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Evaluation of 3D Laser Face Scan as a Novel Orthodontic Diagnostic Tool

Asmaa Salaheldin Seliem, Noha Ibrahim Abdelrahman**, Dina Hussein El-Ghoul*** and Noha Ezat Sabet*****

Abstract:

Objectives: To evaluate the 3D laser facial scanner Planmeca Proface as a novel orthodontic diagnostic tool.

Design: Prospective diagnostic study.

Participants: 60 adult female patients having permanent teeth from 1st molar to 1st molar.

Methods: Fifteen facial soft tissue landmarks were identified and labeled on participant's faces before any scanning procedures, then participants were stabilized in the Planmeca Proface machine. Three dimensional facial scan together with a CBCT scan were captured for each participant. Nine direct facial anthropometric measurements were then measured using a digital sliding caliper on participant's face. The same 9 measurements were measured on the 3D photo and the CBCT scans using Planmeca romexis software. The 3 methods measurements were compared statistically for degree of agreement.

Results: The 3D photo of the laser facial scanner Planmeca Proface was accurate and reliable compared to the direct anthropometric measurements and CBCT scans.

Conclusion: The 3D photo of the laser facial scanner Planmeca Proface was accurate and reliable in capturing facial details, hence can be used as an orthodontic diagnostic tool.

Introduction: Accurate diagnosis is the key to systemized treatment planning and successful treatment outcome. **Arnett and Bergman (1993)[1]** stated that clinical facial examination is critical in orthodontic and surgical diagnosis and treatment

*Teaching assistant of Orthodonrics, faculty of dentistry, Ain Shams University
**Lecturer of Orthodontics, faculty of dentistry, Ain Shams University
***Assistant Professor of orthodontics, faculty of dentistry, Ain Shams University
****Professor of Orthodontics, faculty of dentistry, Ain Shams University

planning to establish facial balance along with occlusal and dental harmony in order to obtain reliable results. Moreover, **Sarver (2015)**[2] has explained in details the importance of facial soft tissue examination and its relation to the concept of goal-oriented treatment planning, which has the advantage of keeping the normal positive elements of patient's soft tissue characteristics in addition to the treatment of patient's problems. **Farkas(1994)**[3] has studied and measured more than 100 facial dimensions and proportions based on several facial anthropometric landmarks in hundreds of people and has described the value of these measurements in clinical documentation and research considering the direct anthropometry as a gold standard technique in facial analysis. With the advent of CBCT, it became an adjunct to the clinical assessment and treatment planning. However, its application in dentistry has been limited due to increased cost, difficult access and dose considerations[4]. CBCT is an excellent device in imaging hard tissue structures and most soft tissue components; however, it doesn't capture the true color texture of the skin, along with the hazards of the radiation dose, hence 3D devices such as stereophotogrammetry and laser scanning are still better soft tissue alternatives for surface texture capture[5]. New 3D nonionizing facial scanning devices are introduced every day in the market utilising different acquisition techniques. However, their diagnostic accuracy should be evaluated before its use in orthodontic diagnosis. **Weinberg et al (2004)**[6] has evaluated the accuracy of the 3D photo obtained by Genex 3D camera system compared to the direct anthropometric measurements and concluded that it is an accurate and precise device to capture facial soft tissue details. Moreover, **Wong et al (2008)**[7] has assessed the accuracy of the 3D photo obtained 3dMD face digital photogrammetry system with respect to direct anthropometry and concluded that the 3dMD system was accurate and reliable in representing facial details. The Planmeca Proface laser facial scanner has not, to our knowledge, been compared to the direct facial anthropometric measurements and to the soft tissue CBCT images, which are more commonly used nowadays. Hence, the aim of our study was to evaluate its accuracy in relation to the direct facial anthropometric measurements and to the soft tissue CBCT images, so as to validate its use as an orthodontic diagnostic tool.

Material and methods:A total of 60 participants were recruited from the outpatient clinic of the Orthodontic Department at the Faculty of Dentistry Ain Shams University. Inclusion criteria: Adult female patients with age ranging from 18 to 30 years, no previous orthodontic treatment, presence of permanent dentition from first molar to first molar. Exclusion criteria: Previous orthodontic treatment, Pregnant participants, Presence of facial scars or defects and Participants with craniofacial abnormalities or syndromes.

Methods: An informed consent was signed by each patient before their enrollment in the current study in which the aim of the study and the methodology were clearly described. A brief case history was taken to exclude previous orthodontic treatment or facial soft tissue procedures. Participants preparation was done by identifying and labeling of 15 facial landmarks as described by **Farkas**[3] (table 1) using a sharpened eyeliner. Followed by participants stabilization in the Planmeca Promax 3D mid Proface machine. A 3D photo using the laser scanner Planmeca Proface together with an ultra-low dose CBCT scans were obtained. Then 9 direct facial anthropometric measurements (table 2) were taken on participants 'faces using a sliding digital caliper, as follow:

N-Pg: Total facial height: Vertical linear measurement of facial dimension as measured from nasion (N) to pogonion (Pg)

N-Sn: Upper facial height: Vertical linear measurement of upper facial dimension as measured from nasion (N) to subnasale (Sn)

Sn-Pg: Lower facial height: Vertical linear measurement of lower facial dimension as measured from subnasale (Sn) to pogonion (Pg)

Ls-Li: Vermilion height: Vertical linear measurement of lips from most prominent point of upper lip or labrale superior (LS) to most prominent point of lower lip or labrale inferior (LI)

Zy(R)-Zy(L): Width of the face: Transverse linear measurement of the face from Zygion right Zy (R) to Zygion left Zy (L)

Ch(R)-Ch(L): Mouth width: Transverse linear measurement of mouth width from Cheilion right Ch(R) to Cheilion left Ch(L)

En(R)-En(L): Intercanthal width: Transverse linear measurement of intercanthal width from Endocanthion right En(R) to Endocanthion left En (L)

Ex(R)-Ex(L): Biocular width: Transverse linear measurement of of biocular width from Exocanthion right Ex(R) to Exocanthion left Ex(L)

Al(R)-Al(L): Width of the nose: Transverse linear measurement of width of the nose from Alare right Al(R) to Alare left Al(L)

The same measurements were taken on the 3D photo image and the soft tissue CBCT image on Planmeca Romexis software. The three sets of measurements were compared to each other.

For the assessment of the agreement between measurements of the 3D face scan with direct method and the CBCT scan method, Dahlberg error, Relative Dahlberg Error (RDE), Concordance Correlation Coefficients (CCC) including the 95% confidence limits and Bland and Altman analysis were used. Intra- and inter-observer reliability were assessed using Cronbach's alpha reliability coefficient and Intra-Class Correlation Coefficient (ICC) The significance level was set at $P \leq 0.05$.

Table 1 Landmarks identification

Point	Landmark	Definition
N	Nasion	The sagittal midline point of the nasal root at the nasofrontal suture
Sn	Subnasale	The midpoint of the point of inflection of the columellar base at the junction of its lower border with the surface of the philtrum
Pg	Pogonion	The most protrusive anterior sagittal midline point of the chin
Ls	Labiale superius	The sagittal midline point of the upper lip (at the upper vermilion border)
Li	Labiale inferius	The sagittal midline point of the lower lip (at the lower vermilion border)
Zy (R)	Zygion right	The most lateral extent of the zygomatic arch on right side
Zy (L)	Zygion left	The most lateral extent of the zygomatic arch on left side
Ch (R)	Cheilion right	The most lateral point at the labial commissure on right side
Ch (L)	Cheilion left	The most lateral point at the labial commissure on left side
Al (R)	Alare right	The most lateral extent of the alar contour on right side
Al (L)	Alare left	The most lateral extent of the alar contour on left side
En (R)	Endocanthion right	The most medial point on the palpebral fissure, at the inner commissure of the eye on right side
En (L)	Endocanthion left	The most medial point on the palpebral fissure, at the inner commissure of the eye on left side
Ex (R)	Exocanthion right	The most lateral point on the palpebral fissure, at the outer commissure of the eye on right side
Ex (L)	Exocanthion left	The most lateral point on the palpebral fissure, at the outer commissure of the eye on left side

Results: Error assessment of the 3D face scan method

The maximum Dahlberg error was 0.3 mm related to **Sn-Pg** and **Ex(R) -Ex (L)** measurements and the maximum relative Dahlberg error was 1.2% related to **Ls-Li** measurement. The maximum LOA size of difference was 0.88 mm related to **Ex(R) -Ex (L)** measurement.

The mean difference was mostly negative which means that the 3D photo method was giving higher values than the direct method. Yet all these measurements were of mean difference lower than 0.9 mm with no clinical significance.

Extremely high values of CCC close to one.

Table 2: Error assessment of 3D face scan method

								Bland & Altman Limits of Agreement (LOA)		Concordance Correlation Coefficient		
								95% confidence limits			95% confidence limits	
		Mean	SD	Dahlberg error DE	Relative Dahlberg Error RDE	Mean of Differece (Reference - measured)	SD of the Difference	Lower	Upper	CCC	Lower	Upper
N-Pg	Direct	107.29	5.97	0.27	0.2%	-0.22	0.31	-0.82	0.39	0.998	0.997	0.999
	3d scan	107.51	6.00									
Zy(R)-Zy(L)	Direct	102.90	4.75	0.25	0.2%	-0.09	0.35	-0.77	0.59	0.997	0.996	0.998
	3d scan	102.99	4.80									
N-Sn	Direct	54.98	3.49	0.24	0.4%	-0.16	0.30	-0.76	0.43	0.995	0.993	0.997
	3d scan	55.15	3.51									
Sn-Pg	Direct	53.89	5.34	0.30	0.6%	-0.19	0.39	-0.95	0.57	0.997	0.995	0.998
	3d scan	54.08	5.33									
LS-LI	Direct f	18.12	3.17	0.21	1.2%	-0.08	0.29	-0.65	0.50	0.995	0.993	0.997
	3d scan	18.19	3.20									
Ch(R)-Ch(L)	Direct	49.05	3.52	0.22	0.5%	-0.07	0.31	-0.67	0.54	0.996	0.994	0.997
	3d scan	49.12	3.49									
En(R) – En(L)	Direct	32.13	2.93	0.29	0.9%	-0.20	0.36	-0.90	0.50	0.990	0.985	0.994
	3d scan	32.32	2.92									
Ex(R) – Ex(L)	Direct	96.71	4.87	0.30	0.3%	-0.06	0.42	-0.89	0.77	0.996	0.994	0.997
	3d scan	96.77	4.82									
Al(R)- Al(L)	Direct	34.61	2.70	0.20	0.6%	0.00	0.28	-0.56	0.56	0.995	0.992	0.996
	3d scan	34.61	2.73									

Comparison of 3D scan and CBCT scan method

The measurements of the 3D face scan method were compared to the measurements of the CBCT method using Dahlberg error, Relative Dahlberg Error (RDE) and Concordance Correlation Coefficients (CCC). The size of the difference between the 2 methods was assessed using Bland and Altman analysis (Table 3)

The maximum Dahlberg error was 0.34 related to **En(R)-En(L)** measurement and the maximum relative Dahlberg error was 1.5% related to **Ls-Li** measurement.

The mean difference is positive which means that the 3D face scan method was giving higher values than the CBCT scan method. Yet all these measurements were of mean difference lower than 1.4 mm with no clinical significance.

Extremely high values of CCC close to one

Table 3: Comparison of 3D scan and CBCT scan method

								Bland & Altman Limits of Agreement (LOA)		Concordance Correlation Coefficient		
						Mean of Differece (3d scan-cbct scan)	SD of the Difference	95% confidence limits			95% confidence limits	
		Mean	SD	Dahlberg error DE	Relative Dahlberg Error RDE			Lower	Upper	CCC	Lower	Upper
N-Pg	3d scan	107.51	6.00	0.26	0.2%	0.07	0.36	-0.65	0.78	0.998	0.997	0.999
	cbct scan	107.44	6.01									
Zy(R)-Zy(L)	3d scan	102.99	4.80	0.27	0.3%	0.05	0.37	-0.68	0.78	0.997	0.995	0.998
	cbct scan	102.94	4.77									
N-Sn	3d scan	55.15	3.51	0.29	0.5%	0.14	0.38	-0.61	0.89	0.993	0.990	0.996
	cbct scan	55.01	3.49									
Sn-Pg	3d scan	54.08	5.33	0.30	0.6%	0.09	0.43	-0.75	0.92	0.997	0.995	0.998
	cbct scan	54.00	5.28									
LS-LI	3d scan	18.19	3.20	0.27	1.5%	0.07	0.38	-0.68	0.81	0.993	0.989	0.995
	cbct scan	18.13	3.23									
Ch(R)-Ch(L)	3d scan	49.12	3.49	0.25	0.5%	0.06	0.35	-0.62	0.74	0.995	0.992	0.997
	cbct scan	49.06	3.45									
En(R) – En(L)	3d scan	32.32	2.92	0.34	1.1%	0.17	0.46	-0.74	1.07	0.986	0.979	0.991
	cbct scan	32.16	2.97									
Ex(R) – Ex(L)	3d scan	96.77	4.82	0.31	0.3%	0.02	0.44	-0.85	0.88	0.996	0.994	0.997
	cbct scan	96.76	4.90									
Al(R)-Al(L)	3d scan	34.61	2.73	0.25	0.7%	0.08	0.35	-0.61	0.77	0.991	0.986	0.994
	cbct scan	34.53	2.67									

Intra-observer and Inter-observer reliability

There was very good to perfect intra-observer and inter-observer reliability regarding all measurements with Cronbach's alpha values ranging from 0.884 to 1.

Discussion: This study aimed to evaluate the accuracy of the 3D images obtained by the laser scanner from Planmeca Proface in comparison to the direct facial anthropometry and CBCT scan images. The results were determined to be clinically acceptable if difference was less than 2mm, the same clinical limit that was used in the previous studies[6,7,8]. The results showed that, the maximum size of the difference between 3D photo measurements and direct anthropometry was less than 0.9 mm and the maximum size of difference between CBCT and 3D photo measurements was less than 1.5 mm, which were all clinically acceptable. Hence, the Planmeca Proface laser facial scanner showed both accuracy and reliability of its facial measurements. Most of the measurements of the 3D photo and CBCT methods were higher than the direct method measurements which was explained by **Weinberg et al**[6] that this may be due to the physical contact of the calipers with the pliable soft tissue, which causes soft tissue deformation and underestimation. Furthermore, it was found that the 3D photo measurements showed higher mean values compared to the CBCT scan measurements which according to **Metzger et al**[9] and **Fourie et al**[10] could be attributed to the poorly defined contours of facial structures on the CBCT volume and the difficulty to identify the landmarks. Regarding the inter-observer reliability, there was very good to perfect reliability regarding all measurements with values close to 1 comparable to previous studies[6,7]. To recapitulate the results of the current study, the Planmeca Proface laser facial scanner was both accurate and reliable in capturing facial details, and when compared to soft tissue CBCT scan.

Conclusions: 1- The 3D photo of the face using Planmeca Proface machine was accurate and reliable to be used as an orthodontic diagnostic tool. **2-** The 3D photo and the CBCT images could be superimposed easily to create a full virtual record of the patient's facial hard and soft tissues.

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