Digital dentistry in research and science

The CAD/ CAM - technology opens new possibilities for the objective evaluation of preparations in the academic training

Roland Felber, Goethe University Frankfurt am Main

Digital dentistry nowadays offers dentists and dental technicians a variety of possibilities in manufacturing aesthetically and clinically interesting materials. New tools like intraoral cameras, 3-D printers and software solutions for the planning of medical care shorten the working process and also offer a more secure treatment of patients. However the question to be asked is if the new techniques will be integrated into the education of our dentists?

The Goethe University Frankfurt a.M. is equipped with a CAD/ CAM laboratory offering a diversity of chairside and labside solutions as well as the connection to production centers (fig. 01). During their preclinical education, students obtain an introduction into all the technical equipment. The demonstrated procedure will then be intensified at a CAD/ CAM-system of their choice.

In their clinical semesters students are allowed to choose between conventional and digital dentistry during the treatment of patients. In the provisioning of crowns and inlays chairside solutions are often given preference to production centers and conventional techniques.

Dr. Paul Weigl points out the reason: “With the chairside solution the entire procedure of medical care: Preparation, manufacturing of the restoration and the insertion into the patient’s mouth can all be done in one single session. This method saves the time of the patient and also offers the students the possibility to treat more patients and thus get the chance to gain more practical experience in their clinical education.”

The subjective evaluation of students’ preparations

In addition to the variety of material and the production of restorations, the CAD/ CAM technology delivers additional value to the academic training. The digital impression of the preparation and the computer-based evaluation of the preparation parameters allow an objective and reproducible evaluation. At the moment, student preparations are judged and assessed by the lecturer without technical support. Thus, it can’t be avoided that the lecturer’s subjective thinking influences the grading. More than 40 years ago, it was scientifically proven in several independent studies that the judgment of the same preparation through different lecturers shows significant divergence. Even the repeated evaluation through the same lecturer at different points of time generated extremely deviating results in the evaluation.

The universities recognized the problem of subjective valuation and therefore try to antagonize with an alignment of the judgment parameters of individual lecturers. Here, the grading scale will be calibrated on the basis of preparations while all the lecturers come to an agreement on the same grading. However, Haj-Ali and Feil figured out in a study, that lecturers tend to judge unacceptable preparations as acceptable ones. Furthermore, the simplification of the grading scale in acceptable and non-acceptable does not reduce the time of judging through the lecturer.

Industrial problem-solving approaches for an objective judgement of the preparation

At turn of the millennium the fabrication of zircon frameworks and their all-ceramic crown caused a boom in the dental CAD/ CAM technology. For the first time the development of CAD/ CAM systems effected that the dental industry generated tools for the objective judgment of students’ preparations based on the CAD/ CAM technology.

Since 2003 KaVo Dental has offered the KaVo PREPassistant®, which allows to compare the students’ preparations with a master preparation.

The student scans its preparation at a KaVo-Everest desktop-scanner. The PREPassistant software puts the master preparation and the student preparation on top of each other and enables visual cuts as well as manual distance-measurement between the two preparations.

E4D® offers an analogous solution with its E4D Compare®. In the year 2013, the medical department of the University of South Carolina investigated the appropriateness of the E4D Compare® in judging students’ preparations. They figured out that explicit digital and objective feedback make students more eager to improve their preparations. On the contrary, students often feel underprivileged through the judgment of a lecturer and thus ask another lecturer instead of enhancing their skills. This reason provides evidence that students prefer electronic judgment, because they have grown up with this technology. The implementation of computer-based judgment systems has positive repercussions for the universities. Students are more independent of their faculty and can improve their skills out of schedule.
The objective judgement of preparations by use of CAD/ CAM technology

The industry uses the digital inspection systems for the quality assurance of preparations. Universities are also dealing with this issue. The PolyClinic for Prosthodontics of the Martin-Luther-University Halle/Saale in cooperation with their colleagues of the Ludwig-Maximilian-University Munich designed a software tool for the analysis of crown-preparations. After the digitalization of the preparation with a scanner and the determination of the margin, the taper, the width of the border and the pathway of the margin will be analyzed.

The Goethe-University Frankfurt a.M. under Dr. Paul Weigl’s guidance searched for a solution in digital judging/assessment of preparations, which facilitates objectivity as well as an easy and fast operating with the system. The key to an objective judgement lies in the digital scan of the preparation. This conforms to a 3D-photo and can be re-accessed at any time without changing the geometrical measurement of the preparation. The fast evaluation of the preparations shall be effected by means of an all-automatic software. This measurement and analysis tool enables the operator the validation of preparation guidelines (fig. 02). These include the recommended reduction to observe the strength of the material-walls. The software immediately shows students the scopes in between the given tolerance-range as well as the need of improvements through all-automatic generated color codes.

Dr. Paul Weigl and his team approached the company Sirona Dental Systems GmbH to implement the aforementioned targets. A system to measure and analyze crown and inlay preparations, called prepCheck®, was elaborated together. prepCheck® is based on the Cerec® system, which is well-established on the market since more than 25 years (fig. 03). The system can directly be moved to the simulation workplace of the students or to the dental chair due to the fact that the housing of the Cerec AC® is mobile. The student takes a digital impression from his preparation with the Cerec BlueCam® and the Cerec Omnicam® camera. The accuracy of measurement amounts 19 micrometers and thus is sufficient to analyse the manual fabricated preparations. The removal of the model is not necessary because of the intraoral camera. This saves students’ time as well as the model does not have to be repositioned for occlusion again after inspection. The evaluation takes place in the software “prepCheck®”. It serves as an “APP” (application) for the Cerec® system and can either be started on the Cerec AC® or on a separate Windows® computer. The Cerec AC® intraoral scanner is available directly after prepCheck® to scan further preparations. That implies that students can simultaneously correct their preparations at the phantom head and examine the diagnostic results of the prepCheck®.

Functional range of prepCheck®

The evaluation of a preparation with prepCheck® can take place in the master- and in the parameter-mode. The lecturer defines a master preparation in the master-mode. It will be prepared in the study model at the working place simulation, too. After scanning the lecturer files his preparation as a master. The students’ preparation will be compared with the masters’ preparation during evaluation and the prepCheck® software displays the clearance between master- and student-preparation colored (fig. 04). The traffic lights definition of colors obtains for the prepCheck® fundamentally: The green-marked areas indicate that the removal of dental substance is still insufficient. So the student continues with his preparation. Red-marked areas show that the student has already removed too much and stops removing dental substance. Blue-marked areas lie in between the predefined tolerance of the lecturer and acknowledge students a sufficient preparation-technique (fig. 05).

Roland Feibler
Dipl.-Ing. Mechanical Engineering

• 8 years experience as an application engineer at Unigraphics Solutions and Geomagic
• Since 2010, a project manager in the Department of Prosthodontics at the Goethe University Frankfurt a.M.
• In total, more than 16 years in the dental industry. Extensive knowledge about dental CAD / CAM.
• Specialist in CAD software development and CAD data exchange.
• Experience with scanners development and manufacturing processes.

Contact: feibler@em.uni-frankfurt.de
www.med.uni-frankfurt.de/ carolinum/
The parameter-mode exists beside the comparison with a master-preparation. According to this method, prepCheck® examines the preparation on dental-medical relevant height, length, space and angle. The parameters, which have to be accomplished, are preset by the lecturer and he defines the tolerance range in between the preparation is allowed to be.

The reduction amounts to the parameter functions, which accents the already removed dental substance. Therefore, the student scans the processing tooth in front of applying the preparation and after finishing the preparation. Both recordings will be laid above on other through the prepCheck® software and then, the student can see the already removed dental substance (fig. 06). The same technique is used for the evaluation of the occlusal reduction. With this method, the student scans the maxilla and mandible and prepCheck® depicts the distance between the preparation and its antagonist colored (fig. 07). As above mentioned, the blue areas lie in between the range of tolerance, the green area demonstrates that dental substance has still to be reduced and the red area shows that too much substance has been removed. If the student moves over the preparation, the local distance-value will be indicated at each position. Moreover, the user can change the transparency of the depicted teeth and can therefore gain an insight in inaccessible areas. This is also possible with the assistance of the cross-sectional view (fig. 08). An additionally posed scaled-paper facilitates the estimating of distances as well as the reductions.

Another important criterion in judging crown- and inlay preparations is the prepared taper. At first, prepCheck® analyses the preparation for undercuts (fig. 09). Those refer to the previously determined insertion path. In the following, the angular-preparation of all four sides, mesial, distal, lingual and buccal will be calculated and depicted. The already known color pattern shows, which areas are located in between the tolerance range (blue), too steep (green) and which are too conic, that means that they are over-contoured (red). Local data of the angle can be requested through the cursor, too (fig. 10).

The investigation of the type of preparation is the next step of analysis. Here, the lecturer defines the pathway of the preparation behind the preparations’ margin. The chamfer or the shoulder preparation can be chosen as a default-setting. The lecturer is allowed to define more types of preparation. Any form of preparation can be defined. The analysis-function of the type of preparation shows the user the distance of his preparation to the predefined curve of the lecturer (fig. 11).

The surface analysis depicts strongly curved areas, e.g. cusps and fissures, dark grey. In the contrary, flat and planar areas are depicted light grey. Sharp-edged areas are marked orange and signalize the user that another equalization of the preparation is still in need (fig. 12).

Patient example
PrepCheck® disposes of a parameter-mode, which enables the analysis of patients’ preparations in the clinical training of students. The intraoral camera of Cerec AC® supports this with a fast digital impression. In the present case patient example, a chamfer on a premolar in the maxilla was prepared (fig. 13). A full-ceramic crown with Cerec® was planned for the restoration. Cerec® offers a wide range of material variety: Aesthetic restorations are possible out of glass-ceramic, lithium-disilicate red (fig. 13). A full-ceramic crown with Cerec® was planned for the restoration. Cerec® offers a wide range of material variety: Aesthetic restorations are possible out of glass-ceramic, lithium-disilicate red (fig. 13). A full-ceramic crown with Cerec® was planned for the restoration. Cerec® offers a wide range of material variety: Aesthetic restorations are possible out of glass-ceramic, lithium-disilicate red (fig. 13).
No further scan is necessary for the validation of the preparation in prepCheck®. prepCheck® is an "APP", based on Cerec® and will be invoked after mapping the preparations’ margin. The analysis of the preparation in prepCheck® is optional. The Cerec® workflow will not be disturbed or interrupted.

In the present case, the reduction amounted between 1 and 2 millimeter and therefore offered enough space for an e.max CAD crown (fig. 15). During analysis of the preparation, a too-slight removal on the mesial side was observed. The chamfer is unincisive there (fig. 16). The prepCheck® has been detected undercuts in reference to the insertion path of the crown (fig. 17) and the analysis of the surface devoted distally a sharp edge (fig. 18). After the student had remedied the deficiencies, the e.max® crown could be placed.

Conclusion
The number of students in the department of dental medicine is increasing. That means for the students, that their lecturers have to care about a rising amount of course participants and consequently have less time for the individual. Furthermore, it has to be avoided that lecturers’ judgments of a student’s preparation are subjectively biased.

The CAD/CAM technique offers the possibility to gather preparations digitally and evaluate them by use of software. The Goethe-University Frankfurt a.M. and the company Sirona have created prepCheck®, a tool for the objective evaluation of preparations in the students’ education. prepCheck® fits on the clinically approved Cerec®-system and enables the analysis and evaluation of preparations in the phantom head as well as directly at the patient.

The evaluation is not solely objective, but reproductive through the digital recording of the situation with the intraoral camera Cerec Omnicam® or Cerec Bluecam®. The range of functions encompasses the analysis of the dental substance removal, the validation of the conicity and moreover the detection of undercuts. The control of the preparation type and the analysis of the surface quality are additional functions. Therefore, prepCheck® is a 3D mirror of the dentist and facilitates the evaluation of preparations not least because of the disproportionate depiction at the screen.

References: