Influence of different 3D printing technologies on the accuracy of working casts fabrication: an in vitro study

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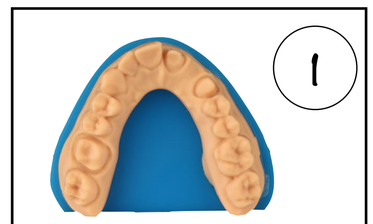
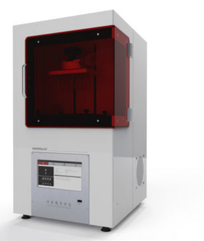
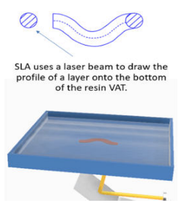
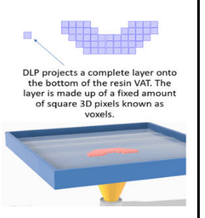
Introduction & Objectives:
In recent years the development of new technologies has invaded all areas of dentistry, in particular, in prosthodontics with the development of CAD/CAM, new materials and subtractive technologies. This subtractive technology has multiple applications: temporary fixed prostheses, splints, diagnostic or treatment casts. For this reason, the aim of this *in vitro* study was to measure the influence of the type of 3D printer, the different printing orientations and the internal thickness of the cast on the accuracy (trueness and precision) of treatment casts.
Methodology: Starting from an upper jaw cast with preparation for a posterior crown and an anterior fixed prosthesis, a STL 0 (standard tessellation language) 0 is obtained, using a laboratory scanner (T710; Medit, Seoul, South Korea). 144 casts are printed, with a SLA (stereolithography) printer (n=72) and with a DLP (direct light processing) printer (n=72). Six groups were created per printer, depending on the printing orientation (0°, 10°, 20°) and the internal thickness of the cast (2 and 4 mm). Once the casts were printed, they were scanned using the same laboratory scanner to obtain an STL. Each of these STLs is overlaid with STL 0 to analyze discrepancies between them by RMS (root mean square) using Geomagic X v.2017 software. Data were statistically analyzed using the Kruskal Wallis test to evaluate trueness, and precision was evaluated using Levene's test ($\alpha = 0.05$).
Results: Trueness of both printers was (0.0739 mm - 0.1947 mm). In DLP, group 3 had the highest mean trueness value (0.131 ± 0.0276), while group 1 had the lowest value (0.145 ± 0.0497mm). In SLA, G8 (0.116 ± 0.0421) had the highest, while G12 (0.151 ± 0.0424) had the lowest. No statistically significant differences ($p<0.05$) were found when analyzing trueness and precision.
Conclusions: Impression orientation in the range of 0 to 20 degrees and cast thickness from 2 to 4mm did not influence the overall accuracy of the DLP and SLA master casts.



1 **Experimental cast**

Extraoral scan
Medit T710 scanner

2 **STL 0**

Variables	DLP printer (n=72) Microlay Versus 385 (3)	SLA printer (n=72) Formlabs Form 2 (3)
1. Type of 3D printer	 	 
2. Orientation impression	 0º 10º 20º	 0º 10º 20º
3. Thickness  	2mm: 0º (n=12) (G1); 10º (n=12) (G2); 20º (n=12) (G3)	2mm: 0º (n=12) (G7); 10º (n=12) (G8); 20º (n=12) (G9)
	4mm: 0º (n=12) (G4); 10º (n=12) (G5); 20º (n=12) (G6)	4mm: 0º (n=12) (G10); 10º (n=12) (G11); 20º (n=12) (G12)

4 **Extraoral scan of printed cast**, with laboratory scanner and overlay of the STL of each printed STL with STL 0

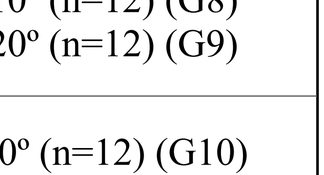
5 **3D analysis of accuracy** (trueness and precision) software Geomagic X

Trueness

1st measurement - discrepancy global of the cast (RMS)

Thickness	
DLP printer	SLA printer
Discrepancy G1 - G4	Discrepancy G7 - G10
Discrepancy G2 - G5	Discrepancy G8 - G11
Discrepancy G3 - G6	Discrepancy G9 - G12

Print orientation	
DLP printer	SLA printer
Discrepancy G1, G2, G3	Discrepancy G7, G8, G9
Discrepancy G4, G5, G6	Discrepancy G10, G11, G12



2nd measurement - points marked in cast (RMS, the X, Y and Z axis)

Precision: is the standard deviation (SD) of the RMS

Results 6

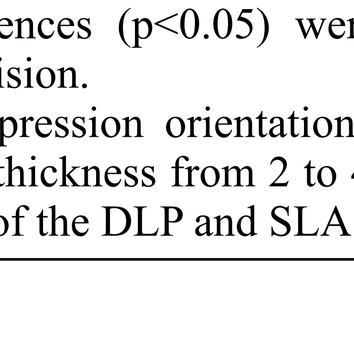
DLP range accuracy (0,103 - 0,194 mm)

Trueness

- Global cast: No differences ($p<0.05$) in RMS
  - Thickness: No differences RMS were found between G1with G4 ($p = 0.429$); G2 with G5 ($p = 0.853$); and G3 with G6 ($p = 0.522$).
  - Print orientation: No differences RMS were found between G1, G2, G3 ($p = 1$) and G4, G5, G6 ($p = 1$).
- Points: differences between groups of 2 mm vs. 4 mm, showing greater trueness in casts with a thickness of 2 mm vs. 4 mm.

Precision: No differences among the groups tested ($p = 0.139$)

	RMS (mm) (trueness ± precision)
Group 1	(0,145 ± 0,0497)
Group 2	(0,141 ± 0,06)
Group 3	(0,131 ± 0,0276)
Group 4	(0,132 ± 0,0279)
Group 5	(0,138 ± 0,0412)
Group 6	(0,142 ± 0,0327)



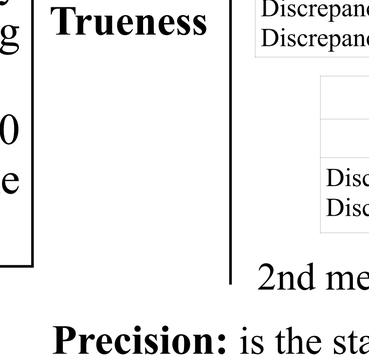
SLA range accuracy(0,073 - 0,193 mm)

Trueness

- Global cast: No differences ($p<0.05$) in RMS
  - Thickness: No differences RMS were found between G7 with G10 ($p = 1$), G8 with G11 ($p = 0.1938$), and G9 with G12 ($p = 0.1570$).
  - Print orientation: No differences RMS were found between G7, G8, G9 ($p = 0.4431$) and G10, G11, G12 ($p = 0.2432$).
- Points: differences between groups of 2 mm vs. 4 mm, showing greater trueness in casts with a thickness of 2 mm vs. 4 mm.

Precision: No differences among the groups tested ($p = 0.432$)

	RMS (mm) (trueness ± precision)
Group 7	(0,133 ± 0,0383)
Group 8	(0,116 ± 0,0421)
Group 9	(0,126 ± 0,0273)
Group 10	(0,127 ± 0,0236)
Group 11	(0,133 ± 0,0191)
Group 12	(0,151 ± 0,0424)



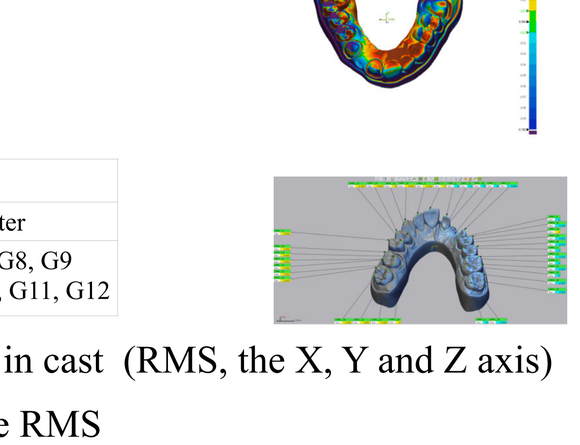
DLP vs SLA range accuracy (0.073 mm - 0.194 mm)

Trueness:

- Global cast: No differences ($p<0.05$) in RMS
- Points: No differences ($p<0.05$)

Precision: No differences among the groups tested ($p = 0.117$) were found when Levene's test was performed.

	RMS (mm) (trueness ± precision)
Group 1	(0,145 ± 0,0497)
Group 2	(0,141 ± 0,06)
Group 3	(0,131 ± 0,0276)
Group 4	(0,132 ± 0,0279)
Group 5	(0,138 ± 0,0412)
Group 6	(0,142 ± 0,0327)
Group 7	(0,133 ± 0,0383)
Group 8	(0,116 ± 0,0421)
Group 9	(0,126 ± 0,0273)
Group 10	(0,127 ± 0,0236)
Group 11	(0,133 ± 0,0191)
Group 12	(0,151 ± 0,0424)



Conclusion 7

1. Dental casts to manufacture fixed prostheses on teeth, with these DLP and SLA printers offer clinically acceptable accuracy results. Furthermore, there are no statistically significant differences in accuracy of the models printed with DLP vs SLA.

2. The variable print orientation and thickness did not influence the accuracy in this type of printed casts with a DLP printer and SLA printer. However, in thickness did influence the selected points, obtaining greater trueness with 2mm thickness.

3. More in vitro studies are needed to compare printed casts of fixed prosthetic treatment to establish well-established protocols.