Lithography-based Ceramic Manufacturing in Digital Dentistry

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The possibility of producing complex parts is what makes additive manufacturing technologies (AMT) interesting for many applications. AM has already found its way into fields as biomedical engineering and dentistry, where customized solutions are relevant. Precision, however, still is the weak point of many systems available. At TU Wien we developed a lithography-based method to produce parts out of different materials such as polymers, highly filled ceramic slurries and composites with a feature resolution down to 20 µm. In case of ceramics, the thermal postprocessing leads to further difficulties regarding precision due to shrinkage and sinter distortion. This study shows the possibilities and current limitations of structuring ceramic slurries using stereolithography by comparing the fitting of stereolithographically manufactured parts to the original file and conventionally produced dental restorations. Together with the Bernhard Gottlieb University of Dentistry the crowns were scanned, matched and analyzed.

II Additive Manufacturing

A CAD-model in a suitable file format (e.g. STL) is virtually sliced into defined layers. Based on the principle of digital light processing (DLP: Fig. 1) a digital micromirror device (DMD) projects blue light (LEDs with a wavelength of 405 - 460 nm) onto the slurry and cures it layer by layer. After each solidified layer the vat is slowly tilted to minimize the forces during the separating step. A coater blade then ensures that there is enough material in the building area for the next layer(s). The thickness of this coating combined with the layer thickness influences the resolution of the part, allowing to print delicate structures with a feature resolution of 20 µm.

In order to ensure the required resolution for dental restorations, printed parts were compared with milled crowns and the original CAD-model. Both were scanned with an introral scanner (Trios®) and overlaid in an inspection software (GOM Inspect®). With the printed part as reference, the deviations to the original STL-file and the milled crown are shown in Fig. 6a and 6b respectively.

Material residues and scanning artefacts lead to misalignment in some spots. The overall matching, however, is promising. With high precision printing and adjusting the shrinkage and distortion during the postprocessing the deviations of 200 µm can be further reduced.

VI Conclusion

It can be shown that with our stereolithography based system, printed restorations of high quality and resolution can be produced and AM has a high chance to find its way into the dental CAD/CAM process. The overall precision of the final parts is comparable with that of conventionally produced crowns. For other dental restorations like multi-unit bridges this still has to be verified. Therefore we need strong partners with competence in this field, like the University Clinic of dentistry.