ORIGINAL ARTICLE
Volume 17 Issue 1 2022
DOI: 10.21315/aos2022.1701.OA09
ARTICLE INFO
Submitted: 17/11/2021
Accepted: 8/03/2022
Online: 23/06/2022

Reliability of OneCeph Cephalometric Analysis Application on the Devices with Different Screen Size

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To cite this article: Kanpittaya P (2022). Reliability of OneCeph cephalometric analysis application on the devices with different screen size. *Arch Orofac Sci*, **17**(1): 137–150. https://doi.org/10.21315/aos2022.1701.OA09

To link to this article: https://doi.org/10.21315/aos2022.1701.OA09

ABSTRACT

This study aimed to assess the reliability of the OneCeph application according to personal computer (PC), tablet and smartphone screen size in comparison with Dolphin software on PC as a gold standard. Cephalometric landmarks were identified on 100 digital radiographs. Twenty-four cephalometric measurements were made with Dolphin software as a gold standard comparing with OneCeph application on smartphone (OS), OneCeph on PC (OP) and OneCeph on tablet (OT). All measurements were repeated after four weeks for intra-examiner reliability with intraclass correlation coefficients (ICC). One-way ANOVA and Kruskal Wallis test were done for measurement comparison between methods (Dolphin, OS, OP and OT). Results for OneCeph on smartphone and tablet, 21 measurements were comparable with Dolphin while other three (NLA, H-angle and UL to S-plane) were not. In OneCeph on PC, 20 measurements were comparable with Dolphin while other four (NLA, H-angle, U1 to A-point and UL to S-plane) were not. All different measurements were clinically insignificant except H-angle. Intra-examiner reliability represented ICC above 0.9. In conclusion, OneCeph application on three different screen size is reliable to use for cephalometric measurement. Most of the measurements are comparable with gold standard and adequate to be utilised in clinical routine. OneCeph on smartphone and tablet are advantageous from the portable feature over PC.

Keywords: *Application; cephalometric analysis; OneCeph; reliability; screen size*

INTRODUCTION

Cephalometric analysis is an essential procedure for any type of orthodontic treatment. Information retrieved from the start until the completion of treatment are important for diagnostic purposes, treatment planning, assessing outcomes to evaluate orthodontic treatment progression (İşeri *et al.*, 1992). With the advancement of computerised imaging, digital tracing methodologies can be easily applied on any digital radiograph for the purpose of cephalometric analysis. Digital radiographs increased the use of cephalometric analysis software instead of manual tracing as it reduced errors from distortion while converting film's hard copy into digital file (Collins *et al.*, 2007) and from measurement with ruler and protractor (Erkan *et al.*, 2012). Most measurement errors from manual cephalometric tracing were eliminated as the software performed the measurements automatically after landmark identification (Liu *et al.*, 2000). A variety of cephalometric analysis software is available (Mamillapalli *et al.*, 2016). For example, Dolphin is a paid subscription software deemed to be standard (Celik *et al.*, 2009; Erkan *et al.*, 2012; Nouri *et al.*, 2015). However, the use of Dolphin software is limited to personal computers (PC). Other alternative software and application exists which may overcome some of the limitations of Dolphin. The OneCeph application has the relevant advantages over Dolphin as it is a free open-source solution that works on both PC, tablets and smartphones.

Since landmark identification on radiographs is a critical step affecting accuracy of cephalometric measurements. Different screen sizes and sensitivities from different platforms may alter a selection point demarcated on a cephalogram/radiograph. The comparison between tablet and PC was made as per previous report (Goracci & Ferrari, 2014) but software for each platform was different, and the comparison was not including smartphone which is the most commonly used devices at present (Mamillapalli *et al.*, 2016). The OneCeph application appears reliable and reproducible as per previous reports (Livas *et al.*, 2019; Shettigar *et al.*, 2019; Mohan *et al.*, 2021; Zamrik & İşeri, 2021). However, the sensitivity of the platform screens were not investigated while assessing the reliability of the OneCeph application. This study aimed to assess the reliability of the OneCeph application according to PC, tablet and smartphone screen size and sensitivities in comparison with Dolphin software on PC as a gold standard.

MATERIALS AND METHODS

This cross-sectional study was approved by the Human Research Ethics Committee (HREC-DCU 2022-099). One hundred digital lateral cephalometric radiographs were recruited from the postgraduate orthodontic clinic, Faculty of Dentistry, Chulalongkorn University. Inclusion criteria were pre-treatment lateral cephalometric radiographs during January 2019 until December 2019, and taken with Kodak Carestream 9000c system (Kodak 9000, Carestream Health Inc, Rochester, NY). Exclusion criteria were unerupted or missing incisors, non-permanent dentition, tooth buds overlying incisors apices, craniofacial deformities, and poor-quality radiographs.

Digital files of radiographs were imported and calibrated by one examiner (PK), a Thai board certified orthodontist, using two fixed points on ruler scale at 10 mm distance on cephalostat rod. Twenty-five cephalometric landmarks were identified manually on all digital images with Adobe Illustrator 2019 software (Adobe System Inc., San Jose, CA) and stored as JPEG files. Cephalometric landmarks were shown in Fig. 1.

Twenty-four cephalometric measurements were 12 angular measurements (5 skeletal, 5 dental and 2 soft tissue measurements) and 12 linear measurements (7 skeletal, 3 dental and 2 soft tissue measurements). The cephalometric measurements were described in Table 1. Measurements performed with four methods using two software/application across three platforms (Table 2) by the same examiner (PK) for a maximum of one hour per day to prevent visual fatigue. The four methods included Dolphin on PC (Dolphin), OneCeph on smartphone (OS), OneCeph on PC (OP) and OneCeph on tablet (OT). The measurements performed with two software/application namely, Dolphin 3D software 11.9 premium (Dolphin Imaging & Management Solutions, Chatsworth, CA, USA) and OneCeph application (Version beta 9, Google Play Store, Google Inc., updated 17 October 2019). Platforms for cephalometric measurements were Samsung Note10 Plus as a smartphone, 31.54-inch 1920 × 1080 full HD resolution LG monitor as a PC and MI PAD 4 Xiaomi as a tablet. The gold standard control group (Dolphin) (Celik *et al.*, 2009; Nouri *et al.*, 2015) consisted of Dolphin software on PC with 31.54-inch 1920 × 1080 full HD resolution LG monitor. Cephalometric landmarks were

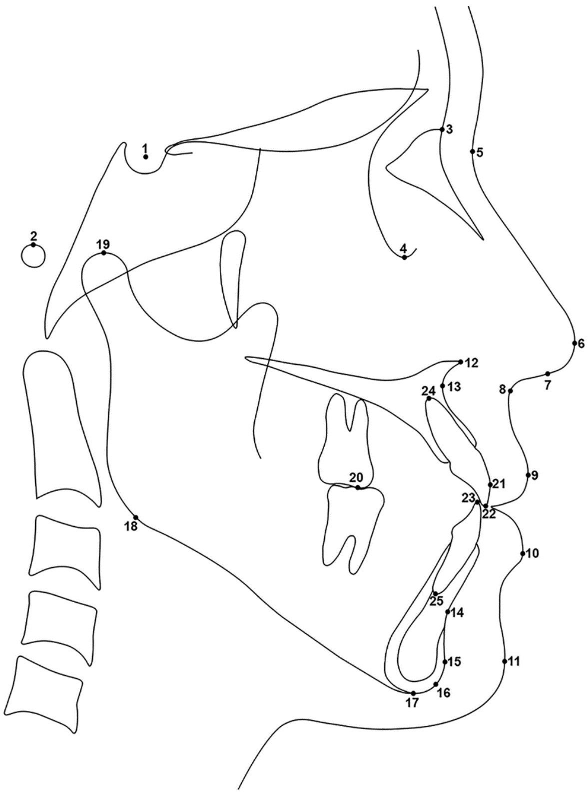

Fig. 1 Twenty-five cephalometric landmarks identified in digital radiograph for measurements: 1. Sella (S), 2. Porion (Po), 3. Nasion (N), 4. Orbitale (Or), 5. Soft tissue Nasion (N'), 6. Pronasale (Pn), 7. Columella (Cm), 8. Subnasale (Sn), 9. Upper lip (Ls), 10. Lower lip (Li), 11. Soft tissue Pogonion (Pog'), 12. Anterior nasal spine (ANS), 13. A-point, 14, B-point, 15. Pogonion (Pog), 16. Gnathion (Gn), 17. Menton (Me), 18. Gonion (Go), 19. Condylion (Co), 20. U6, 21. Most anterior point of U1 (U1 facial), 22. U1i, 23. L1i, 24. U1a and 25. L1a.

identified with a mouse on PC platforms (for both OneCeph and Dolphin), while on smartphone and tablet platforms, the user finger was utilised to resemble general use of such platforms. The brightness, magnification, contrast, zoom in and zoom out were freely enhanced by the examiner.

Four weeks after the first measurements were taken (Zamrik & İşeri, 2021), 10 radiographs were randomly selected to be remeasured in all groups to determine intra-examiner reliability with intraclass correlation coefficient (ICC).

All statistical analyses were conducted with the Statistical Package for the Social Sciences (SPSS 22.0; SPSS Inc., Chicago, IL, USA). Normality test was assessed with Kolmogorov-Smirnov for all measurements taken from each platform. Descriptive statistics followed to determine mean and standard deviation (SD) for all measurements. The comparison of cephalometric measurements were performed with one-way ANOVA test and post-hoc Tukey test to compare differences among groups (Dolphin, OS, OP and OT). Kruskal-Wallis and pairwise comparisons were performed for non-parametric variables. The level of significance was determined at 0.05 significant level with 95% confidence interval.

RESULTS

Means and standard deviations of all cephalometric measurements were shown in Table 3. Intra-examiner reliability for all cephalometric measurements in four groups determined with ICC were 0.957–0.998 in Dolphin, 0.904–0.997 in OS, 0.929–0.997 in OP and 0.939–0.998 in OT. The comparisons among groups by one-way ANOVA and Kruskal-Wallis tests, and the results of post-hoc Tukey test and pairwise comparisons were given in Table 4 and Table 5, respectively. There was no statistically significant difference between the groups except for NLA, H-angle, U1 to point A (mm) and UL to S-plane (mm).

Angular and linear measurements from OS were comparable with Dolphin (gold standard) except for the following three soft tissue measurements: NLA, H-angle and UL to S-plane. Mean differences of these measurements were 6.676°, 7.416° and 1.307 mm, respectively. Angular and linear measurements from OP were comparable with Dolphin (gold standard) except for the following three soft tissue measurements and one dental measurement: NLA, H-angle, UL to S-plane and U1 to point A.

Table 1 Cephalometric measurements

Measurements	Descriptions
SNA (°)	Anteroposterior position of the maxilla relative to the anterior cranial base
SNB (°)	Anteroposterior position of the mandible relative to the anterior cranial base
ANB (°)	Difference between SNA and SNB angles
SN-GoGn **(°)**	Angle between sella turcica-nasion (SN) line and the mandibular plane (Go-Gn)
FMA (MP-FH) (°)	Angle between Frankfort (orbital-porion) and mandibular planes
U1-NA (°)	Angle between nasion-A point (NA) line and the long axis of upper incisor
L1-NB (°)	Angle between nasion-B point (NB) line and long axis of lower incisor
U1-L1 (°)	Angle between the long axes of upper and lower incisors (interincisal angle)
IMPA (L1-MP) (°)	Angle between long axis of lower central incisor and the mandibular plane (tangent to lower border of mandible)
FMIA (L1-FH) (°)	Angle between Frankfort (orbital-porion) and mandibular planes
NLA (°)	Angle between upper lip and base of the nose
H-Angle (°)	Angle between soft tissue pogonion-upper lip (H-line) and soft tissue pogonion-soft tissue nasion
N I to A (mm)	Linear measurement from nasion perpendicular line to A-point
Co-A (mm)	Linear distance from condylion (Co) to A-point
Co-Gn (mm)	Linear distance from condylion (Co) to gnathion (Gn)
A-Co-Gn (mm)	Difference between Co-Gn and Co-A distance
LAFH (mm)	Linear distance from anterior nasal spine (ANS) to menton (Me) represents the lower anterior facial height
N I to Pog (mm)	Linear measurement from nasion perpendicular line to pogonion (Pog)
Wits Appraisal (mm)	Linear measurement between A point and B point projected onto the bisecting occlusal plane
U1-NA (mm)	Linear measurement from the tip of upper incisor to NA line
L1-NB (mm)	Linear measurement from the tip of lower incisor to NB line
U1-A point (mm)	A line is constructed through point A parallel to nasion perpendicular and the distance measured to the facial surface of the upper incisor; it relates the upper incisor to the maxilla
UL to S-Plane (mm)	Linear measurement from most prominent point of upper lip to Steiner's S line
LL to S-Plane (mm)	Linear measurement from most prominent point of lower lip to Steiner's S line

Table 2 Software/application and platforms for four methods

Methods	Groups	Software/Application	Platforms
Dolphin	Dolphin	Dolphin 3D software 11.9 premium (Dolphin Imaging & Management Solutions, Chatsworth, CA, USA)	31.54-inch 1920 × 1080 full HD resolution LG monitor
OneCeph on smartphone	OS	OneCeph application (Version beta 9, Google Play Store, Google Inc., updated 17 October 2019)	Samsung Note10 Plus
OneCeph on PC	OP	OneCeph application (Version beta 9, Google Play Store, Google Inc., updated 17 October 2019)	31.54-inch 1920 × 1080 full HD resolution LG monitor
OneCeph on tablet	OT	OneCeph application (Version beta 9, Google Play Store, Google Inc., updated 17 October 2019)	MI PAD 4 Xiaomi as a tablet

Table 3 Means, standard deviations and ICC (intra-examiner reliability)

Type of measurements	Type of tissues	Cephalometric measurements	Methods	Means	SD	ICC
Angular measurements	Skeletal	SNA (°)	Dolphin	84.22	3.74	0.984
			OS	84.26	3.83	0.904
			OP	84.33	3.73	0.977
			OT	84.20	3.74	0.983
		SNB (°)	Dolphin	80.79	3.96	0.998
			OS	80.91	4.35	0.956
			OP	80.73	3.98	0.997
			OT	80.75	3.98	0.998
		ANB (°)	Dolphin	3.45	2.68	0.991
			OS	3.45	2.67	0.989
			OP	3.60	2.67	0.989
			OT	3.46	2.65	0.991
		SN-GoGn **(°)**	Dolphin	28.87	6.34	0.991
			OS	28.84	6.42	0.987
			OP	28.83	6.25	0.988
			OT	28.91	6.44	0.973
		FMA (°)	Dolphin	24.81	6.17	0.981
			OS	24.80	6.15	0.981
			OP	24.72	6.14	0.978
			OT	24.56	6.57	0.981
	Dental	U1-NA (º)	Dolphin	24.95	9.79	0.978
			OS	24.83	9.85	0.980
			OP	24.92	9.59	0.976
			OT	24.95	9.76	0.979
		L1-NB (º)	Dolphin	30.23	7.35	0.991
			OS	30.16	7.32	0.993
			OP	30.21	7.14	0.992
			OT	30.14	7.34	0.992
		U1-L1 (º)	Dolphin	121.38	13.33	0.970
			OS	121.56	13.25	0.975
			OP	121.26	12.85	0.978
			OT	121.48	13.30	0.977
		IMPA (º)	Dolphin	97.00	7.56	0.983
			OS	96.93	7.52	0.988
			OP	97.03	7.21	0.988
			OT	96.94	7.53	0.986
		FMIA (º)	Dolphin	58.19	8.65	0.985
			OS	58.28	8.67	0.986
			OP	58.28	8.50	0.986
			OT	58.31	8.68	0.986

(*Continued on next page*)

Table 3 (*Continued*)

Type of measurements	Type of tissues	Cephalometric measurements	Methods	Means	SD	ICC
	Soft tissue	NLA (°)	Dolphin	100.93	8.42	0.988
			OS	94.26	10.71	0.971
			OP	94.19	15.65	0.954
			OT	96.49	10.60	0.939
		H-Angle (°)	Dolphin	17.88	4.75	0.996
			OS	10.46	3.59	0.997
			OP	10.32	2.88	0.993
			OT	10.26	2.84	0.997
Linear measurements	Skeletal	N I to A (mm)	Dolphin	1.85	3.48	0.982
			OS	1.83	3.49	0.978
			OP	2.04	3.44	0.982
			OT	1.85	3.50	0.981
		Co-A (mm)	Dolphin	81.64	4.84	0.984
			OS	81.69	4.97	0.976
			OP	80.07	11.13	0.978
			OT	81.77	4.91	0.989
		Co-Gn (mm)	Dolphin	109.57	6.67	0.992
			OS	109.65	6.78	0.993
			OP	108.35	10.39	0.975
			OT	109.77	6.75	0.994
		A-Co-Gn (mm)	Dolphin	27.94	4.34	0.994
			OS	27.97	4.35	0.995
			OP	27.39	5.33	0.976
			OT	28.01	4.36	0.992
		LAFH (mm)	Dolphin	63.88	5.10	0.984
			OS	63.76	5.28	0.973
			OP	63.57	5.35	0.984
			OT	63.96	5.15	0.970
	Dental	N I to Pog (mm)	Dolphin	−1.84	7.33	0.957
			OS	−1.87	7.33	0.956
			OP	−1.44	7.72	0.946
			OT	−1.84	7.34	0.954
		Wits Appraisal (mm)	Dolphin	0.45	3.53	0.994
			OS	0.48	3.55	0.992
			OP	0.66	3.53	0.996
			OT	0.47	3.51	0.995
		U1-NA (mm)	Dolphin	5.40	3.36	0.957
			OS	5.41	3.55	0.956
			OP	5.28	3.32	0.932
			OT	5.41	3.37	0.948

(*Continued on next page*)

Table 3 (*Continued*)

Type of measurements	Type of tissues	Cephalometric measurements	Methods	Means	SD	ICC
		L1-NB (mm)	Dolphin	6.45	2.68	0.995
			OS	6.54	2.86	0.996
			OP	6.56	2.61	0.982
			OT	6.45	2.68	0.994
		U1 to point A (mm)	Dolphin	7.23	2.73	0.981
			OS	7.21	2.73	0.979
			OP	6.06	3.32	0.929
			OT	7.24	2.74	0.941
	Soft tissue	UL to S-Plane (mm)	Dolphin	2.99	2.23	0.997
			OS	1.69	2.49	0.994
			OP	1.55	2.23	0.992
			OT	1.61	2.26	0.993
		LL to S-Plane (mm)	Dolphin	2.85	2.53	0.995
			OS	2.21	2.46	0.997
			OP	2.13	2.38	0.997
			OT	2.18	2.40	0.996

Table 4 Comparison of cephalometric measurements with one-way ANOVA test and Kruskal-Wallis test among the groups

Type of measurements	Type of tissues	Cephalometric measurements	Methods	*p*-value
Angular measurements	Skeletal	SNA (°)	Dolphin OS OP OT	0.995[a]
		SNB (°)	Dolphin OS OP OT	0.990[a]
		ANB (°)	Dolphin OS OP OT	0.975[a]
		SN-GoGn **(°)**	Dolphin OS OP OT	1.000[a]
		FMA (°)	Dolphin OS OP OT	0.992[a]

(*Continued on next page*)

Table 4 (*Continued*)

Type of measurements	Type of tissues	Cephalometric measurements	Methods	*p*-value
	Dental	U1-NA (º)	Dolphin OS OP OT	1.000[a]
		L1-NB (º)	Dolphin OS OP OT	1.000[a]
		U1-L1 (º)	Dolphin OS OP OT	0.999[a]
		IMPA (º)	Dolphin OS OP OT	1.000[a]
		FMIA (º)	Dolphin OS OP OT	1.000[a]
	Soft tissue	NLA (º)	Dolphin OS OP OT	0.000[***b]
		H-Angle (º)	Dolphin OS OP OT	0.000[***a]
Linear measurements	Skeletal	N I to A (mm)	Dolphin OS OP OT	0.978[b]
		Co-A (mm)	Dolphin OS OP OT	0.800[b]
		Co-Gn (mm)	Dolphin OS OP OT	0.815[b]

(*Continued on next page*)

Table 4 (*Continued*)

Type of measurements	Type of tissues	Cephalometric measurements	Methods	*p*-value
		A-Co-Gn (mm)	Dolphin OS OP OT	0.755[a]
		LAFH (mm)	Dolphin OS OP OT	0.955[a]
	Dental	N l to Pog (mm)	Dolphin OS OP OT	0.974[a]
		Wits Appraisal (mm)	Dolphin OS OP OT	0.972[a]
		U1-NA (mm)	Dolphin OS OP OT	0.991[a]
		L1-NB (mm)	Dolphin OS OP OT	0.987[a]
		U1 to point A (mm)	Dolphin OS OP OT	0.021[***b]
	Soft tissue	UL to S-Plane (mm)	Dolphin OS OP OT	0.000[***a]
		LL to S-Plane (mm)	Dolphin OS OP OT	0.122[a]

Notes: [a] One-way ANOVA (parametric data); [b] Kruskal-Wallis test (non-parametric data); [***] *p*-value < 0.05

Mean differences of these measurements were 6.737°, 7.553°, 1.442 mm and 1.172 mm, respectively. Angular and linear measurements from OT were comparable with Dolphin (gold standard) except for the following three soft tissue measurements: NLA, H-angle and UL to S-plane. Mean differences of these measurements were 4.441°, 7.613° and 1.386 mm, respectively. All the *p*-value and mean differences of the method comparison were shown in Table 5.

DISCUSSION

Digital radiographs increased the use of cephalometric analysis software instead of manual tracing as it reduced errors from image manipulation (Collins *et al.*, 2007; Erkan *et al.*, 2012). Most measurement errors from manual tracing were eliminated as the application performed the angular and linear measurements automatically after landmark identification (İşeri *et al.*, 1992). However, inconsistent of landmark identification in cephalometric software and application is an important source of errors. Thus, in our study, we identified landmarks on radiographs and stored the digital files before measuring with all methods.

Previous studies evaluated the reliability of application for cephalometric analysis including OneCeph. The reliability of applications were compared with conventional cephalometric tracing (Mohan *et al.*, 2021; Zamrik & İşeri, 2021) and other cephalometric software/application (Aksakallı *et al.*, 2016; Livas *et al.*, 2019; Shettigar *et al.*, 2019). Some were reliable (Livas *et al.*, 2019; Shettigar *et al.*, 2019; Mohan *et al.*, 2021; Zamrik & İşeri, 2021), some were not (Aksakallı *et al.*, 2016). OneCeph was found to be reliable compared with manual conventional tracing method (Mohan *et al.*, 2021; Zamrik & İşeri, 2021) and digital methods (Livas *et al.*, 2019; Shettigar *et al.*, 2019). Applications for cephalometric analysis have been offered in all types of platforms. Size and sensitivity of the device's screen were a factor affecting landmark identification. Previous study reported a comparison of cephalometric analysis application on PC and tablet to manual tracing (Goracci & Ferrari, 2014). But the comparison was made between different software on different platform (Goracci & Ferrari, 2014) which is not a comparison on the same basis. Therefore, we chose OneCeph application which was available in all platform to make the comparison of the same application on PC, tablet and smartphone. Moreover, from previous study conventional cephalometric tracing method was a reference to compare with the measurements from software on PC and tablet (Goracci & Ferrari, 2014) while the comparison should be made between digital cephalometric tracing methods.

Table 5 Multiple comparison of cephalometric measurements and mean differences

Type of measurements	Type of tissues	Cephalometric measurements	Method comparison					
			Dolphin-OS		Dolphin-OP		Dolphin-OT	
			p-value	Mean differences	*p*-value	Mean differences	*p*-value	Mean differences
Angular measurements	Soft tissue	NLA (°)	0.000[**b]	6.676	0.000[**b]	6.737	0.001[**b]	4.441
		H-Angle (°)	0.000[**a]	7.416	0.000[**a]	7.553	0.000[**a]	7.613
Linear measurements	Dental	U1-A point (mm)	–	–	0.011[**b]	1.172	–	–
	Soft tissue	UL to S-Plane (mm)	0.000[**a]	1.307	0.000[**a]	1.442	0.000[**a]	1.386

Notes: [a] Tukey test (Parametric data); [b] Pairwise comparison (Non-parametric data); ** *p*-value < 0.05

Consequently, we assessed the reliability of the OneCeph application on three different platforms (PC, tablet and smartphone) in comparison with a gold standard (Dolphin software on PC) by determining the cephalometric measurements in all platforms. The ICC values were above 0.9 for all measurements indicated that the reproducibility of Dolphin software, OS, OP and OT was satisfied. Three soft tissue cephalometric measurements, specifically NLA, H-angle and UL to S-plane were different between Dolphin and OneCeph in all platforms. These findings are partially supported by previous study showing that UL to S-plane and NLA measured from OneCeph on smartphone were different from a manual cephalometric tracing method (Zamrik & İşeri, 2021). The observed difference on UL to S-plane was probably due to the different way that both method have to identify the starting point of the S-line. Meaning the identification in OneCeph application was manually performed while in Dolphin software was automated. In regard to the NLA measurement, landmark points for angle construction in OneCeph application were located out of soft tissue area (Fig. 2) which attributed to the chance of differences observed. As for H-angle, we believe differences were presented potentially due to errors in the OneCeph application algorithm. Because the same cephalometric landmarks for H-angle were identified on both method but the measurements from Dolphin software were two-fold lower when compared to OneCeph application.

Additional measurement, U1 to point A was found to be different only between Dolphin and OP. The observed differences were probably due to a limitation of OneCeph application on PC. It is the only platform for OneCeph application that users could not zoom in and out freely to identify the landmarks. The lack of zooming option was probably an obstacle for accurate

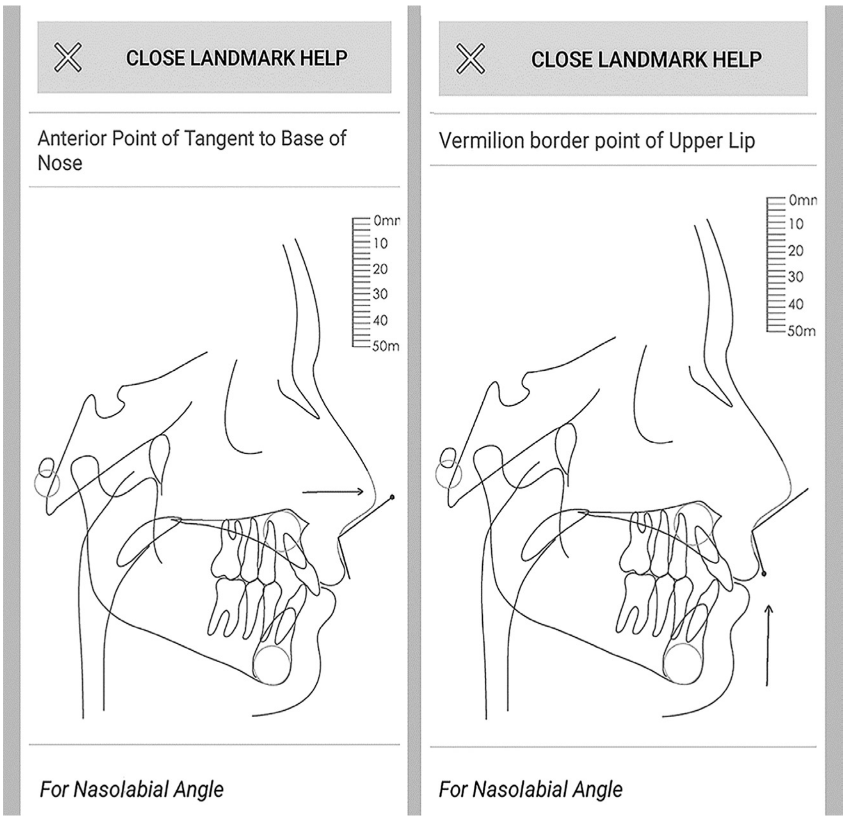

Fig. 2 Nasolabial angle landmarks in OneCeph application

landmark identification. Moreover previous study showed a difference of U1 to point A between OneCeph on smartphone and manual cephalometric tracing method because the application incorrectly calculated the distance from A-line to incisal edge of upper incisor instead of most anterior point of labial surface of upper incisor (Zamrik & İşeri, 2021). In contrast we found no differences of U1 to point A between Dolphin-OS and Dolphin-OT as the location of U1 (most anterior point for the upper incisor) was correctly described in OneCeph application (Fig. 3). As a result we suggest the difference in U1 to point A measurement in OneCeph on PC was from lack of zooming option rather than mismatch measurement between Dolphin software and OneCeph application.

There were four from 24 measurements that represented significant difference between OneCeph application in all platforms with Dolphin software. Mean differences of four measurements ranged from 4.441° to 7.613° for angular measurement and 1.172 to 1.442 mm for linear measurement. The observed mean differences were less than two units measurement for both degree and mm which limited within one standard deviation of normal cephalometric values in accordance with previous studies (Chen *et al.*, 2004; Sutthiprapaporn *et al.*, 2020). Except for H-angle (angular measurement) that the observed difference was two-fold higher when compared to normal cephalometric values (Suchato & Chaiwat, 1984; Sutthiprapaporn *et al.*, 2020). Though the comparison of OneCeph application in all platforms and Dolphin software represented significant difference of four measurements however clinical significance should be addressed regarding to standard deviation of the normal values (Chen *et al.*, 2004). Meaning only H-angle indicated clinical difference for cephalometric measurement between OneCeph application on any platform and Dolphin software while other three measurements were clinically insignificant.

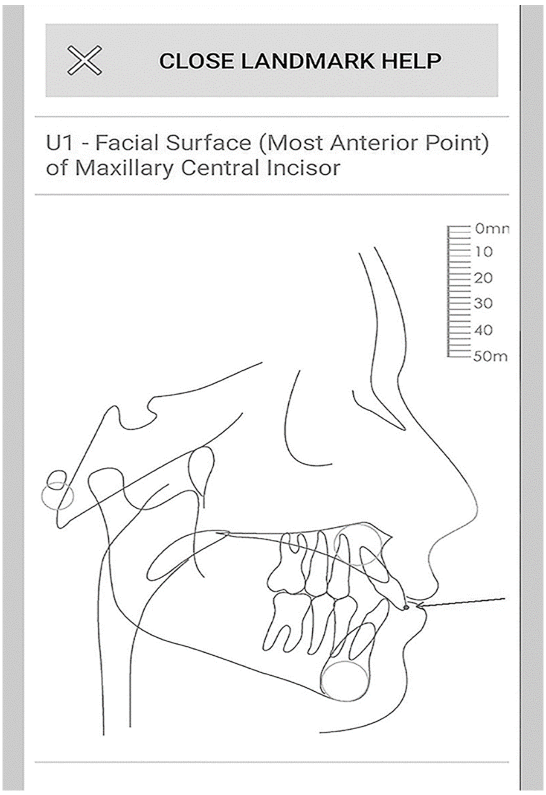

Fig. 3 U1 facial, landmark for U1 to point A in OneCeph application.

Although we identified landmarks on radiographs before measuring with all methods to minimise error, there was an inaccuracy from the process. Because the examiner could freely adjust brightness, magnification, contrast, zoom in and zoom out while using OneCeph application on tablet and smartphone. Therefore, it should be recognised as another factor that can affect the accuracy of the measurement.

OneCeph is a free, user-friendly application for cephalometric analysis which facilitates and supports orthodontic diagnosis in the real clinical practice (Livas *et al.*, 2019; Shettigar *et al.*, 2019; Mohan *et al.*, 2021; Zamrik & İşeri 2021). Though it is available only on Android operating system, devices selection for Android based system are extensively used and affordable. Not only the availability of the device to use with, OneCeph application is also working without internet connection which means the measurements can be done offline in the rural area (Mamillapalli *et al.*, 2016). It is recommended to use OneCeph on smartphone and tablet rather than PC as the application is designed to use with portable devices and the limitation of application on PC. The measurements from OneCeph application are accurate and reliable to use in daily orthodontic practice except for H-angle. Further upgrades will improve the measurements of the OneCeph application.

CONCLUSION

The majority of measurements from OneCeph application on three different screen size and sensitivity are reliable comparing with the gold standard Dolphin software. For clinical routine, it is sufficient to utilise the application on clinical basis as it is a free and easy accessible application for cephalometric analysis. The use of OneCeph on smartphone and tablet have advantages over PC as they are portable.

ACKNOWLEDGEMENTS

This article was supported by Grants for Development of New Faculty Staff, Ratchadaphiseksomphot Endowment Fund, Chulalongkorn University (DNS 64_003_32_001_1). Special thanks to Dr. Joao Nuno Andrale Requicha Ferreira for valuable suggestions and proofreading.

REFERENCES

Aksakallı S, Yılancı H, Görükmez E, Ramoğlu Sİ (2016). Reliability assessment of orthodontic apps for cephalometrics. *Turk J Orthod*, **29**(4): 98–102. https://doi.org/10.5152/TurkJOrthod.2016.1618

Celik E, Polat-Ozsoy O, Toygar Memikoglu TU (2009). Comparison of cephalometric measurements with digital versus conventional cephalometric analysis. *Eur J Orthod*, **31**(3): 241–246. https://doi.org/10.1093/ejo/cjn105

Chen YJ, Chen SK, Yao JC, Chang HF (2004). The effects of differences in landmark identification on the cephalometric measurements in traditional versus digitized cephalometry. *Angle Orthod*, **74**(2): 155–161. https://doi.org/10.1043/0003-3219(2004)074<0155:TEODIL>2.0.CO;2

Collins J, Shah A, McCarthy C, Sandler J (2007). Comparison of measurements from photographed lateral cephalograms and scanned cephalograms. *Am J Orthod Dentofacial Orthop*, **132**(6): 830–833. https://doi.org/10.1016/j.ajodo.2007.07.008

Erkan M, Gurel HG, Nur M, Demirel B (2012). Reliability of four different computerized cephalometric analysis programs. *Eur J Orthod*, **34**(3): 318–321. https://doi.org/10.1093/ejo/cjr008

Goracci C, Ferrari M (2014). Reproducibility of measurements in tablet-assisted, PC-aided, and manual cephalometric analysis. *Angle Orthod*, **84**(3): 437–442. https://doi.org/10.2319/061513-451.1

İşeri H, Yılmaz O, Açıkbaş A (1992). The evaluation of accuracy and reliability of the measurement of cephalometric radiographs by tracing and direct digitization methods. *Turk J Orthod*, **5**(1): 1–6. https://doi.org/10.13076/1300-3550-5-1-1

Liu JK, Chen YT, Cheng KS (2000). Accuracy of computerized automatic identification of cephalometric landmarks. *Am J Orthod Dentofacial Orthop*, **118**(5): 535–540. https://doi.org/10.1067/mod.2000.110168

Livas C, Delli K, Spijkervet FKL, Vissink A, Dijkstra PU (2019). Concurrent validity and reliability of cephalometric analysis using smartphone apps and computer software. *Angle Orthod*, **89**(6): 889–896. https://doi.org/10.2319/021919-124.1

Mamillapalli PK, Sesham VM, Neela PK, Mandaloju SP, Keesara S (2016). A smartphone app for cephalometric analysis. *J Clin Orthod*, **50**(11): 694–699.

Mohan A, Sivakumar A, Nalabothu P (2021). Evaluation of accuracy and reliability of OneCeph digital cephalometric analysis in comparison with manual cephalometric analysis: A cross-sectional study. *BDJ Open*, **7**(1): 22. https://doi.org/10.1038/s41405-021-00077-2

Nouri M, Hamidiaval S, Akbarzadeh Baghban A, Basafa M, Fahim M (2015). Efficacy of a newly designed cephalometric analysis software for McNamara analysis in comparison with Dolphin software. *J Dent (Tehran)*, **12**(1): 60–69.

Shettigar P, Shetty S, Naik RD, Basavaraddi SM, Patil AK (2019). A comparative evaluation of reliability of an Android-based app and computerized cephalometric tracing program for orthodontic cephalometric analysis. *Biomed Pharmacol J*, **12**(1): 341–346. https://doi.org/10.13005/bpj/1645

Suchato W, Chaiwat J (1984). Cephalometric evaluation of the dentofacial complex of Thai adults. *J Dent Assoc Thai*, **34**(5): 233–243.

Sutthiprapaporn P, Manosudprasit A, Pisek A, Manosudprasit M, Pisek P, Phaoseree N *et al.* (2020). Establishing esthetic lateral cephalometric values for Thai adults after orthodontic treatment. *Khon Kaen Univ Dent J*, **23**(2): 31–41.

Zamrik OM, İşeri H (2021). The reliability and reproducibility of an Android cephalometric smartphone application in comparison with the conventional method. *Angle Orthod*, **91**(2): 236–242. https://doi.org/10.2319/042320-345.1