3D Printing of Ceramic Crowns, Material and Process Characterization

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Introduction

In the past for practical reasons and today even for purely aesthetic reasons, human beings have always had a strong interest in dental restoration. In the latest year, a growing interest for additive manufacturing techniques was demonstrated. This interest is visible as well in the field of dental restorative solutions. Additive manufacturing of all-ceramic crowns could be achieved and produced mainly with stereolithography and digital light processing. This master thesis aims to investigate various challenges encountered through the piezoelectric or mechanical micro-valve drop-on-demand Inkjet printing method. More precisely, 3 different aims were pursued. Firstly, a comparison between 2 recirculating printheads, namely the Ricoh GEN5 and the Seiko RC1536A. Secondly, printing trials to obtain samples made of Zirconia (3Y-TZP) with good resolution and mechanical properties comparable to additive manufacturing and milling methods currently used in the dental field were done and the mechanical properties of the parts were characterized. Finally, printing trials using commercial wax as support material to create a free-standing structure were conducted and fully characterized as well.

Materials and Methods

A new printing cage was developed to handle the Seiko RC1536A printhead as well as additional tools, notably for flowrate measurement and continuous logging of many useful values to keep track of changes during the experimentation phase.
Dropwatching was implemented to optimize the drop formation and achieve stable jetting conditions after waveform optimization.

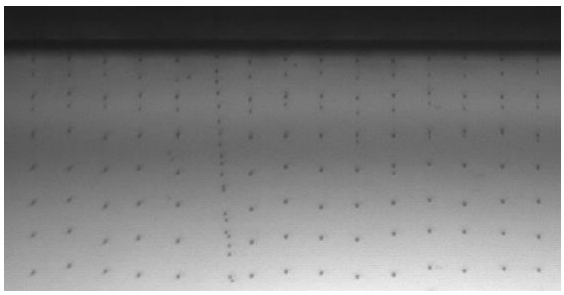

Fig. 1 Characterization of the Seiko RC1536A printhead jetting behavior under dropwatching setup

Results and discussions

The results obtained have demonstrated the proper functioning of the Seiko RC1536A. In terms of comparison, the main advantage of the Ricoh GEN5 is its nominal resolution of 600 DPI compared to the 360DPI of the Seiko RC1536A. On the other hand, the maintenance part of the Seiko is much more interesting because the printhead has no internal filters allowing working with a much higher flowrate.

Concerning the characterization measurements of the samples carried out, the results highlighted the importance of density on the final flexural strength of the samples. A maximal density of 99.5% of the theoretical density was achieved while printing layers of 3.6µm with the Seiko RC1536A. The biaxial bending test performed on the cylindrical samples gave a maximal value of 589MPa ± 63 on a printing batch.

Tests have also been conducted with wax as base layer and as the surrounding material. The mechanical properties measured were slightly lower, mainly due to the fact that the underside of the parts tested presented breakage initiators after printing due to the base layer being uneven. Regarding the wax surrounding, the suspension was partially deposited layer after layer on the edge of the parts. This creates an excess of wax-suspension mixture on the edge that ultimately lowers the final mechanical properties of the samples.

Fig. 2 Printing batch produced on a wax base layer used for mechanical characterization

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