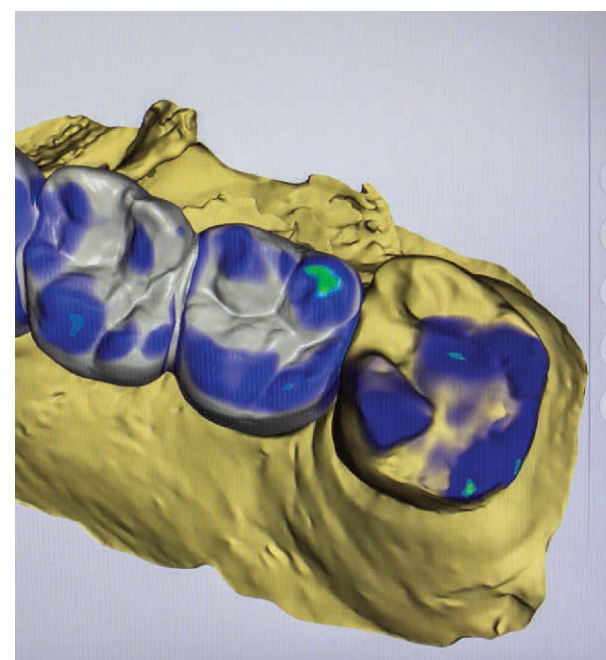


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"Digital technology and techniques are transforming the profession. We are preparing our students for the dentistry of today — and tomorrow."  
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— DR. MARKUS BLATZ



# ADVANCING LEADERSHIP IN DIGITAL DENTISTRY

ONGOING INITIATIVES IN EDUCATION, RESEARCH, AND PATIENT CARE KEEP PENN DENTAL MEDICINE ON THE LEADING EDGE OF DIGITAL DENTISTRY

JUST OVER TWO YEARS AGO, Penn Dental Medicine opened two state-of-the-art facilities that placed it squarely on the leading edge of the digital age of dentistry.

The Digital Design and Milling Center and the Center for Virtual Treatment Planning are the most visible successes of the School's ongoing Digital Innovation Initiative, aimed at incorporating the latest in digital dental technologies and techniques throughout almost all areas of education, research, and patient care.

Today, the two Centers, located on the lower level of the Thomas Evans Building, serve as both the cornerstones and building blocks of Penn Dental Medicine's commitment to the future of digital dentistry, as the School continues to enhance its global leadership and expertise in the field.

The Digital Design and Milling Center and the Center for Virtual Treatment Planning provide a full range of state-of-the-art digital technology and equipment that allow dental students and residents to digitally plan restorations, develop virtual treatment plans for complex cases, and manufacture restorations on-site.

"Digital technology and techniques are transforming the profession," says Dr. Markus Blatz, Professor and Chair of Preventive and Restorative Sciences, Assistant Dean for Digital Innovation and Professional Development, and a leader of the School's Digital Innovation Initiative.

"We are preparing our students for the dentistry of today — and tomorrow," Blatz says.

"The incorporation of digital dental technologies has been a great success story, ever since we made this our focus well over a decade ago."

Since the Centers opened, digital dental technologies have continued to become even more embedded school-wide, advancing the goal of the School's Digital Innovation Initiative to open up new possibilities for teaching students, conducting research and continuing education, and delivering seamless and cutting-edge patient care.

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OPPOSITE, CENTER: The Digital Design and Milling Center, where the vast majority of indirect, single-unit restorations for patients within the School's care centers are designed and milled.

BOTTOM, LEFT: The Center for Virtual Treatment Planning focuses on complex cases, creating a virtual patient to treatment plan.



## LEADING WITH DIGITAL INNOVATION

Penn Dental Medicine's leadership in digital dentistry was evident this past spring when deans and dental school leaders from across the country visited campus to tour the Digital Design and Milling Center and the Center for Virtual Treatment Planning and to discuss the role of digital innovation in education and research. The visit, hosted by Dr. Mark Wolff, Penn Dental Medicine's Morton Amsterdam Dean, was planned in conjunction with the American Dental Education Association Annual Session, which was held in Philadelphia in March.

"We were able to share our digital innovation and how we successfully implemented key aspects in our programs and clinics," says Blatz. "The acceleration of incorporating digital applications across clinical care and education at the School has exceeded expectations."

Today, the vast majority of indirect, single-unit restorations for patients within the School's care centers are designed and milled in-house in the Digital Design and Milling Center, which is headed by Dr. Julian Conejo, Assistant Professor of Clinical Restorative Dentistry and Director of Chairside Digital Dentistry. A key aspect of the successful digital transformation at the School has been a comprehensive faculty training program, developed and taught by Conejo, to ensure faculty members are well versed in the application and teaching of digital dental technologies.

Conejo foresees a future when the School will be alginate-free, referring to the material typically used to make dental impressions. Now, with 18 intraoral optical scanners deployed throughout the School's clinical care centers, the School is continuing to move in that direction.

Trained in the use of digital technologies from the very beginning of their preclinical education, DMD students are required to complete a minimum number of CAD/CAM fabricated restorations, and starting this academic year, they are learning how to manage complete denture cases digitally as well. All aspects are done digitally — from



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— MICHAEL BERGLER

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the intraoral scan to the design and milling or use of printed materials to create the final denture.

"Creating dentures digitally is one of the fastest-progressing topics in our field, and there are several systems and new innovations on the market for using printed materials," Blatz says. "We are evaluating several of those systems to find out which would be best for our patients."

In the past two years, the School also has acquired four 3D printers, two of them in each of the Centers, which students use to print models from digital wax-ups, supplementing a long-standing collaboration with Penn Libraries Biotech Commons 3D printing service.

"Our goal is to ensure that our students have the skills and knowledge to prepare them for the future of dentistry," says Michael Bergler, Clinical Assistant Professor in the Division of Restorative Dentistry, and

Director of the Center for Virtual Treatment Planning. Within his Center, he works with postdoctoral residents on complex cases with a focus on creating "a virtual patient" and employing virtual treatment planning software.

"Based on the data we can collect from a patient's intraoral scans, cone beam tomography, and face scans, we are able to create a virtual patient on screen," explains Bergler. "By superimposing all these data sets, residents can simulate different treatment protocols."

"Virtual treatment planning is a more detailed way and a much more predictable way" of meeting patient needs, says Bergler, noting that since the Center's launch in 2020, residents have excelled in using the software. The patient response has been positive as well.

"Seeing the plans on screen gives patients more security in going through the treatment process," says Bergler. "It's a win-win all around."

## SMILE DESIGN: THERE'S AN APP FOR THAT

The thing about technology is it never stops moving forward, and keeping up requires the ability to stay at the forefront of evolving resources and applications. A new course introduced into the curriculum this past spring is designed to put second-year dental students in the mindset of doing just that as they prepare to begin seeing patients. The course — advanced restorative aesthetics — builds upon students' preclinical education in dental aesthetics and digital dentistry, with an introduction to smile design apps on their mobile devices a key part of the class.

“The course is purposely offered just prior to the start of students' clinical work so advanced aesthetics principles are part of what they carry with them throughout their clinical experiences,” says Blatz, who designed and teaches the course. “Through this course, students learn aesthetics not from looking at things and reading from a book, but by designing smiles within the apps in a 3D environment.”

Students design smiles using sample cases built into the apps. As an educational tool, Blatz notes that the apps provide an interactive 3D platform for reinforcing the aesthetic parameters of tooth placement and discussing aesthetics concepts.

“Through a digital scan, the artificial intelligence within the smile design apps can almost instantaneously suggest what an ideal smile could look like,” explains Blatz. “From there, a clinician can modify and adjust it together with the patient to simulate the desired outcome and create a treatment plan.” The new course introduces students to this evolving clinical tool, which Blatz notes can be a valuable resource to practicing clinicians as a starting point for aesthetic treatment planning.

OPPOSITE: Michael Bergler works with postdoctoral residents on virtual treatment planning.

TOP, BOTTOM: In a new advanced restorative aesthetics course, Dr. Markus Blatz, introduces students to a smile design app and uses it to reinforce the aesthetic parameters of tooth placement.

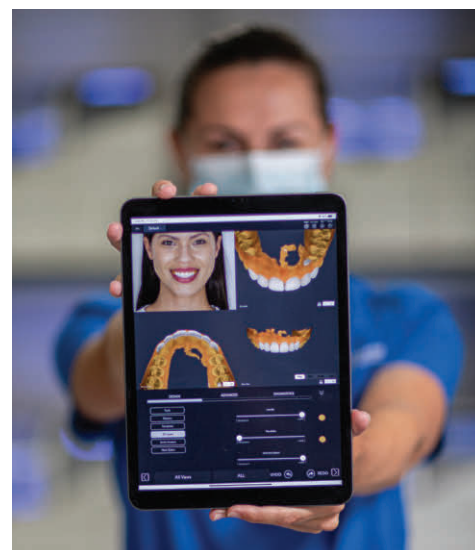


“Through a digital scan, the artificial intelligence within the smile design apps can almost instantaneously suggest what an ideal smile could look like.”

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The course also places an emphasis on minimally invasive aesthetic restorations and adhesive dentistry, such as laminate veneers, bonded ceramic inlays and onlays, and resin-bonded bridges — other fast-evolving topics that go hand-in-hand with digital technologies, notes Blatz.

“Our goal is to ensure our students are well-reversed in the latest techniques, technologies, protocols, and materials to best serve their patients,” he says.



## SHARING OUR EXPERTISE

Over the past two years, Penn Dental Medicine has significantly expanded online continuing education, sharing its expertise in digital dentistry with students, faculty, and dentists around the world. Programs such as the weekly “Excellence in Restorative Dentistry Online Lecture Series” feature international opinion leaders discussing new treatment protocols and technologies and Bergler developed a series of lectures on virtual treatment planning as well (view all online programs at [www.dental.upenn.edu/cde\\_online](http://www.dental.upenn.edu/cde_online)).

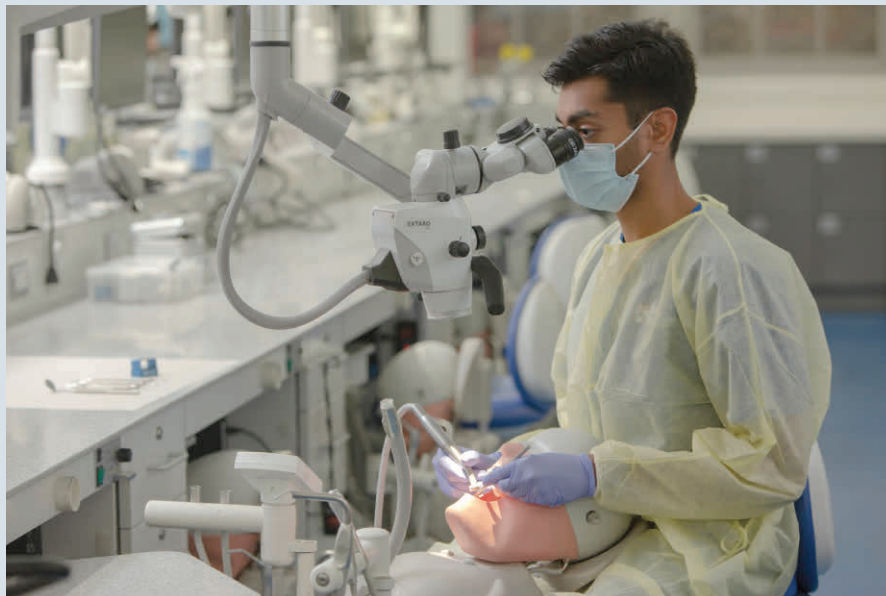
In another new initiative, the Center for Virtual Treatment Planning launched a series of lectures this past spring that gives postdoctoral students in Prosthodontics and Periodontal Prosthesis the opportunity to present their virtual treatment planning cases through the School’s online continuing education portal.

Called the “Case of the Quarter,” it focuses on the students’ experiences using the latest digital technology to virtually plan restorative, implant and surgical treatments, and demonstrate protocols for workflows. The cases address a range of issues, including the collection of digital data, intraoral and facial scanning, creating a digital plan, and relating the form and functional goals of traditional treatment planning compared with the digital planning.

“The series gives the residents the opportunity to present to the outside community what they have accomplished and what we are doing as a school,” Bergler says. “It demonstrates the leading technology in this area and the predictable clinical outcomes virtual treatment planning produces.”

“Besides continuing education, the number of publications on digital dentistry from our centers has skyrocketed in the recent past. That, along with our enhanced presence on various social media platforms and at international meetings is enabling us to educate a global audience on new dental technologies,” adds Blatz. “And, as Editor-in-Chief of the *Compendium of Continuing Education in Dentistry*, we dedicate a majority of articles and an annual thematic issue to this important topic.”

## RESTORATIVE MICROSCOPY: ANOTHER TOOL IN PRECISION DENTISTRY



Complementing the use and advances in digital dentistry, students are now also learning how the magnification and illumination of dental microscopes can enhance precision in restorative care. For the first time this summer, rising second- and third-year Penn Dental Medicine students learned to refine composite and crown preparations in the preclinical simulation lab using high-powered dental microscopes.

This restorative microscopy course was launched “to teach students the value of precision dentistry using the dental microscope,” says Dr. Alan Atlas, Clinical Professor of Restorative Dentistry and Endodontics and Director of Restorative Microscopy, who has headed this initiative. “Students have enthusiastically embraced it.”

According to Atlas, it is the only curriculum-based course in restorative microscopy being taught at any dental school worldwide, and is another example of how Penn Dental Medicine is at the forefront of preparing students for the future of dentistry. The restorative microscopy course, officially part of the first- and third-year curriculum, will

continue to be conducted in the summer session within the preclinical simulation lab.

The School currently has three clinical dental operating microscopes for training in the lab, one in the periodontal clinic, and two in the general restorative clinics with plans for five more to be added there within the next year.

The impact of working with microscopes was reinforced in a recent study led by Atlas that compared the marginal gaps of preparations for CAD/CAM crowns finished using loupes at 3x magnification versus dental microscopes with 10x magnification.

“The results showed that the marginal fit was significantly better with preparations done with the dental microscope,” Atlas says of the study, published in May in *The Journal of Prosthetic Dentistry*.

“Ultimately,” adds Atlas, “we’re teaching our students a philosophy of care that emphasizes obtaining the best outcomes for our patients.”

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ABOVE: DMD students are now learning to use a dental microscope in restorative care with a microscope course now part of the first- and third-year curriculum.



## RESEARCH LEADING THE WAY TO A DIGITAL FUTURE

There is little doubt that digital technology will play an outsized role in the future of dentistry, and research at Penn Dental Medicine is helping to determine what that future may look like. Companies in this realm continue to turn to Penn Dental Medicine for feedback on both dental materials and CAD/CAM equipment and software that is moving the field forward.

Consider the day when a robot guided by digital data could prepare a tooth for restoration; it may not be that far off. Blatz is currently collaborating with a European company to soon begin clinical and laboratory testing to provide feedback on just such a robotic system. “This would revolutionize how we do things,” says Blatz.

There is also research underway to gauge the accuracy of artificial intelligence (AI) programs in reading and evaluating radiographs. AI-powered technology helps to improve diagnostics and treatment by identifying possible issues in the radiograph and helping to ensure the clinician doesn’t overlook something. If that information is combined with other health data, Blatz says, “we can funnel this information with the help of AI to come up with more consistent, more calibrated, and more patient-centered treatment plans.”

In the Center for Virtual Treatment Planning, current research with industry partners includes testing 3D printing of ceramics and other new materials as well as a new printing technology that could print multiple materials and multiple colors within the same restoration. “Right now, we can only print one material at a time,” Bergler says. “Combining materials could add a whole new dimension on how to fabricate final restorations in the future.”

A professional metrology software for 3D evaluations and measurements was recently acquired to increase the quality and possibilities for new research projects, adds Bergler.

And in the Digital Design and Milling Center, where new zirconia materials and digital implantology have been a primary focus of clinical and laboratory research, students



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and postdoctoral residents are also becoming more involved in projects. This summer, the Center hosted its first predoctoral intern as part of the School’s Summer Research Program. Matthew Lee (D’25) worked with Conejo on a pilot study that compared full-arch abutment-level implant impressions with different intraoral scanning methods.

“As we approach the statistical analysis phase of the study, it is great to see how technology is making full-arch implant impressions easier,” Conejo says. The study was accepted for a poster presentation at the Greater New York Dental Meeting in November, which Lee will present.

Also advancing the School’s depth of research in the area of CAD/CAM ceramics over the past two years was the recruitment of Dr. Yu Zhang, adds Blatz. Joining Penn Dental Medicine in 2020, Zhang, Professor in the Department of Preventive & Restorative Sciences, has an international reputation for

his work to enhance the strength, durability, and aesthetics of dental ceramics.

“Our goal is to help advance the profession with solid evidence-based techniques and technologies,” stresses Blatz. “So in all we do, our main focus is to use technology to better serve our patients based on their specific and individual needs.” ■

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ABOVE: This summer, Dr. Julian Conejo worked with Matthew Lee (D’25) in the Digital Design and Milling Center on a study comparing intraoral scanning methods as part of the School’s Summer Research Program.