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AAO Foundation Final Report Form

Type of Award: **Research Aid Award**

Name(s) of Principal Investigator(s): **Dr. Saro Atam (Student - PI); Dr. Wellington Rody Jr. (Mentor).**

Institution: **Stony Brook University**

Title of Project: **Orthodontic Digital Workflow: From 3D Printing to Appliance Fabrication**

Period of AAOF Support: **07-01-20 to 06-30-21**

Amount of Funding: **$ 5,000**

Summary/Abstract:

Introduction: A substantial body of literature is slowly building up which attempts to guide orthodontists in the implementation of in-house digital laboratories with rapid prototyping capabilities for the fabrication of thermoformed appliances (TAs) such as aligners and retainers; however, research findings are still contradictory, and many questions remain unanswered.

Objectives: The aims of this study were twofold: 1) To evaluate the influence of build orientation and layer thickness on the manufacturing of 3D printed models using the two most common 3D printing systems, stereolithography (SLA) and digital light processing (DLP), and 2) To investigate the influence of 3D printing systems and parameters in the fit of thermoformed appliances (TAs) over the dentition.

Materials and Methods: The upper and lower arches of two typodonts were selected as the sources of Standard Triangulation Language (STL) files for 3D printing. One typodont contained a complete aligned permanent dentition, whereas the other exhibited a crowded class I malocclusion. A total of 04 master STL files were obtained: an upper arch aligned (UAA), a lower

arch aligned (LAA), an upper arch crowded (UAC), and a lower arch crowded (LAC). Each STL master file was used to generate dental casts using the two most common 3D printing systems: stereolithography (SLA) and digital light processing (DLP). Different layer thicknesses (Z-Axis) were tested in combination with two different orientations of the dental casts relative to the printer platform (vertical and horizontal). A total of 96 models were printed. The master STL files were reproduced in triplicate for each setting parameter and printing system in order to reduce random error and experimental bias. In order to analyze dimensional accuracy, the STL files of the printed models were digitally superimposed onto a master STL file using a comparison software (Geomagic Control X; 3D Systems). The deviations between the tested model and the reference scan were quantified by the Root Mean Square (RMS), which is a measure of the magnitude of all deviations. The lower the RMS value, the more accurate the prototype (test file) when compared to the master STL file. Subsequently, the 32 most accurate SLA and DLP printed models were used to fabricate thermoformed appliances (TAs) under standardized laboratory conditions. Appliance fit was assessed qualitatively and quantitatively. For the qualitative analysis, three orthodontists evaluated the appliances in their corresponding master typodonts in order to independently assess the TAs for proper fit. In addition, the intaglio surfaces of the appliances were scanned and superimposed to the corresponding master STL files using the Geomagic Control X software. A measure of fit was determined by the mean of all the calculated positive and negative gap distances between each appliance and its respective master file. Quantitative and qualitative measures were analyzed with linear regression models and post-hoc t-tests were conducted to determine which printer and which parameter setting was optimal.

Results: The fastest printing time of 17 minutes was achieved by the DLP system with a z-layer height of 200 μm in the horizontal orientation. For models printed vertically in an angulation of 80 degrees, the printing time was reduced to an average of 43 minutes with a z-layer height of 300 μm in the SLA system. In the DLP technology, the lowest RMS value was found for the LAC typodont printed vertically (0.18 ± 0.04). For the SLA printer, the lowest RMS value of 0.11 ± 0.02 was observed in the UAC typodont printed horizontally. The mean RMS values of all typodonts did not differ significantly according to the type of technology when printed vertically. Statistically significant differences ($p < 0.05$) between printing technologies were found for the UAC, LAC and UAA typodonts when printed horizontally. Color-coded heatmaps demonstrated slight contraction on the palate and the palatal cusps of the posterior teeth in the upper models printed horizontally with DLP technology. On the other hand, slight expansion was observed on the buccal cusps of posterior teeth, incisal third of lingual surface of anterior teeth, and palatal surface of the upper second molars. For the lower models printed with DLP technology, slight contraction was noted on the lingual cusps and buccal surfaces of posterior teeth while expansion was mainly noted in the retromolar area and incisal third of lingual surface of anterior teeth. The SLA modeled TAs slightly outperformed appliances fabricated on DLP models in their retention, stability, anterior coverage, and posterior coverage. By and large, most TA's scored very well thus indicating that 3D printing performance at higher Z-Axis values seem to meet the clinical needs required for orthodontic applications

Questions:

1. Were the original, specific aims of the proposal realized? **Yes.**

2. Were the results published? **Not yet. Manuscript preparation is underway.**

    a. If so, cite reference/s for publication/s including titles, dates, author or co-authors, journal, issue and page numbers. **Not Applicable**.

    b. Was AAOF support acknowledged? **AAOF support will be acknowledged in the publication.**

    c. If not, are there plans to publish? If not, why not? **The plan is to submit a manuscript for publication by the year-end.**

3. Have the results of this proposal been presented? **Yes. The results of this project were presented during Saro Atam's Master's Thesis public defense.**

    a. If so, list titles, author or co-authors of these presentation/s, year and locations. **Title: "Evaluation of crowded and aligned dental models produced by different 3D printing technologies". Dr. Saro Atam. Stony Brook University, June 2021.**

    b. Was AAOF support acknowledged? **Yes. AAOF support was acknowledged.**

    c. If not, are there plans to do so? If not, why not? **We would like to discuss the results of this clinically relevant research project at future orthodontic meetings, if a good opportunity arises.**

4. To what extent have you used, or how do you intend to use, AAOF funding to further your career?

    AAOF funding has been pivotal for my career development as a clinician-scientist. With the generous support of the AAOF Research Aid Award (RAA), we were able to direct our research towards a better application of 3D printing technology in a busy orthodontic setting. We were able to optimize parameters that may be helpful to guide and fulfill the 3D printing requirements for orthodontics with a more efficient in-house manufacturing process. In addition, the experience that I gained from my master's degree will be a vital stepping stone for my career development as an academician and clinician. I believe our promising results will help myself and my colleagues to further explore this evolutionary era of 3D printing in orthodontics. Furthermore, receiving the AAOF Charles J Burstone Award for this research project has reinforced my career goal in becoming a clinician- scientist in academia.

Accounting for Project: **The remaining funds on the award is approximately $ 800.00 (Initially budgeted for travel expenses but not used due to the COVID-19 pandemic).**