Clinical

CAD/CAM restorative principles

Costin Marinescu[1]

Introduction

CAD/CAM is part of "today" in dentistry and is defining the future faster than we think. More than 25 years have passed since the first system was introduced on the market, and the current advancements in restoration design are vastly superior. Certain aspects in the designing stage require more attention as the current CAD/CAM platforms in dentistry necessitate a wealth of information in order to design specific occlusal schemes, interproximal contacts, or anatomical features specific to individual patients. The lack of virtual information can be, however, compensated through proper diagnosis of the condition that generated the need for a new restorative treatment. An accurate diagnosis and proper treatment planning lead to the design of a prosthesis with true restorative and preventive values.

Pioneered by W. H. Mörmann[1] in the early 1980s, the first CAD/CAM system, CEREC, (Sirona Dental Systems) opened the era of CAD/CAM in dentistry (Figure 1). The evolution of CAD/CAM has been almost exponentially fueled by the continuously in creasing computing power and the development of more precise and accurate acquisition units as well as milling machines. Nowadays, the E4D system (D4D Technologies) is capable of acquiring an image without the use of titanium/zirconium dioxide powder; the Lava C.O.S. system (3M ESPE) can capture images from a live video stream of data, and so on (Figure 2).[2] In the near future, impression materials will most likely become obsolete, and errors related to pouring a cast will soon become a thing of the past. In a few years, everything that is involved in a dental impression material will be measured only in bits (ones and zeros) and not in water/powder and filler/catalyst ratios.

With the CAD/CAM systems, the milling precision is conditioned by various factors but, most importantly, by an

Figure 1: Three-dimensional image capture of left mandibular first premolar and adjacent teeth.

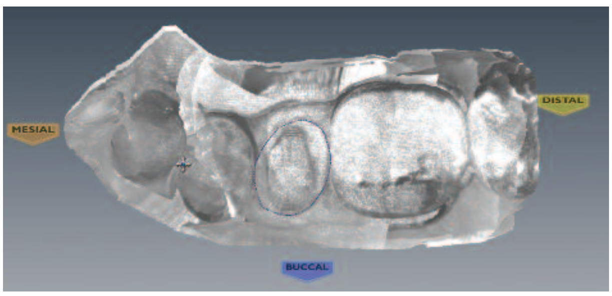

Figure 2: E4D's ICE (I See Everything) mode image capture (D4D Technologies).

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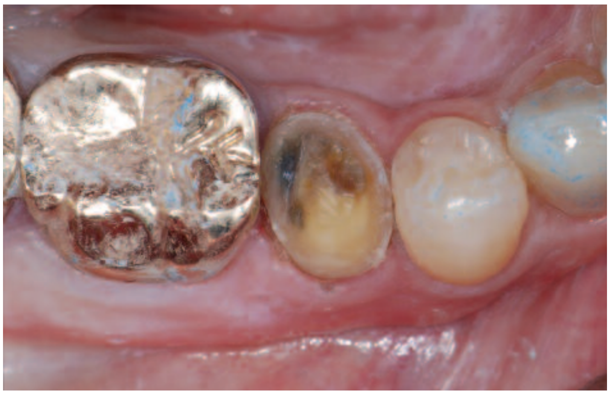

Figure 3. Left mandibular first premolar prepared with 1mm shoulder margin and 90° exit angle.

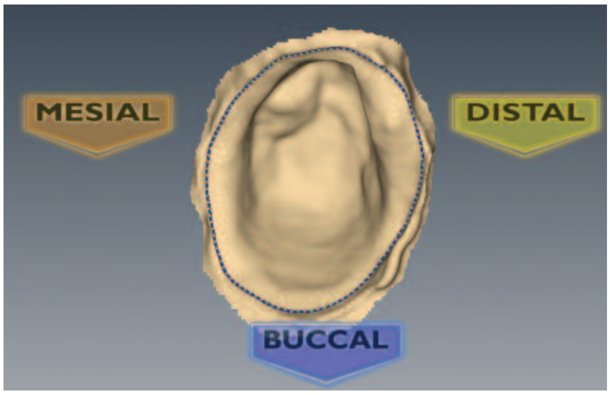

Figure 4. Outline of the preparation's margin

accurate impression (Figures 3 and 4).[3,4] This actually represents an amazing positive aspect of the CAD/CAM technology. Sources of errors such as impression distortions, die stone volumetric modifications, or casting imperfections specific to the traditional refractory cast fabrication simply disappear. Other challenges arise though, and they are mostly related to software design, operator skill, and milling technologies. One of the most important challenges that CAD/CAM technology faces today in dentistry is the capability of generating restorations that integrate functionally, aesthetically, and biologically, not only with the existing dentition but with the entire system of joints, muscles, and teeth, all constituting the stomatognathic system. Currently, in order for the CAD/CAM software to generate a customized virtual restoration, automatic measurements of the adjacent teeth are taken and the proposed restoration's anatomy is matched to the existing occlusal morphology specific to each patient (Figure 5).[5] However, the future belongs to the virtual articulators that will collect data imported directly from radiographic cephalometric measurements, temporomandibular joint (TMJ) geometry, and muscle biometric parameters.

The most important idea behind designing a dental restoration in the CAD environment is related to the restoration of form in correlation with the function. Furthermore, the altered function due to individual factors specific to every patient is an equally important aspect that takes the design of the restoration from an anatomically determined form to a customized, functionally driven design. In almost every instance of an inlay, onlay, or any other coronal or implant prosthesis that is fabricated, one of the most important determinants of the future form is the diagnosis of the initial condition that generates the need for a new restorative treatment. The examination and, implicitly, the diagnosis of the dental pathology define the restoration's specific characteristics such as design, material selection, occlusion scheme, and aesthetic integration. The coronal emergence profile along with the preparation margin's placement play a major role in the periodontal health prognosis (Figure 6).[6] A 90° exit angle at the preparation margin paired with an approximately 90° restoration fit on the preparation margin ensure optimum distribution of forces from the restoration to the tooth structure. The 90°

Figure 5. Bite registration using soft wax to create a dynamic registration.

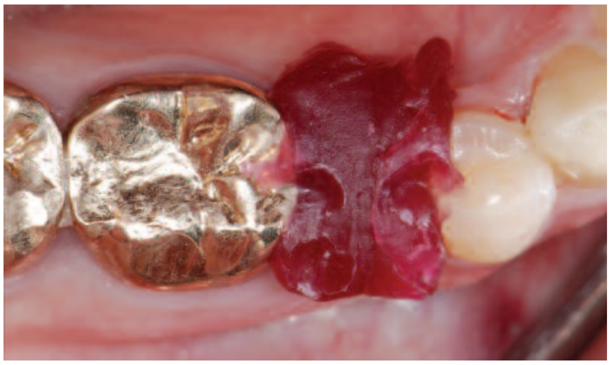

Figure 6. Bite registration using soft wax—static registration.

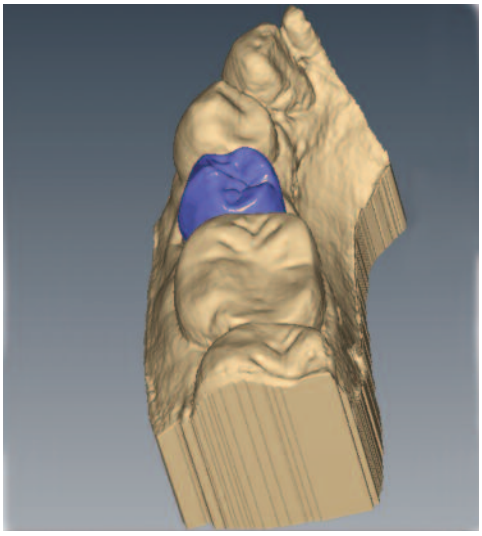

Figure 7. Computer generated restoration - cusp alignment.

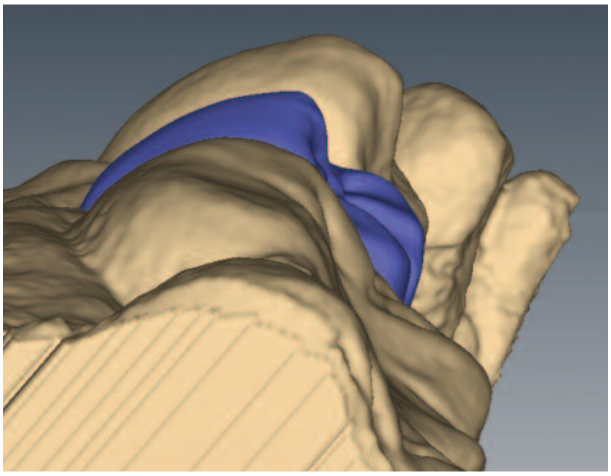

Figure 8. Crown's buccal contour alignment.

exit angles for all-ceramic restorations as well as the tooth preparation's margins generate a minimum amount of horizontal components of force upon the distribution of occlusal forces to the existing tooth structure (Figure 7).[7] In the CAD/CAM environment, it is difficult to evaluate the root surface emergence profile unless very careful tissue retraction is performed or the preparation margin is placed supragingivally. In many instances, the cloning technique can supply valuable information about the emergence profile and the occlusal scheme. However, it is important to determine if the preoperative emergence profile and occlusal scheme are conducive to optimum periodontal health and complement a balanced occlusion. If not, modifications to these parameters are recommended within the limitations of anatomical form and function (Figure 8).[8]

Case report

A male patient, age 65 years, requires a new full-coverage restoration for the left mandibular first premolar. Upon the 3-dimensional image capture of completed preparation, the image is positioned for the optimum restoration path of insertion and occlusal plane. The image acquisition can be done either using titanium oxide powdering or not, depending on the CAD/CAM system used. Gingival retraction is critical, but it is often difficult to obtain the root's emergence profile angulation (Figure 9).[9] In such cases, the cloning step would prove itself very useful in approximating of the restoration's emergence profile. The bite registration scanning can be a very tricky step as the current systems can record only static images while dynamic bite registration technologies are just being developed (Figure 10).[10]

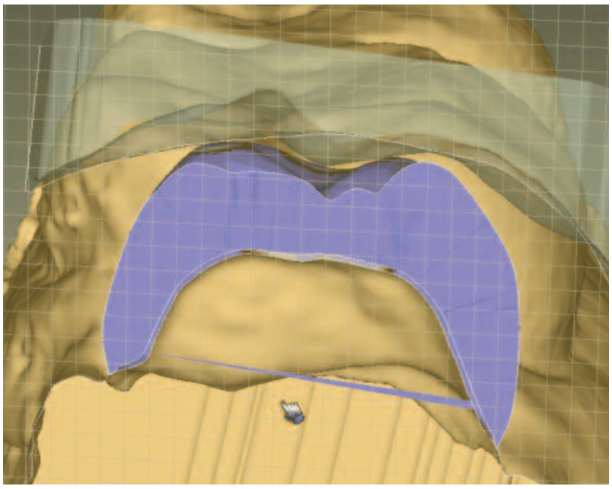

Figure 9. Occlusal relationships between the restoration and opposing dentition.

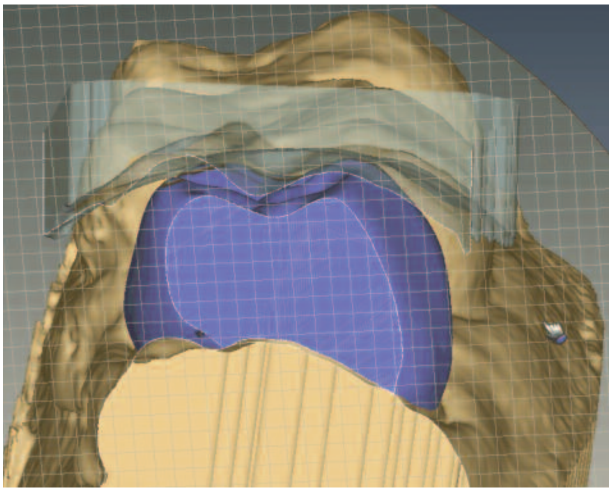

Figure 10. Occlusion.

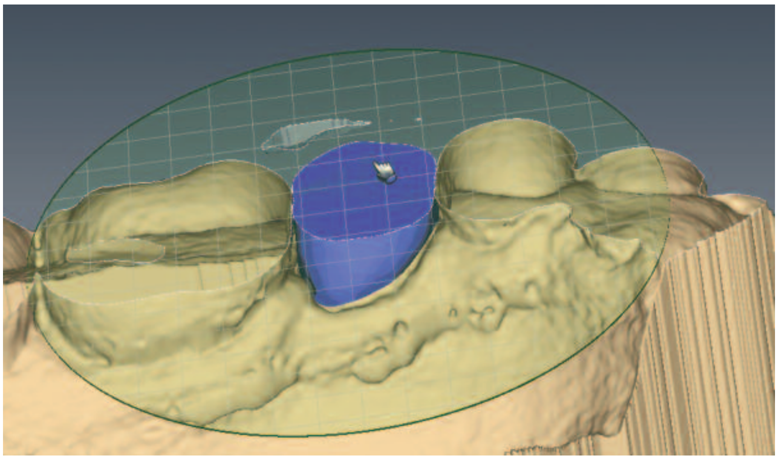

Figure 11. Interproximal contact distribution.

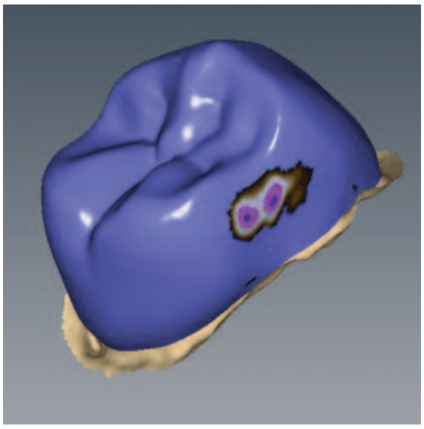

Figure 12. Distal contact.

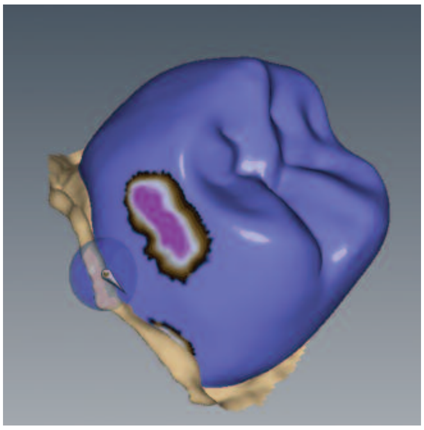

Figure 13. Mesial contact.

In the near future, with the event of merging data from computed tomography scans of the TMJ and the digital recording of the mandible protrusive and lateral excursions, the bite registration information can be enriched with relevant data toward constructing the optimum occlusal contacts and guidance for the new restoration.

With the use of a molded material such as wax, we can instruct the patient through all mandible excursions while the wax is recording the patterns. Consequently, while designing the restoration's occlusal aspect, we can evaluate the possibility of occlusal interferences and implicitly the cusp's steepness.

While this occlusal design might not be matching the TMJ anatomical configuration, in the absence of joint, muscle, or occlusion pathology, we can assume that this occlusal pattern approximation is acceptable. In our case, the relationship of "tip of the cusp/bottom of the fossa"[11] (Figure 11) will be used in the design of this restoration due to the lack of more intricate data about the joint anatomy or mandible's excursive patterns.

The interproximal contacts are also essential design features of the future restoration (Figure 12).[12] Not only is the contact strength important, but also the position and area of force distribution.

Coordinating all these parameters can be difficult, because it does require information such as:

- The contact intensity of adjacent teeth in the quadrant
- The position and volume of interproximal papilla
- The presence of any periodontal conditions with/without tooth mobility
- The individual anatomical characteristics which can be quantified by observing a contralateral corresponding tooth (if available).

The qualitative aspect of the interproximal contacts has a significant impact toward reaching a stable occlusion scheme (by preventing the tooth migration on a horizontal component) (Figure 13).[13] Periodontal health is especially correlated with the quality of interproximal contacts and

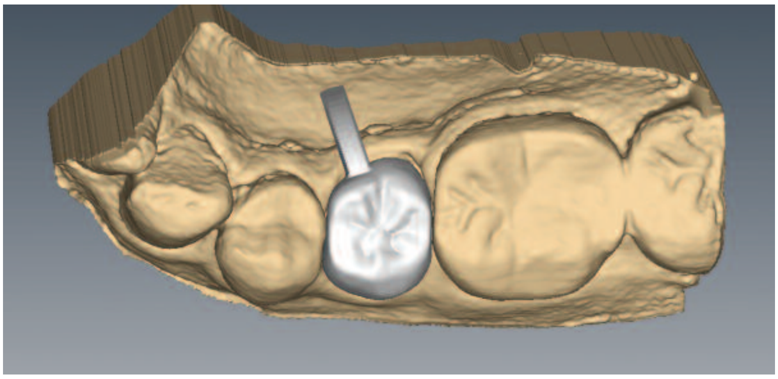

Figure 14. The sprue is placed at least one mm away from the cementable margin.

embrasures as it is highly sensitive to modifications in food trituration dynamics. Having as a baseline the ideal contact position for specific teeth in the adult dentition[14] (Figure 14), we can start developing a plan for the individual contact characteristics by taking into consideration the patient's specific factors that define his dentition and, very importantly, the path ology that led to the need for a new restoration. In many instances, such as an open contact, papilla recession, post crown lengthening or orthodontic treatment, the contact design plays a very important role in the curing and/or preventing the original pathological condition. In the design of this particular case, the contact strength is calibrated at zero, as through the glazing procedure approximately 50-μm thickness will be added to the over all ceramic surface.

The glaze thickness is variable depending upon the type of ceramic used and individual technique. As a result, this stage of the restoration design and fabrication becomes highly dependent on subjective factors that vary within the interval defined by the ceramic material manufacturer and the established glazing technique. Regardless of the variability incurred in the crystalizing, baking, and glazing step, the results need to be standardized and properly quantified as they are retroactively meaningful in the earlier stages of virtual restoration design (such as the occlusal and interproximal contact strength). Once the restoration has been milled and lab processed (in our case, polished, glazed, and then intaglio-etched using 4.9% hydrofluoric acid), it is delivered to the patient through cementation using a self-adhesive resin cement (RelyX Unicem, 3M ESPE).

Conclusions

The CAD/CAM systems used today are indeed very powerful and allow us, the clinicians, to offer our patients precise restorations as part of services that come closer and closer to the concept "on demand"[15,16] (Figures 15 and 16). There still is room for improvement when it comes to designing restorations integrated with the entire stomatognathic

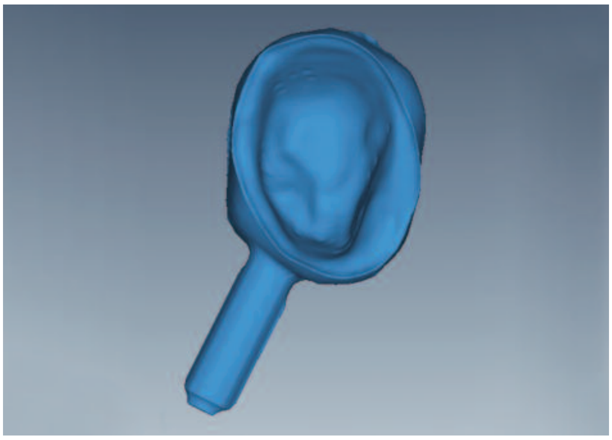

Figure 15. Intaglio view of the restoration.

Figure 16. Full-coverage all-ceramic (IPS Empress CAD [Ivoclar Vivadent]) restoration cemented with a self-etching adhesive resin cement (RelyX Unicem [3M ESPE]).

system of teeth, muscles, joints, and all the associated supporting structures. The data acquisition technology needs to keep up with the processing computing power as the software development needs to learn more from the experience and variability of human nature. In dentistry, the integration of data pertaining to the anatomical and physiological aspects of the mouth needs to seamlessly collaborate with objective and subjective factors that pertain to each individual patient, such as medical history, preferences, habits, lifestyle, and personal expectations.

Disclosure

Dr. Marinescu reports no disclosures.

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