The digitized occlusion:
Using something old with something new

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Fig. 1_Tooth #30 being designed in the CEREC Software 4.0.
Fig. 2_The Biogeneric calculation evaluates adjacent teeth or user-defined teeth.
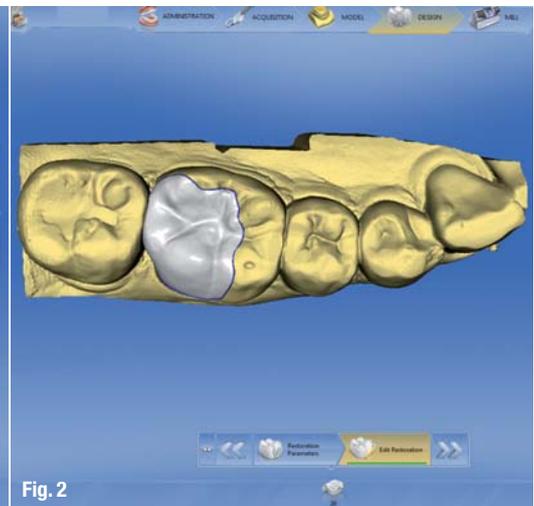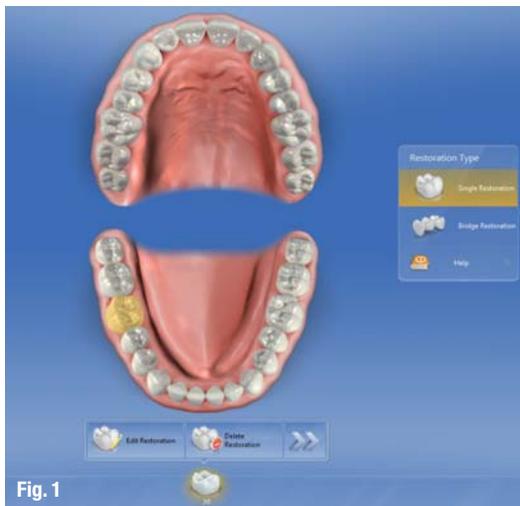

Fig. 1

Fig. 2

Fig. 3_Occlusal and interproximal contacts are also taken into consideration.
Fig. 4_The clinician has control of the "Biogeneric Shape" by scrolling through its database of teeth.

_There is an envelope of occlusal function that we are constantly mastering for our patients. Many times it is exceptionally easy to find a position or shape of a tooth that fits within the patient's comfort and functional zones. However, there are many instances where it can be quite challenging. Using something old with something new can be of great assistance to achieving a restorative shape that the patient will immediately find comfortable.

_Using something new

Computerized dental anatomies have greatly evolved over the years. There was a time during CAD/CAM computer design where only limited
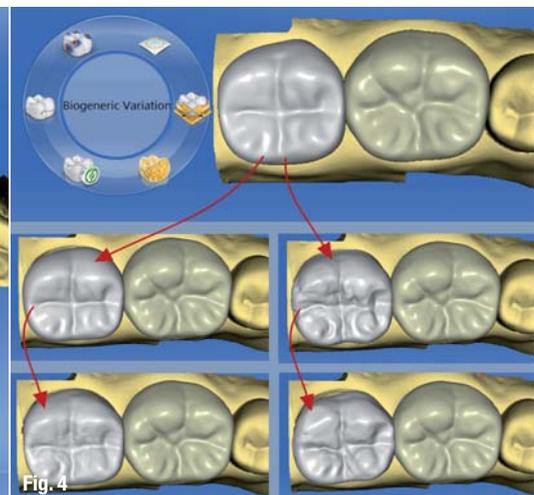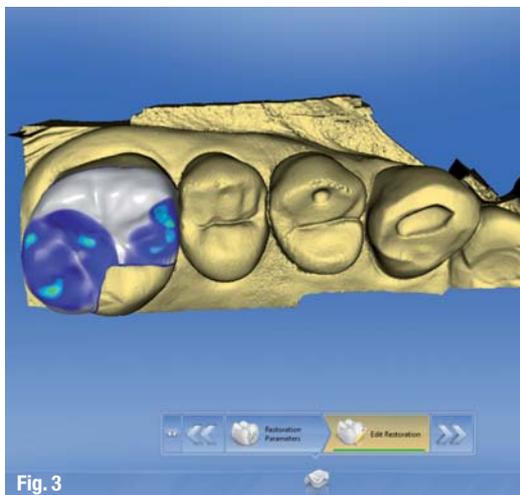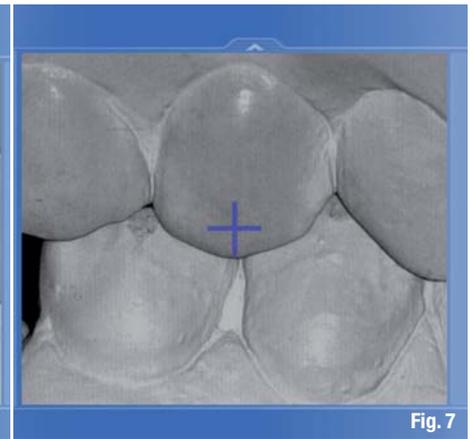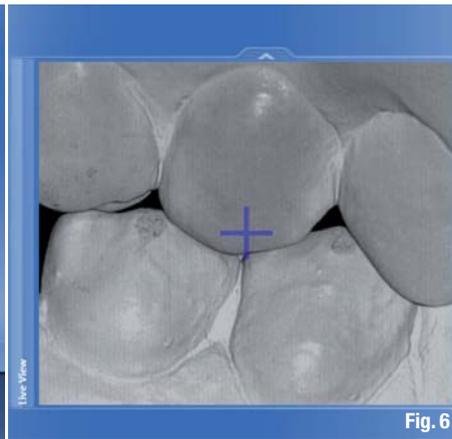

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7
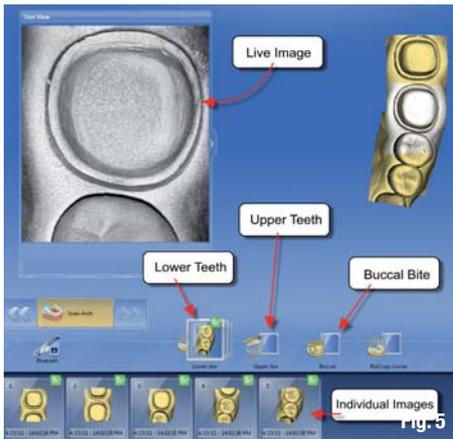
anatomies were available, and these patterns had to be manipulated greatly by the doctor to fit the clinical situation. This made for a longer design time and, most importantly, made the restoration appear more natural.[1] Today, there are more advanced mathematical calculations for dental anatomy.

Modern tooth-modeling software uses a database detailing the measurements of several thousand naturally occurring tooth samples. Common structures such as cusp tips, cusp slopes, marginal ridges and fissures give the blueprint for computer determination of the "average tooth." The differences between this average tooth and the scanned referenced teeth make up the core for the mathematical calculation, much like with facial recognition software used by government intelligence agencies. Analysis reveals that only 20 data location points are necessary to describe 83 per cent of the variability in naturally occurring tooth surfaces.[2, 3, 4, 5] This mathematical calculation for tooth morphology therefore predicts the virgin state of the tooth.

It has been shown to have a digitally proposed surface within 156 μ of the original surface.[1] Be-

cause the described process obtains its results through data derived from naturally occurring teeth, the method is referred to as "Biogeneric tooth modeling."[2, 3]

This mathematical calculation of dental anatomy starts with designating the tooth number to be designed. This establishes which database of dental anatomies that it will use to determine the calculations. In other words, the true tooth number needs to be selected for the calculation, or a different tooth number anatomy will be generated (Fig. 1).

The next step for the calculation is to show the computer a tooth that it can use for guidance on the proposed design. This can be done a couple of ways. Primarily, a tooth within the prepared quadrant (not the prepared tooth) will be analyzed automatically by the computer, and is typically the distal neighbor of the prepared tooth (Fig. 2). If the clinician knows of a better tooth to reference, this can easily be selected within the prepared arch, within another area of the dentition, or even off a model. This referenced dataset will trigger the computer to search the entire database, which may contain hundreds of different virgin anatomies for that particular tooth number.[2, 3, 4]

Fig. 5_Digitally scanned teeth are organized into specific libraries.
Fig. 6_During imaging, the position of the upper and lower teeth is not correct and space is seen.
Fig. 7_The dentist sees the error and instructs the patient to close properly.
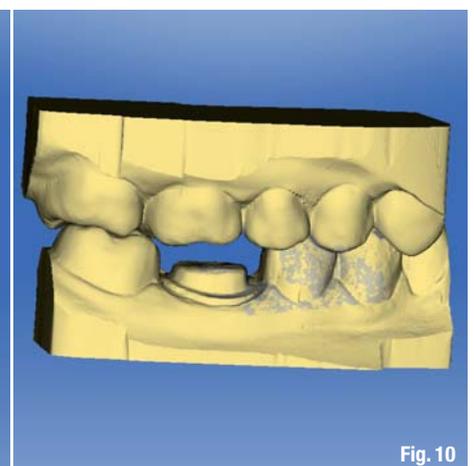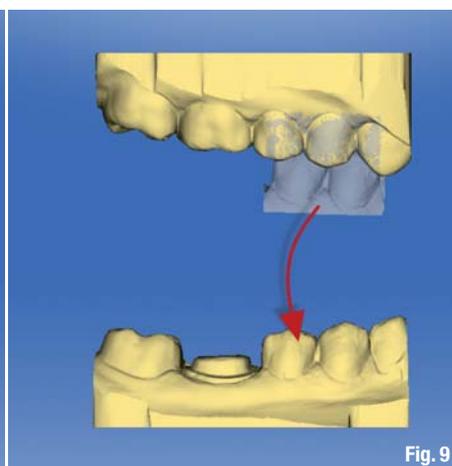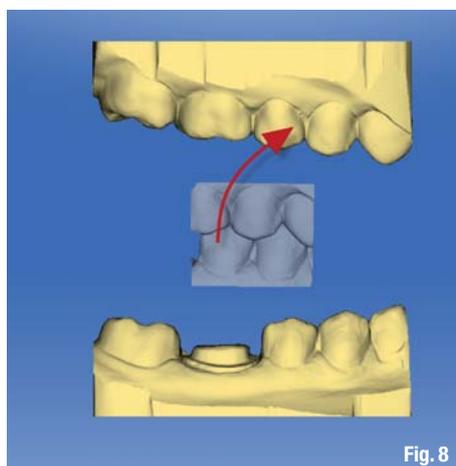
Figs. 8 & 9_The buccal bite images are used to articulate the upper and lower models.
Fig. 10_The digital articulation is completed.

Fig. 8

Fig. 9

Fig. 10

The computer proposal will morph into various shapes as it is going through the calculation. It also looks for ratios of tooth size and position within the arch. This is a great advantage, because these digital dental anatomies are not limited by size, but can fit within any range of tooth dimensions. The finalized digital anatomy is a reflection of what the computer discovered through its analysis of the reference tooth. It also places the three-dimensional shape in contact with the opposing teeth (Fig. 3). If the clinician would like to see variations of the Biogeneric calculation, a slider allows that to happen. This tool is referred to as "Biogeneric Variation." If images have to be re-taken, "Biogeneric Variation" is the new name (Fig. 4). The slider travels through

Fig. 11

Fig. 11_The prior crowns are removed and teeth prepared.

anatomies within the Biogeneric database and reveals them through morphing of the proposal. This allows for a truly customized shape for the clinical situation, and within function.

_Digital scanning

During the course of treatment, the upper and lower arches or quadrants are scanned into the computer using the CEREC Bluecam digital scanning camera. The CEREC system can have multiple preparations within the same arch or in opposing arches. Each arch is saved in its corresponding library of images within the software and evaluated for quality of margin integrity, path of draw, preparation geometry, etc. (Fig. 5). The major advantage of digital impressions is that the physical impression is eliminated from the process. This allows for immediate feedback to the clinician if the information is correct, rather than waiting to evaluate the inverse of the physical impression many minutes later.

There are never any tears or bubbles with digital impressions. They also never distort. Therefore, they have tremendous value to the doctor and the patient, especially because the images are taken so easily and within a minute. After the upper and lower arches are captured, they are articulated by images taken from the buccal direction.

The articulation for the upper and lower jaws is done in a static maximum intercuspation position utilizing what is referred to as the "buccal bite." This would be similar to a triple tray type using physical impression material, but by doing it digitally, the position never changes. Articulation of the models is completed within the software, and the maximum intercuspation position is always repeatable. There is never flex or variation with the articulator because of its digital nature. Therefore, if taken correctly, the buccal bite can place the maxillary and mandibular teeth in a very specific position that can be designed to within microns of space.[5] Another major advantage of an optical buccal jaw registration is that the position can be seen in the computer as the scan is taking place, much like when preparation images are being taken.

How many times does a patient try and help the procedure by biting toward the area of work during an impression? Or, can you even find their centric occlusion through impression material and while anesthetized? The relation is hidden under physical impression material, and may not be realized until physical stone models are mounted on an articulator. However, with digitally scanned articulation, it can easily be seen that it may be incorrect, or the jaws are not stable, during the imaging (Fig. 6). The clinician simply stops the scan, coaches the patient into the proper position, and then scans again (Fig. 7). This greatly enhances the predictability of occlusion of the final restoration.

The operator takes control of the articulation of the three models: upper, lower and buccal bite. The buccal bite is dragged to the corresponding portions of the upper and lower models. The software then recognizes similar surfaces and "shrink wraps" the buccal bite down. The same is done for the opposing arch. This establishes the digital maximum intercuspation position within the software (Figs. 8–10).

The repeatable digital maximum intercuspation position also allows for multiple units to be designed in a highly predictable manner. Whether the restorations are being designed side by side or from one arch to another, the occlusal morphology and pinpoint placement of occlusal stops can be confidently placed knowing the arches are stable within the digital world.
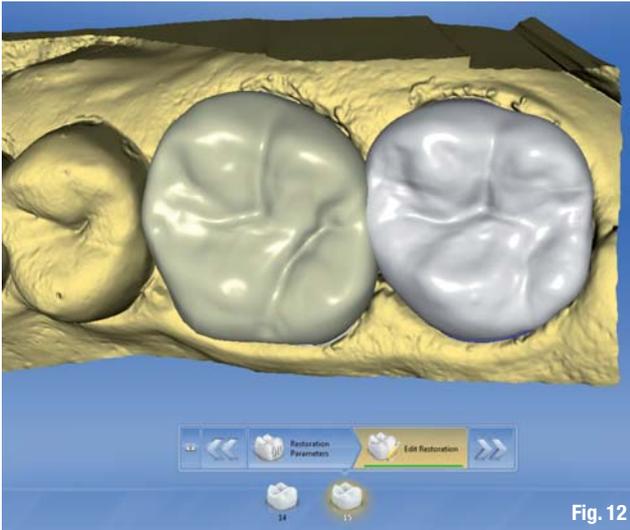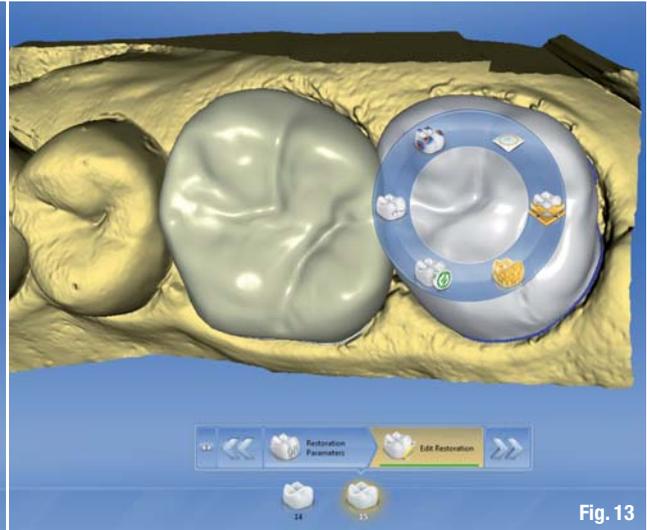
Fig. 12

Fig. 13

_Case 1

A 45-year-old female presented with two por-celain-fused-to-metal crowns with recurrent caries on tooth numbers 14 and 15. They were estimated to be about five years old. Her chief complaint was that it was difficult to floss between them. Clinically, the crowns had very tight interproximal contacts and closed embrasures. Dental floss was nearly im-possible to penetrate through the contact, and re-current caries subsequently developed (Fig. 11). The crowns were removed, core build-ups completed, and the intraoral scans taken:

_Preparation quadrant (upper left);
_Opposing quadrant (lower left);
_Buccal bite images.

The models within the CEREC Software 4.0 were articulated, and the Biogeneric calculation was com-pleted for the two teeth. Because the interproximal contacts were of utmost concern for the patient, both designs were manipulated at the same time to achieve better contact strength and embrasure shape. The interproximal contact between 13 and 14 was designed to mimic the same shape between 12 and 13. The initial Biogeneric proposal for #15 placed the mesial portion into the distal of #14 (Figs. 12, 13). Right-clicking the proposal brought up the myriad of tools to adjust the proposal (Fig. 14). A tool was selected that would reposition just the mesial portion of #15. It could then be repositioned in any direction (Figs. 15, 16). It was simply moved distally. A broader contact was established between the two designs, but with better embrasures than the prior crowns. Minor customization of the occlusal scheme was then done.

The digital crowns were milled with CEREC's MC XL milling chamber out of IPS e.max CAD blocks (Ivoclar Vivadent). Each crown milled in roughly 10 minutes

Fig. 12_The initial proposals for 14 and 15 were excellent; however, 15 encroached into 14.
Fig. 13_A design tool wheel emerges when right-clicking on the design.

Fig. 14_The mesial portion of 15 was selected for movement.
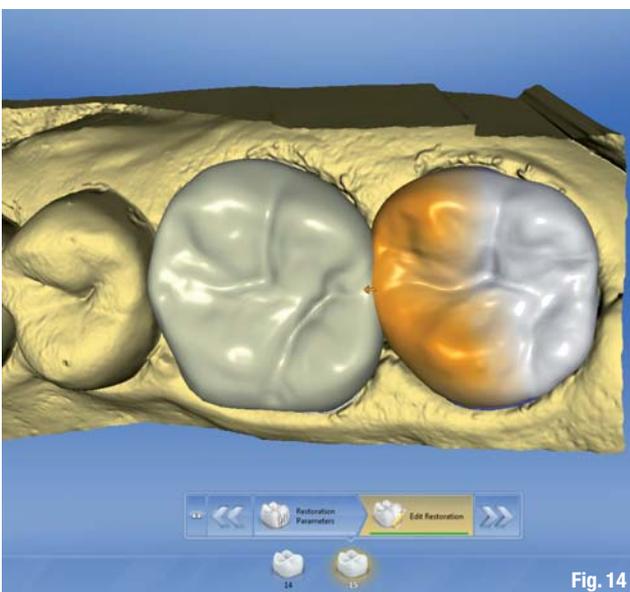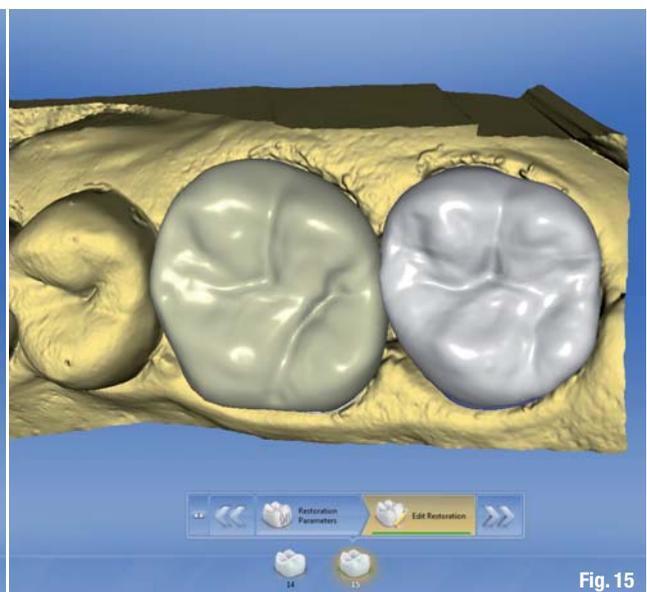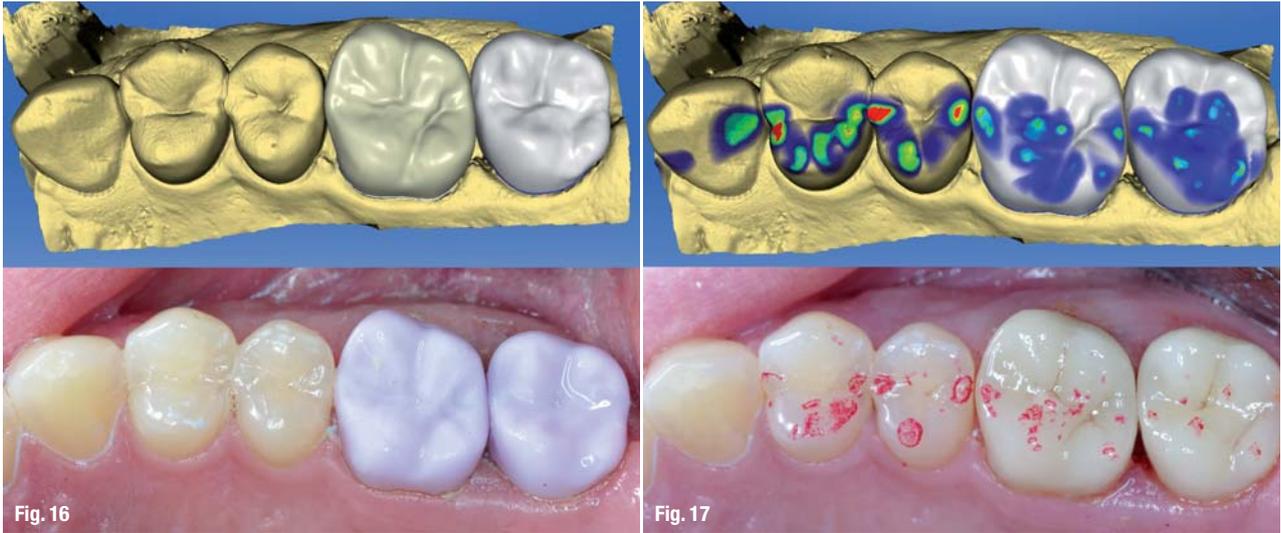**Fig. 15**_The mesial portion was moved into the appropriate position.

Fig. 14

Fig. 15

Fig. 16

Fig. 17

Fig. 16_A comparison of the final Biogeneric anatomy and milled IPS e.max CAD prior to firing.

Fig. 17_A comparison of the finalized CEREC occlusal contacts with occlusal contacts made intraorally.

Fig. 18_An old restoration may still have valuable occlusion information.

Fig. 19_The preoperative model is spliced with the preparation model during imaging.

and they were tried in to evaluate fit and interproximal contact. The crowns were then fired in a ceramic oven CS (Ivoclar Vivadent) to convert the lithium metasilicate material ("blue block") into the final lithium disilicate structure known as e.max (colour conversion and glazing also occurs during this process).

The crowns were removed from the oven, tried in and inserted. Because of the accuracy of CEREC's design calculations, easy modification methods and milling accuracy, no adjustment was required for this case (Fig. 17). The patient was shocked that there were no adjustments, as she remembered multiple adjustments being made for her prior restorations. She was quite pleased with the result.

_Using something old

Many times, large direct restorations will fail and eventually require an indirect restoration. The oc-

clusal pattern of the old restoration may not have detailed anatomy, but it most likely has the occlusal guidance paths already worked out over many years of service. For instance, a tooth may have a very large amalgam restoration with recurrent caries that requires replacement. Although failing, it has tremendous value to the design steps in the CAD software. The surfaces of the restoration have the occlusal motion paths developed over it (Fig. 18). Using the pre-operative surface as a guideline for a digital restoration could very well aid in preventing occlusal interferences from being designed into the restoration. This is a feature within the CEREC program, and is referred to as "Biogeneric Copy." This is an alternative method from the Biogeneric Tooth Model "Biogeneric Individual" with buccal bite articulation.

The pre-operative occlusal pattern is easily scanned into prior to treatment. This is usually done while waiting for anesthesia, and is done similarly
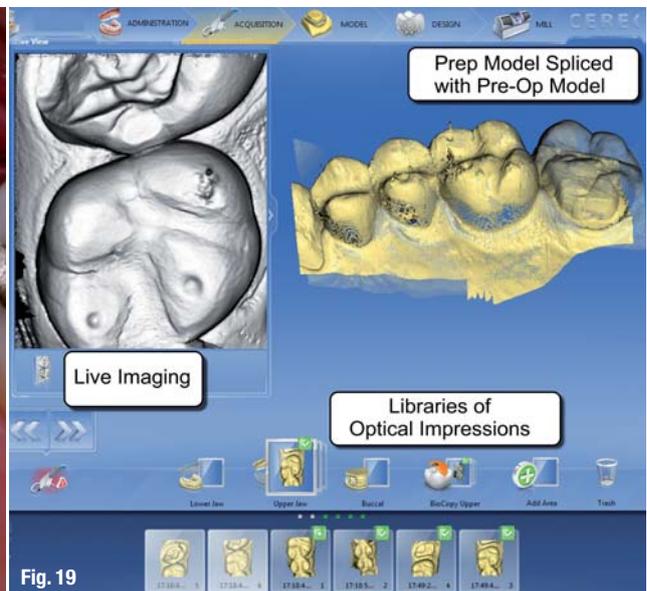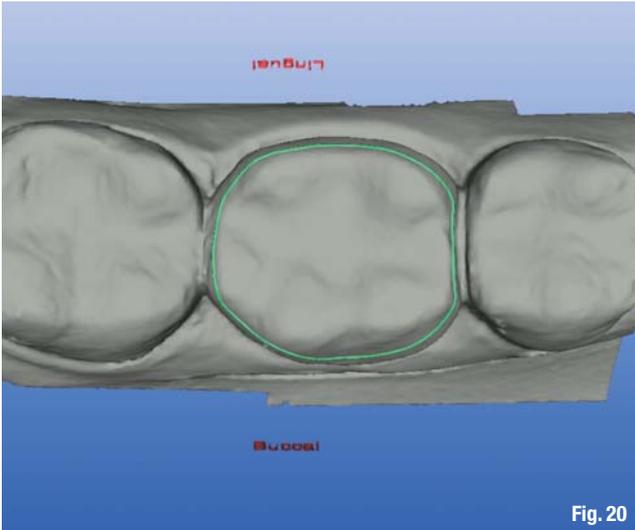

Fig. 18

Fig. 19

Fig. 20

Fig. 21

to a physical impression to be used for a provisional restoration. A pre-operative scan must accurately capture the three-dimensional shape of the soon-to-be-prepared tooth, along with adjacent teeth. Crossing the midline is not usually necessary unless working on anterior teeth. The adjacent teeth's anatomies are used as stitching abutments within the software. This means that the pre-operative model will be compared with the prepared tooth digital model and the two models are spliced three-dimensionally (Fig. 19). If the stitching abutments within the preoperative model and the prepared model were not the same or lacking data, the models would not be able to be spliced. The scanned data is saved within the program and used later during the restoration design phase.

The design phase of Biogeneric Copy is simply drawing a zone for which the computer will duplicate (Fig. 20). Then the design is manipulated as the clinician sees fit. Decisions can be made for resto-

ration shape while comparing the proposed design to the pre-operative scan taken before tooth preparation. The pre-operative surface is essentially a shell to construct the digital design of the restoration. The Biogeneric calculation determines the rest of the areas outside of the copied zones. The design (in white) is compared to the pre-operative scan (in gray) (Fig. 21). A speckled gray/white appearance shows that the two surfaces are in complete congruence. For any area where there is white, it is protruding outside the boundary of the original tooth surface and may cause an interference with occlusion. With good clinical judgment, this is usually not a problem.

_Case 2

A 38-year-old male went through extensive jaw surgery and orthodontics to alleviate a severe class 2 malocclusion. His vertical dimension of occlusion was opened up about 2 mm in the posterior and

Fig. 20_A circle is placed to designate areas for the computer to copy the preoperative surface.
Fig. 21_The preoperative shell (gray) is compared to the digitally designed restoration (white).

Fig. 22_New vertical dimension of occlusion established intraorally with composite and ready for reproduction in ceramic.
Fig. 23_The finalized ceramic crowns (IPS e.max CAD) at 18, 19 and 20 reflect the occlusion and shape established in composite.
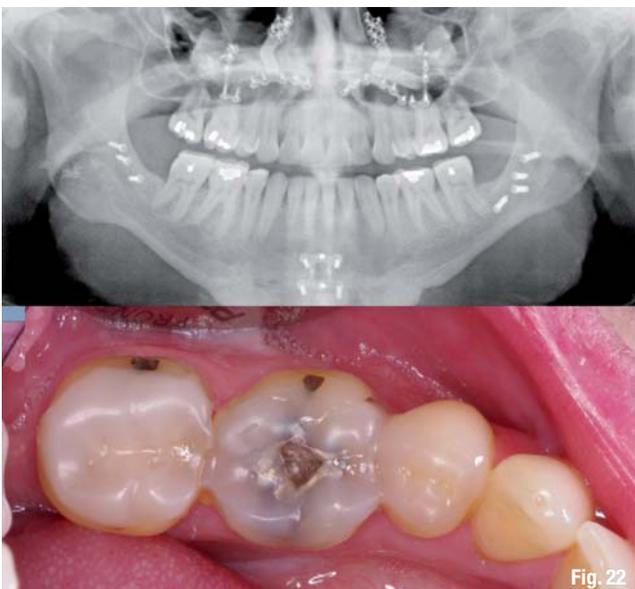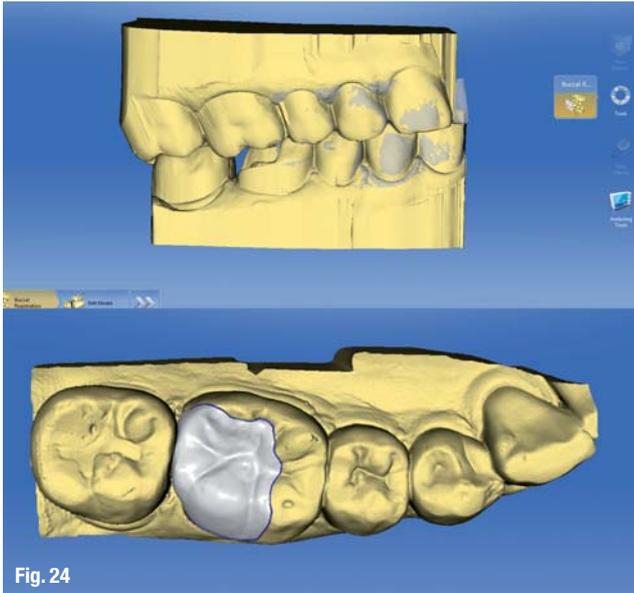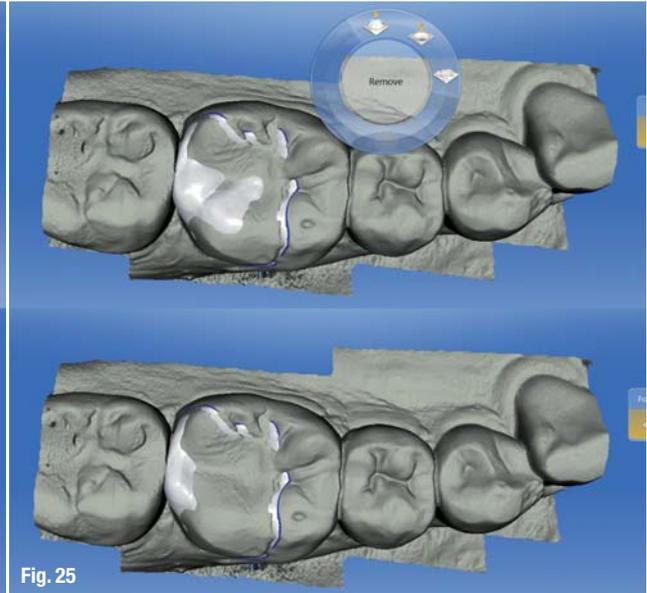

Fig. 22

Fig. 23

Fig. 24

Fig. 25

Fig. 24_The upper and lower models were articulated and the Biogeneric proposal was calculated.
Fig. 25_The Biogeneric proposal was compared with the preoperative amalgam surface and adjustments were made.

stabilized with composite. Over the course of many months, the composite was adjusted and monitored for chewing efficiency and comfort (Fig. 22). After many occlusion checks in the office, it was time for the definitive restorations.

Having all of the patterns of occlusion agreeable to the patient, the three-dimensional shapes just needed to be reproduced into ceramic. Biogeneric Copy was the method of choice. Anesthesia was given, and the lower quadrants were scanned in prior to removing the composite and amalgam. Conservative preparations were completed and the prepared quadrant was scanned into the software. Using the pre-operative shape as a guideline for the final restoration, CEREC was able to reproduce the shape developed into composite over many months. The crowns were milled and inserted with no occlusal adjustment. The patient was happy that there was no difference between the established composite shapes and the finalized ceramic shapes (Fig. 23). The major advantage to this technique is that it uses the ultimate articulator: the patient himself.

_Using something new with something old

There are two exceptional methods used in the CEREC Software 4.0 program to establish anatomical design and occlusion:

1. Biogeneric Individual: a mathematical calculation with buccal bite articulation
2. Biogeneric Copy: the reproduction of current anatomy.

The buccal bite articulation sets the digital teeth in one static occluding position and does not show lateral or protrusive interferences. A CR-CO movement

is also not capable in this static position. This should be considered a snapshot of the patient's occlusion, and the doctor needs to be very aware of potential interferences outside the CO position. This is not difficult to do because adjacent tooth incline planes can be compared, as well as cusp tip positions, for example. With the articulation of upper and lower models with the buccal bite, one can see the true intermaxillary space and build the design appropriately. However, there are no motion paths within the CEREC program, and this will probably be a desirable feature in the future. The pre-operative surface is the best indicator to the motion paths of the jaws currently.

The Biogeneric Copy method as illustrated earlier will show motion paths of the mandible through years of service. However it has a limitation as well: a previously placed restoration may not have complete three-dimensional height for occlusion in some areas. In other words, it may not have function in all areas that it possibly could because the restoration was made in infraocclusion in some areas. For instance, a large amalgam may not have a marginal ridge that is in occlusion because the operator did not make it high enough directly in the mouth years ago. Therefore, the new Biogeneric Copy milled restoration copied from this amalgam would be limited as well at the same amalgam marginal ridge.

Although each method has a specific limitation, they can now be utilized together in the new CEREC Software 4.0. Therefore, the best of both methods can be used to determine the occlusion points and avoid interferences with jaw motion paths. The Biogeneric mathematical calculation is used to make the best anatomy and place the design in harmony with the maximum intercuspation position. Then, the Biogeneric Copy model can be utilized to analyze

potential interferences that were not present with the prior failing restoration. It is truly the best of both worlds to establish anatomy and determine occlusion in the digital world.

_Case 3

An onlay was necessary for tooth #30 after recurrent caries of a large amalgam. Prior to preparation, preoperative images were taken for the Biogeneric Copy model. The tooth was prepared and three sets of images were then taken: preparation quadrant, opposing quadrant and buccal bite images. The software now had everything required to calculate the restoration.

The upper and lower digital models were articulated using the buccal bite images and the lower Biogeneric Copy model was automatically spliced to the lower preparation model. The margin was marked and the Biogeneric calculation took place (Fig. 24). The occlusal contacts of the Biogeneric proposal appeared to be correct; but after comparing it to the preoperative Biogeneric Copy model, it revealed that there was an interference along the incline plane of the buccal cusp. So, this area was relieved (Fig. 25). However, the Biogeneric proposal actually calculated a better position for the distal marginal ridge and it was left as designed. The prior amalgam was deficient in height at the marginal ridge.

The digital restoration was milled out of IPS e.max CAD (Ivoclar Vivadent) and crystallized. The restoration was bonded in with Multilink Automix (Ivoclar Vivadent) and no occlusal adjustments were required (Fig. 26).

_Conclusion

The newest CEREC Software 4.0 has opened doors that were only dreams years ago: better flow, more efficient tools, multiple models and multiple-unit design. Having the ability to design multiple restorations in unison has greatly increased the design mode. It has a major impact when designing any adjacent restorations, but it is phenomenal at the midline between teeth numbers 8 and 9. The esthetic position of the midline is achieved easily because of this.

Esthetic dental anatomies are also easier to achieve with the ability of the software to calculate exceptional designs that are customized for every tooth. But the function does not suffer because the design can be compared to a preoperative shape, as well as the intermaxillary space. This makes for a very efficient method in achieving proper occlusion digitally and ultimately in the final restoration delivered to the patient._

Fig. 26
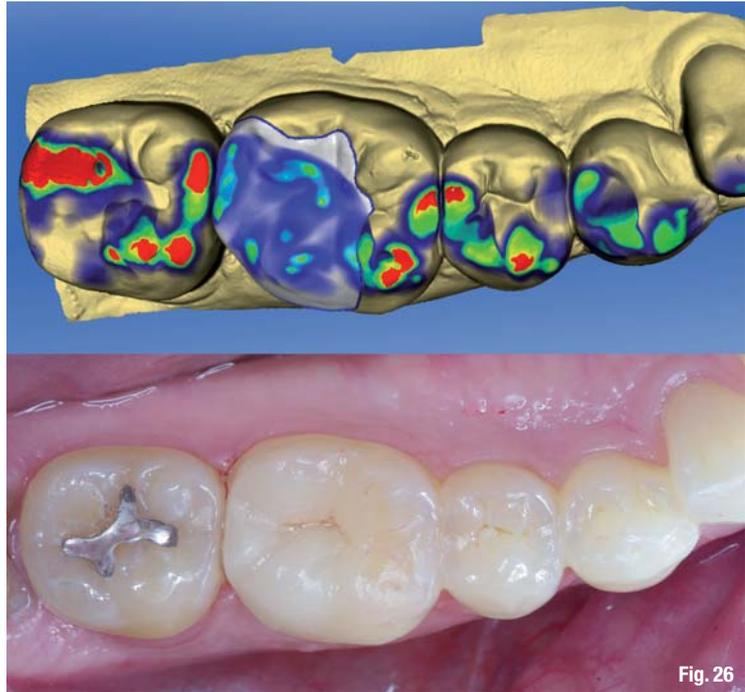
_References

1. Ender A, Mörmann WH, Mehl A. Efficiency of a mathematical model in generating CAD/CAM-partial crowns with natural tooth morphology. Clin Oral Investig. 2011 Apr; 15(2):283-9. Epub 2010 Feb 9.
2. Dunn M. Biogeneric and User-Friendly: The CEREC 3D Software Upgrade 3.00. Int J Comput Dent. 2007;10(1):109–117.
3. Richter J, Mehl A. Evaluation for the full automatic inlay reconstruction by means of the biogeneric tooth model. Int J Comput Dent. 2006;9 (2):101–111.
4. Mehl A, Blanz V. Biogeneric tooth reconstruction—new fundamental method to describe and reconstruct the occlusal morphology of teeth. In: Mormann WH, ed. State of the Art CAD/CAM Restorations. Hanover Park, Ill: Quintessence Publishing Co; 2006:113–121.
5. Fasbinder DJ, Poticny DJ. Accuracy of occlusal contacts for crowns with chairside CAD/CAM techniques. Int J Comput Dent. 2010;13(4):303–16. English, German.

Fig. 26_The digitized occlusion was completed with anticipation of a glaze layer. The final restoration did not require any adjustment.

_about the author

Dr Todd Ehrlich graduated Magna Cum Laude from UTHSC at San Antonio and served as president of its Alumni Association. His "CERECOLOGY" advanced training program is considered one of the premier training seminars for CEREC. He is a beta tester for Sirona, and is an administrator on Dentaltown's website. He can be contacted at drehrlich@cerecology.com.