECTION THREE

BONDING TO ZIRCONIA/ALUMINA AND METAL *(STAINLESS STEEL, GOLD OR ALLOYS)*

with Dr. Nate Lawson, University of Alabama

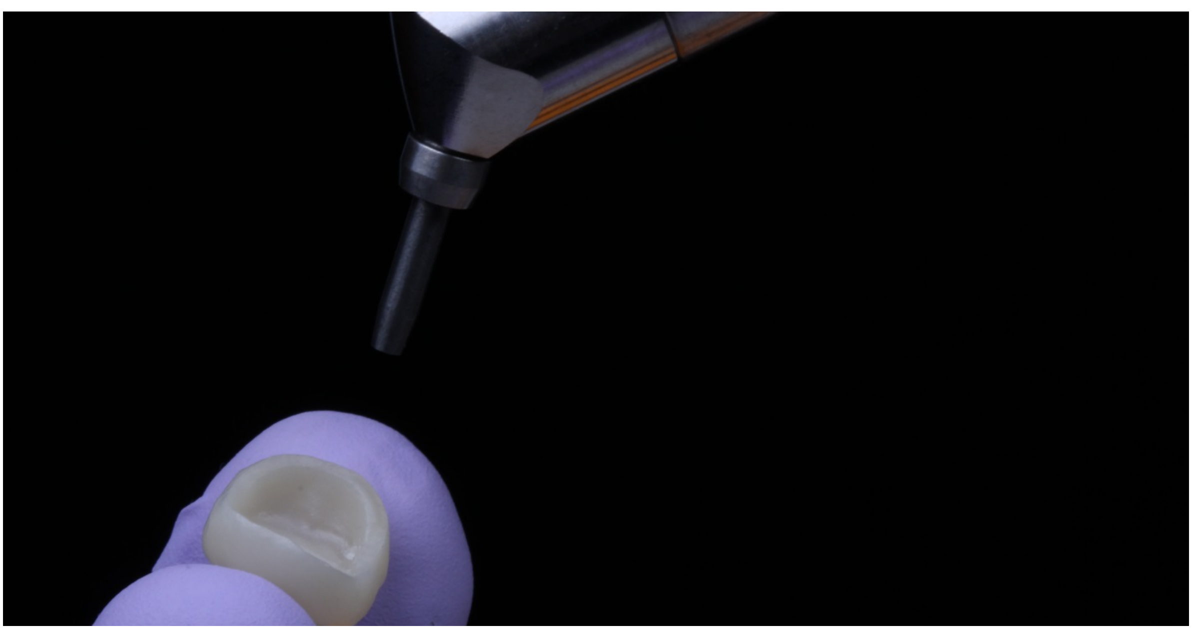
Dr. Nate Lawson is the director of the Division of Biomaterials at the University of Alabama at Birmingham School of Dentistry, program director of the Biomaterials residency program and the interim director of the Advanced Esthetic and Restorative Dentistry residency program. He graduated from UAB School of Dentistry in 2011 and obtained his Ph.D. in Biomedical Engineering in 2012. He has served as an investigator on more than 50 research grants, published 50 peer-reviewed articles, four book chapters, more than 25 articles in trade journals and 75 research abstracts. His research interests are the mechanical, optical and biologic properties of dental materials and clinical evaluation of new dental materials.

Dr. Nate Lawson knows a thing or two about dental materials. After completing a Ph.D. program in dental materials at the University of Alabama, Dr. Lawson spent a few years in private practice before returning to the school to teach. Today Dr. Lawson is the director of the Division of Biomaterials and program director of the Biomaterials residency program at UAB. He's published more than 150 articles, abstracts, book chapters, and periodicals related to dental materials, and regularly tests the properties of new dental materials in the laboratory and dental clinic for several companies. Dr. Lawson is also a general dentist who sees patients in the UAB School of Dentistry Faculty Practice and Research Clinic. So, when it came time to discuss the properties of bonding to zirconia, alumina and other metals, Dr. Lawson was a natural choice.

First used for medical purposes in 1969, zirconia is a ceramic composed of zirconium and oxygen, a material both brittle and capable of insulating heat. The zirconium and oxygen atoms on the crystalline grains of zirconia can exist in tetragonal, monoclinic and cubic forms. Pure monoclinic zirconium dioxide typically exists in stable form at room temperature, then undergoes a phase transformation with the addition of heat to tetragonal (at about 1,173 degrees Celsius) to cubic (at about 2,370 degrees Celsius).

Addition of 3-percent yttrium oxide can stabilize the tetragonal phase of zirconia at room temperature. Yttria-stabilized zirconia can revert back to the monoclinic phase through cooling.

"The tetragonal phase of zirconia is more dense than the monoclinic phase," Dr. Lawson explains. "Clinically, a stress such as sandblasting, grinding or chewing may occur on a zirconia crown, which would start a crack in the material. In response, the grains of zirconia may start to transform from tetragonal to monoclinic. As they transform, they get larger as the monoclinic phase is less dense. Therefore, they compress the forming crack and stop its progression. This is called transformation toughening, which is why zirconia is known as a tough ceramic."



Sandblasting zirconia with alumina creates surface texture to improve bonding.

The cubic phase of zirconia can be stabilized by adding 4% to 5% yttrium oxide. Atoms in cubic zirconia are arranged in a more symmetrical manner than other phases. More light passes through it, which makes cubic zirconia crowns more translucent. However, cubic zirconia does not undergo transformation toughening, and therefore the crowns can be weaker than other zirconia crowns.

As the toughest and strongest dental ceramic, 3% mol yttria-stabilized (3Y) zirconia can be used for full-coverage crowns, fixed partial dentures, frameworks and even full-arch hybrids. Restorations involving 4% and 5% mol yttria-stabilized (4Y and 5Y) zirconia are more useful for anterior single-unit crowns or fixed partial dentures that need more translucency.

Successful bonding to zirconia depends on proper surface treatment, the most common of which features mechanical roughening of the surface through alumina particle air abrasion and chemical bonding with a 10-methacryloyloxydecyl dihydrogen phosphate (MDP) monomer. Dr. Lawson says the most common practice is to air abrade with 50 micron alumina particles at 2 bar pressure (about 30 psi) for 10 seconds from a distance of about 10 millimeters.

The intaglio surface of a milled zirconia crown will already feature some texture from the milling tools, but alumina particle abrasion will produce a finer texture that will improve bonding.

Traditional 3Y zirconia are composed of tetragonal crystals that will compress cracks and preserve its strength, but 5Y zirconia can be weakened by alumina particle abrasion. Dr. Lawson recommends using a lower pressure of 1 bar (about 15 psi) to minimize surface damage to 5Y zirconia. The strength of 5Y zirconia crowns is re-established once they are bonded with resin cement.

TheraCem, formulated with MDP, allows chemical bonding strength to zirconia restorations without the need for a primer.

“Just as zirconia crowns can’t be etched with hydrofluoric acid like lithium disilicate crowns, zirconia crowns don’t chemically bond with the silane primers used on lithium disilicate crowns,” Dr. Lawson explains. “Instead, zirconia crowns bond with a molecule called 10-MDP. The molecule has functional groups on each end that allow it to be a link between resin cement and zirconia. On one end is a methacrylate group that can bond with other methacrylate-based resins like bis-GMA and UDMA, and on the other end is a phosphate group that can chemically bond to zirconia.”

Dr. Lawson points to a series of published studies to prove that 10-MDP can bond to zirconia. Research published in the January 2017 *Dental Materials Journal* performed contact angle measurements to show that application of 10-MDP makes a zirconia surface hydrophobic. Researchers in a second study published in the January 2016 issue of *Dental Materials* used X-ray photoelectron spectroscopy to show that phosphorous—present in 10-MDP but not zirconia—deposited on the surface of zirconia coated with 10-MDP. A third study published in the August 2017 *Journal of Adhesive Dentistry* used Fourier Transform Infrared Spectroscopy to show that the phosphorous-based functional groups in 10-MDP were reactive when mixed with zirconia.

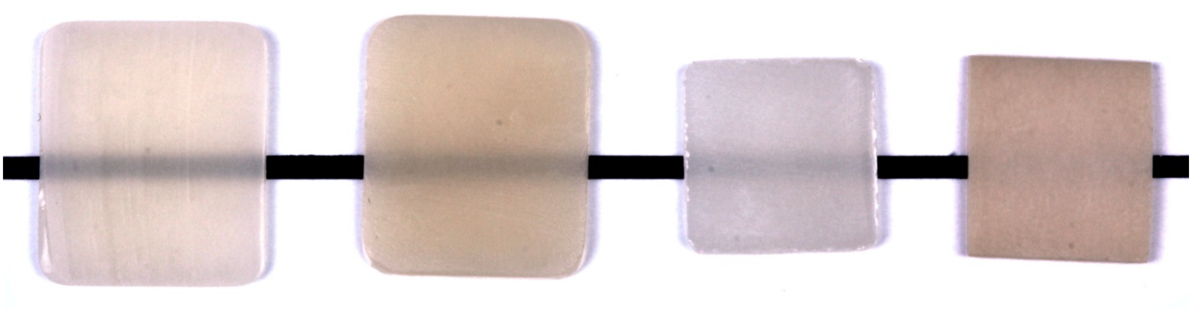
A fourth study published in the August 2017 issue of *Dental Materials* used a technique called Time-of-Flight Secondary Ion Mask Spectometry to show that zirconia and 10-MDP were mixed and ionized into small fragments. Fragment masses revealed compounds of 10-MDP bonded to zirconia before the ionization occurred. Magic angle spinning nuclear magnetic resonance found that hydrogen and/or ionic bonding occurs between 10-MDP and zirconia based on their interatomic spacing when the two substances are mixed.

Applying an MDP-containing primer such as Z-Prime Plus will achieve a chemical bond to a zirconia restoration.

From a clinical perspective, achieving chemical bond to a zirconia restoration is possible by following a standardized protocol that will generate mechanical retention and chemical priming, which are the main components in the bonding procedure. This can be accomplished by sandblasting the surface using aluminum oxide powder, and then applying a dedicated MDP-containing primer, such as Z-Prime Plus (BISCO), prior to cementing with a resin-based cement.

The potassium hydroxide in ZirClean removes phospholipid contamination of zirconia that occurs during intraoral try-in.

When the restoration has ideal height/taper relationship, a self-adhesive resin cement, such as TheraCem (BISCO), can be used. One of the many benefits of TheraCem is that it contains MDP in its formulation, achieving optimal bond strength without the need of a separate primer. If the preparation does not have an ideal height/taper relationship, a traditional bonding procedure will be required in order to assure the retention of the restoration. In this case, bonding to the tooth structure using a bonding agent, such as All-Bond Universal is recommended. The application of an MDP-containing primer, such as Z-Prime Plus will achieve chemical bond to the zirconia restoration, and depending on the type of restoration, a resin-based dual-cured cement, such as Duo-Link Universal is indicated for crown, bridges, inlays and onlays; a light-cured cement, such as Choice 2, is indicated for veneers.



The translucency of 1mm thick blocks of (left to right): high-translucency lithium disilicate, low-translucency lithium disilicate, 5Y zirconia, 3Y zirconia.

4

SECTION FOUR

BONDING TO COMPOSITE CAD/CAM BLOCKS

with Dr. Kari Pihlman,
Helsinki, Finland

Dr. Kari Pihlman is in private dental practice in Helsinki, Finland. He was a clinical teacher for the MSc Program of Restorative Dentistry for International Postgraduates Institute of Oral Health at the University of Helsinki.

Dental composite restorations have come a long way since 1962, when Dr. Ray Bowen patented the formula for bisphenol A-glycidyl methacrylate, or bis-GMA. The idea back then was to use composite resins as an alternative to silicates and unfilled resins. The earliest composite resins had better mechanical properties than silicates or unfilled resins, but were hard to polish, offered poor adhesion and marginal adaptation and poor appearance.

In Helsinki, where Dr. Kari Pihlman has been practicing dentistry for more than 40 years, composites are often used as an excellent alternative to zirconia and other alloys.

“In a clinical setting, every restoration that is offered to patients does not have to be manufactured from the same material,” says Dr. Pihlman, who has lectured worldwide on restorative and bonding materials and techniques. “Some patients will need just a few restorations rather than a full mouth rehabilitation, or the patient may not need for all restorations to be made in zirconia.”

“Some clinicians prefer to use restorative materials that are tough and hard, but sometimes, based on the clinical circumstance, a harder material does not necessarily mean that it is the best choice,” he continues.

Composite-based restorations have lower elastic modulus, meaning that they are more elastic and forgiving when it comes to occlusal loads, and due to this, they can act as shock absorbents. Also, due to the loss of tooth structure, endodontically treated tooth can be weaker, and placing a restoration made of a stiff material may lead to fractures. The shock absorbing properties of an indirect composite material may provide properties that are ideal for areas of high occlusal stress, especially for patients with TMJ disorder, compromised occlusion or parafunction (bruxism).

Dr. Pihlman says that smaller composite CAD/CAM blocks can be used for inlays, onlays or single-unit permanent crowns, and bigger blocks can be used for milling temporary bridges.

Superior composite performance was not always the case. The first generation of macrofilled direct composites in the 1970s gave way to microfilled composites, filled with 35% to 50% pre-polymerized 0.02 micrometer to 0.04 micrometer silicone dioxide particles. Microfills offered high compressive strength and enamel-like translucency but suffered from higher thermal expansion, greater water sorption, polymerization shrinkage, and lower levels of elasticity, tensile strength and fracture toughness.

The development of microhybrids with reduced particle sizes of 0.04 micrometers to 1 micrometer offered improved handling and polishing, suitable for posterior and anterior regions as a universal composite. Nanofilled composites consist of zirconia/silica nanoparticles from 5 nanometers to 20 nanometers in length. Distribution of the particles offers restorations high load potential, suitable for posterior and anterior regions.

For crown preparations, the enamel margin should be lightly beveled to properly expose enamel rods prior to the etching procedure. The general preparation guidelines for full ceramic materials, including the minimal material thickness, should be followed.

In order to achieve mechanical retention, sandblasting the composite restoration’s internal surface is recommended. After the surface has been thoroughly rinsed and dried in order to remove any debris and remaining powder, an MDP-containing primer, such a Z-Prime Plus, can be used in order to achieve bonding to both the restoration and the resin-based cement.

For bonding the restoration, the cavity should be treated according to the instructions of the bonding material used (such as etching with Select HV Etch and bonding with All-Bond Universal from BISCO).

Retentive indirect composite crowns can be cemented by BISCO’s TheraCem without a bonding agent, but non-retentive composite crowns should be bonded with All-Bond Universal and a resin-based, dual-cured cement such as Duo-Link Universal from BISCO.

Dr. Pihlman says the ideal finished surface for an adjusted composite resin can be achieved by using first coarse and fine silicon tips followed by aluminum oxide brushes and/or diamond paste.