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Comparison of Dental Mock-ups manufactured by different techniques: Molded and Milled (an in vitro study)

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Introduction: The demand for overall esthetics has increased, placing the spotlight on improving dental esthetics. Porcelain veneer restorations are minimally invasive restorations which provide esthetic improvement, therefore proper tooth structure preparation is important. A diagnostic mock-up eases the preparation process for the clinician and allows better communication with the patient. With recent technologies, a more convenient production of the mock-up could be feasible.
Materials and Methods: After impressions and photographs, the gathered data was digitized for use on a software for the designing of the digital smile design. 10 resin models were printed and 10 silicone indices were fabricated on top, for the fabrication of molded composite resin mock-ups. While 10 PMMA mock-ups were directly milled from the digital design. 20 preoperative resin models were printed for the fitting of each mock-up individually on a model. All fitted mock-ups were then scanned and uploaded onto a comparison software, to be compared to the reference digital smile design. All mock-ups were subjected to linear measurements digitally using the software and physically using a digital caliper. Statistical analysis was carried out to evaluate the accuracy of each group.
Results: Volumetric and linear measurements showed higher trueness of the milled mock-ups to the reference digital smile design.
Conclusion: The study exhibited a difference between the milled and molded mock-ups, showing the milled mock-ups are of higher accuracy. Within the limitations of this study, the production of CAD/CAM mock-ups decrease the number of errors along the process.

Keywords: Digital smile design, Mock-up, Milling

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Introduction

The demand for improving esthetic appearance increased over the past years, making it no less important than mastication.[1] Although until mid 1990s dental esthetics was only limited to simple alterations in the dentition.[2] Nowadays, clinicians are constantly searching for the finest details to produce in order to provide their patients with the best image.[3,4] In light of esthetic treatments, porcelain veneers were introduced as an esthetic, long term solution to esthetic rehabilitation cases.[5,6] In addition, porcelain veneers preserve the tooth structure making it a minimally invasive restoration. [7]

In order to reach a proper non-invasive tooth preparation, guidance is needed. Therefore, the use of a diagnostic mock-up has been introduced.[8] Not only does a diagnostic mock-up guide the clinician during the preparation process, it also previews the patient with the final esthetic outcome. This step allows better communication between the patient, the clinician and the lab technician, as well as, provides better understanding of the process. Any desired changes are communicated and executed easily. [9,10]

Diagnostic mock-ups could be produced conventionally or digitally. The production of the mock-up conventionally is done using a diagnostic wax-up with a silicone index on top. The conventional method requires several steps and is liable to errors in communication or handling since it is highly operator dependent. [11,12] On the other hand, the production of the mock-up digitally requires the use of CAD/CAM technology which minimizes the number of errors along the process. [13]

The aim of this study is to evaluate the difference in accuracy of diagnostic mock-ups manufactured using two different techniques; moulded mock-up using silicone index and milled mock-up. Both mock-ups will be produced from the same digital smile design.

Materials and Methods:

A patient with spacing problem was selected in the Faculty of Dentistry Ain Shams University Hospital. Digital photographs were taken, as well as analogue impressions of the upper and lower arches. The impressions were then poured and scanned using an extraoral scanner (D850, 3Shape, Copenhagen, Denmark) for uploading onto the smile design software. The smile designing process was done using a digital software called Exocad (Darmstadt, Hessen, Germany). Using the retracted and smiling photographs a digital smile design of the future restorations was created. The future tooth shapes were used from the software's library and adjusted according to the patient's facial and smile features.

Moulded Mock-up Group:

Ten resin (Phrozen Aqua Gray 4K, Phrozen Technology, Taiwan) models of the digital smile design were printed using Phrozen Sonic Mini 4K 3D Printer (Phrozen Technology, Taiwan). Ten silicone indices were then fabricated on top of the models producing one index for each model, using condensation silicone (Silaxil, Lascod, Florence, Italy). The indices were then used to mould a Bis-acryl composite mock-up (Structur 2 SC, VOCO GmbH, Cuxhaven, Germany). Ten preoperative resin models were printed using the STL file of the scanned stone models and the molded mock-ups were then fabricated on top. No modifications or finishing was done to the mock-ups, the excess was only removed during the setting stage of the resin. The ten mock-ups were then scanned to obtain STL files using D850 3Shape extraoral scanner.

Figure 1: Moulded Mock-up

Milled Mock-up Group:

Using the STL file of the digital smile design, ten milled PMMA (Polident, Slovenia) diagnostic mock-ups were created using a milling machine (DWX-52D, DGSHAPE, California, USA). Also, ten preoperative resin models were printed and the mock-ups were then fitted on top. The models with the mock-ups on top were then scanned to obtain STL files.

All the STL files of the scanned mock-ups were uploaded onto an analysis software (Geomagic Control X, 3D Systems, Morciville, USA) and segmented to allow higher accuracy of the comparison process; including only the mock-up area and not the rest of the scan. The STL file of the digital smile design was uploaded onto Geomagic software and then each STL file of the mock-ups was uploaded individually for comparison to the original design. The comparison was done by superimposing each mock-up project and the digital smile design project. This procedure shows the volumetric differences between the uploaded projects.

Each mock-up in both groups was also subjected to linear measurement analysis digitally on Geomagic and by an analogue Digital Caliper. All linear measurements were done on the upper left central incisor's most apical part of the gingival contour to the incisal margin, as well as the central's mesiodistal width at the center of the incisor, and the mesiodistal width of the anterior maxillary teeth from canine to canine. These measurements were done to assess any dimensional alterations, and were done by the same operator.

Results

The coloured maps provided by Geomagic software showed higher variation of the moulded mock-ups to the digital smile design, especially around the margins. This could be due to the removal of excess Bis-acryl composite material or excess force produced during seating of the indices.

Also, statistically the Root Mean Square produced by the Geomagic software, showed a difference between the groups representing higher accuracy of the milled mock-up to the digital smile design.

In regard to the Digital linear measurements, comparing the digital smile design to the moulded mock-ups, a significant increase was found in the height and width of the central, with insignificant difference in the canine-to-canine width. Comparing the digital smile design to the milled mock-ups, there was only a significant difference in the canine-to-canine width.

In regard to the Analogue linear measurements, comparing the digital smile design to the moulded mock-ups, the digital linear measurement results were confirmed. However, when comparing the digital smile design to the milled mock-ups, there was no significant difference in any of the measurements.

Discussion

The aim of this study is to assess the accuracy between the conventionally produced resin mock-up using a silicone index and the digitally produced milled mock-up. The comparison was done volumetrically and linearly to observe any changes from the original reference design. The comparison to the original design expresses the trueness of the produced object,

which is a common method of measurement of accuracy implemented in many studies. (14,15)

Table (1): Mean ± standard deviation (SD) of (RMS) for both groups

(RMS) (mean±SD)		p-value
Milled Mock-up	Moulded Mock-up	
0.11±0.02^{C}	0.18±0.02^{A}	<0.001*

Means with different superscript letters within the same horizontal row are significantly different, *; significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

Table (2): Mean ± standard deviation (SD) of digital linear measurements deviations (mm) for different groups

Measurement	Digital linear measurements deviations (mm) (mean±SD)		p-value
	Milled Mock-up	Moulded Mock-up	
Upper left central height	0.21±0.12^{B}	0.27±0.15^{AB}	0.004*
Upper left central width	0.05±0.03^{C}	0.18±0.12^{AB}	0.001*
Canine-to-canine width	0.73±0.02^{A}	0.10±0.07^{C}	<0.001*

Means with different superscript letters within the same horizontal row are significantly different, *; significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

Table (3): Mean ± standard deviation (SD) of analog linear measurements deviations (mm) for different groups

Measurement	Analog linear measurements deviations (mm) (mean±SD)		p-value
	Milled Mock-up	Moulded Mock-up	
Upper left central height	0.07±0.06^{C}	0.37±0.12^{B}	<0.001*
Upper left central width	0.07±0.04^{B}	0.19±0.14^{AB}	<0.001*
Canine-to-canine width	0.39±0.17^{B}	0.96±0.04^{A}	<0.001*

Means with different superscript letters within the same horizontal row are significantly different, *; significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

Since the aim was to assess the production method, the smile designing was chosen to be done virtually to provide us with access to a wider variety of designs, as well as, to allow proper integration between the design and the patient's features from the photographs. (16) According to the obtained results, the milled mock-ups were more accurate to the digital smile design and the moulded mock-ups represented significant deviations especially at the margins area and incisal edges. These deviations could be due to the forces applied during index placement, Bis-acryl composite polymerization shrinkage or injury to margins during removal of excess material. Therefore, the production of milled mock-ups is preferred to avoid inconsistencies from the operator and the production process.

Conclusion

A significant difference was observed between the moulded and milled mock-ups when compared to the digital smile design. The statistical analysis confirmed the higher accuracy of the milled mock-ups. Therefore, within the limitations of this study, a digital workflow should be considered more reliable when manufacturing diagnostic mock-ups. While, the moulded mock-ups are more operator dependent and could be subjected to more errors.

References

1. Dawood A, Purkayastha S, Patel S, Mackillop F, Tanner S. Microtechnologies in implant and restorative dentistry: A stroll through a digital dental landscape. Proc Inst Mech Eng Part H J Eng Med. 2010;224(6):789–96.
2. Garber DA, Salama MA. The aesthetic smile: Diagnosis and treatment. Periodontol 2000. 1996;11(1):18–28.
3. Arikatla SK, Chalasani U, Mandava J, Yelisela RK. Digital smile design and mock-up technique for esthetic treatment planning with porcelain laminate veneers. 2018;21(4):373–7.
4. Giudice A Lo, Ortensi L, Farronato M, Lucchese A, Castro E Lo, Isola G. The step further smile virtual planning: Milled versus prototyped mock-ups for the evaluation of the designed smile characteristics. BMC Oral Health. 2020;20(1):1–10.
5. Gürel G. Predictable and precise tooth preparation techniques for porcelain laminate veneers in complex cases. Int Dent SA [Internet]. 2007;9(1):30–40. Available from: http://www.moderndentistrymedia.com/jan_feb2007/gurel.pdf
6. Land MF, Hopp CD. Survival Rates of All-Ceramic Systems Differ by Clinical Indication and Fabrication Method. J Evid Based Dent Pract [Internet]. 2010;10(1):37–8. Available from: http://dx.doi.org/10.1016/j.jebdp.2009.11.013
7. Gurel G, Morimoto S, Calamita MA, Coachman C, Sesma N. Clinical performance of porcelain laminate veneers: outcomes of the aesthetic pre-evaluative temporary (APT) technique. Int J

Periodontics Restorative Dent [Internet]. 2012;32(6):625–35. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23057051
8. Buonocore MG. Molecular biology and medicinal chemistry. J Dent Res. 1955;30(10):849–53.
9. Granell-Ruiz M, Fons-Font A, Labaig-Rueda C, Martínez-González A, Román-Rodríguez JL, Solá-Ruiz MF. A clinical longitudinal study 323 porcelain laminate veneers. Period of study from 3 to 11 years. Med Oral Patol Oral Cir Bucal. 2010;15(3):1–7.
10. Gürel G. Porcelain Laminate Veneers: Minimal Tooth Preparation by Design. Dent Clin North Am. 2007;51(2):419–31.
11. Simon H, Magne P. Clinically based diagnostic wax-up for optimal esthetics: the diagnostic mock-up. J Calif Dent Assoc. 2008;36(5):355–62.
12. Magne P, Magne M, Belser U. The diagnostic template: a key element to the comprehensive esthetic treatment concept. Int J Periodontics Restorative Dent [Internet]. 1996;16(6):560–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9242094
13. Coachman C, Calamita M, Sesma N. Dynamic Documentation of the Smile and the 2D/3D Digital Smile Design Process. Int J Periodontics Restorative Dent. 2017;37(2):183–93.
14. Ender A, Mehl A. Accuracy of complete-arch dental impressions: a new method of measuring trueness and precision. Univ Zurich. 2013;109:121–8.
15. Ender A, Mehl A. In-vitro evaluation of the accuracy of conventional and digital methods of obtaining full-arch dental impressions. Quintessence Int (Berl). 2015;46(1):9–17.
16. Sancho-Puchades M, Fehmer V, Hämmerle C, Sailer I. Advanced smile diagnostics using CAD/CAM mock-ups. Int J Esthet Dent. 2015;10(3):374–91.