

RELIABILITY OF DOLPHIN CEPHALOMETRIC IMAGING SOFTWARE BY OBSERVERS WITH DIFFERENT LEVELS OF EXPERIENCE

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ABSTRACT

Objective: *This study aimed to investigate the reliability of Dolphin Imaging Software (Version 11.95) for experienced and new users.*

Methodology: *A prospective cross-sectional study was designed involving the identification of 16 cephalometric landmarks by three observers on 28 lateral cephalograms using Dolphin Imaging Software (DIS). One of these observers was novice, and the other two observers were well-experienced in using the DIS. Consequently, three linear and six angular cephalometric measurements were derived by the software. To determine intra-observer differences, six (20% of total sample size) radiographs were re-digitized after two weeks of the first recording. Both the inter-observer and intra-observer reliabilities were determined via Interclass Correlation Coefficient (ICc) and Intraclass Correlation Coefficient (ICC) respectively using SPSS version 27.0.*

Results: *The ICc values signified a strong correlation among the experienced and new users.*

Conclusion: *Dolphin Imaging Software (version 11.95) showed an excellent agreement among different observers with a distinctive range of proficiencies.*

Keywords: *Digital Cephalometry, Reliability, Dolphin Imaging Software*

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INTRODUCTION

Malocclusion is a common condition which may involve irregular alignment of teeth, faulty positioning of jaws or both¹. In order to establish the true nature of malocclusion, information regarding the underlying skeletal and dental relationships is essential for definitive treatment planning². Broadbent introduced lateral

cephalometric radiographs in 1931 so that dentofacial proportions can be assessed and the skeletal anatomic basis for malocclusion can be determined³. Traditionally, cephalometric evaluation has been carried out by recording it on an X-ray film and tracing on an acetate sheet with a lead pencil followed by taking geometric measurements manually with a protractor and ruler. With technological advancement, this approach has shifted from conventional to digital cephalometric evaluation using various specialized computer software⁴.

Digital radiographic systems are being preferred nowadays as they offer several advantages over conventional cephalograms. Digital computer-assisted cephalometric programs are time-saving, offer effortless storage, transfer and duplication of radiographs and they reduce measurement and magnification errors because these measurements are carried out automatically or semi-automatically⁵. Furthermore, they eliminate the chemical and other environmental hazards that are used in the development of radiographic films^{6,7}. The Dolphin Imaging Software (DIS) is a commercially available software among an array of paid and open-source software. It is an FDA-cleared Class II medical

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device which is designed to capture, store and modify patient's images, perform cephalometric analysis and treatment simulation⁸. It is a semi-automated software that requires manual landmark identification by the observer leading to automatic tracing and cephalometric analysis. It also allows enhancement and enlargement of the radiographs which can facilitate improved landmark identification⁹.

Whichever cephalometric method is used, conventional or digital, random and systematic errors need to be minimized for correct measurements¹⁰. Most of errors occur during patient positioning in cephalostat, radiographic acquisition and landmark identification^{11,12}. By far the greatest errors arise in landmark identification¹³. Hence, the basis of accurate results lies in precise identification of landmarks leading to an accurate cephalometric tracing and measurements which aid in correct orthodontic diagnosis.

Incorporating any new modality in a workspace entails the fundamental concept of operator-driven reliability, which standardizes its usage leading to uniform outcomes¹⁴. In order for a software to be efficient, it should be user-friendly and bring about consistent results from time to time even among users with variable experience¹⁵. According to Yoon et al, experience and training significantly influence proper cephalometric tracing and orthodontic diagnosis¹⁶. This becomes even more important when one has to purchase an expensive software like DIS.

Numerous studies have been conducted for comparing DIS with other such available software and manual cephalometry^{17,18}. According to our findings, there is no published information that shows the comparison of the reliability of cephalometric measurements taken from the DIS by operators with varied experience in Pakistan. This study was designed to bridge that gap. Its rationale was to identify how reliable DIS is for operators with differing proficiencies. This will help orthodontists in making an informed decision regarding purchasing the DIS, particularly while having a team of diverse experiential background. Therefore, the objective of this study was to inspect how reliable Dolphin Imaging Software is for both novice and expert users.

METHODOLOGY

This prospective cross-sectional study was conducted in the outpatient department of Orthodontics, Shifa College of Dentistry/Shifa Dental Hospital, Islamabad, Pakistan. The study protocol was approved by the Ethical Review Committee of the hospital (SCD-2024-011). The study duration was 03 months (13-06-2024 to 13-09-2024). A total of 28 digital lateral cephalograms were included in the study using convenience sampling technique. These consisted of 18 female and

10 male subjects with an age range of 8 – 29 years. The inclusion criteria were as follows: Good quality digital cephalograms taken in natural head position, and cephalograms taken from the same cephalogram machine. The exclusion criteria were poor quality cephalograms with inaccurate head positioning, artifacts or distortions.

All the cephalograms were recorded using the cephalometric device for Villa Rotograph Evo D (Villa Systemi Medicali S.p.A. Buccinasco, Milan, Italy) to ensure standardization. The Dolphin Imaging Software (DIS version 11.95, Patterson Dental Supply, Inc. dba Dolphin Imaging and Management Solutions, Chatsworth, CA 91311, USA) was utilized to import these digital radiographs which was then used for manual landmark identification on the screen independently by three different observers with varied experience in using the DIS. One observer had no experience in using DIS, one had more than one year of experience and another had more than three years of experience. The radiographic images were opened on a colored 19 inches monitor (HP Compaq LA, 1905wg, USA) at a screen resolution of 1024 x 768. The radiographs were randomly numbered from 1 to 28 within the software. Before digitization, distance between two fixed points was measured on cephalometric rod that was visible on the radiograph. Then, all cephalograms were calibrated in millimeters (mm) according to the measured separation between two points.

A total of 16 anatomical landmarks (Table 1 and Figure 1) were chosen to be located. Based on these landmarks, three linear and six angular values were automatically evaluated by DIS. These included skeletal, dental and soft tissue measurements. (Table 2)

The digitization of landmarks was done by using the crosshair locator controlled by the mouse while enhancing and manipulating the images as needed, for better identification. (Figure 2) We used Microsoft® Excel® (2016 MSO (16.0.14228.20216) 32-bit) to copy the resultant measurements from DIS after completion of digitization.

To determine intra-observer differences, six (20% of total sample size) radiographs were randomly selected and re-digitized with two weeks interval between each recording by each of the three observers.

To analyse the data, IBM® Statistical Package for the Social Sciences® software SPSS version 27.0 (Chicago, USA) was used. The data was imported from Excel to SPSS for analysis. We used the intraclass correlation coefficient (ICC) and interclass correlation coefficient (ICc) to statistically assess the intra-observer and inter-observer reliability of cephalometric measurements made with the Dolphin Imaging Software (DIS)

respectively. The inter-observer and intra-observer agreements are excellent if the resultant value is 0.75–1, good if value is 0.60–0.74, fair if value is 0.40–0.59, and poor if value is less than 0.40¹⁹.

RESULTS

The intra-observer reliability was assessed with the usage of intra-class correlation (ICC) so that the accuracy of the cephalometric measurements could be verified. The ICC values for the repeated measurements for observer 1, observer 2 and observer 3 were in the range of 0.834 – 0.998, 0.927 – 0.997 and 0.864 – 0.998 respectively. This indicates an excellent correlation. (Tables 3, 4 & 5)

The inter-observer reliability was employed to assess the accuracy of cephalometric measurements among

the three observers. In our study, all the measurements were carried out by the three observer with different experience levels. The range of interclass correlation (ICc) values for all observers was 0.805 to 0.995, indicating an excellent correlation (Table 6). Conclusively, in our study, the values for inter-observer and intra-observer reliability are all above 0.8 indicating an excellent agreement.

DISCUSSION

This study assessed the inter-observer reliability of DIS (Version 11.95). The difference in landmark identification by different operators leads to tracing variance which causes dissimilar cephalometric measurements. It is an established fact that among many factors, training level and experience of the observer

TABLE 1: HARD TISSUE AND SOFT TISSUE LANDMARKS USED IN THE STUDY

Landmark	Description
Point A	Deepest point on the anterior contour of maxillary alveolar process
Point B	Deepest point on the anterior contour of mandibular alveolar process
Sella (S)	Geometric center of sella turcica
Nasion (N)	Most anterior point on frontonasal suture
Anterior Nasal Spine (ANS)	Most anterior point on the anterior surface of maxilla
Posterior Nasal Spine (PNS)	Most posterior point on posterior surface of maxilla
Menton (Mn)	Most inferior point on inferior border of chin
Gonion (Go)	Most posteroinferior point on the angle of mandible
Upper Incisor tip (UI)	Incisal tip of maxillary incisor
Upper Incisor root	Root apex of maxillary incisor
Lower Incisor tip (LI)	Incisal tip of mandibular incisor
Lower incisor root	Root apex of mandibular incisor
Soft Tissue Pogonion (Pog')	Most anterior point on anterior surface of soft tissue outline of chin
Pronasale (Po)	Most anterior point on tip of nose
Labrale Superioris (Ls)	Most prominent point on anterior surface of upper lip
Labrale Inferioris (Li)	Most prominent point on anterior surface of lower lip

TABLE 2: LINEAR AND ANGULAR VARIABLES USED IN THE STUDY

Variables	Descriptions
SNA	The antero-posterior position of maxilla (point A) with respect to anterior cranial base (S-N plane) in sagittal plane
SNB	The antero-posterior position of mandible (point B) with respect to anterior cranial base (S-N plane) in sagittal plane
ANB	The antero-posterior position of maxilla and mandible with respect to each other in sagittal plane
Maxillo-Mandibular plane angle (MMA)	The relationship of maxilla and mandible with respect to each other in vertical plane
Maxillary length (ANS – PNS)	The antero-posterior length of maxilla
Upper incisor inclination (UI-SN)	The inclination of most proclined maxillary incisor to anterior cranial base
Lower Incisor inclination (LI-MP)	The inclination of most proclined mandibular incisor to mandibular plane
Upper lip to E line (Ls – E line)	The anteroposterior position of upper lip to Esthetic line
Lower lip to E line (Li – E line)	The anteroposterior position of lower lip to Esthetic line

TABLE 3: INTRA-OBSERVER (OBSERVER 1) CEPHALOMETRIC MEASUREMENTS USING DOLPHIN IMAGING SOFTWARE

Variables	Measurement 1 (Mean)	Measurement 2 (Mean)	ICC
SNA	80.55	79.83	0.945
SNB	76.45	77.13	0.995
ANB	4.07	2.72	0.899
PP-MP	28.12	28.32	0.923
ANS-PNS	49.60	49.28	0.957
UI-SN	102.58	103.38	0.955
IMPA	95.02	94.63	0.834
UL-E	-4.10	-4.80	0.866
LL-E	-2.08	-1.95	0.998

SNA; Sella-Nasion-A point, SNB; Sella-Nasion-B point, ANB; A point-Nasion-B point, PP-MP; Palatal plane-mandibular plane, ANS-PNS; Anterior nasal spine-posterior nasal spine, UI-SN; Upper incisor-Sella-Nasion plane, IMPA; Incisor-mandibular plane angle, UL-E; Upper lip-Esthetic line, LL-E; Lower lip-Esthetic line, ICC; Intraclass correlation coefficient.

TABLE 4: INTRA-OBSERVER (OBSERVER 2) CEPHALOMETRIC MEASUREMENTS USING DOLPHIN IMAGING SOFTWARE

Variables	Measurement 1 (Mean)	Measurement 2 (Mean)	ICC
SNA	82.35	82.87	0.982
SNB	78.53	78.78	0.983
ANB	3.93	4.08	0.990
PP-MP	26.83	27.05	0.927
ANS-PNS	50.70	50.68	0.993
UI-SN	106.55	106.78	0.995
IMPA	93.17	93.93	0.997
UL-E	-3.82	-3.65	0.997
LL-E	-3.83	-4.17	0.995

SNA; Sella-Nasion-A point, SNB; Sella-Nasion-B point, ANB; A point-Nasion-B point, PP-MP; Palatal plane-mandibular plane, ANS-PNS; Anterior nasal spine-posterior nasal spine, UI-SN; Upper incisor-Sella-Nasion plane, IMPA; Incisor-mandibular plane angle, UL-E; Upper lip-Esthetic line, LL-E; Lower lip-Esthetic line, ICC; Intraclass correlation coefficient.

are quite contributory in causing cephalometric error. For this reason, the purpose of this study was to find out the agreement for measurements recorded by three independent observers on DIS (Version 11.95) with variable length of experience using this software. As it is evident from our results, there was an excellent inter-observer reliability. This could be, due to in part many improvements in the 11.95 version of this software which increase its dependability.

Although the digital analysis of cephalogram is widely used around the world due to numerous advantages, it is important that the measurements are precise and reliable. As DIS is not an open-source program and is only commercially available, its usage is still limited in Pakistan. Many previous studies have already confirmed the reliability and validity of Dolphin

Imaging Software (DIS) for cephalometric analysis^{17, 18}. Previous studies have also compared the reliability of cephalometric measurements using the DIS with manual tracing or other digital software^{18,21}. In our opinion, it is also important to assess the reliability among different users of a software before comparing the reliability of one software with another.

Our findings contrast with a study by Power et al, where Dolphin version 8 was revealed to have errors in different measurements such as SNA, SNB, SNMx, MxMd, UIMx and LAFH and systematic error in UIMx which showed the lowest correlation of 0.74²¹. However, Power et al used Lin's Concordance Correlation where the correlation agreement values are different than the ICC which was used in current study. Therefore, it cannot be directly compared with our study.

TABLE 5: INTRA-OBSERVER (OBSERVER 3) CEPHALOMETRIC MEASUREMENTS USING DOLPHIN IMAGING SOFTWARE

Variables	Measurement 1 (Mean)	Measurement 2 (Mean)	ICC
SNA	82.25	82.18	0.949
SNB	78.35	78.30	0.985
ANB	3.92	3.87	0.977
PP-MP	26.27	26.52	0.993
ANS-PNS	49.13	49.68	0.864
UI-SN	106.22	106.53	0.997
IMPA	93.35	92.72	0.996
UL-E	-3.83	-4.17	0.995
LL-E	-1.90	-2.28	0.998

SNA; Sella-Nasion-A point, SNB; Sella-Nasion-B point, ANB; A point-Nasion-B point, PP-MP; Palatal plane-mandibular plane, ANS-PNS; Anterior nasal spine-posterior nasal spine, UI-SN; Upper incisor-Sella-Nasion plane, IMPA; Incisor mandibular plane angle, UL-E; Upper lip-Esthetic line, LL-E; Lower lip-Esthetic line, ICC; Intraclass correlation coefficient.

TABLE 6: INTER-OBSERVER CEPHALOMETRIC MEASUREMENTS USING DOLPHIN IMAGING SOFTWARE

Variables	Observer 1 (Mean)	Observer 2 (Mean)	Observer 3 (Mean)	ICc
SNA	80.19	82.19	82.50	0.951
SNB	76.41	78.40	78.32	0.982
ANB	3.76	3.86	4.20	0.981
PP-MP	27.77	26.99	26.24	0.959
ANS-PNS	46.92	51.16	49.98	0.805
UI-SN	106.79	110.77	110.87	0.985
IMPA	96.03	95.64	95.67	0.982
UL-E	-2.34	-2.07	-2.25	0.995
LL-E	-0.22	0.02	-0.35	0.994

SNA; Sella-Nasion-A point, SNB; Sella-Nasion-B point, ANB; A point-Nasion-B point, PP-MP; Palatal plane-mandibular plane, ANS-PNS; Anterior nasal spine-posterior nasal spine, UI-SN; Upper incisor-Sella-Nasion plane, IMPA; Incisor mandibular plane angle, UL-E; Upper lip -Esthetic line, LL-E; Lower lip -Esthetic line, ICc; Interclass correlation coefficient.

In the current study, nine cephalometric measurements were evaluated, including six angular measurements (SNA, SNB, ANB, PP-MP, UI-SN and IMPA) and three linear measurements (UL-E, LL-E and ANS-PNS). As the results showed an excellent ICc score among all the three observers, this implies that no significant difference was found for the results between the new and experienced DIS users. However, such results are not corroborated elsewhere.

In the current study, when the mean values of the evaluated measurements were compared, the differences were not substantial; however, when comparing all the values obtained for each measurement, the difference of 2mm in linear measurements, and maximum difference of 4° in angular measurements was observed. More

variation was observed by some previous studies^{13,22}.

Point A landmark identification in a lateral cephalogram is more difficult than identifying other landmarks²³. Nevertheless, all measurements which included point A also showed ICc value of more than 0.950 for all observers using DIS. In addition, there are many methods of cephalometric analysis utilizing different landmarks, however, orbitale, menton, porion, apex of mandibular incisor, nasion, posterior nasal spine and gonion are the most inconsistent points^{24,25}. In this study, all measurements which include the aforementioned points showed more than 0.950 ICc value except ANS-PNS which exhibited interclass correlation coefficient value of 0.805. However, it is still considered to be an excellent correlation. In our study, all the measurements were

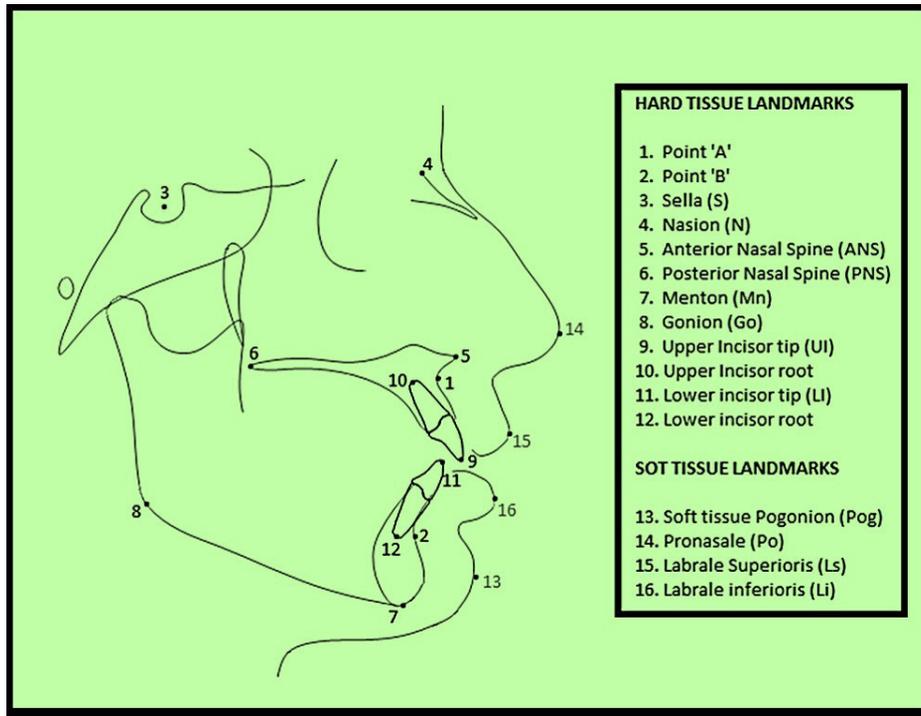


Fig 1: Anatomical landmarks of hard and soft tissue

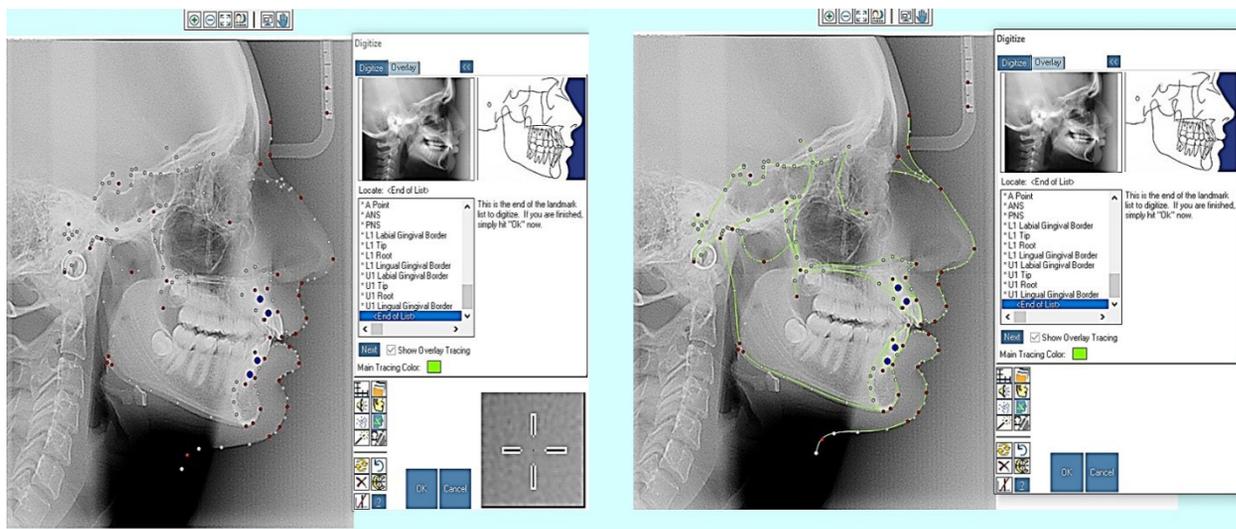


Fig 2: Digitization of landmarks using the mouse-controlled crosshair locator

carried out by two observers who had more than one year of experience with the DIS (Version 11.95) and by one observer with no previous experience of using this software. Thus, it could be stated that DIS is a comprehensible digital software for all practitioners regardless of their duration of experience. An excellent ICc value for the angular and linear measurements in the current study also suggested its reliability for landmark identification. This renders the DIS an efficient and reliable cephalometric tool in independent clinical practice and departmental orthodontic setups where clinicians and operators spanning from no experience to different levels of DIS expertise can rely

on its outcomes.

The limitation of this study was that the sample size was very small and was performed on a limited number of landmarks. Therefore, in future it may be repeated on a large sample with large number of landmarks to improve the reliability of results.

CONCLUSION

Our study showed that there was an excellent agreement among observers using the Dolphin Imaging Software (Version 11.95) with varying range of experience.

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