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RESEARCH ARTICLE

REVISED Evaluation of additive manufacturing processes in the production of oculo-palpebral prosthesis [version 2; peer review: 1 approved, 1 approved with reservations]

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Abstract

Background: Within the broad spectrum of rehabilitation, maxillofacial prostheses are those that are made to restore the appearance of a person who has suffered facial deformation due to cancer, accidents, congenital diseases, among others. Although these are not made to restore functionality, they have a major impact on restoring the patient's quality of life as it is an area so closely linked to their identity. For his reason, they have to be carefully tailored for each patient, which tends to increase cost and production time

Objectives: The purpose of this research is to compare different additive manufacturing mechanisms, to evaluate which of them achieves the best reproduction of the leather details and maintains the desired dimensional properties.

Methods: The manufacturing equipment will be selected comparing 7 different 3D printing of an oculo-palpebral model for a future maxillofacial prosthesis, obtained from the "Mais Identidade" Method. They were evaluated according to their economic, physical and aesthetic characteristics.

Results: The results of the evaluations show that: the highest score in the economic evaluation was obtained by PhotonS; in the physical evaluation it was obtained by PhotonS, Phrozen Suffle XL and PRO95; and in the aesthetic evaluation it was obtained by PRO95 and Objet500. Finally, according to the multi-criteria evaluation, the highest score was obtained by the Photon S and PRO95.

Keywords
Maxillofacial prosthesis, anaplastology, Digital Models, Additive Manufacturing, 3D-Printing

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> **REVISED** **Amendments from Version 1**
>
> We clarified some details about printing parameters and statistical analysis; the abstract was better structured; and conclusion is more concise.
>
> **Any further responses from the reviewers can be found at the end of the article**

1. Introduction

Prosthesis encompasses a wide range of mechanisms for the replacement of body parts, in order to rehabilitate the characteristics of the missing part in function or appearance. Within them, there is a branch known as "maxillofacial prostheses", among which are nasal, ear, oculo-palpebral prostheses, *etc.*[1] They are generally used by patients who have suffered cancer (52%), deformities due to accidents (17%) and/or congenital diseases (19%), among others.[2]

Most of the prostheses, being systems that simulate missing body parts, must be personalized for each patient, which tends to raise their costs. Traditional manufacturing methods require a lot of professional and patient time. In addition, in the public health system, when the service exists and is covered, there are patients who wait between 6 months and 2 years for their rehabilitations. Once the appointment is obtained, they can only be served between 30 minutes to 2 hours per appointment due to the shortage of time and high demand. With the method proposed by the NGO "Mais Identidade", global work times can be reduced by half.[3] In the elaboration of a facial prosthesis, three main stages must be carried out[4]: obtaining the shape of the patient's anatomy, traditionally cast from a plaster mold; modelling, made from thermoplastic materials for modelling; and fabrication, using a negative version of the sculpture and placing layers of intrinsically characterized medical grade silicones; in addition to the fabrication of the ocular prosthesis,[5,6] with the different difficulties that this can entail, which will finally form part of the maxillofacial prosthesis. But, in the manufacturing process of these prostheses, the patient's self-perception, emotional stability, personality characteristics and social circumstances are the most important factors when treating maxillofacial defects, as well as the rehabilitation process.[7,8]

With the aim of optimizing the process and making prostheses more accessible and of good quality, both data acquisition and manufacturing, a digital manufacturing process is chosen. Which consists of: Data acquisition, such as digitization through 3D scanning or photogrammetry; Prosthesis design (reverse engineering software) and rapid prototyping (3D printing).[9,10] These technologies can offer advantages such as obtaining digital color 3D colour models, which can be modelled using affordable CAD software for printing on biomaterials such as ceramics and polymers for medical applications[11] and, in the future, even directly on medical grade silicone.[12,13]

In this sense, the purpose of this research is to compare additive manufacturing mechanisms, from a 3D model of the oculo-palpebral model for a future maxillofacial prosthesis, obtained from the "Mais Identidade" Methodology. It will be evaluated which of the additive manufacturing mechanisms achieves the best reproduction of the leather details and maintains the desired dimensional properties, according to the original file. To select the manufacturing method, the oculo-palpebral models manufactured in 7 different 3D printing mechanisms were evaluated, according to their economic, physical and aesthetic characteristics.

The structure of this paper is the following: section 2 briefly details the printing techniques used for the testing; section 3 describes the procedure of the experiments; section 4 presents and evaluates the results; section 5 discusses the evaluations and the context in which they were made; section 6 proposes suggestions for future work and research conclusions.

2. Resin 3D printing comparison

It is the process by which physical objects are generated from 3D digital files. These files, prior to being printed, go through software in which they are divided into thin layers, with the desired printing characteristics (speed, layer thickness, *etc.*).[14] For the "Mais Identidade" method, layer levels in the range of 100 μ to 16 μ are used to obtain a high level of detail.

2.1 Fused Deposition Modelling (FDM)

It is the most used method of 3D printing. This method uses a thermoplastic filament that goes through a heating system where it is heated to a temperature at which it is moldable and extruded to take the desired shape.[15] For the present investigation, PLA filament will be used as a material for printing the prototypes due to its printing practicality, low cost and because it is the most used material in this technology.

2.2 Stereolithography

This method covers liquid resins that go through a photopolymerization process, which exposes them to a specific range of light, with which they undergo a chemical reaction that solidifies them.[15] This technology is usually faster and has a higher level of finish than FDM. Within stereolithography, there are variants such as[16]:

(1) SLA: A UV laser cures the resin point by point in the resin tank using a projector and a set of mirrors.

(2) LCD: An LCD screen projects the UV light and passes through a filter that allows the exposure of light in the necessary points.

(3) DLP: A projector emits light and through a mirror generates the shapes to be printed layer by layer.

The resins used, both in SLA and LCD and DLP, go through the photopolymerization process when interacting with a light range of 405 nm. Generally, each equipment uses its own resin, so basic light curing resins will be used for prototypes.

2.3 POLYJET

This method is based on the injection of polymers that are cured by ultraviolet light. This technology stands out for its high speed and high print resolution, as well as being able to reproduce functional models without the need to assemble them.[17] For this research, Vero black was used to print the model, and Sup706 was used for the support.

3. Methods

The selection of the ideal additive manufacturing equipment for printing models that are used in the manufacturing process of maxillofacial prostheses by the "Mais Identidade" method is detailed in Figure 1.

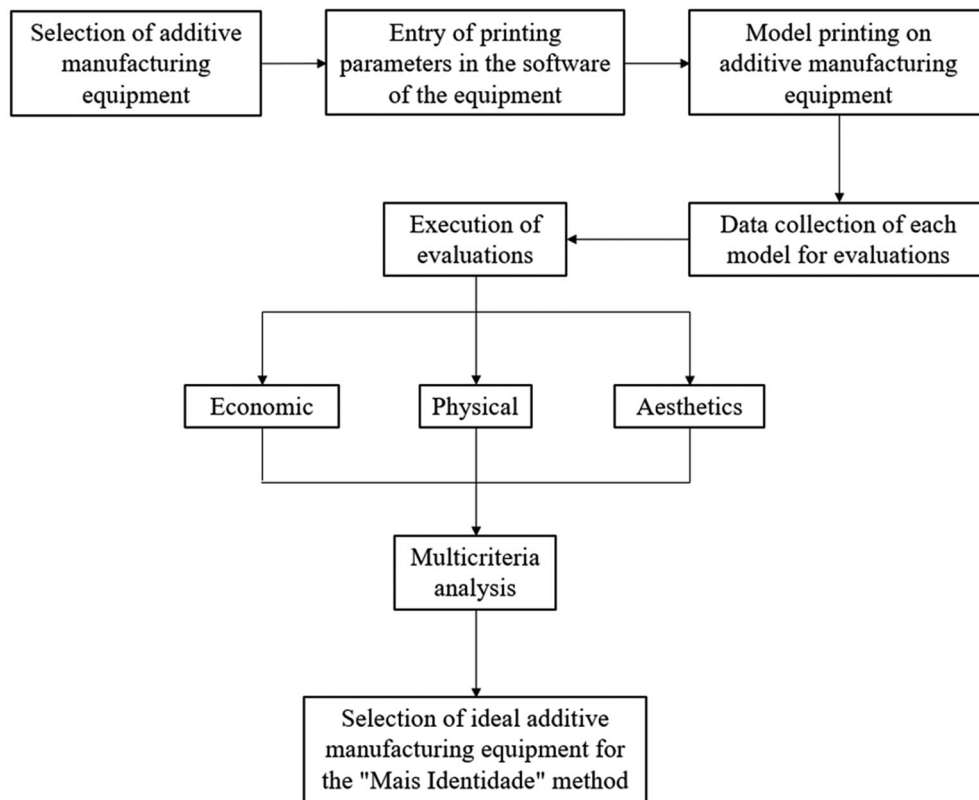**Figure 1. Methodological flowchart.**

Table 1. Characteristics of additive manufacturing equipment.

Technology	Equipment	Characteristics		
		Print speed	Layer thickness	Resolution
FDM	Mini L	0-120 mm/s	100 µm	100 µm
LCD	Photon S	20 mm/hr	20 µm	47.5 µm
	DS-200	20 mm/hr	25 µm	75 µm
	Phrozen Shuffle XL	20 mm/hr	25 µm	75 µm
DLP	MoonRay S	3.81–25.4 mm/hr	20 µm	100 µm
	PRO95	12.7–50.8 mm/hr	20 µm	95 µm
POLYJET	Objet500 Connex3	-	16 µm	600 dpi

3.1 Selection of additive manufacturing equipment

The following technologies were used for the tests: FDM, SLA, LCD, DLP and POLYJET. Table 1 specifies the characteristics of the equipment selected for its good resolution and precision.

3.2 Entry of printing parameters in the software of the equipment

For the tests, the model to be printed was a clinical case of a 75-year-old patient with an oculo-palpebral trauma. For the input parameters, the best printing options were selected: per layer, material to be used, printing temperature (FDM), exposure times (SLA, LCD, DLP), *etc.*

3.3 Model printing on additive manufacturing equipment

For the tests, three impressions per equipment were made, to make an average with the data, based on the Design of Experiments theory. The printed models, as they require supports, must go through a post process that eliminates them to obtain the final model.

3.4 Data collection of each model for evaluations

For each impression, the data of the printing parameters were taken, to register them and carry out the economic and physical evaluations.

3.4.1 Economic data collection

To carry out the economic evaluations of each equipment, the data shown in Table 2, must be collected from each impression.

Table 2. Printing data by model.

Cost per liter of resin (Clk)	
Print volume (V)	
Printing time (T)	
Equipment Value (EV)	
Rescue Value (RV)	
Useful life (UL)	
Days per year (Ds)	365 days/year
hours per day (Hr)	24 hr/day
Design (D)	0 hr
Specifications (E)	560/hr
Control (C)	T*1%
Post Printing (PP)	2060/hr
Man Hour (MH)	15 $/hr

Using the previous data, the cost was calculated using the following equations:

1. Cost of material used

$$MC = \frac{C*V}{1000}$$

Equation 1: Material Cost Calculation.
Source: TRESDE company quotation tables.

Where:

- MC : Material Cost ($)

- C : Cost per liter or kilogram (S/liter or kilogram)

- V : Print Volume (mL o gr)

2. Cost hours machine worked

$$MHC = T*MH$$

Equation 2: Calculation cost Hour Machine Worked.
Source: TRESDE company quotation tables.

Where:

- MHC : Machine Hour Cost ($)

- T : Printing Time (Hr)

- MH : Machine Hours ($/hr)

Taking into consideration that the Machine Hour is calculated as follows:

$$MH = \frac{EV - RV}{UL*D*Hr}$$

Equation 3: Calculation of Machine Hour.
Source: TRESDE company quotation tables.

Where:

- EV : Equipment Value ($)

- RV : Rescue Value ($)

- UL : Useful Life (years)

- D : Days per Year (days/year)

- Hr : Hours per day (hours/day)

3. Cost man-hour worked

$$CMH = (D + E + C + PP)*MH$$

Equation 4: Cost calculation Man Hour worked.
Source: TRESDE company quotation tables.

Where:

- CMH : Cost per Man Hour ($)

- D : Design (Hr)

- E : Especifications (Hr)

- C : Control(Hr)

- PP : Post Printing (Hr)

- MH : Man Hour ($/hr)

- Taking into consideration that the cost of Man Hour is a fixed cost of $15/hr

4. Printing cost

$$PC = MC + MHC + CMH$$

Equation 5: Cost Per Impression Calculation.
Source: TRESDE company quotation tables.

3.4.2 Physical data collection

For physical evaluations, each printed model is digitized and compared to the original digital file. To do this, each model is covered with developer spray to obtain better scans; reference points are placed on the back face of the model; in the ZEISS software it is scanned with the COMET 8M model; the rotary option is selected, with 10 stops and the back and front of the model are scanned, obtaining the results shown in Figure 2.

With help of the reference points, the two shots are coupled to turn it into a single digitized model. Finally, the digitized model is compared with the original digital model and the deviation between both is obtained for each case, as shown in Figure 3.

3.5 Execution of evaluations
After registering the previously mentioned necessary data, economic, physical and aesthetic evaluations are made.

The economic evaluation was scored based on the manufacturing cost of each prototype. The physical evaluation, based on the precision obtained according to the average deviation of the models printed by each device. The aesthetic evaluation was carried out by Dr. Rodrigo Salazar, specialist in maxillofacial rehabilitation, according to his appreciation
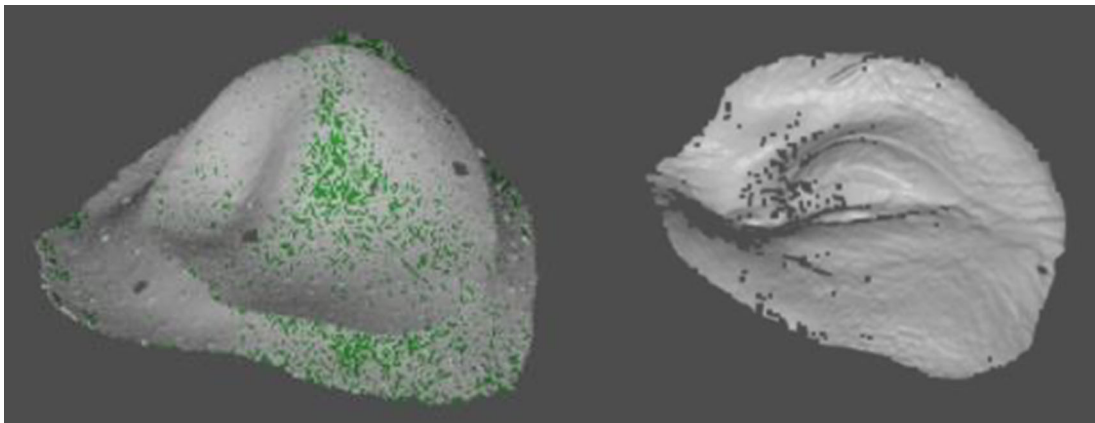

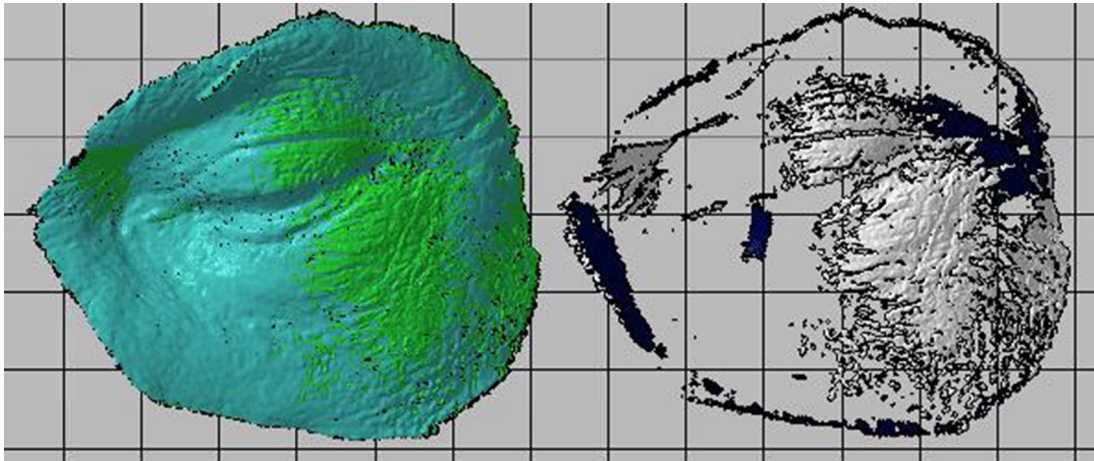**Figure 2. Front and back face scan.**

Figure 3. Alignment and boolean of digitized and original models.

of the prototypes. Each evaluation has a score from 1 to 5, where 5 (five) represents the most economical, precise and aesthetic, respectively; and 1 (one) the lowest.

3.6 Multicriteria analysis
After making the evaluations of each of the 3 criteria, weights were assigned to each of the criteria and based on them an average was obtained. Since it was considered that each aspect is equally important, each of them corresponds to 1/3 of the final score.

4. Results
4.1 Oculo-palpebral model printing
4.1.1 Mini L

For printing on the MINI L, with FDM technology, the 3DTALK slicer was used and parameters are shown in Table 3. The model is shown in Figure 4.

The model does not reproduce correctly, as it has complex parts that FDM printers cannot reproduce, resulting in a low-quality print with holes. For this reason, it was decided to leave out the FDM technology in the evaluation.

4.1.2 Photon S

For printing on the Photon S, with LCD technology, the CHITUBOX slicer was used and parameters are shown in Table 4. The model is shown in Figure 4.

4.1.3 DS-200

For printing on the DS-200, with LCD technology, the 3DTALK slicer was used and parameters are shown in Table 5. The model is shown in Figure 4.

4.1.4 Phrozen Shuffle XL

For printing on the Phrozen Shuffle XL, with LCD technology, the CHITUBOX slicer was used and parameters are shown in Table 6. The model is shown in Figure 4.

Table 3. Printing parameters for Mini L.

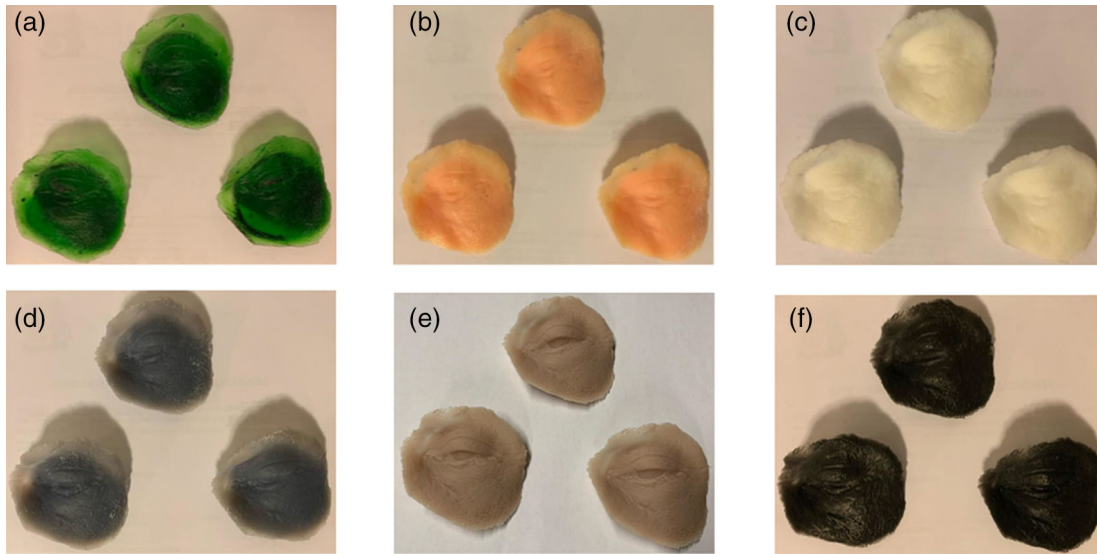| Filament	Layer thickness	Wall thickness	Printing speed	Infill density	Support density
White PLA	0.1 mm	0.8 mm	40 mm/s	15%	15%

Figure 4. Oculo-palpebral model printed in: (a) Photon S, (b) DS-200, (c) Phrozen Shuffle XL, (d) Moon Ray S, (e) PRO 95 and (f) Objet500 Connex3.

Table 4. Printing parameters for Photon S.

Resin	Layer thickness	Number of bottom layers	Bottom layers exposure time	Normal layers exposure time	Support density
Basic	0.02 mm	3	50 s	8 s	15%

Table 5. Printing parameters for DS-200.

Resin	Layer thickness	Number of bottom layers	Bottom layers exposure time	Normal layers exposure time	Support density
Modelo	0.025 mm	3	30 s	4 s	15%

Table 6. Printing parameters for Phrozen Shuffle XL.

Resin	Layer thickness	Number of bottom layers	Bottom layers exposure time	Normal layers exposure time	Support density
Modelo	0.025 mm	3	30 s	4 s	15%

4.1.5 MoonRay S

For printing on the MoonRay S, with DLP technology, the RayWare slicer was used and parameters are shown in Table 7. The model is shown in Figure 4.

Table 7. Printing parameters for MoonRay S.

Resin	Layer thickness	Support thickness	Support strength
Model Gray	0.02 mm	Low	Low

4.1.6 PRO95

For printing on the PRO95, with DLP technology, the RayWare slicer was used and parameters are shown in Table 8. The model is shown in Figure 4.

4.1.7 Objet500 Connex3

For printing on the Objet500 Connex3, with Polyjet technology, a proprietary slicer was used the parameters are shown in Table 9. The model is shown in Figure 4.

4.2 Model data collection

The printing data per piece are shown in Table 10. Values such as: Days per year (Ds), Hours per day (Hr), Design, Specifications, Control and Post Printing Man-Hours are specified in Section 3.4.1.

Using the data obtained and equation 3.1 – 3.5, the printing cost was obtained as shown in Table 11.

As a result of the alignment and boolean cut of the digitized models with the originals, as shown in Figure 5, the deviation between them and the corresponding physical data in Table 12 is obtained.

Table 8. Printing parameters for PRO95.

Resin	Layer thickness	Support density	Support strength
Die & Model Tan	0.05 mm	Low	Low

Table 9. Printing parameters for Objet500 Connex3.

Materials	Layer thickness	Support density	Support strength
Varoblack y Sup706	0.016 mm	Low	Low

Table 10. Printing data per model.

	Photon S	DS-200	Phozen XL	MoonRay S	PRO95	Objet500 Connex3
Cost per liter of resin (Clk)	90 $/L	180 $/L	180 $/L	200 $/L	200 $/L	201 $/Kg
Print volume (V)	15 mL	29 mL	20 mL	25 mL	28 mL	77 gr
Printing time (T)	6.33 hr	4.75 hr	5.8 hr	5.46 hr	1.68 hr	1.5 hr
Equipment Value (EV)	899 $	6000 $	2599 $	6500 $	11000 $	330000 $
Rescue Value (RV)	89 $	600 $	250 $	650 $	1100 $	33000 $
Useful life (UL)	0.5 years	2 years	1 years	5 years	6 years	6 years

Table 11. Model printing cost.

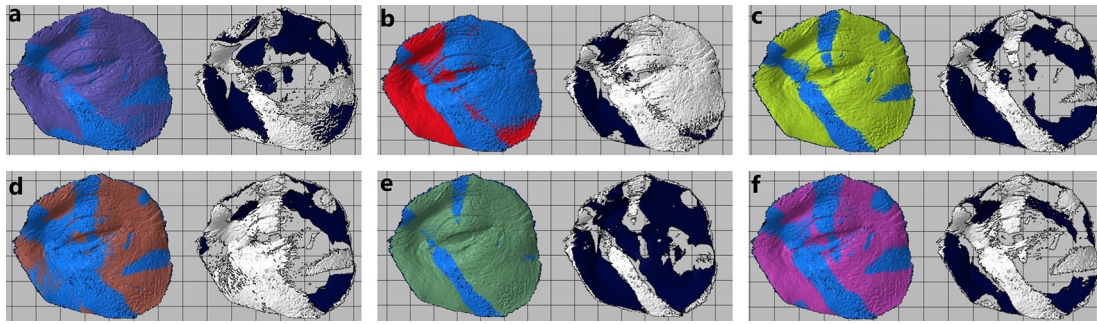|	Photon S	DS-200	Phozen XL	MoonRay S	PRO95	Objet500 Connex3
Material cost	$ 1.35	$ 5.27	$ 3.60	$ 5.00	$ 5.60	$ 15.50
Machine hour cost	$ 1.17	$ 1.46	$ 1.56	$ 0.73	$ 0.32	$ 8.47
Cost per man hour	$ 7.20	$ 6.96	$ 7.12	$ 7.07	$ 6.50	$ 8.98
Printing cost	$ 9.72	$ 14.70	$ 12.27	$ 12.80	$ 12.42	$ 32.95

Figure 5. Scanned oculo-palpebral model of: (a) Photon S, (b) DS-200, (c) Phrozen Shuffle XL, (d) Moon Ray S, (e) PRO 95 and (f) Objet500 Connex3.

Table 12. Deviation between original and printed models.

	Photon S	DS-200	Phozen XL	MoonRay S	PRO95	Objet500 Connex3
Volume of model 1	10.974	10.435	11.553	10.599	10.873	11.090
Volume of Boolean 1	0.131	0.487	0.174	0.244	0.168	0.477
Deviation 1	1.350%	5.018%	1.793%	2.514%	1.731%	4.914%
Volume of model 2	11.163	10.436	11.454	10.664	10.84	11.220
Volume of Boolean 2	0.149	0.544	0.166	0.354	0.156	0.519
Deviation 2	1.535%	5.605%	1.710%	3.647%	1.607%	5.347%
Volume of model 3	11.227	10.335	11.497	10.613	10.828	11.209
Volume of Boolean 3	0.128	0.656	0.159	0.235	0.173	0.484
Deviation 3	1.319%	6.759%	1.638%	2.421%	1.782%	4.987%
Mean deviation	1.401%	5.794%	1.714%	2.861%	1.707%	5.083%

4.3 Evaluation of the models

4.3.1 Economic evaluation

As shown in Table 13, the equipment with the best score and the lowest printing cost is the Photon S. While the equipment with the lowest score and the highest printing cost is the Objet500 Connex3.

4.3.2 Physical evaluation

As shown in Table 14, the devices that are in the range of deviation with the best score are: Photon S, Phrozen Shuffle XL and PRO95, while the devices with the highest deviation are: DS-200 and Objet500 Connex3.

Table 13. Economic evaluation.

Printing cost range ($)	41 – 50	31 – 40	21 – 30	11 – 20	0 – 10
Score	1	2	3	4	5
Photon S					$ 9.72
DS-200				$ 13.70	
Phrozen Shuffle XL				$ 12.27	
MoonRay S				$ 12.80	
PRO95				$ 12.42	
Objet500 Connex3		$ 39.95			

Table 14. Physical evaluation.

Deviation range	8-10%	6-8%	4-6%	2-4%	0-2%
Score	1	2	3	4	5
Photon S					1.401%
DS-200			5.794%		
Phrozen Shuffle XL					1.714%
MoonRay S				2.861%	
PRO95					1.707%
Objet500 Connex3			5.083%		

Table 15. Aesthetic evaluation.

Deviation range	Low	Regular low	Regular	Regular good	Good
Score	1	2	3	4	5
Photon S				X	
DS-200		X			
Phrozen Shuffle XL			X		
MoonRay S				X	
PRO95					X
Objet500 Connex3					X

4.3.3 Aesthetic evaluation

As shown in Table 15, the prints of the PRO95 and Objet500 Connex 3 obtained the best score, while the equipment with the least score was the DS-200 printer.

4.3.4 Multicriteria evaluation

Finally, as shown in Table 16, the equipment with the best combined score were the Photon S and the PRO95, with 4.67 out of 5.

The Photon S, due to its LCD technology, is an economical equipment, with a high level of precision and suitable for using a wide range of resins. The disadvantages of the equipment are its printing volume, $11.5 \times 6.5 \times 16.5$ cm, in addition to having components with a short useful life, LCD screen, FEP film, *etc.*

The PRO95, due to its DLP technology, has an excellent level of precision, its large printing volume, as well as being one of the fastest stereolithography equipment on the market. The disadvantages of the equipment are its high cost, which exceeds $10,000 and its manufacturing cost is almost four times that of the Photon S.

Table 16. Multicriteria evaluation.

Equipment	Physical evaluation	Economic evaluation	Aesthetic evaluation	Total
Weight	33.33%	33.33%	33.33%	100.0%
Photon S	1.67	1.67	1.33	4.67
DS-200	1.00	1.33	0.67	3.00
Phrozen XL	1.67	1.33	1.00	4.33
MoonRay S	1.33	1.33	1.33	4.00
PRO95	1.67	1.33	1.67	4.67
Objet500 Connex3	1.00	0.67	1.67	3.33

For the choice of equipment to be used in the "Mais Identidade" methodology, the volume of work, acquisition capacity, reliability of the equipment, among other parameters, must be considered.

5. Discussion

In the investigation, a standardized methodology was proposed in order to minimize the variation between tests. As in the printing process in LCD and DLP equipment, both in the steps in the use of the slicer and in post printing. In the same way, the sensitivity of the Comet 8M scanner must be taken into account when digitizing, since these equipment, when there is a change in the environment, movements in the work area, high temperatures, among others, can alter the quality of results.

This research shows in detail the process of economic, physical and aesthetic evaluation carried out on 3d models of maxillofacial prostheses by 5 different 3d printing equipment, to finally make a multicriteria analysis. It is worth mentioning that this study is limited to the 3 exposed criteria, since they were considered the most important for the purposes of the +ID workflow, although any other if relevant could be included for better decision making. Likewise, only 5 printers were evaluated for accessibility to them, but the study is easily replicable for any 3D printing equipment.

Previous research on additive manufacturing (3D printing) demonstrates the feasibility of its use for manufacturing processes of maxillofacial prostheses. Unlike these investigations, this one focuses on the equipment within the Peruvian market for the selection of the ideal team for the "Mais Identidade" process, evaluated based on the investigation of the Mais Identidade Institute, in conjunction with Dr. Rodrigo Salazar. Likewise, it was decided to use these seven pieces of equipment in the investigation due to time limits and accessibility to them.

6. Conclusions and future work

Based on the Multicriteria Analysis, the Photon S and PRO95 had the best score with 4.67 out of 5. While in the economic evaluation the Photon S printer obtained the best score with 9.72 dollars; in the physical evaluation, the Photon S, Phrozen Shuffle XL and PRO95 obtained the same score with a deviation between 0 and 2%; and in the aesthetic evaluation, the PRO95 performed the best prints.

In this way, it is recommended in future research to broaden the spectrum of evaluation with criteria such as: Printing volume, printing speed, volume of work; as well as organizational factors: budget, conditions or workflow As well as expanding the range of technologies and equipment to be evaluated, since with technological advances, equipment may arise that is more suited to the needs of each organization.

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Reviewer Report 21 February 2023

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✓   **Dinesh Rokaya** [iD]

Department of Clinical Dentistry, Walailak University International College of Dentistry, Walailak University, Bangkok, Thailand

The authors have made the necessary corrections and improved the manuscript.

Figure 1 fitting the manuscript means Figure 1 should fit within the manuscript layout.

The manuscript looks good and it can be approved.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 03 October 2022

https://doi.org/10.5256/f1000research.122926.r150240

?   **Rodrigo de Faria Valle Dornelles** [iD]

[1] Hospital Beneficência Portuguesa de São Paulo, São Paulo, Brazil
[2] Faculdade de Medicina Campus Guarujá, UNAERP, Guarujá, Brazil

The present study proposes to quantitatively evaluate the quality and cost results of different methods of producing oculo-palpebral prostheses by means of 3D printing. The authors have background and experience for the production of the piece and summarize the workflow. The additive manufacturing methods used and the calculation methods used to define costs are described. Quality was assessed objectively by Boolean principles and subjectively by one of the authors. The conclusion was based on findings with the formulas described and on a subjective assessment of the most appropriate method.

Is the study design appropriate and is the work technically sound?
- The subjective assessment would be more appropriate if it were performed by more than one professional not connected to the study

Are sufficient details of methods and analysis provided to allow replication by others?
- It was not clear the parameters used for printing, especially with regard to FDM

Are all the source data underlying the results available to ensure full reproducibility?
- Same reason as before, and not clear why the FDM method was discarded

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
No

If applicable, is the statistical analysis and its interpretation appropriate?
I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Plastic Surgery; Cranio-Maxillo-Facial Surgery; 3D researcher

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 05 Feb 2023

> **Salvatore Binasco Lengua**, Plus Identity Institute, Sao Paulo, Brazil
>
> Thank you for the feedback.
>
> In a new version of the manuscript we have clarified the points you mentioned about printing parameters and ruling out FDM technology. We will also take into account the comment about an evaluator not linked to the study for future work.
>
> ***Competing Interests:*** No competing interests were disclosed.

Reviewer Report 23 September 2022

https://doi.org/10.5256/f1000research.122926.r150243

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Dinesh Rokaya (iD)

Department of Clinical Dentistry, Walailak University International College of Dentistry, Walailak University, Bangkok, Thailand

This is an interesting study but needs significant corrections and editing of the manuscript.

Abstract:
- "Prosthetic restorations are made to adapt or attach missing human parts in order to restore function and appearance." Please remove this line as this is generally for intraoral prostheses. And add one line on the role of the maxillofacial prosthesis in the restoration of the maxillofacial defect.

- Add objectives of this research.

- It is better to add some results.

Introduction:
- Please add some common biomaterials that can be printed for medical applications.[1]

- In the introduction, it will be useful to add a paragraph on the ocular prosthesis in the restoration of the ocular defect.[1,2]

Materials and Methods:
- Please add references for the data in Table 1, and Tables 4-9.

- Add references for the equations used.

- ○ Please describe more on the statistical analysis.

Results:
- ○ Figure 1 should be edited to make it better fitting in the manuscript.

Discussion:
- ○ More discussion needs to be done comparing with other studies.

- ○ Please add the limitations of this research.

Conclusion:
- ○ It is long. Present the conclusion in a better way and make it concise.

Overall:
- ○ Revision is required.

- ○ Re-access is needed after the revision.

References

1. Rokaya D, Kongkiatkamon S, Heboyan A, Dam V, et al.: 3D-Printed Biomaterials in Biomedical Application. 2022. 319-339 Publisher Full Text

2. Amornvit P, Rokaya D, Shrestha B, Srithavaj T: Prosthetic rehabilitation of an ocular defect with post-enucleation socket syndrome: A case report.*Saudi Dent J*. 2014; **26** (1): 29-32 PubMed Abstract | Publisher Full Text

3. Rokaya D, Kritsana J, Amornvit P, Dhakal N, et al.: Magnification of Iris through Clear Acrylic Resin in Ocular Prosthesis.*J Funct Biomater*. 2022; **13** (1). PubMed Abstract | Publisher Full Text

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Dentistry, Prosthodontics, Maxillofacial Prosthetics, Dental Biomaterials

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 05 Feb 2023

Salvatore Binasco Lengua, Plus Identity Institute, Sao Paulo, Brazil

Thank you for the feedback. A new version of the manuscript was uploaded.

We did the changes in the abstract for a better preview of the paper and added the topics you recommended in the introduction. The Data in Table1 and 4-9 was made by us, based on the printing parameters on the printers used. We also correct the discussion and conclusion.

Just a question:
What exactly do you mean by Figure 1 best fitting the manuscript?

Competing Interests: No competing interests were disclosed.

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