SPECIALTIES

HOW TO USE NEW MATERIALS AND WORKFLOWS TO RESTORE EDENTULOUS PATIENTS

Finding the right materials to create a simplified restorative workflow for predoctoral dental students.

[by P. Bradford Smith, DDS and John C. Mitchell, PhD]

Patients with edentulous arches are prevalent in today's society. But with the advent of implants, more patients are able to have similar form and function to what they were previously accustomed. Within our dental program, we wanted to find a material and system that would allow optimal outcomes and allow our predoctoral students to complete cases from start to finish.

Complete edentulism is a multifactorial concern for a patient's physical and psychological health. Our patients' chief complaints with total edentulism and the available prostheses are the following: loss of taste; difficulty chewing efficiently; maintaining stability and adherence to soft tissue and bony structures; speech concerns; texture of prosthesis; size of prosthesis; and periodic sore spots.

Three biomimetic and biocompatible materials recently entered the marketplace. They're all millable and permit composite resins or milled crowns to be bonded to the substructures. The three materials are TRINIA™, from Shofu, Trilor® from Bioloren, and Pekkton® Ivory from Cendres+Métaux Medtech. These high-performing polymers all vary slightly in makeup and composition. TRINIA and Trilor are fiber-reinforced.

TRINIA is the product we've been testing. Unlike bone, it's isotropic, meaning mechanical properties, including strength, are similar in all directions. We'll review in vitro findings and several clinical cases that used this new material.

Finding the right materials

It's estimated 30 percent of adults over the age of 65 are edentulous, especially in underserved communities.[1] Edentulous patients wanting a fixed hybrid type of prosthesis present to our clinic on a regular basis. These cases can be very complex in a graduate program but can be insurmountable in a predoctoral program.

We set out to find an implant system and restorative material suited for faculty guided predoctoral procedures.[2-4] Because of the patient pool's concern for metal allergy, we were also looking for a metal-free option.[5,6] In dealing with edentulous maxilla and mandibles, there's a wide array of treatment options to consider.[7-12] Our goal was to stay away from complicated procedures such as bone augmentation or distraction osteogenesis.

Short implants have had very good success rates[13,14] and could reduce the restorative complexity for our students. In addition, the material for the prosthesis needed to be forgiving, reparable and relatively easy to seat in the mouth.[15,16] The combined Bicon SHORT® implant system and the TRINIA fiber-reinforced hybrid resin material showed great promise as a solution.[15-22] Before placing the fiber-reinforced composite substructures in patients, we performed in vitro studies to determine the material's flexural strength and flexural modulus. We compared those to zirconia and cast metals.[23,24]

Having a flexural modulus similar to bone[25-29] would be advantageous in that it would allow the two systems to work in synergy and preserve bone support[30-33] around the implants while reducing post placement chipping and fractures of teeth and the substructure. A second concern was the material should have a density similar to bone in order to help the patient have a more natural feeling, as if they had their own dentition.

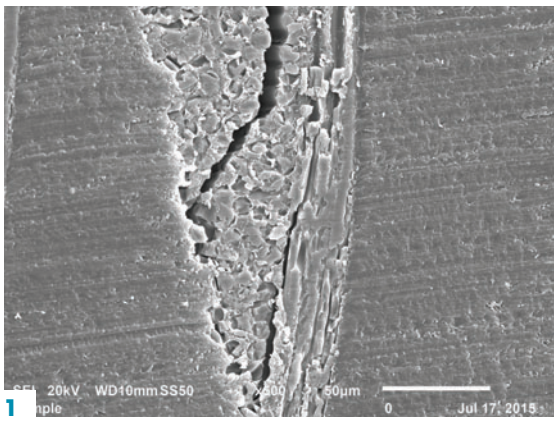
Previous patient retrospective studies found some patients didn't like the bulkiness of the fixed hybrid prosthesis and the resulting time-consuming maintenance needed to retain proper oral hygiene.[12]

Material tests

TRINIA blocks were obtained from commercially available stock, and a Beuhler IsoMet™ 5000 slow speed rotary diamond linear precision saw was used to cut 0.25 mm thick samples from the block in directions parallel to, perpendicular to, and 45° to the long axis of a TRINIA block. Samples were placed into dimethyl sulfoxide (DMSO) solvent for 30 days, sputter-coated with gold, and imaged in a scanning electron microscope (SEM). Fiber orientation and the interaction between fiber and polymer were photographed (**Figs. 1-2**).

To measure the flexural strength of TRINIA, blocks were cut into microtensile bars following ISO 4049. The resulting bars were individually measured using an electronic digital caliper.[25] Specimens of TRINIA with final dimensions of 2 x 2 x 25 mm (+/- 0.1 mm) were made without regard to orientation of the cut within the block. Specimens were stored in reverse osmosis (RO) water at 23° C for 24 hours before flexure testing. A universal testing machine was used to perform 4-point-bend testing (crosshead speed = 0.5 mm/min). Flexure strength and flexural modulus were reported. Data was analyzed using two factor ANOVA along with post-hoc tests (**Table 1**).

TRINIA displayed densely packed perpendicular bundles of interwoven fibers. These bundles ran continuously in both directions regardless of the orientation of the sample cut.



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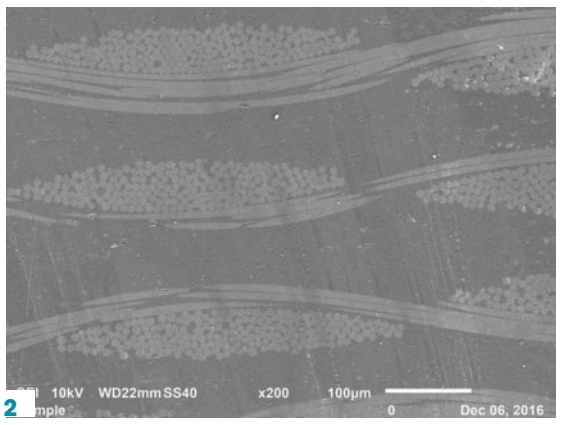

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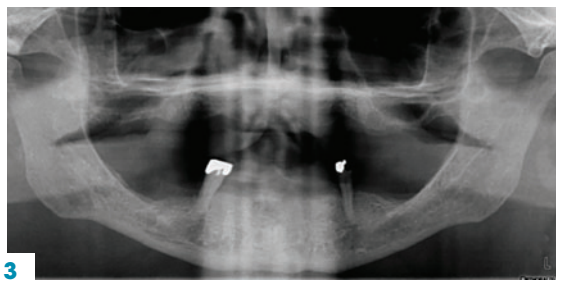
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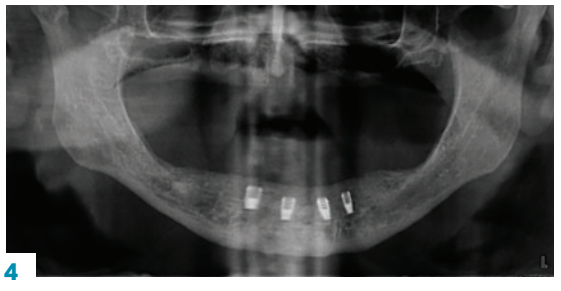
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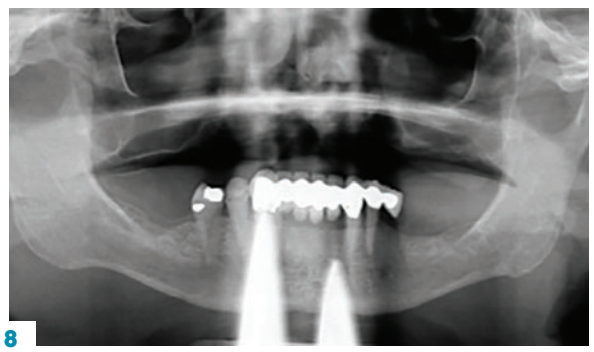
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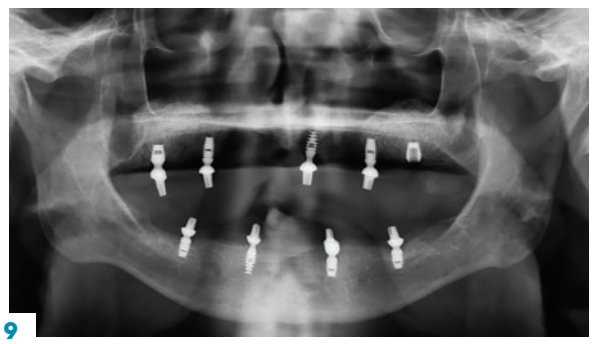
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AT A GLANCE

1. Scanning electron micrograph showing "layers" of woven fibers. Each of these layers has glass fibers running into and parallel to the image plane, similar to the warp and weft of fibers in a woven textile.

2. A lower magnification scanning electron micrograph of one of the sections through the TRINIA material. Notice that the cut shows four "layers" of woven fibers.

3. A radiograph of Patient 1 upon initial evaluation.

4. A radiograph of Patient 1 before uncovering of implants.

5. An intraoral photograph of the four implant abutments at time of first seating of the TRINIA prosthesis for Patient 1.

6. A photograph of Patient 1 at time of seating of TRINIA prosthesis.

7. A photograph of Patient 2 at initial consultation.

8. A radiograph of Patient 2 at initial consultation.

9. A radiograph of Bicon implants and abutment at time of initial try in of the TRINIA fixed hybrid prosthesis.

10. An intraoral photograph of mandibular arch of Patient 2 with healing caps over the Bicon implants showing the AP spread established in this case.

11. Patient 2 at delivery appointment of Maxillary and Mandibular TRINIA prosthesis.

PROPERTIES	TRINIA	BONE	ZIRCONIA OXIDE	CAST METAL CO-Cr	TriLor	PEKK Ivory
Flexural Strength	393 MPa	170 MPa	750-1465 MPa	500-800 MPa	540 MPa	200 MPa
Young's MOE	18.8 GPa	14.8-20 GPa	200 GPa	210 GPa/600 MPa	26 GPa	5 GPa
Tensile Strength	169 MPa	90-190 MPa	115-711 MPa	1100-1900 MPa	380 MPa	115 MPa
Density	1.68g/cm³	1.7g/cm³	5-6.15g/cm³	10 g/cm³		
Fracture Toughness	9.7 MPa/m½	6.4MPa/m½	6-10 MPa/m½	6 MPa/m½		
Vickers Hardness	347 VHN	120-160 VHN	12 VHN	420 VHN		
Compressive Strength	347MPa?	170 MPa	1200-5200 MPa	7000 MPa	530 MPa	246 MPa
Poisson's Ratio		0.1-0.2	0.22-0.32	0.27-0.30		

Table 1: *This table compares the mechanical properties of TRINIA from our tests as well as from the manufacturer and other research tests with literature values for the other most common substructure materials in use today.*

The following case studies demonstrate an example of a difficult restorative case for a predoctoral dental student made simpler with available products and techniques. We found Bicon SHORT Implants and TRINIA metal-free substructures are a strong combination when used for completely edentulous patients.

PATIENT 1

A 71-year-old male presented with a full maxillary denture and retained lower left canine and lower right first premolar (**Fig. 3**). He desired a semi-permanent solution to improve fit, function of upper and replace all missing teeth on the lower. An initial panoramic radiograph was taken for surgical and restorative planning purposes. The patient and doctor discussed options and it was decided a new maxillary full denture and a fixed hybrid prosthesis on the lower arch would be acceptable treatment options.

The patient's medical history was evaluated for a mandibular fixed hybrid prosthesis using four Bicon implants and a TRINIA substructure. A CBCT revealed adequate bone for implantation and reviewed clinically after properly dissecting the mental nerve to avoid paresthesia. Four implants were placed through the anterior to increase the AP spread. Mandibular full thickness mucoperiosteal flap across the ridge was released and mental foramen were identified bilaterally. The posterior implant was placed 5 mm anterior to the mental foramen. All sites were prepared, checked for parallelism and enlarged to receive four implants each 4 mm x 8 mm with a 2.5 well (**Fig. 4**).

After normal healing and integration, 5 x 5 mm healing abutments with 2.5 mm wells were placed. At the impression appointment, the sulcus was prepared using a sulcus reamer and a PVS impression was taken and sent to the lab. The patient was happy with the wax try-in and the lab was instructed to finish the case. Delivery was uneventful (**Figs. 5, 6**).

At the one-month, post-op appointment the patient reported being able to eat corn on the cob and was happy with the fit and function of his hybrid, and the prosthesis continued to perform properly at subsequent follow-up visits.

PATIENT 2

A 69-year-old male presented with an existing maxillary full denture and mandibular fixed partial denture (Tooth Nos. 22-27) with pain and suppuration on abutment teeth supporting the FPD (**Figs. 7, 8**). All existing abutment teeth were carious and periodontally involved. It was decided with the patient the best treatment option would be to extract the remaining mandibular teeth. All options were presented to patient and patient desired a fixed hybrid for both arches.

All dental records were taken including a CBCT which revealed inadequate bone height for traditional implant lengths. The decision was made to use four Bicon SHORT implants with a TRINIA framework and Ceramage teeth from Shofu.

Surgical guides were fabricated using Anatomage software. A maxillary sinus lift was performed on the upper right and left quadrant areas using a lateral sinus window approach. Bone grafts were placed with 50/50 allograft and xenograft with a PRF membrane. After normal healing time all remaining mandibular teeth were atraumatically removed and socket preservation performed using non-demineralized bone grafting material and CollaTape. The patient was fitted with interim full dentures on both arches.

Healing occurred without incident and an appointment was made for implant placement. The maxillary arch received two 5 x 6 mm, one 3.5 x 8 mm and two 4 x 8 mm Bicon SHORT Implants during the first implant placement appointment. The implant in the upper left area was placed as a precaution against the possible loss of one in the premolar area. All Maxillary implants successfully integrated.

At a second appointment, four Bicon SHORT implants, three 4 x 6 mm and one 3.5 x 8 mm were placed in the mandibular arch (**Figs. 9, 10**). After normal healing time, both the maxillary and mandibular arches were fitted with a fixed hybrid prosthesis fabricated from a TRINIA substructure and Ceramage denture teeth. The patient was happy with the fit, function and comfort (**Fig. 11**).

Conclusion

The previous case studies demonstrate difficult restorative cases made easier with the products and techniques now available. Using Bicon SHORT Implants and TRINIA metal-free substructures in our predoctoral clinics has become a successful combination for completely edentulous patients.

TRINIA telescopic prosthetic material has revolutionized the ability for our predoctoral students and general practitioners to be successful with all-on-four semi-removable prosthetic appliances. This combination is a great option for patients who do not want any metal prostheses in their mouth, but want a semi-permanent restoration when edentulous. Many patients comment that their new fixed-hybrid feels very similar to their original teeth because they do not have the additional weight of a metal framework.[12]

This product has a lower flexural modulus than zirconia, and can be used with a greater distal cantilever on the prosthesis without undue torque or component failure. Having a material with a flexural modulus close to that of bone allows it to bend at relatively the same rate and helps to maintain healthy bone support around the implants; but more importantly this allows the patient to function similar to when they were dentate. TRINIA has high flexural and compressive strengths. It is also easily adjustable chairside and can be bonded for exact fit.

Using the Bicon implant system and telescoping crown abutments, the TRINIA base is a perfect match. Within the system of four implant copings, two are passive and two are retentive. The patients report the restorations feel natural, lightweight and chew and function similar to their natural dentition.

Our in-vitro findings demonstrated TRINIA could not only withstand the compressive and functional loads placed upon it during mastication, but it had a more favorable flexural modulus when compared to metal or zirconia materials.

Patient satisfaction has been noted to be highly positive to the use of these two materials as a system. Patients especially appreciate the similar density to bone, so there is a weightless feeling to the prosthesis similar to natural dentition.

One of the most important physical characteristics of TRINIA is in its isotropic mechanical properties. Deformation in the mouth is significantly reduced due to the interwoven glass fiber mesh contained in the resin matrix. The torque on the mandible is negligible because of the matched modulus. These two properties allow a greater distal extension on the substructure, which in turn allows for safer and more predicable implant for predoctoral dental students. ●

References and author biographies are available online at dentalproductsreport.com.