The E4D in-office CAD/CAM unit has been employed in an investigative laboratory study to design and mill an unconventional IPS e.max restoration that would be coupled with the Tempcap as a final implant-supported crown. The combination of the Tempcap, in-office CAD/CAM procedures and e.max allows the clinician to create an immediate final restorative product with ideal characteristics.

The procedure is a simple, efficient and effective solution for the restoration of implants.

Following the surgical placement of a dental implant, several requirements must be met to maxi-
mize healing and osseointegration of the implant body to bone:

- Minimal forces, if any, should be exerted on the implant body, permitting proper healing and preventing a non-osseous union.2
- The gingival architecture must be managed meticulously to prevent contamination, minimizing the risk of peri-implantitis and possible failure.3
- There must be sufficient time for the process of osseointegration.4
- Temporization and immediate restorations should not violate these factors.5

The Tempcap (Research Driven, Ontario, Canada) is a healing cap and restorative platform combined (Fig. 1). It has an all-metal construction, and it contains two to three retentive pin projections (Fig. 2). Tempcap is available in different widths and heights to accommodate different implant sizes (Fig. 3) and is compatible with existing instrumentation (Figs. 4).

The function of the Tempcap is:

- to allow for optimal gingival healing
- prevent contamination of the surgical field
- minimize forces and micro-vibrations on the implant
- facilitate the simple yet successful restoration of the implant (Fig. 5).

CAD/CAM stands for computer-aided design and computer-aided manufacturing. CAD enables the individual to digitally capture an image of a prepared tooth or structure and then design an indirect (out of the mouth) restoration by using software.6

After the ideal restoration has been produced, the design is then fabricated out of a material by a milling machine. In-office E4D units (D4D Technologies) are currently available to allow for immediate chairside fabrication without the use of a commercial laboratory.

IPS e.max (Ivoclar Vivadent) is a relatively new metal-free dental material used in indirect restorations. It is an aesthetic material composed of lithium disilicate and has ideal physical and esthetic properties, allowing it to be the first choice for CAD/CAM restorations. IPS e.max has strength second only to gold and has the ability of detailed CAM production.7

**Methodology**

The Tempcap was selected and placed on an Ankylos (DENTSPLY) implant body (master cast with soft tissue) (Fig. 6). Digitization was achieved by using an E4D camera (Fig. 7), in which several images were captured to compile an accurate image (Figs. 8 and 9). CAD design was used with E4D software to determine and delineate margins (Fig. 10).
Tooth design was initiated incorporating several parameters:

- ideal esthetics and emergence profile (Fig. 11)
- adequate proximal contacts
- appropriate occlusal scheme
- material thickness requirements
- internal surface morphology to adapt to Tempcap
- design that can be milled via CAM technology

Numerous design iterations were required to achieve the desired design requirements (Figs. 12-14). IPS e.max was selected for milling (Fig. 15) and was executed by an E4D CAM unit (Fig. 16). Milling limitations, such as bur contact and prosthesis fracture, required CAD design modifications. Reiterations in CAD/CAM design were carried out until a successful restoration was achieved (Fig. 17).

The unfired IPS e.max crown was tried for fit and esthetics and then subsequently fired (Fig. 18), resulting in its color change. The crown was further stained, glazed and fired (Fig. 19), resulting in a highly esthetic final restoration (Fig. 20). The restoration’s internal aspect (Fig. 21) was assessed.
for path of insertion, retention and fit.

The IPS e.max prosthetic crown was further assessed for fit, taking into account marginal fit, occlusion and proximal contacts (Fig. 22).

A secondary investigation utilized a more complex Tempcap to assess the limit of the CAD/CAM unit’s capability. A stand-alone Ankylos (DENTSPLY) implant body was coupled with a Tempcap abutment with three retentive pin projections (Fig. 23). The abutment was digitized with the same methodology as described. An IPS e.max crown was executed and assessed (Figs. 24 and 25).

**Discussion**

This study has determined that the Tempcap can be successfully and accurately digitized and milled by in-office CAD/CAM technology (D4D Technologies) to create an ideal prosthetic crown from IPS e.max within a laboratory setting. CAD software can be manipulated to generate forms beyond the scope of the unit.

Complex units, such as the three-pronged Tempcap may be successfully designed and milled. IPS e.max has the capability to be milled in com-
plex patterns, while still maintaining its structural integrity.

However, further laboratory studies, quantitatively assessing stresses and strengths and utilizing a larger sample size, are required to validate the concept. Subsequent clinical investigations are required to assess the clinical significance and viability of the Tempcap with CAD/CAM technology. The potential to fabricate the Tempcap entirely from e.max should also be considered.

**Conclusions**

In-office CAD/CAM technology can be utilized and manipulated to generate digitized forms beyond the scope of the morphogenesis. CAM manufacturing has limiting factors that must be realized when producing modified prostheses. CAD modifications must account for these discrepancies. IPS e.max has the ability to be milled in extremely detailed designs.
The Tempcap can be optically scanned and digitized in order to design and create a CAD/CAM IPS e.max restoration using E4D technology. The utilization of the Tempcap as a successful provisional abutment has been documented1; the utility of the abutment as a simple, efficient and cost-effective component seems promising. These advances simplify the procedure and reduce the cost, ultimately allowing a greater accessibility for both patients and clinicians.

Editorial disclaimer: Dr. Les Kalman is the co-owner of Research Driven and the inventor of the Tempcap.

References