Incisal Edge 2024/25

It’s My Esthetic

Exploring advancements in dental esthetics

INDEX

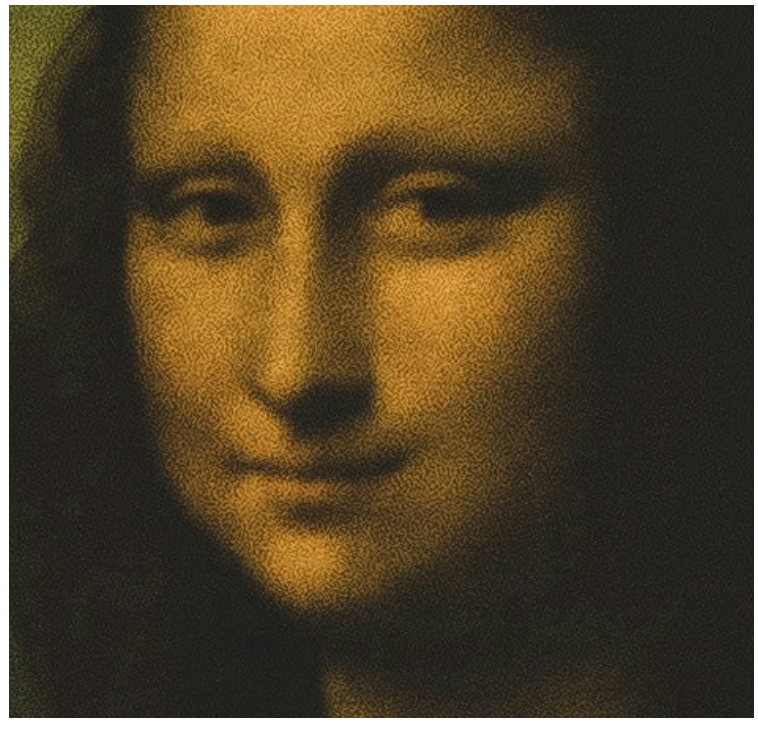
CHAP-
TER 01

Introduction

Leonardo da Vinci's Mona Lisa epitomizes the Renaissance approach to portraiture with her famously subtle, closed-mouth smile. While art historians debate the meaning behind her expression, the absence of visible teeth reflects the artistic and social conventions of her era. During the Renaissance, dental health was generally poor due to limited oral hygiene and the increasing prevalence of sugar in upper-class diets. Tooth loss, decay, and discoloration were common among the upper strata, making a closed-mouth expression both artistically desired and practically necessary.

The practice of concealing the patron's teeth extended far beyond the Mona Lisa. Jan van Eyck's "Portrait of a Man" (1433), Hans Holbein's portraits of Tudor nobility including Henry VIII, and Titian's depictions of Emperor Charles V all maintain closed-mouth expressions despite varying personalities and social positions. Even Diego Velázquez's Spanish royalty portraits throughout the 17th century adhered to this standard.

Simply examining the dental health of many of these patrons makes these artistic decisions seem appropriate. Queen Elizabeth I, despite her wealth, had severely blackened teeth due to sugar



Arguably the most famous smile in the world - The Mona Lisa



Left: *Scandanavian viking skull showing filed teeth- an esthetic choice used to increase intimidation and fear*
Middle: *Japanese practice of Ohaguro depicted in artwork*
Right: *Portrait of Queen Elizabeth I, who had severely decayed teeth, showcasing a closed mouth*

Dental esthetics represents the intersection of health, psychology and culture

consumption—a luxury marking high status. However, official portraits maintained her regal dignity through closed-mouth expressions.
Similarly, Louis XIV suffered extensive dental problems throughout his life, yet portraits by Hyacinthe Rigaud invariably show sealed lips in royal composure. This disconnect between private dental reality and public representation illustrates how the closed-mouth convention maintained social facades.

Today's ideal smile features straight, uniformly white teeth. This standard, reinforced by Hollywood glamour and social media, created unprecedented pressure for dental perfection. The smile evolved from something to hide to something to showcase, representing confidence, success, and social desirability.

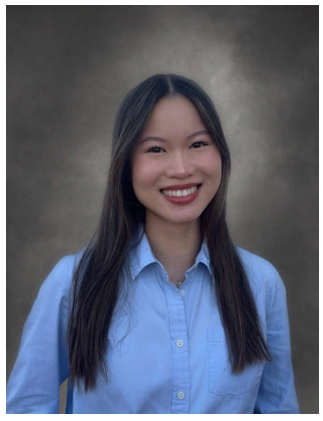
The pursuit of perfect smiles has generated a multi-billion-dollar cosmetic dentistry industry. Procedures like whitening, veneers, and orthodontics became increasingly common, with individuals investing thousands in their dental appearance. This reflects the smile's new role as social and economic capital—a visible marker of health, wealth, and personal investment.

As global communication expanded, Western dental standards increasingly influenced other cultures. For example, in Japan, blackened teeth were considered aesthetically desired. Black teeth also signified fertility, maturity, and marriage. Likewise, many African and Scandinavian tribes preferred to shape their teeth to create intimidation especially within the warrior classes of society. In modern times, these aesthetic choices are largely unseen and Western dental standards have become prevalent.

However, dental esthetics is not exactly uniform, and many societies maintain aspects of their tradition while adapting to modern expectations. Even within the Western sphere, Europeans are more likely to be dismissive of dental esthetics due to varying societal influences, such as an increased prevalence in smoking and a universalized healthcare system.

The evolution of dental aesthetics from the hidden smiles of historical portraits to contemporary gleaming grins reflects profound changes in technology, health understanding, social values, and cultural exchange. While the Mona Lisa's enigmatic expression once represented sophisticated portraiture, today's ideals celebrate a confident display of perfect teeth.

This evolution reveals how beauty standards are neither universal nor permanent but reflect complex interactions of practical constraints, cultural values, and technological possibilities. At the University of Texas School of Dentistry, countless students and faculty are currently striving to discover new possibilities within the realm



Left: DS1 Britney Nguyen
Right: Patient case study illustrating the detrimental esthetic effects of improper color matching

CHAP-TER 02

What is Dental Color?

By: Britney Nguyen

Picture this: A 38-year-old marketing executive, Lucy, scheduled a consultation with you, her dentist, and presents with concerns about the appearance of her smile. Her job involves giving presentations and leading client meetings, so she would like to revise the existing crown on her front tooth that now has underlying darkness peeking through. As a newly graduated dentist, you begin to recall concepts you learned in dental school related to optical properties of dental biomaterials and shade selection.

Dentists serve as both artists and scientists, combining artistic considerations with scientific principles from psychophysics to carefully and seamlessly match restorative materials to a patient's natural tooth shade or esthetic preferences. Competence in this skill is a vital aspect of dental care, as it not only enhances the appearance of a patient's smile but also plays a crucial role in maintaining the integrity of a patient's bite and the functionality of their teeth.

Essential Knowledge for Accurate Dental Shade Matching
To achieve optimal results, a thorough understanding of human perception of color, the principles of color science, and the complex nature of tooth color and appearance is required.

Human Perception of Color
To perceive color, a light source, an object, and an observer are required. Electromagnetic radiation illuminates the tooth, and the observer then uses their subjective ability to interpret the visual image and perceive the reflected color.

Principles of Color Science
Munsell's color system is commonly used to arrange colors in an orderly fashion. Three dimensions are considered: hue, value, and chroma. Hue is displayed as a color wheel. Value refers to the lightness of those colors and is deemed brighter with increasing lightness. Chroma refers to the saturation or intensity of color.

Other optical properties, such as translucency, gloss, and fluorescence, can influence color perception. Translucency is the degree to which light is scattered upon transmission to an object. Transparent objects will primarily transmit light without scattering it making the object appear "see-through". Completely opaque objects block the passage of transmitted light. Gloss refers to a mirror-like visual appearance that originates from the geometrical distribution of reflected lights off surfaces. Smoother surfaces will appear glossier. Fluorescence results from an external stimulus such as ultraviolet light being reemitted off a fluorescent surface in the form of longer wavelengths.

Complex Nature of Tooth Color and Appearance
The surroundings of an object influence its overall appearance due to the impact on eye adaptation and prior visual experiences. Using standardized daylight-balanced lighting and having neutral backgrounds in the operatory helps to avoid color distortion and increase the accuracy of shade selection by minimizing perceptual biases.

Factors that influence the success of color matches include lighting conditions, background effects, hydration level of the teeth, and surface texture and gloss.

After a thorough evaluation, you plan a treatment sequence that begins with laser removal of the existing crown, followed by in-office bleaching of the dark prepared tooth, and finally, placement of a new crown using your refreshed knowledge of accurate dental shade matching.

Dr. Joe Ontiveros

A Major Obstacle Faced Choosing Dental Biomaterials

A major concern with using ceramic-based shade guides for a composite restoration is that the actual composite shade may or may not match the original ceramic classical tabs. Large color differences also exist among the composite materials of the same shade designations.

To avoid color differences between dental biomaterials and teeth, dentists should use composite-specific shade guides and/or a layering technique where multi-shade or multi-opacity composites are layered to mimic natural tooth structure.

Factors that influence the success of color matches include lighting conditions, background effects, hydration level of the teeth, surface texture and gloss.

Mitigation Strategies to Address Color Differences

Layering and blending of dental biomaterials with the tooth surface allows for a more natural appearance. Digital instruments such as cameras, scanners, and spectrophotometers can also aid the dentist in quantifying color differences for a more objective approach to color matching.

Expert insights with Dr. Ontiveros

While researching the topic of this article, I developed a deeper appreciation for the complex steps and extensive knowledge required to deliver adequate and precise shade matching in restorative dentistry. This prompted me to seek faculty members with expertise in this area, and I have been fortunate to connect with Dr. Joe Ontiveros, Head of Esthetic Dentistry, at UTSD, and Head of the Oral Biomaterials Division for the Houston Center for Biomaterials and Biomimetics. During the Summer of 2025, I will be working with Dr. Ontiveros on a project focused on gloss retention single-shade composites. This opportunity will allow me to build a stronger understanding of color science and introduce me to new materials available for esthetic dirven restorative dentistry.

What are some of the most common mistakes clinicians make in shade selection?

"Since teeth change color when dehydrated, within minutes, it is important to capture the shade at the beginning of the appointment before dehydration occurs and valuable color information is lost. It is a common mistake to wait too long into the appointment to capture the shade.

Another common mistake is staring too long at the shade guide/teeth during shade selection. The physiology of the eyes adjusts when staring and we lose color information. It is best to take several quick glances, approximately five seconds per glance, to keep the eyes fresh."

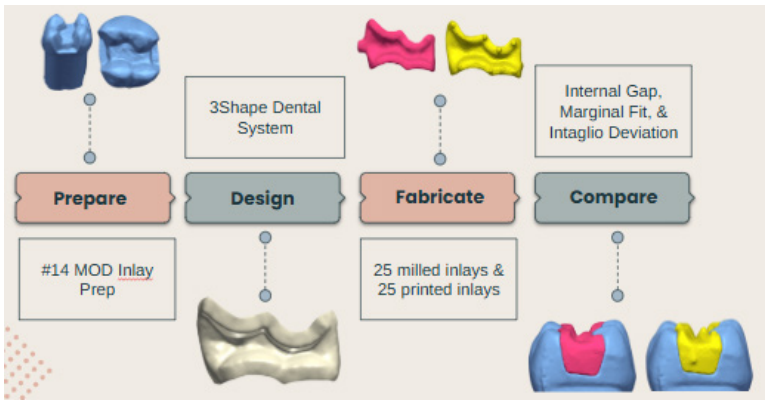
If a patient is unhappy with a restoration due to minor color differences, how would you suggest the dental provider address the situation?

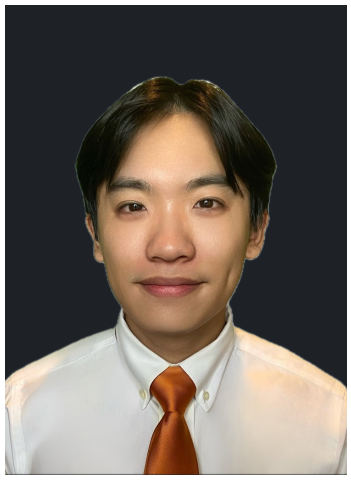
"If the same dental provider is making corrections, then it may be just an issue of making minor shade corrections. This will depend on the material. If the restoration is direct composite, making adjustments to the final composite layer, using a different shade of composite, can generally improve the situation. If the scenario deals with indirect materials, such as a ceramic restoration, this presents a greater challenge. If the restoration is lighter, sometimes bleaching the surrounding teeth can be an option. If the restoration is too dark, then a remake may be the only option."

CHAPTER

03

Digital workflows offer many advantages to providers. This includes unique esthetic benefits as providers are able to create, analyze and examine their restorations in greater detail.





Top: Work flow for developing digital inlays
Middle Left: Dr. Michelle Thompson
Middle Right: Dr. Vinu Sista
Bottom: DS2 Tai Van

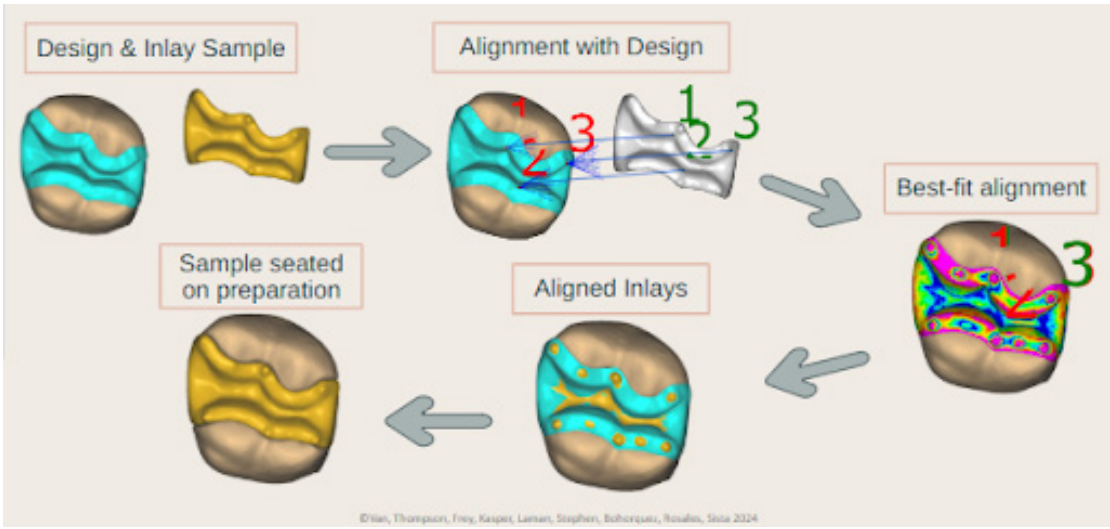
Exploring the Future of Indirect Dental Restorations: 3D Printing vs. Milling

By: Tai Van

With the rise in dental innovations over the years, indirect dental restorations have become faster and more accurate. At the heart of this shift is CAD/CAM (Computer-Aided Design and Computer-Aided Manufacturing) technology. With CAD/CAM systems, dental offices can now scan a patient's teeth to create a precise 3D model, design restorations digitally, and produce them on-site on the same day. This technologically advanced technique eliminates the need for traditional impressions, temporary restorations, and the multiple appointments often required when working with off-site dental labs. The advancements in CAD/CAM implementation has made dental procedures more efficient, less stressful for patients, and in many cases, more affordable.

For years, milling has been the norm for creating these in-office restorations. Milling involves cutting away at a block of material. While milling has been effective, a new fabrication method has started gaining traction: 3D printing. This technique builds up material layer by layer based on a digital model and promises even more precise restorations according to previous studies. But how do these two methods, milling and 3D printing, compare in terms of accuracy, fit, and overall performance?

Previous studies comparing the accuracy of fabrication methods only utilized discrete points to measure discrepancies. Even under a microscope, having to physically measure discrepancies makes standardizing the measurements difficult. Also, constraints on the data points limits comprehensive analysis of accuracy. There had to be a better way to compare the fitment and accuracy of restorations. This study set out to improve upon previous comparison methods, while verifying the conclusions of previous studies supporting the superior accuracy of



Left: *Using an entirely digital workflow, the samples were seated onto the prepared tooth.*

Bottom: *Areas of the prepared tooth were segmented for further analysis.*

3D-printing, by comparing the two fabrication methods for making composite inlays. With a sample size of 50 fabricated inlays, each inlay provided approximately 660 points of measurements with the help of GeoMagic Control X.

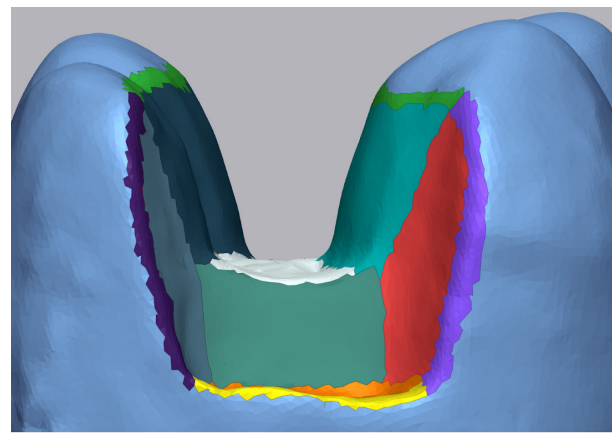
To start, a plastic tooth replicating an upper molar (tooth #14) was prepared for a resin inlay according to CAD/CAM dimensional standards. An inlay is a form of indirect restoration that mimics a filling. After preparing the tooth, a handheld 3D scanner digitalized the inlay preparation for designing. Exocad, a premiere dental software, was used to design the restoration. The digital design was exported to fabricate two sets of restorations: one using milling and the other using 3D printing. In total, 50 restorations were fabricated (25 restorations were made using each method). The restorations were not altered or polished after fabrication, ensuring the comparison focused solely on the accuracy of the fabrication methods.

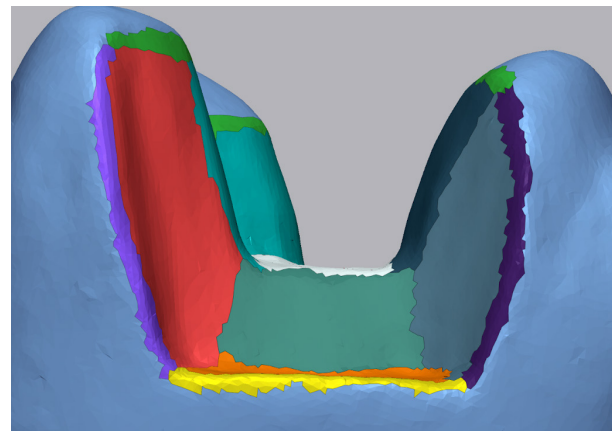
After fabrication completion of all the samples, a benchtop scanner digitized each fabricated sample into 3D files. The 3D scans of each fabricated inlay was digitally seated onto the inlay preparation to measure how well the inlays fit onto the prepared tooth. The measurements were analyzed with GeoMagic Control X to assess the accuracy, internal fit, and marginal adaptation (how well the edges of the fabricated inlay align with the edges of the tooth).

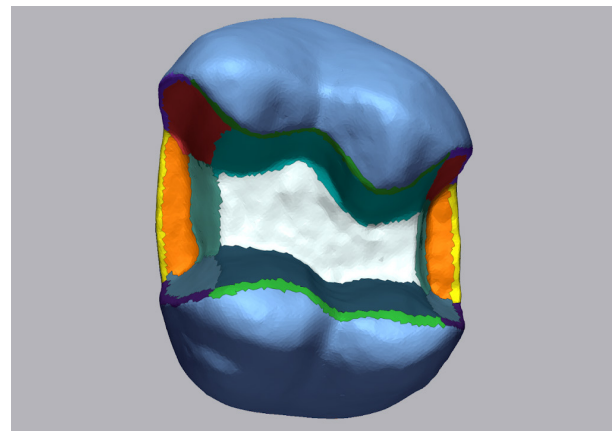
Key Findings
The study found no significant difference between milling and 3D printing in terms of overall accuracy, internal gap, or marginal fit. Both methods produced restorations that fit within the clinically acceptable tolerances of 120 microns. This means that both methods are capable of creating restorations that function well.

What Does This Mean for Patients and Dentists?
The main takeaway from this study is that both milling and 3D printing are viable and clinically acceptable methods for making dental restorations. Both techniques offer restorations that fit within a very small margin of error, making them both suitable for use in everyday dental practices. Ultimately, the rise of digital dentistry, whether through milling or 3D printing, is changing the way dental procedures are performed for the better. With the ability to create accurate restorations in-office, patients no longer need to wait weeks for their indirect dental restorations to be processed. Shade matching and patient satisfaction with the final look can be attained the same day.

Patients no longer neeed to wait weeks for their indirect dental resrations. Shade matching and patient satisfaction with the final look can be achieved in the same day







CHAP-TER 04

Reimagining Orthodontic Esthetics

By: Chloe Ku

Popular belief holds that traditional metal brackets used in orthodontic treatment are esthetically unappealing. Although this temporary inconvenience will lead to a lifelong beautiful smile with adherence to retainer usage, it remains a hurdle to seeking dental correction. Advances in biomedical engineering, biomaterials research, and technology have allowed for the development of more discreet options like clear aligners or tooth-colored braces, reducing this concern. Dr. Kurt Kasper, Professor and Research Director in the Department of Orthodontics at the UTHealth Houston School of Dentistry, dedicates biomaterials research towards developing and characterizing orthodontic appliances to have a more esthetic appeal.

Dr. Kasper's first research experience in his undergraduate studies set the stage for his career, as he became fascinated with doing work that related measurements in the lab with the lives of patients. He went on to Rice University, where he earned his PhD in Bioengineering. Following his education and work in this field, Dr. Kasper eventually joined the Department of Orthodontics at UTSD in 2014, where his research focuses on applying the concepts of biomaterial engineering to orthodontic appliances. He does work in craniofacial bone regeneration and 3D printing in orthodontics that involves clear aligner therapy, nasal alveolar molding for cleft lip/palate, and customized orthodontic brackets.

Left: DS1 Chloe Ku Right: Dr. Kurt Kasper

Clear, removable retainers for the retention of teeth positioning following orthodontic treatment have gained popularity for their improved aesthetics and reduced costs. Orthodontists employ various techniques, including 3D printing and thermoforming, to create them. One of Dr. Kasper's studies explored whether keeping masking sheets on during the thermoforming process affects the fit and translucency of plastic retainers. This study, conducted as a Masters of Science in Dentistry thesis by Dr. Angela Pelehac and overseen by Dr. Kasper, investigated Taglus® Tuff, a polyethylene terephthalate glycol (PETG) thermoplastic. The manufacturer claims that leaving the masking sheets on during thermoforming will result in an "ultra-clear" retainer.

Forty models were 3D-printed and divided into four groups based on the presence of masking sheets during the thermoforming process: masking sheet on intaglio (inner) and cameo (outer) surfaces, masking sheet only on intaglio surface, masking sheet only on cameo surface, and no masking sheet. They used a pressure molding machine to thermoform the material over models. To test for dimensional accuracy, a superimposition analysis compared the surface of the model with the surface of a cast from the appliance using a metrology software, which then calculated deviations in fit.

A spectrometer measured the translucency parameter, obtaining reflectance spectral data against a black and white background. Statistical analyses compared the effects of masking sheets on fit and translucency.

After analysis, the results revealed that keeping the masking sheets on the plastic for thermoforming had a statistically significant effect on the fit, but did not have a statistically significant effect on translucency. Regarding deviations on the fit measurements, negative deviations indicated a tight fit and positive deviations indicated a loose fit. In general, retaining the masking sheets for thermoforming showed to affect the negative deviations, with the group with the masking sheet on the cameo side only demonstrating the largest negative deviations, indicating the tightest fit. The results of the translucency parameter values were similar amongst all groups.

Statistical significance does not always align with clinical significance. In this study, because the differences in values were within an acceptable range for orthodontic retention, the findings of fit are not clinically significant, although they might feel slightly tighter to the patient. The results of the translucency testing does not align with the manufacturer's claims of keeping the masking sheets on for increased optical clarity, so aesthetics are not impacted in terms of translucency. Despite following the manufacturer's instructions, practitioners may not see a difference in the visual translucency of the retainer after thermoforming.

3D-printed model and geometric form pair oriented on the flat platform of the Biostar thermoforming machine utilizing a placement guide.

For future studies, the impact of leaving masking sheets on during the thermoforming process on other clinically relevant parameters, such as durability and comfort can be assessed long term. Dr. Kasper hopes to study whether patients notice the slight dimensional differences in fit, and whether people can detect the differences in the appearance of the retainers. Moving beyond instrumental analysis, these studies will more accurately evaluate the real-world clinical significance of these findings.

Currently, Dr. Kasper is working on characterization work of orthodontic biomaterials. He recently investigated the staining properties of subtle, tooth-colored 3D-printed orthodontic brackets that are customized to fit the shape of the tooth when exposed to common solutions they might encounter such as coffee or wine. Results of the study indicated that these brackets are susceptible to discoloration, so further work will be done to optimize a discreet appearance while maintaining functional expectations.

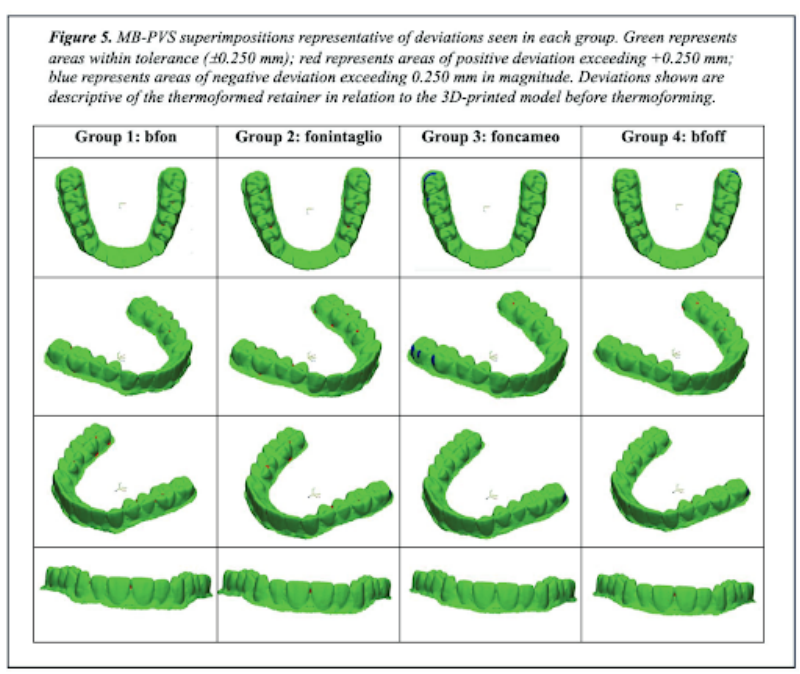
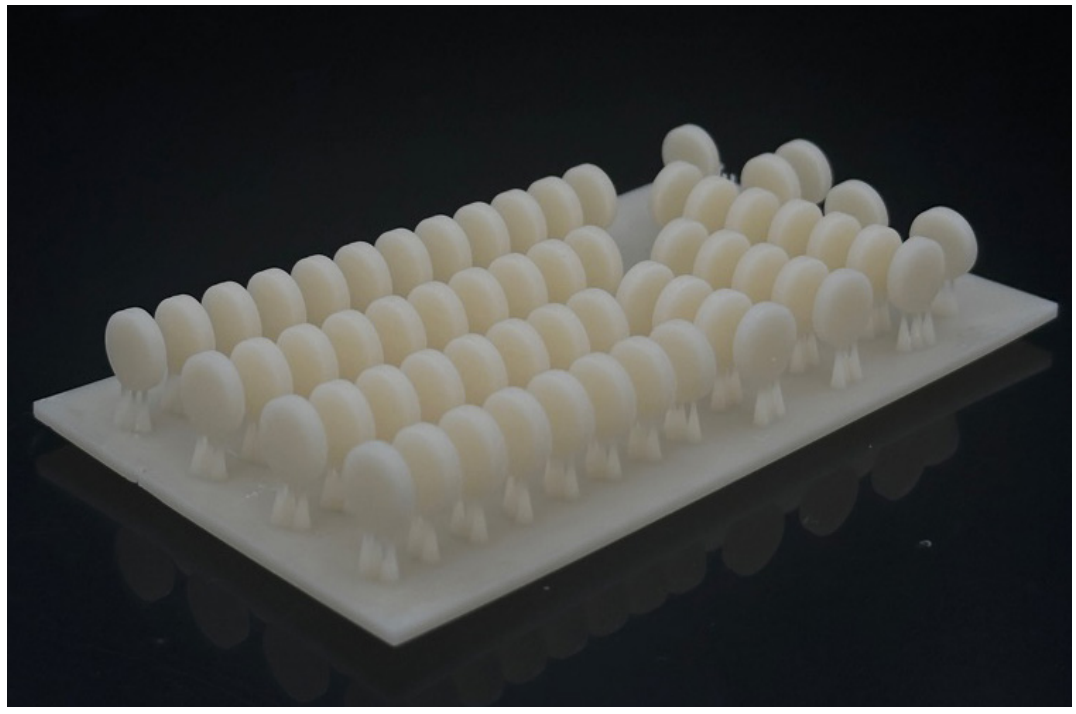
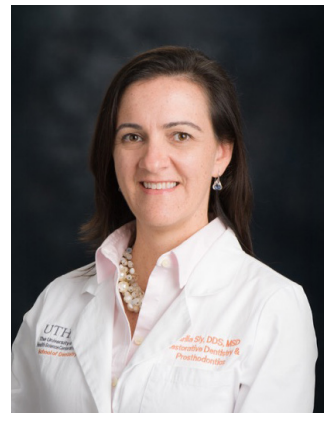


Figure 5. *MB-PVS superimpositions representative of deviations seen in each group. Green represents areas within tolerance (±0.250 mm); red represents areas of positive deviation exceeding +0.250 mm; blue represents areas of negative deviation exceeding 0.250 mm in magnitude. Deviations shown are descriptive of the thermoformed retainer in relation to the 3D-printed model before thermoforming.*

The findings from the study on thermoformed retainers empower orthodontists to make evidence-based decisions when fabricating retainers, ensuring both optimal performance and harmonious design. As biomaterials continue to evolve, future studies will shift toward clinical relevance, focusing on patient experience, comfort, long-term durability, and visual appeal. Dr. Kasper's ongoing research demonstrates a commitment to advancing orthodontic materials for improved patient outcomes.

Figure 3. *Thermoformed disk with lower portion cropped out of frame (left). Corresponding PVS model representative of the intaglio surface of the thermoformed appliance (right).*





Left: 3D Printed Platform GC
Top Right: Dr. Mariela Sly
Bottom Right: DS2 Michael Landavazo

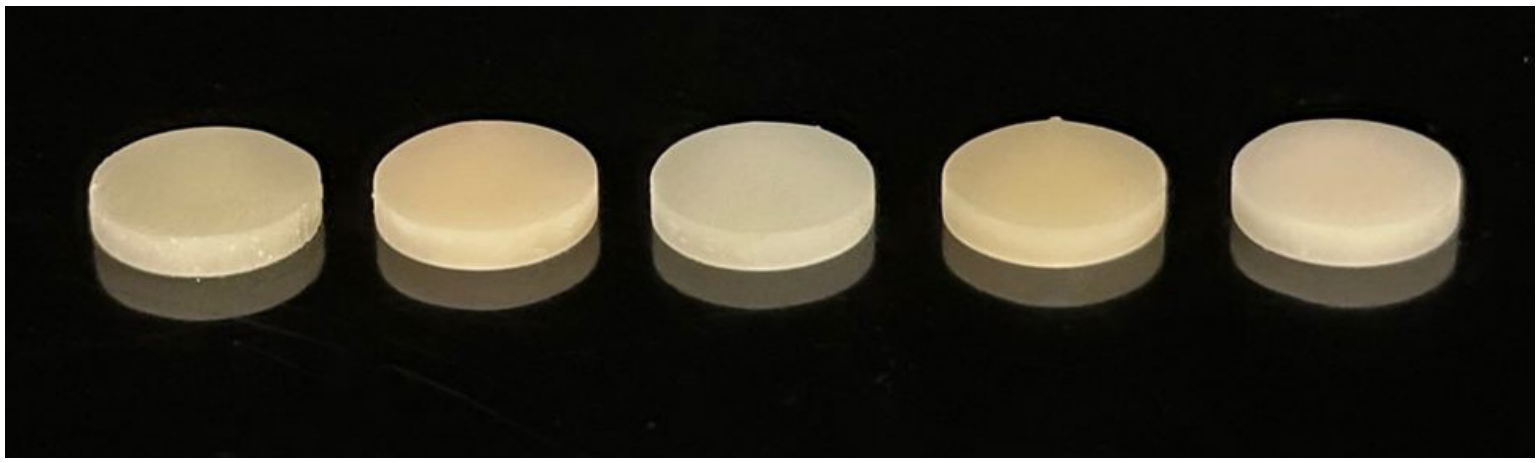
CHAP-TER 05

Retainer Esthetics

By: Michael Landavazo

Introduction

The color stability of materials, particularly in the context of dental applications, plays a significant role in ensuring both esthetic quality and functionality. Temporary resins are commonly used for dental restorations, and understanding their color properties is critical for ensuring that they meet esthetic standards throughout their service life. This experiment, conducted during the summer research program at UT Health Houston School of Dentistry, involved performing a color analysis of five different temporary resin materials using a spectrophotometer. The research was carried out under the guidance of five faculty members and in collaboration with four other students. The goal was to assess the color stability of these materials, both before and after exposure to various staining solutions, simulating real-world conditions in dental practices. Reflecting on my experience, I will discuss the methodology used, the challenges encountered, and the conclusions drawn from the experiment.



Polished 3D printed temporary resin materials before staining; left to right: AD, BV, GC, DO, PP

Preparation
The initial phase of the experiment involved selecting the five temporary resin materials, which represented different brands of 3D-printable resins commonly used in dental applications. The resins selected were:

1. Asiga DentaTooth (AD)
2. Dentona Optiprint Lumina (DO)
3. Pro3dure Printodent (PP)
4. Bego VarseoSmile Temp (BV)
5. GC Temp Print (GC)

These materials were chosen due to their widespread use in dental restoration procedures. Each resin had a different composition, and the experiment sought to evaluate how each material performed in terms of color stability after exposure to commonly encountered staining agents. The resins were printed using a 3D-printer (ASIGA MAX UV), following the manufacturers' instructions for both the printing and post-processing stages. The specimens were created in a uniform disc shape with a diameter of 10 mm and a thickness of 2 mm. This consistency in specimen size ensured that each sample had an equal surface area for color measurement. After printing, the specimens were finished using silicon carbide abrasive papers (#240, #320, and #600) for 10 seconds each under water cooling on an EcoMet 6 grinder-polisher, followed by polishing with PoGo disks for 40 seconds to ensure smooth surfaces for accurate color measurements.

Statistical Analysis
To evaluate the significance of the results, a two-way ANOVA was performed to assess the effect of the material type and staining solution on the color change (ΔE00). A Tukey's post-hoc multiple comparison test was then used to assess differences among the levels within each variable, with a significance level set at $\alpha = 0.05$. This statistical approach helped to identify which materials were more or less prone to color changes when exposed to different staining agents.

Analysis of Results
The results revealed noticeable differences in the color stability of the five resin materials when exposed to different staining solutions. The specimens were first measured for their color properties, and then after the exposure, the color changes were quantified using the CIEDE2000 color difference (ΔE00) scale.

- **Asiga DentaTooth (AD)** exhibited the least color change, showing remarkable resistance to staining from coffee, red wine, and Dr. Pepper.
- **Dentona Optiprint Lumina (DO)** showed moderate color change, especially after exposure to red wine and black tea.
- **Pro3dure Printodent (PP)** had a notable color shift across all staining solutions, particularly when exposed to coffee and Dr. Pepper.
- **Bego VarseoSmile Temp (BV)** displayed considerable color changes, particularly in response to coffee and red wine.
- **GC Temp Print (GC)** exhibited slight color change but remained relatively stable when compared to some of the other materials, particularly when exposed to black tea.

The two-way ANOVA indicated that both the material type and the staining solution had a significant effect on the color change (ΔE00). Tukey's post-hoc analysis further revealed specific differences between the materials and the staining solutions, with Asiga DentaTooth (AD) being significantly more resistant to staining than Bego VarseoSmile Temp (BV) and Pro3dure Printodent (PP) after exposure to coffee and red wine.

Conclusion
This research underscores the critical role that scientific inquiry plays in advancing dental aesthetics. As dental materials continue to evolve, understanding their esthetic properties—particularly their ability to maintain a natural appearance over time—will be essential for ensuring that patients receive durable and aesthetically pleasing restorations. The development of resins with superior color stability, for instance, can greatly enhance patient satisfaction by reducing the need for frequent touch-ups and improving the longevity and performance of dental restorations.

Research in this field is vital not only for improving the aesthetic outcomes of dental procedures but also for advancing material science in general. By systematically analyzing and understanding how different materials respond to real-world conditions, such as staining, we can make informed decisions that enhance both the function and the beauty of dental treatments. As we move forward, continued research will play an instrumental role in shaping the future of dental esthetics, offering innovations that can improve the quality of life for patients and advance the field of restorative dentistry. Overall, this experience deepened my understanding of color analysis and its significance in material development, providing valuable insights that will inform both future research and clinical practices

INCISAL EDGE 2025

By: Evan Ji (DS1)