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BASIC RESEARCH

Effect of intraoral scanner, printer and digital analog system on the accuracy of 3D printed models

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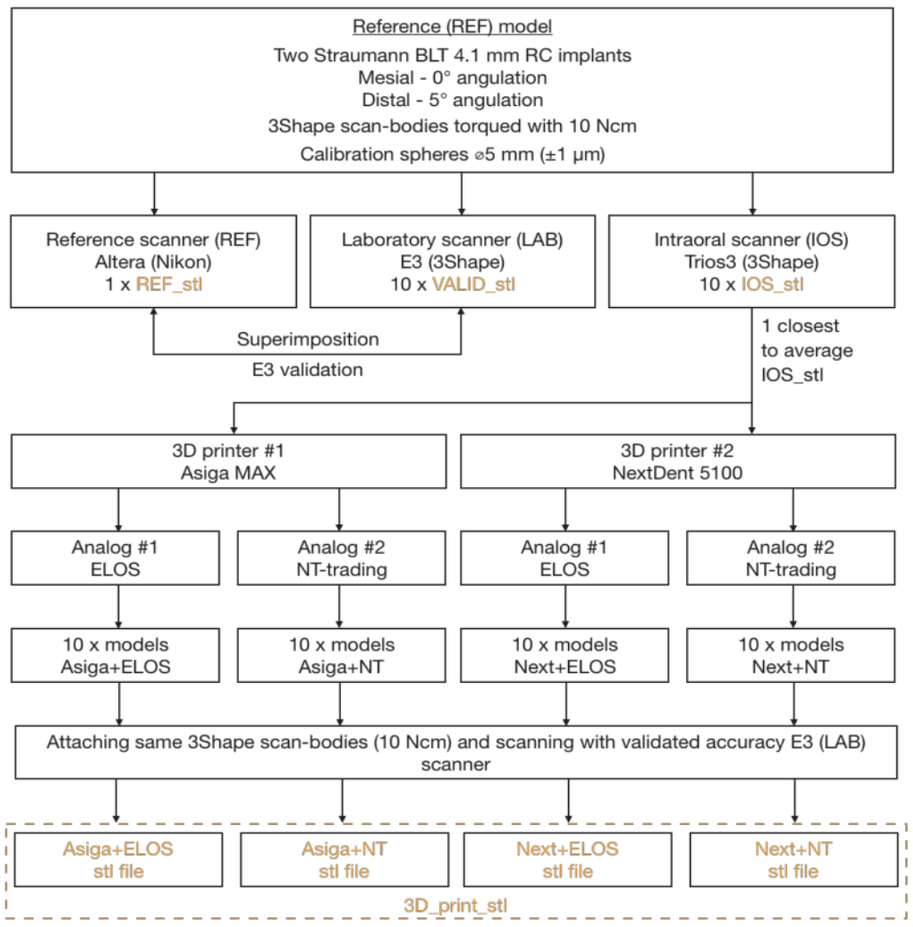
Abstract

Background and Aim

The clinical fit of an implant prosthesis at the implant-abutment junction is directly dependent on the accuracy of impression and cast.[1] Digital workflow for producing implant-supported restorations involves the usage of intraoral scanners (IOS).[2,4] From IOS data 3D printed master model is often fabricated using the selected type of digital analogs.[3] There is a lack of data regarding the effects of IOS, 3D printer, and digital analog type effect on the local and global accuracy of digital analog positions in 3D printed master model. Moreover, errors arising in each step/stage should be identified. The aim of the study was to estimate the effect of IOS, two 3D printers and 2 digital analog systems on 3D positions of the digital analogs comparing reference, IOS and 3D printed model data sets. The null hypothesis was that there are no statistically significant differences between the data sets.

Methods and Materials

Two Straumann BLT 4.1 mm RC implants were inserted in the reference model (REF) left quadrant, in the location of second premolar and second molar with 5° angulation. Three calibration spheres of 5 mm in diameter (±1 µm) where placed on the left quadrant at the model base. Scan bodies (3Shape) were attached to the implants and model was scanned with Nikon Altera 10.7.6. industrial scanner (REF-stl). REF model was scanned 10 times with E3 (3Shape) scanner for validation. Ten digital impressions were taken with 3Shape Trios3 intraoral scanner. The closes to the overall average or IOS impressions STL file (IOS-stl) was selected for 3D printing. Asiga MAX and Next Dent 5100 3D printers, ELOS Print Model Analog and NT-trading DIM-ANALOG were used to produce 4 groups (n=10 each) of 3D printed implant models. Later they were scanned with a validated E3 scanner (3D-print-stl). Distance, angulation, rotation, vertical shift measurements were performed using Geomagic Control X 2018 software.



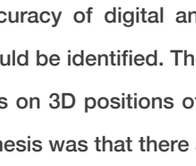


Fig 1: REF model

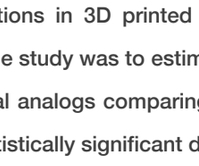


Fig 2: 3D printed REF model replica

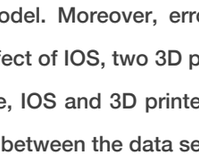


Fig 3: Trios3 intraoral scanner

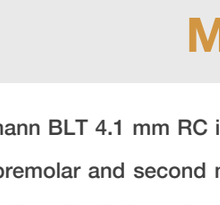


Fig 4: 3D printer Asiga MAX

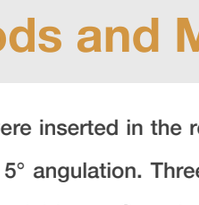


Fig 5: 3D printer NextDent 5100

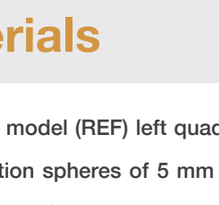
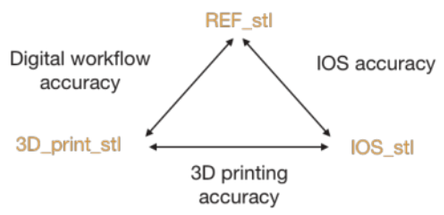


Fig 6: ELOS and NT-trading implant analogs

Results



Distance	Distance between the center points at the bottom of two scan-bodies
Vertical shift	Distance from the plane (drawn through 3 spheres) to the center point at the bottom of the scan-body
Angulation	An angle between center axes of two scan-bodies
Rotation	An angle between selected horizontal edges of two scan-bodies projected to the plane (drawn through 3 spheres)
Local measurement	Measured on the same model between mesial and distal scan-bodies
Global measurement	Measured after two model superimposition, comparing mesial to mesial and distal to distal scan-bodies

Table 1: Accuracy validation of E3 scanner

Trueness	Precision	Repeatability
26.0 µm	16.8 µm	3.4 µm

Table 2: IOS accuracy

RMS	LOCAL	GLOBAL	
	Both scan-bodies	Mesial scan-body	Distal scan-body
Distance	53.0 µm	82.7 µm	138.3 µm
Vertical shift	34.7 µm	66.5 µm	45.5 µm
Angulation	0.283°	0.215°	0.279°
Rotation	0.230°	0.143°	0.152°

Table 3: 3D printing accuracy two-way-ANOVA: p<0.05

RMS	LOCAL				GLOBAL							
	Both scan-bodies				Mesial scan-body				Distal scan-body			
	Nx El	As El	Nx Nt	As Nt	Nx El	As El	Nx Nt	As Nt	Nx El	As El	Nx Nt	As Nt
Distance	159,1	48,2	187.6	80.2	204.8	207.5	144.2	166.2	198.7	207.4	349.5	110.9
Vertical shift	21.0	33.1	41.8	45.3	190.6	132.2	90.8	117.2	112.5	101.1	12.9	36.7
Angulation	0.367	0.458	0.823	0.290	0.386	0.394	0.590	0.355	0.314	0.319	0.820	0.445
Rotation	0.371	0.323	0.723	0.642	2.168	2.186	3.520	7.516	2.405	2.611	5.080	7.694

Table 4: Accuracy of digital workflow two-way-ANOVA: p<0.05

RMS	LOCAL				GLOBAL							
	Both scan-bodies				Mesial scan-body				Distal scan-body			
	Nx El	As El	Nx Nt	As Nt	Nx El	As El	Nx Nt	As Nt	Nx El	As El	Nx Nt	As Nt
Distance	87.4	37.2	115.9	40.7	301.2	267.8	239.0	238.2	196.7	267.9	59.3	186.2
Vertical shift	29.6	39.7	51.7	46.8	279.5	261.5	220.8	186.2	81.2	160.2	35.9	81.5
Angulation	0.862	0.212	1.404	0.622	0.431	0.369	0.442	0.362	1.047	0.351	1.377	0.982
Rotation	0.392	0.769	1.420	1.035	2.546	1.853	4.044	7.625	2.738	2.644	5.524	8.696

Conclusion

1. Asiga MAX 3D printer performed more accurately than NextDent 5100.
2. ELOS Print Model Analog showed most accurate results both locally and globally than NT trading.
3. Intraoral scanning had significant influence in overall error propagation.
4. Further studies are needed to evaluate other factors.

References

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