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Inter-Examiner Variability in Implant Analog Placement in 3D-Printed Full-Arch Implant Casts

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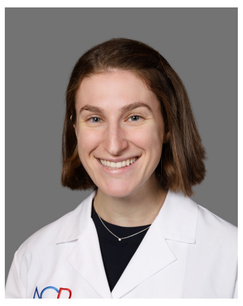


Purpose

Digital workflows are increasingly utilized in implant prosthodontics for treatment planning and fabrication of implant-supported prostheses. Intraoral scanners are routinely used to record three-dimensional implant positions, and current literature supports their use for full-arch implant impressions.

Despite digital workflows, physical casts remain important for verification of framework fit and abutment cementation. These casts may be fabricated using 3D printing technologies.

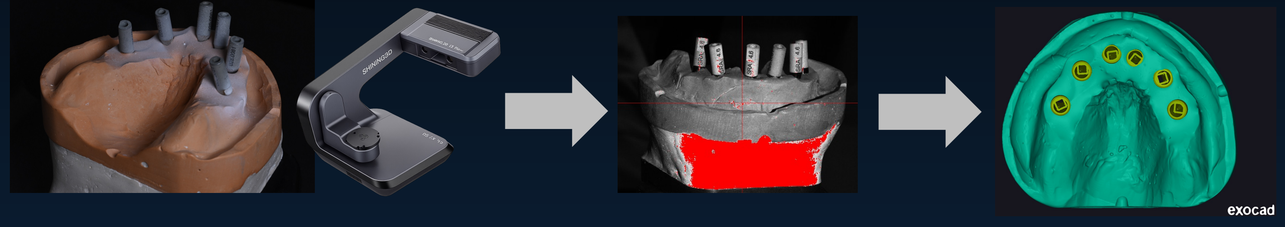
3D-printed implant casts however have been shown to have errors in implant analog placement. Previous literature seldom reports in detail the methodology for analog placement. These positional discrepancies may influence the clinical reliability of these casts for framework evaluation.

The objective of this pilot study was to evaluate the inter-examiner variability in implant analog placement and its potential effect on framework fit evaluation.

Materials & Methods

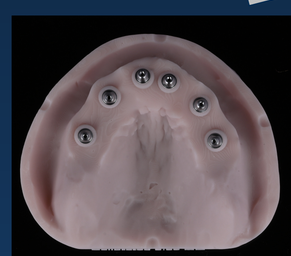
A master cast with six abutment-level implant analogs was used to simulate a clinical scenario of an edentulous maxilla to be restored with an implant-supported fixed complete dental prosthesis (IFCDP). A metal-ceramic IFCDP was fabricated, and its passive fit was verified.

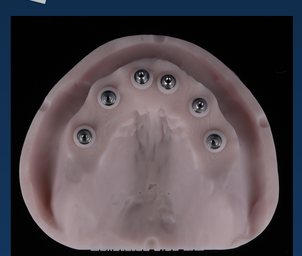
The master cast was digitized using a laboratory scanner to generate a reference STL file. A digital cast was designed using CAD software.



Ten casts were printed using a digital light processing 3D printer. Samples were divided into two groups (n = 5), and two examiners (EE, SK) independently placed abutment analogs into the printed casts.

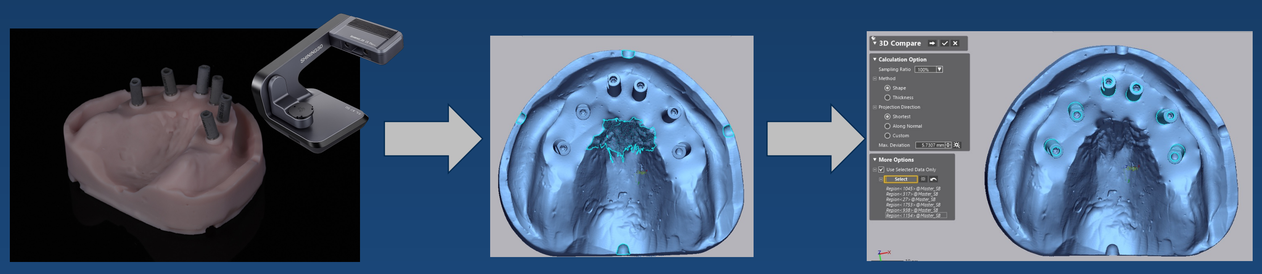
Model Parameters		
Analog Horizontal Offset	0.06 mm	
Analog Vertical Offset	0 mm	





Print Parameters	
Technology	Digital Light Processing
Print Orientation	0 degrees (flat)
Layer Thickness	100 µm
Supports	3 mm
Models/Print	2

The test casts were digitized using a laboratory scanner and compared with the reference STL using 3D inspection software. Four locating notches and palatal rugae were used for superimposition to the reference STL.



The metal-ceramic IFCDP was seated on each test cast and passivity was evaluated.

IFCDP Assessment
Fit without screws
Sheffield test

Results

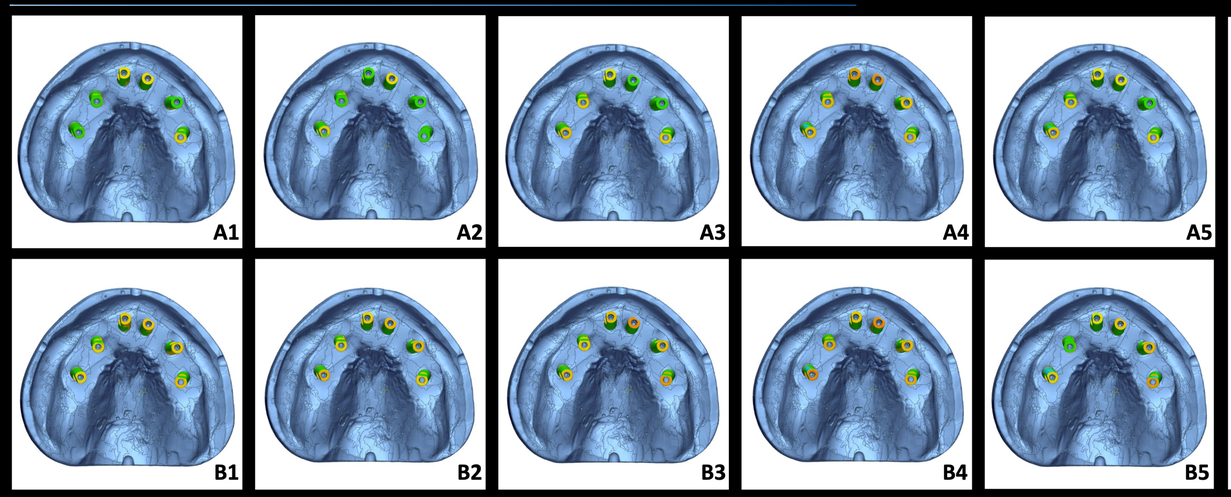


Figure 1. Superimposition color maps (mm) demonstrating 3D positional deviation of implant analogs in each test cast relative to the master cast.

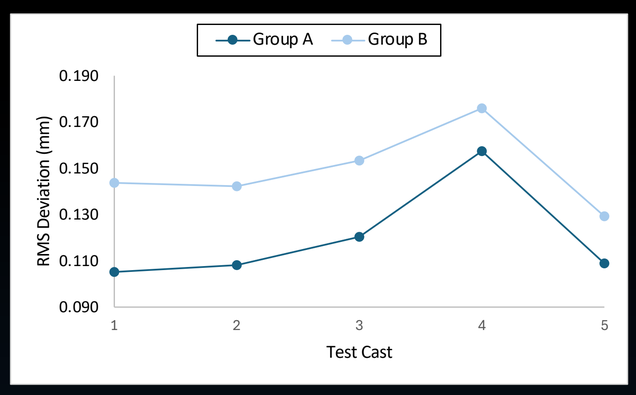


Figure 2. Overall RMS deviation (mm) of implant analog positions in each test cast following implant analog placement.

Position	N	A		B		Difference		P-value
		Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	
1	5	0.0796	0.0090	0.1002	0.0196	0.0206	0.0160	0.045
2	5	0.0745	0.0119	0.0816	0.0177	0.0071	0.0213	0.495
3	5	0.0783	0.0283	0.0822	0.0218	0.0039	0.0335	0.806
4	5	0.0790	0.0237	0.1005	0.0211	0.0215	0.0175	0.051
5	5	0.0635	0.0129	0.0911	0.0142	0.0276	0.0131	0.009
6	5	0.0778	0.0044	0.1078	0.0132	0.0300	0.0135	0.008
Total	5	0.0754	0.0106	0.0943	0.0143	0.0189	0.0111	0.019

Table 1. Comparison of mean positional deviations (mm) between Groups A and B at each analog position. Positions 1 through 6 represent the six analogs, from maxillary right to maxillary left.

IFCDP Assessment		
	Group A	Group B
Fit test	0/5	0/5
Sheffield test	1/5	1/5

Table 2. IFCDP assessment outcomes for Groups A and B.

- Significant inter-examiner differences were identified following implant analog placement.
- Group B demonstrated greater mean deviations at analog positions 1, 5, and 6, as well as in the combined analysis of all six analog positions ($p < 0.05$).
- The IFCDP did not consistently demonstrate passive fit on the test casts.

Conclusions

- Inter-examiner implant analog placement significantly influenced positional deviation in 3D-printed full-arch implant casts.
- Operator-dependent analog placement variables may influence the clinical applicability of printed casts for framework verification and abutment cementation.
- Further investigation is needed to establish standardized printing and implant analog placement protocols for 3D-printed full-arch implant casts.

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