Dental implants offer a predictable and efficient option for replacement of missing posterior teeth. Implant selection, surgical technique, occlusion, and restorative materials are all important factors in treatment success. When multiple teeth are missing in a quadrant, particular attention must be paid to restoration design and to the development of a stable occlusion to minimize premature occlusal contact, excursive interferences, and restorative material wear.

CASE REPORT
This 45-year-old woman came into the office with no significant medical conditions. She was a nonsmoker and did not have any evidence of immunologic compromising conditions. Periodontal conditions were normal without signs of infection or other pathology. Four months earlier, tooth No. 31 was treated endodontically and temporized with glass ionomer cement (HY-bond [Shofu]). Tooth No. 28 was extracted after being deemed to have a nonrestorable root fracture (Figure 1). She had several failing composite restorations and a porcelain-fused-to-metal bridge opposing the teeth to be replaced (Figure 2).

The clinical exam and radiographs revealed about 14 to 18 mm of bone from the alveolar crest to the radiographic mandibular canal, and ample, healthy attached gingiva covering the edentulous portion of this ridge for proper implant healing and soft-tissue maintenance. Periodontal cleaning and examination was completed, and an appointment was made for the procedure.

Despite a lengthy dental history, the patient was enthusiastic and very receptive to the idea of replacing her missing teeth with 2 root-form implants and CAD/CAM all-porcelain restorations. The implants would be placed, 3 months allowed for integration, and then abutments placed and restorations fabricated.

IMPLANT PLACEMENT
Numerous implants are suitable for the replacement of missing posterior teeth. A few examples include Maestro (BioHorizons), Groovy (Nobel Biocare), and Screw-Vent (Zimmer Dental). Maestro implants are designed with a roughened surface (Resorb-able Blast Texturing) that is reported to aid in osseointegration by increasing surface area, and they come mounted with an abutment that quickly is modified for direct porcelain fabrication. This system also has implant choices of varying thread designs suited for varying bone quality and architecture found in different regions of the mouth. In this case, a D2 thread design was used because of the porous cortical and coarse trabecular bone that is normally found in the posterior mandible.

Anesthesia, isolation, and a full-thickness flap were completed followed by sequential osteotomy formation with a series of drills using an electric handpiece, sterile water, and gentle force. A measuring tool was used to ensure that ideal placement resulted, with 2.0 to 3.0 mm of interproximal space between each of the implants, about 6.0 mm from the center of each implant. This was done to prevent gingival encroachment and to aid in cleansing ability.

Two 12.0-mm (long) by 5.0-mm (diameter) D2 implants were placed into the osteotomy sites (Figure 3). The prosthetic abutments were then removed, cover screws placed, and the tissues reproximated over the implants with 4-0 chromic gut sutures. The patient returned in 1 week for a follow-up visit; healing was exceptional without patient complaints. The patient was then given an appointment to be seen 3 months later for a single-visit prosthesis fabrication.

RESTORATIVE PROCEDURES
Many restorative materials (both porcelain-to-metal and all-ceramic) are aesthetically pleasing and also have the strength to replace posterior teeth. All-ceramic restorations like Procera (Nobel Biocare), 3G OPC (Pentron Laboratory Technologies), VITA In-Ceram (Vident), and many others have proven to be suitable for this purpose, and the porcelain choice today often is determined by the clinicians’ comfort and experience with the material.

CEREC (CEREC 3D [Sirona]) CAD/CAM restorations have more than 20 years of restorative success (Chart 1). The porcelain blocks used have wear very similar to natural enamel. An example of 2 porcelain choices for CEREC restorations are VITA Mark II (Vident) and ProCAD (Ivoclar Vivadent). Both have the ability to be stained and glazed and have proven to be cost effective, aesthetic, and...
suitable for porcelain crowns on natural teeth or implant abutments. VITA Mark II has proven to have durability and long-term success with a mean survival rate reported at a greater than 97% success rate for nearly 5 years; this is comparable to other all-ceramic materials. Wear rates for this porcelain is similar to natural enamel which may minimize the abrasion from opposing teeth.

The fit to the implant abutment is excellent, and their design, fabrication, and finish are simple and efficient with practitioner experience. These porcelain polishes well and can also be glazed to reduce the chances of plaque accumulation and implant failure from bacterial pathogens. Staining adds the benefits of a smoother surface and the ability to customize color of the monochromatic porcelain block. It also provides the least abrasive opposing surface and helps to hide abutment metal show-through. Glazing also produces the least abrasive surface for the opposing dentition and directly influences the strength of the CAD/CAM porcelain material (Chart 2).

The patient returned to the office 10 months after implant placement to begin restorative treatment. The first priority was to establish a posterior, vertical occlusal stop in order to stabilize occlusion and to allow for efficient implant crown construction (Figure 4).

The CEREC restoration was designed individually on the model, and the abutments were powdered and the entire quadrant was scanned by the CEREC 3D acquisition unit. From this image the restoration was designed in the Dental Database mode using a library of tooth shapes and sizes, which is refined and customized by the dentist. After about 5 minutes of design manipulation and 15 minutes of milling, the restoration was completed and the VITA porcelain was tried in the mouth (Figure 6). The occlusion and contours were adjusted with a finish diamond on a high-speed handpiece with copious water and left in a roughened, nonpolished state while verifying even contact with the contra-lateral side (Figure 7).

FIGURE 5. An all-porcelain preparation was done on the molar for the fabrication of a CEREC restoration, thus providing a definitive occlusion before the implant crowns were designed.

FIGURE 6. After milling, the porcelain is tried in and the occlusion adjusted.

FIGURE 7. All excursive movements are checked to ensure the lack of interferences or prematurities.

FIGURE 8. The titanium alloy Maestro abutments are screwed securely into place. The abutments have an anterotational bevel that can be placed on the facial aspect, thus providing additional porcelain thickness to help hide abutment show-through.

FIGURE 9. Laser-tissue recontouring around the distal abutment was followed by a polyvinyl siloxane impression.

### Chart 1. Advantages of CAD/CAM CEREC Implant Crowns

1. Efficient design and fabrication.
2. Reduced implant component inventory.
3. No need for temporary fabrication or problems.
4. Never heat buildup on abutments from temporary fabrication.
5. Excellent adaption of porcelain to abutment.
6. Tissue contact surfaces can be glazed.
7. Adjacent tooth contacts ideally controlled.
8. Wear similar to natural teeth.

### Chart 2. Hiding Metal Abutments Under All-Porcelain Restorations

1. Place abutment bevel toward the facial for added porcelain thickness.
2. Porcelain chosen with sufficient visual opacity.
3. Ample reduction of abutment preps.
4. Stain porcelain.
5. Use opaque luting cement.

### ENDO CROWN (TOOTH NO. 31) AS THE POSTERIOR OCCLUSAL STOP

Decay was excavated from tooth No. 31, and then a caries indicator (Sable Seek [Ultradent Products]) was used several times to ensure complete decay extirpation. An all-ceramic crown preparation was then finalized using a tapered diamond and an end-cutting diamond to flatten, smooth, and define the margins. As with all porcelain restorations, care is taken to ensure there are no sharp corners that may impart stress points within the final porcelain restoration. Ample porcelain thickness is ensured by a 2.0- to 3.0-mm occlusal clearance in all excursive movements and 1.5- to 2.0-mm buccal and lingual reduction. The preparation was designed to create maximum resistance and retention form by having porcelain fill the pulp chamber, extending about 3.0 mm into the pulp canals, thus increasing the surface bonding area (Figure 5).

The tooth was then isolated, a glycero-in based dusting adhesive applied (VITA CEREC Liquid [Vident]), a titanium dioxide reflective medium blown (VITA CEREC Liquid [Vident]), a titanium dioxide reflective medium blown, and the occlusion adjusted. The CEREC restoration was placed on tooth No. 31, and a “pull” impression was taken with a polyvinyl siloxane impression. The model was scanned by the CEREC 3D acquisition unit. From this image the restoration was designed in the Dental Database mode using a library of tooth shapes and sizes, which is refined and customized by the dentist. After about 5 minutes of design manipulation and 15 minutes of milling, the restoration was completed and the VITA porcelain was tried in the mouth (Figure 6). The occlusion and contours were adjusted with a finish diamond on a high-speed handpiece with copious water and left in a roughened, nonpolished state while verifying even contact with the contra-lateral side (Figure 7).
silo(xane (Splash! [Discus Dental]) in a prefabricated, quadrant bite tray (Ex-
acta Tray [Exacta Dental]). This was then poured in stone and mounted on a
simple (plastic), hinged articulator. Slight smoothing and recontouring of
the stone mimicking the gingival was done to allow for a smooth surface with
slight pressure on the tissues.

The CEREC machine is most adept at imaging abutments directly
without impressions taken or models made, however when multiple units
are made along with staining and glazing, it is often more time efficient to
verify contacts, contours, and occlusion from a model (Figure 10). The patient
was allowed to relax in the office for about 90 minutes.

To accurately incorporate a func-
tional mock-up occlusion into the restorations, the CEREC Correlation
mode was used.

Since there was no preoperative
anatomy to copy here, a light-cured
resin (Triad [DENTSPLY]) was used to
develop the anatomy. The model was
then lubricated with the Triad model-
release agent, the temporary resin
material placed on the model, the arti-
culator closed, and excess material
carved away with a lab knife. It was
then light-cured with an incomplete
curing time of 20 seconds to ensure
complete removal later.

In this design mode the preoper-
ative occlusal table, as well as some
facial and lingual contours, was
scanned into the computer and put
into the restoration by the computer
(Figure 11). Design time was lessened
because there were no occlusal con-
tours or heights to manipulate with
the computer. Intraoral fitting time is
less because gross occlusal adjusting is
seldom needed.

The mock-up was then powedered
with titanium dioxide and the entire
quadrant scanned into the acquisition
unit with 3 images (Figure 12). This
allows the design of the first implant
crown to be milled and virtually seated
in the computer so the second one can
be designed without re-scanning or
waiting. The computer used the por-
celain of tooth No. 31 and the tooth
mesial to the implant abutments for
reference points to align the mocked-
up occlusion (Figure 13).

During designing, the margins
were drawn 2.0 to 3.0 mm away from
the abutment and onto the gingiva
(Figure 14). This “overdrawing” of the
margin allows the porcelain to be
milled precisely to the tissue. However,
it will be relieved, rounded, and con-
toured after fabrication. Because of
tissue drift from No. 31 and the place-
ment of the implant, the author chose
to make a bicuspid in the area of tooth
No. 28 and a small molar in the posi-
tion of teeth Nos. 29 to 30 (Figure 15).

The occlusal tables were narrowed
cuspidally (slightly) to reduce the
chances of any parafunctional or ex-
cursive occlusal contacts (Figure 16).
The occlusion was then checked and
adjusted to have very light contact on
the implant crowns (Figure 17).

The CEREC restorations were
then stained and glazed in a single
bake over a 20-minute period and
then bench-cooled for about 5 min-
utes (Figure 18). During this time, di-
rect composite restorations were
placed on several other teeth utilizing
a microhybrid composite (Esthet-
X Micro [DENTSPLY Caulk]).

DELIVERY AND FOLLOW-UP
All 3 CEREC restorations were tried
in place and the occlusion was
checked (Figure 19). Since the CEREC
correlation mode was used, there was
very little adjustment made to the
occlusion. Slight adjustments were
made to the opposing arch porcelain
with a bullet-shaped finishing bur to
relieve an occlusal prematurity and
then polished with porcelain polish-
ing points (Dialite [Brasseler USA])
and a diamond polishing paste (Bras-
se].

Tooth No. 31 was isolated and the
preparation was scrubbed with alcohol
using a microbrush. The porcelain was
touched with hydrofluoric acid for 2
minutes and then silanated. The res-
toration was then placed with a self-
adhesive, dual-cured resin cement
(RelyX Unicem [3M ESPE]). Excess ce-
ment was removed and the restoration
was cured for 20 seconds from 3 sides
with a halogen light.

The implant abutment porcelain
was then tried in the mouth, sand-
blasted (Microetcher [Danville Engi-
nering]), silanated, and cemented
with an opaque, resin luting agent
(Insure Pink Opaque [Cosmedent]),
then baked over a 20-minute period and
cured for 20 seconds from 3 sides
in a unit with 3 images (Figure 12).

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cured for 20 seconds from 3 sides
in a unit with 3 images (Figure 12).

Figure 13. The posterior implant CEREC
restoration was designed while the first
implant porcelain was being milled. The com-
puter shows a “virtual seating” of the anterior
implant porcelain while it was being fabricat-
ed. A “virtual seating” of the completed
restorations on the molar and anterior implant
is done by the computer so that the distal
implant crown can be fabricated.

Figure 14. The design was done in Correla-
tion mode. The margins of the restoration
were drawn about 3 mm away from the abut-
ment onto the virtual gingiva. The porcelain in
these areas will be rounded, smoothed and
glazed so there is no positive gingival impinge-
ment by the porcelain.

Figure 15. Immediately after milling the
restorations, they were seated on the model
and the bite was adjusted.

Figure 16. The occlusal anatomy was refined
and the occlusal tables were slightly narrowed
cuspidally to reduce chances of interfer-
ences.

Figure 17. The endo crown on the molar was
in solid occlusion, and excursive movements
were checked to verify light occlusal contact.

Figure 18. Staining and glazing was done in a
single bake and bench-cooled in a total time
of about 25 minutes. One week after insertion
shows good aesthetics and healthy response
to gingival tissues.

Figure 19. The occlusion was rechecked sev-
eral times with articulating paper and areas of
porcelain adjustment were polished.

Figure 20. After 22 months, the function and
aesthetics are excellent and the long-term
prognosis is very good.

The patient was then seen at one
week and one month. Hygiene care
was reviewed at each of these appoint-
ments. Since the quadrant was re-
stored with individual teeth, flossing
and brushing are to be done with con-
vventional methods and reinforced
with the use of interdental brushes and
flossing aids.

CONCLUSION
Many implant systems, porcelain
materials, and restorative techniques
can provide serviceable restorations
when posterior teeth are missing.
These systems provide quality, depend-
ability, and efficient rehabilitation of
dentulous areas. The one-year follow-
up with this patient showed great
patient acceptance of the implants and
restorative materials. A recare exam
at 22 months continued to show good
function, wear, and tissue acceptance.
A very good long-term prognosis for
the restorations can be expected
(Figure 20).

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Disclosure: Dr. Griffin has no financial interest in any way with the products, materials, or suppliers used in this article.