The Precision and Reliability of Facial Measurements Obtained Using Conventional and Digital Laser Scanning Methods: an in Vivo Study

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Abstract

Aim To evaluate the precision and reliability of the conventional method of facial measurement with the smartphone-based LiDAR (Light Detection and Ranging) scanning method.

This prospective study was performed on forty-seven patients. Measurements between anthropometric soft tissue landmark points were obtained on each participant by two operators, who were blinded to each other's measurements for interrater reliability, using two techniques: i) conventional (C) method using Vernier calliper (Mitutoyo, Kawasaki, Japan) and ii) LiDAR (L) method using the LiDAR scanner (iPhone- 12Pro, iOS 15.2.1, Apple Inc.). Intraclass Correlation Coefficient (ICC) analysis was used to evaluate the intra-observer reliability of the repeated measurements and measurement accuracy between the different measurement methods.

On comparison of the mean values of conventional and LiDAR vertical measurements, the values are statistically not significant with a p-value of 0.704. On comparison of the mean values of conventional and LiDAR horizontal measurements, the values are statistically not significant with a p-value of 0.129. Intraclass correlation is very high, with an agreement of 0.9 and above, indicating LiDAR measurements are highly reliable and reproducible.

The digital scanning system (LiDAR) is equally accurate in reproducing facial measurements compared to the conventional system, making it an excellent alternative analytical tool for taking facial measurements.

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Introduction

Nowadays, the introduction of a digital scanning system in medicine has been pivotal, as it has become one of the major aspects of the healthcare industry. The digital analysis of facial hard and soft tissues has helped us inspect and understand the dentoskeletal relationships with higher precision. In previous decades, there has been a comprehensive change in the evaluation of maxillofacial relationships and measurements. Starting from the use of traditional plaster models as diagnostic materials in orthodontic dentistry, to the use of lights, cameras, and projectors in the early 1960s for scanning we have advanced to high-tech digital laser scanning systems.[1,2] This shift has bought about evolutionary changes in the medical as well as orthodontic and maxillofacial fields of dentistry.[3]

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Innovations in digital facial analysis have paved the way for the development of minimally invasive and less time-consuming techniques based on digital processing and optical characteristics.[4] Interestingly, the studies compared scans made with the same scanning system and reported an overall linear error of less than a millimeter.[5] Facial scanning is a fast, repeatable, economical, and high-resolution technique for recording the external morphological features allowing manipulation of the facial scan in multi-directions.[6] Facial scanning system with the use of advanced technologies like an integrated digital unit to produce realistic facial images and also records digital maxillofacial radiographs, this technology helps clinicians to visualize and plan the treatment procedure with greater precision. Although these new smart scanning methods is advanced and provides high resolution, the biggest drawback of this is the need for accuracy and professional handling. The drawbacks mentioned above lead to the urge to find an alternative to obtain suitable face scan images. LiDAR (Light Detection And Ranging) scan has been found to overcome these issues as LiDAR scanning technology is inbuilt into phones, making it portable and allowing easy access. This makes it available for a more significant population and allows universal use. Adding on to the fact, it is a more economical option when compared to the digital facial scanner.[7,8] With the advent of digital technology and the evolution of 3-D techniques, there is a need to determine the precision and reliability of the facial measurements obtained by these digital methods before they can be used in the healthcare field. Hence in this study, the conventional measurement method of facial measurements is compared with the digitized facial scanning method to evaluate their precision and reliability. The measurement appliances used in this study are based on different principles of measurement comparing the different diagnostic recording systems. The two systems being, the LiDAR scanning technology which is inbuilt into phones, and the conventional Vernier caliper method.

Materials and methods

Digital and conventional facial profile measurements were obtained for forty seven subjects at Manipal College of Dental Sciences Mangalore (Manipal Academy of Higher Education, Manipal), Karnataka, India. The inclusion and exclusion criteria included subjects with the absence of visible facial deformities and excessive facial hairiness (beard). The screening and imaging process ensured that potential subjects satisfied the inclusion and exclusion criteria for this study.

The study was approved by the Institutional ethics committee reference no. 22040 and written informed consent was obtained from all participants before the conduction of the study.

Figure 1. Frontal photograph of the subject with reference points, in order from top to bottom: Glabella (Gb) (part of the forehead above and between the eyebrows), Pronasale (Prn) (The tip of the nose), Pogonion (Pog) (the anterior most prominent point on the chin); L-R Zygion (Zy) (most lateral point of the zygomatic arch).

Patient Sample and Data Collection

Based on the article published by Kim et al.,[9] the correlation coefficient derived was 0.51. With an alpha error of 1% and a power of 90%, the Z values of the given alpha and beta values were 2.57 and 1.28. With the correlation coefficient and using the above formula, the required sample size was 47 for the study.

Participants were instructed to sit upright, adopting a natural head position, and to keep their eyes open, looking to the horizon without facial expression for the two groups - conventional(C) and LiDAR (L). Anthropometric soft tissue landmarks - Medial points - glabella (Gb), pronasale (Prn), pogonion (Pog); and Bilateral points - Zygion (Zy) were marked, and linear dimensions were measured between medial points and bilateral points (figure 1). Measurements between landmark points were obtained on each participant by two operators, who were blinded to each other's measurements for interrater reliability, using two techniques: i) Conventional (C) method group - Done directly on the participant's face using the digital Vernier calliper (Mitutoyo, Kawasaki, Japan) to an accuracy of one-tenth (1/10) of an mm. (Figure 2 & 3). ii) LiDAR (L) method group - Digital measurement is done with the LiDAR scanner (iPhone- 12Pro, iOS 15.2.1, Apple Inc.) This is a class I scanner; this type of scanner is safe to use under all conditions [10,11] (Figure 4). The patient was positioned in the direction of the scanner camera, with the measuring operator standing in front of each subject and holding up the smartphone with their dominant hand, making sure that the subjects arches were always in occlusion.

Figure 2. Vertical measurements recoded using digital Vernier calliper.

Statistical Analysis

The order of the manual and digital measurements was decided randomly by flipping a coin. Documented data were recorded in a Microsoft Excel™ spreadsheet and evaluated for reliability using SPSS 20.0 (IBM Chicago). Descriptive statistics of mean and standard deviation were compared between any two measurement techniques using paired t-test. Intraclass Correlation Coefficient (ICC) analysis was used to evaluate the intra-observer reliability of the repeated measurements and measurement accuracy between the different measurement methods.

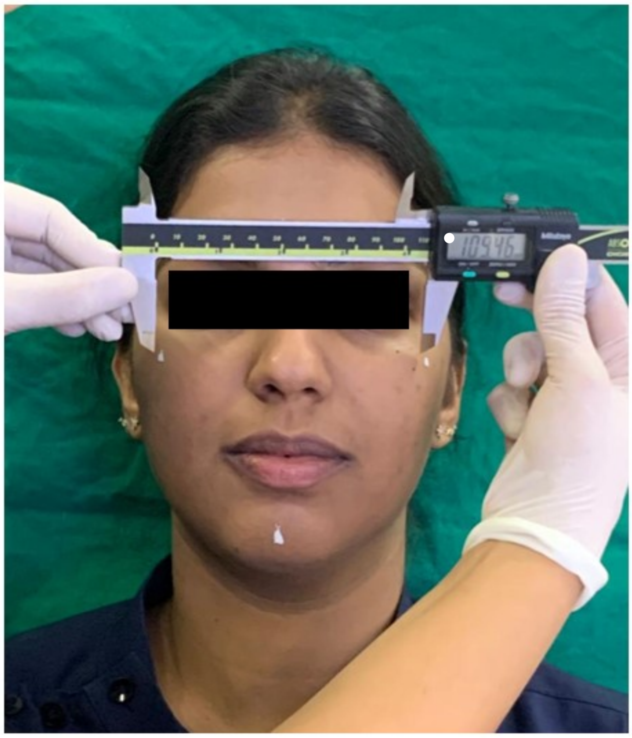

Figure 3. Horizontal measurements recoded using digital Vernier calliper.

Results

The mean standard deviation between the conventional measurements and digital measurements were evaluated by performing the paired t test with obtaining the t-value and p-value (Table 1). On comparison of the mean values of conventional and LiDAR vertical measurements, the mean values of LiDAR vertical are higher with a difference of 0.222 is statistically not significant with a p value of 0.704. On comparison of the mean values of conventional horizontal rounded off measurements and LiDAR horizontal, the mean values of conventional horizontal rounded off measurements are higher with a difference of 0.822 and are statistically not significant with a p value of 0.129. Table 2 shows the correlation between the two pairs - conventional measurements and LiDAR measurements.

Figure 4. Measurements recoded using LiDAR scanner.

		N	Mean ± SD	Mean difference ± SD	t	P VALUE
Pair 1	Conventional Vertical Rounded Off	45	120.44±9.27			
	LiDAR vertical	45	120.67±10.53	-0.22±3.9	-0.38	0.704
Pair 2	Conventional Horizontal Rounded Off	45	112.38±10.46			
	LiDAR Horizontal	45	111.56±11.67	0.82±3.56	1.55	0.129

Table 1. Shows the mean standard deviation between the conventional measurements and LiDAR measurements by performing the paired t test with obtaining the t value and p value.

A positive correlation means as one parameter value increases the other also increases. A negative correlation means as one parameter increases the other decreases. The correlation between the parameters conventional vertical rounded off and LiDAR vertical showed an excellent positive correlation, and is significant with a p value of <0.001. The correlation between the parameters conventional horizontal rounded off and LiDAR horizontal showed an excellent positive correlation and is significant with a p value of <0.001 (Table 2). Intraclass correlation is very high agreement of 0.9 and above indicating phone measurements are highly reliable and reproducible (Table 3).

SNO	PARAMETERS BEING CORRELATED	N	Correlation(r)	P VALUE
1	Conventional Vertical Rounded Off & LiDAR vertical	45	0.93	<0.001
2	Conventional Horizontal Rounded Off & LiDAR Horizontal	45	0.954	<0.001

Table 2. Shows the correlation between the two pairs - conventional measurements and LiDAR measurements.

Intraclass Correlation Coefficient –							
	Intraclass Correlation	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures (Vertical measurements)	.923	.864	.957	24.940	44	44	<0.001
Single Measures (Horizontal measurements)	.948	.908	.971	37.690	44	44	<0.001

Table 3. Interclass correlation coefficient.

Discussion

In the present study, few measurements showed inconsequential differences between manual and digital measurements as this could be a result of internal characteristic differences between the two methods, because the digital measurement captures the point and makes it stable therefore allowing better location of the reference points, and it contains digital tools to measure diameters and distances along selected reference points. No statistical differences were found between the 2 measurements, in the horizontal and the vertical dimensions of facial analysis.[12,13] This is consistent with Pellitteri F. et al,[14] evaluated various scanning methods for the identification of landmarks by analyzing facial index during the orthodontics while observing them conventionally and digitally through a three dimensional (3D) app from a smartphone also these findings and landmarks identification and reliability were similar to the study done by Coward TJ et al,[15] where the landmarks of ears and face were reproduced through laser scanning. On the other hand, in comparison to the findings from this study, significant differences were noted by Mai HN et al in 2020, when 3D facial scans through a smartphone-based app were performed on inanimate objects and human subjects. However, meta-analysis and systematic review of digital measurements through mobile-compatible 3D scanning did not show efficacy as professional systems for facial scanning. Generally, the differences were within the clinical range.[8]

A study by Pojda et al in 2021, assessed the sensors for high-definition and optical scanning systems used for orthodontic diagnosis and treatment planning and they confirmed that orthodontic 3D imaging for facial scanning is more convenient and cheaper alternatives hence opening new frontiers for artificial intelligence in orthodontic dentistry.[16,17] Thurzo, A. et al in 2022 evaluated CBCT and TrueDepth smartphone application-associated facial scans which showed significant differences between the 3D imaging unit and digital scanning application whereas the current study depicts the digital facial evaluation which surpasses the conventional modalities as smartphones have TrueDepth scanners which has an added advantage of artificial intelligence in performing quick and cost-effective scans in real-time processing and also the digital scans which can be performed without manually measuring values on patient's face while reducing radiation exposure from 3D imaging units. Other advantages of phone-based scanners include ease of data transfer and retrieval, feasibility and storage of information, and virtual diagnosis for orthodontic cases.[18] The use of digital facial scanning is a virtuous alternative for the assessment of pre- and post-diagnostic facial examination, which provides an excellent tool with superior features in orthodontic dentistry.

The limitations of this study are that the inbuilt digital facial scanning software provides the numerical value of whole numbers as software is programmed accordingly, which does not tell the limit of the upper and lower numbering system, further decimal and fractional values can be incorporated for more precise evaluation and assessment of numerical values in future while developing digital scanning applications. Smartphone scanning cannot compete with 3D imaging units like cone beam computed tomography scans when comparing accuracy, the only disadvantage with a 3D imaging unit is its availability and radiation exposure. The contemporary development in LiDAR scanners presents many advantages over 3D imaging units and conventional methods, still, it is not sufficient to estimate accurate facial scanning in decimal and fractional values. The gradually improving precision and quality of the LiDAR scanner, present in Apple devices have the potential to be used in orthodontic dentistry.

Conclusions

Digital facial scans provide a magnificent tool for routine diagnostic evaluation in orthodontic dentistry. The smartphone scanning method used in this study provided consistent and comparable measurements in contrast to manual measurements.

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Declaration of Interest

The authors report no conflict of interest.

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