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Restorations

Co-Sponsor:
Foundation
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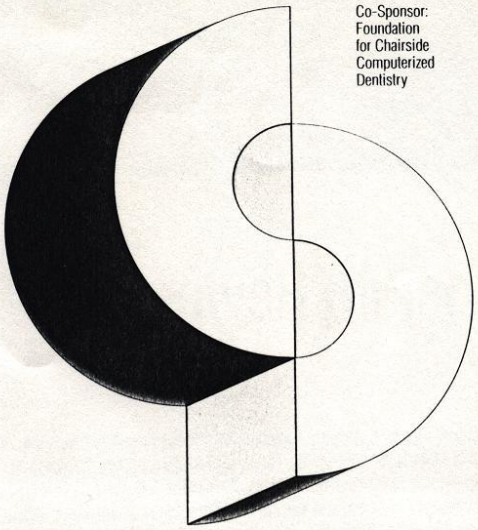
Computerized
Dentistry



INTERNATIONAL SYMPOSIUM ON COMPUTER RESTORATIONS

Editor
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State of the Art of the CEREC-Method

3 – 4 May 1991
Hotel Mövenpick
Regensdorf-Zurich
Switzerland

PROCEEDINGS

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The finished inlay is tried in and then cemented with a special luting composite. The final operation consists in manually adjusting the occlusion with a rotary diamond instrument. The accuracy of fit of the inlay is clearly inferior to the accuracy of conventionally cast restorations. Leakages of up to 250 microns may occur [18] but are filled with luting composite so that a tightly fitting restoration can be produced [21] . The clinical success of this method has yet to be demonstrated by long-term clinical studies.

3.5 The Duret system

A more comprehensive solution was introduced in 1985 by Dr. Duret, a dentist in Grenoble, (France), in cooperation with the French company Hennson Int. [5,6,29]. It allows to produce crowns and small bridges. In this case data acquisition is done independent of the milling machine which has 3.5 axes and is somewhat more complex. All that is needed in the dentist's office is the data recording system for the optical impression. The digitized data can then be transmitted to the CAD/CAM machine so that several dentists can use the system. Here too data are acquired with a small CCD camera. As the system works with somewhat larger preparations a single recording is usually not enough, and 4 pictures are taken of each preparation. Thus 4 images of the prepared teeth are made from different angles of view and reconstructed in the computer. To improve contrasting, here again the tooth is stained with titanium dioxide powder. Depth information is also obtained from a striation pattern. To compose the various images a modified rubberdam clamp with three wires with small spheres as reference points is placed over an adjacent tooth. The camera in this case has a higher resolution of 512x512 pixels and a point resolution of about 20 microns.
On the finished CAD computer image the preparation margin has now to be marked manually which requires a highly skilled dentist. The original shape of the tooth was recorded prior to the preparation and can now be used directly as the basis for the restoration. If this information is not available, the shape of the tooth is obtained from a model database and adapted to the preparation. The CAD software used is the EUCLID system (Matra Datavision Company) on a Micro VAX II (Digital Equipment Corp.) [27]. The internal shape of the crown is now adapted to

the prepared tooth, whereby some space is provided for the cement. The external shape is adjusted to the opposing teeth and the adjacent teeth, whereby additional information obtained from an electronic facebow can be incorporated.
The finished restoration is fabricated by a small 3.5-axes machine [10]. Materials that are said to be applicable are ceramics, composites or metals from which inlays, onlays, 3/4 crowns, full crowns, small bridges or even full dentures can, according to the inventor, be made.
Unfortunately no detailed description of the system has so far been published, and apart from a few demonstrations the inventor is keeping a low profile. Serial production was announced for 1987, but has so far not started. It is assumed that design related problems with the milling machine which obviously does not have an adequate number of axes has been the principal reason. Moreover, the problems of tool selection and tool life may be difficult to solve [10]. So far clinical experience with the Duret process has not been made nor has the accuracy of fit of such restorations in the mouth ever been studied.

3.6. The Minnesota system

According to the Minnesota system, also known as DentiCad^{R} [25-28], only the optical impression is obtained at the dental office. Fabrication is taken over here again by a central place (e.g. a dental laboratory). In this way the money to be spend by the dentist on the data acquisition system is said to be kept below $ 5000. The system was developed by Reckow et al. at the University of Minnesota with the support of the US National Institute for Dental Research. Data recording is done by a stereo photogrammetric process using a standard 35 mm camera which makes several pictures through a special fibre-optical waveguide. The information is recorded on conventional film material which provides a better resolution. Then the photographic material is digitized with a resolution of 4096x4096 pixels which corresponds to a theoretical pixel resolution of 2.44 microns for an object field 10 mm edge length. According to the developers such accuracy cannot be achieved with a video camera.
The information recorded is stored as grey-level pictures and translated into three-dimensional coordinates whereby special contour searching al-