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ORIGINAL ARTICLE

The Reliability and Validity of the Measurements in Unilateral Cleft Lip and Palate Laser Scanned 3D Dental Casts

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Abstract

Objective: To evaluate the reliability and validity of the Next Engine 3D Laser scanner. **Material and Methods:** A total of 30 dental casts of unilateral cleft lip and palate (UCLP) children with 90 linear variables were measured using digital caliper while the laser-scanned 3D dental casts (LS3DM) were measured using Mimics Software. All scanned data coordinates (in x, y, z) were transferred into Mimics software in STL format to be measured. All the variables were measured using a computer mouse accurate to 0.5 mm. The intra-class correlation coefficient (ICC) was used to evaluate the intra- and inter-examiner reliabilities and also for the validity of two methods. **Results:** Intra-examiner reliabilities of digital caliper and LS3DM were found excellent (ICC 0.916-0.995) and inter-examiner reliabilities of LS3DM were good to excellent (ICC 0.816-0.990). The validity of LS3DM measurements was confirmed based on the ICC values were in the range of 0.913-0.996. The overall time frame for conducting measurements was shorter using a laser-scanned model (10 min.) than using a digital caliper (5 hours). **Conclusion:** The LS3DM is a valid reliable tool for future high impact research in our institution.

Keywords: Measurements, Methods and Theories; Reproducibility of Results; Cleft Lip.

Introduction

Evaluation of reliability and validity of a study is essential that the derived data becomes more trustworthy and confident [1]. Validity refers to whether the value of measurements truly measures the intended objectives [2]. On the other hand, reliability means repeatability of the measurements [2]. The data may have a high-reliability index but at the same time may not be valid. Thus, both validity and reliability must be tested before embarking any study that involves measurements.

A standardized method and clear description of landmarks for measurement may enhance the reliability of measurements [1]. The landmarks selected, the appropriate tools for measurements, the researcher's skill, experiences of the researcher would ensure the validity of the measurements [2].

The current trend in high impact research and publication also emphasizes the incorporation of digital technology in the research methodology [3]. Several published studies have assessed its validity and reliability of the 2D and 3D digital models and several different software that were used to analyze the digital dental casts [3-7].

Stone dental casts are extensively being used for clinical and research. It has advantages that the fabrication of dental cast was economical and the casts itself enable 3D assessments. On the other hand, dental casts occupied spaces in the dental office and difficult to transport from one office to the other. The dental casts have high compressive strength but brittle. Thus, there were possibilities of damage that important information may be lost. In recent years, due to the inconvenience of transport, the chance of destruction and expenses of dental casts as well as the advantages of digital techniques (digitation methods; such as laser, optical, stylus, etc.), there has been a worthy concern in alternatives to dental casts in dentistry. The replacement of dental casts with the 3D digital dental cast has provided an alternative method owing to its perfect techniques of capturing images, ease of access, storage and transfer for diagnostic, clinical, and information purposes [3-7].

Dental casts in the research of unilateral cleft lip and palate (UCLP) children is very common in dentistry from the last two decades. A very limited research has been conducted on the 3D digital model in the research of UCLP children and has proven the reliable and valid alternative method to dental casts [8-11]. However, no research has been conducted using a combination of Next Engine Laser Scanner and Mimics software in the research of UCLP digital dental casts.

We have, therefore, paid particular attention to evaluate the validity and reliability of laser-scanned 3D digital models (LS3DM) in assessing treatment outcomes of UCLP children by benchmarking its measurement with the digital caliper's measurements.

Material and Methods

Sample

A total of 30 maxillary dental casts were selected from the archive of the School of Dental Sciences, Universiti Sains Malaysia. Inclusion criteria were; 1) non-syndromic UCLP children, 2) individuals aged 5-12 years, 3) dental casts were taken before any orthodontic treatment and bone

grafting, 4) cheiloplasty and palatoplasty had been performed. However, subjects with any associated anomalies or syndromes were excluded from the study. All the 30 maxillary dental casts were scanned and converted into LS3DM by Next Engine laser scanner. Ninety linear variables were measured using digital caliper while the LS3DM were measured using Mimics Software.

Data Collection

Conversion of Dental Cast Into Laser Scanned 3D Dental Models

Next Engine laser scanner is a device for recreating three-dimensional (3D) objects on a computer including scanner and Auto-drive (Figure 1). The Auto drive consists of a gripper arm, platter pad and platter shaft. The cast can be carried by a platter pad and fixed on the gripper arm. The cast can also be adjusted to four directions; raise up, lower, right and left by platter pad screw. Gripper arm screw used to move gripper arm up-down. A 360-degree scan option was chosen from the panel that scan the cast from every angle. By triangulating distances between the reflecting laser beam and the scanned cast surface, the next engine 3D laser scanner can detect not only an object's length and width but also its depth (Figure 1).

First, the scanner collects surface data of the object by flashlight, and then four laser beams slowly move across the surface of the object, capturing data points that form the geometric structure of the object (Figure 1). The software allows examiners to analyze the images in every aspect by manipulating the digital models on their personal computers.

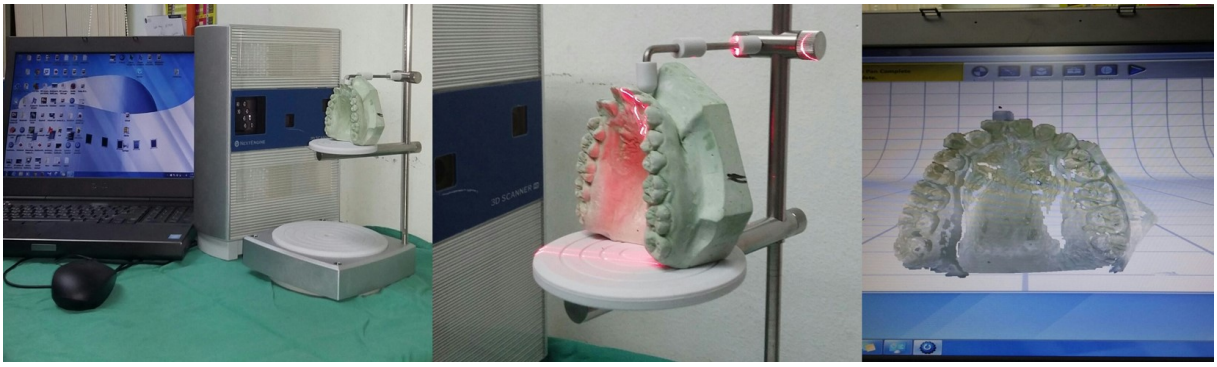

Figure 1. Conversion of the dental cast into Laser Scanned 3D dental models using Next Engine laser scanner.

The dependent variables were as follows: 1) Inter Canine Width: Distance between cusp tips of the upper deciduous canines (Figure 2); 2) Inter Molar Width: Distance between the mesiolingual cusps or centers of the corresponding facets of the upper deciduous first molars (Figure 2) [12]; 3) Arch Depth (AD): Perpendicular line from the mesial contact area of the central incisor to inter first molar width (Figure 2) [13].

Measurements by Mimics Software

All scanned data coordinates (in x, y, z) were transferred into Mimics software in STL format to be measured. All the variables were measured using a computer mouse accurate to 0.5 mm.

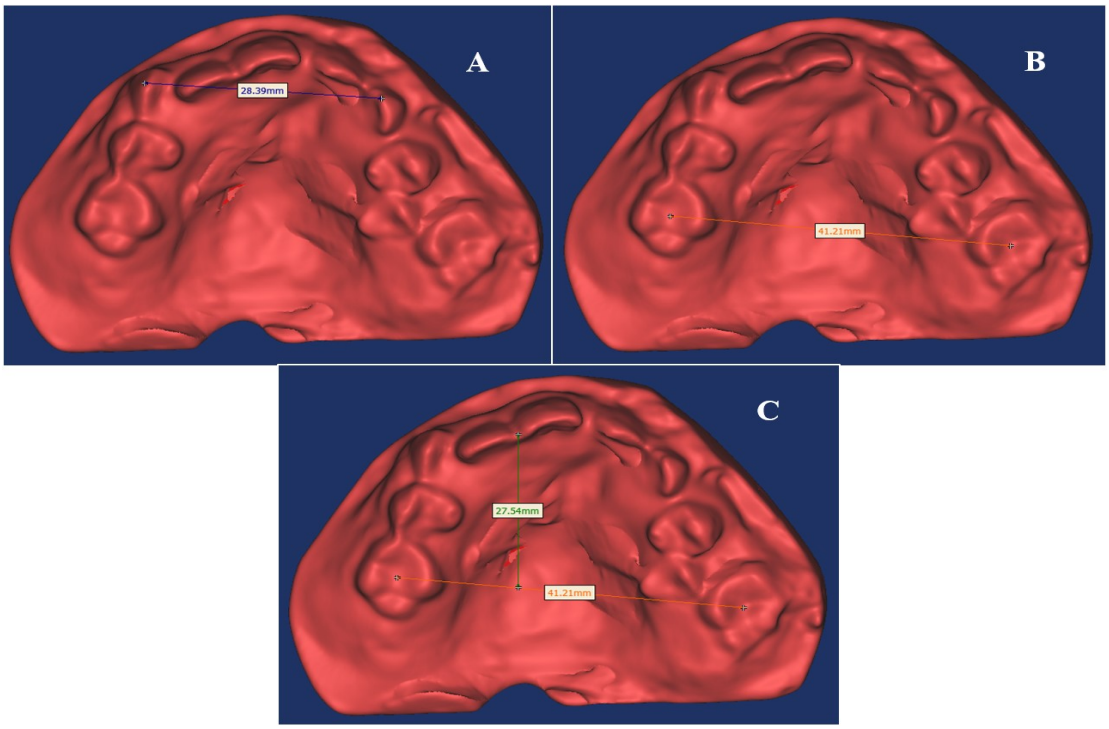

Figure 2. Showing the measurements. A) Inter canine width; B) Inter molar width; C) Arch depth.

Measurements by Digital Caliper

A hand-held digital caliper (series 500 Digimatic ABSolute Caliper, Mitutoyo Corporation, Kawasaki, Japan), was used to measure the dental casts manually. This caliper had a measurement resolution of 0.01 mm, was accurate to 0.02 mm in the 0–200 mm range.

Reliability Test

Intra examiner reliability test was conducted with an interval of 2 weeks between the first and repeated measurements on all 30 dental casts and 30 LS3DM using Mimics software. Inter examiner reliability test was conducted by comparing data between two different examiners on all 30 LS3DM.

Validity Test

The data obtained from LS3DM were compared against digital caliper's data since it has been widely used. A high correlation between the two methods would indicate the measurement using LS3DM is valid.

Duration of Conducting Measurement

The duration of measurement for LS3DM consists of scanning and measurement using Mimics software while for the duration of measurement for dental casts using digital caliper excluding dental cast fabrication.

Statistical Analysis

The intra-class correlation coefficient (ICC) was used to evaluate the intra- and inter-examiner reliability and also for the validity of two methods. ICC values and their 95% confidence intervals were calculated using SPSS statistical software version 24.0 (IBM, Armonk, NY, USA) based on a mean-rating (k=3), absolute-agreement, 2-way mixed-effects model. Based on the 95% confident interval of the ICC estimate, value less than 0.5, between 0.5 and 0.75, between 0.75 to 0.90 and more than 0.90 are indicative of poor, moderate, good and excellent reliability, respectively.

Ethical Aspects

This study was approved by the Ethics Committee of the Hospital Universiti Sains Malaysia (HUSM) [USM/JEPeM/17100564].

Results

Table 1 shows the result of intra examiner reliability of the measurements of ICW, IMW and AD in dental casts using a digital caliper. ICCs for all these variables were in the range of 0.916-0.995, which indicates an excellent correlation.

Table 1. Intra examiner reliability of ICW, IMW and AD in dental casts using a digital caliper.

Variables		Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
			Lower Bound	Upper Bound	Value	df1	df2	p-value
ICW	Single Measures	0.995[a]	0.987	0.998	417.061	18	18	<0.001
IMW	Single Measures	0.993[a]	0.985	0.997	269.873	29	29	<0.001
AD	Single Measures	0.916[a]	0.832	0.959	22.234	29	29	<0.001

Table 2 shows the result of intra examiner reliability of the measurements of ICW, IMW and AD in LS3DM using Mimics software. ICCs for all these variables were in the range of 0.916-0.990 which also indicates an excellent correlation.

Table 2. Intra examiner reliability of ICW, IMW and AD in LS3DM using Mimics software.

Variables		Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
			Lower Bound	Upper Bound	Value	df1	df2	p-value
ICW	Single Measures	0.987[a]	0.968	0.995	155.644	18	18	<0.001
IMW	Single Measures	0.990[a]	0.980	0.995	202.254	29	29	<0.001
AD	Single Measures	0.916[a]	0.471	0.974	45.818	29	29	<0.001

Table 3 shows the result of the inter-examiner reliability of the measurements of ICW, IMW and AD in LS3DM using mimics software. ICCs for all these variables were in the range of 0.816-0.990, which also indicates the good to excellent correlation.

Table 4 shows the results of the validity of two methods of measurements using digital calipers in plaster dental casts and Mimics software in LS3DM. The ICC coefficients were statistically significant, p<0.001 and the values of coefficient were in the range of excellent (0.913-0.996) correlation.

Table 3. Inter examiner reliability of ICW, IMW and AD in LS3DM using Mimics software.

Variables		Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
			Lower Bound	Upper Bound	Value	df1	df2	p-value
ICW	Single Measures	0.986[a]	0.958	0.995	169.973	18	18	<0.001
IMW	Single Measures	0.990[a]	0.980	0.995	209.834	29	29	<0.001
AD	Single Measures	0.816[a]	0.271	0.936	17.937	29	29	<0.001

Table 4. Validity of two different methods (LS3DM vs. dental cast).

Variables		Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
			Lower Bound	Upper Bound	Value	df1	df2	p-value
ICW	Single Measures	0.996[a]	0.990	0.999	514.685	18	18	<0.001
IMW	Single Measures	0.995[a]	0.975	0.998	622.341	29	29	<0.001
AD	Single Measures	0.913[a]	0.801	0.961	26.213	29	29	<0.001

Scanning procedure of a LS3DM from a dental cast using Next Engine laser scanner took around 30 minutes and measurement for a LS3DM including all linear measurements using Mimics software took around 3 minutes. The total duration of measurement for 30 LS3DM took around 90 minutes/1.5 hours.

The duration of measurement for a dental cast using a digital caliper took around 10 minutes. The total duration of measurement for 30 dental casts took around 300 minutes/5 hours.

Discussion

The ability to accurately and reliably quantify the performance of LS3DM, is crucial that this would become the standard for both research and clinical use. This study assessed the validity and reliability of LS3DM for measuring the maxillary arch dimension (ICW, IMW, AD) in UCLP patients.

Cleft lip and palate (CLP) is one of the most common congenital anomalies in the head-neck region. Affected patients suffer a multitude of problems, including both functional and aesthetic diversities. A wide variety of dental anomalies such as angulation and alignment of the tooth, missing tooth, severe crowding are observed in CLP patients compared to the normal patients [14-22]. The maxillary dental arch dimension is compromised in affected people than normal patients [23]. Studies have claimed that arch depth, interdental width, arch length were significantly smaller in CLP patients compare to normal patients [24]. Since the maxillary arch dimension is relatively different from the normal group, it is necessary to study the arch dimension of the cleft group. To the best of our knowledge, no data is available on the measurement of the maxillary arch dimension of UCLP patients in LS3DM using Mimics software in Malaysia. Thus, we have chosen UCLP subjects which will provide information treatment outcome based on maxillary arch dimension.

Evaluation of reliability and validity of a new measurement is necessary for the clinical and research uses. In recent years, the replacement of dental casts with a 3D digital dental cast is a worthy and perfect alternative method in dentistry. There are some methods by which dental casts

can be converted to digital casts, such as laser, digital photograph, stereolithography, optical, stylus, etc. [3-5,11].

In this study, we converted the dental cast into LS3DM from Next Engine laser scanner and evaluated the reliability and validity of the LS3DM using Mimics software by benchmarking its measurement with the digital caliper's measurements. We found an excellent correlation of intra-examiner reliability for LS3DM using Mimics software and digital caliper. We also found good to excellent correlation in terms of inter-examiner reliability for LS3DM. Regarding the validity of LS3DM method, our study also showed a high correlation between the measurements of LS3DM using Mimics software and digital caliper.

Some previous studies have established validity and reliability between dental casts and laser-scanned digital models while measuring the arch dimension [3-7]. But most of those studies were either on the normal patient or using different devices. Our study tested the Next Engine laser scanner device for converting dental casts of UCLP patients for the measurements of the maxillary arch dimension. Some authors evaluated a total of 40 different malocclusion patients; 20 dental casts by digital caliper and 20 LS3DM by OrthoCAD device and found the highest correlation of validity and reliability of two methods [4]. A similar study evaluated normal orthodontic patients using Minolta VIVID 900 non-contact 3D surface laser scanner to convert LS3DM and revealed the Minolta VIVID 900 digitizer is a reliable device for LS3DM which is an appropriate alternative of dental casts [5].

Regarding UCLP patients, few studies have published the evaluation of treatment outcomes using LS3DM and proven the reliable and valid alternative method to dental casts [8-11]. But all of those studies were based on the dental arch relationship. However, our study evaluated the treatment outcome on LS3DM based on the maxillary arch dimension (linear and angular measurements) and showed that LS3DM by Next Engine laser scanner device is reliable and valid alternative tools.

Laser scanned models is the most relevant and desired method amongst all having three dimensions of an object as well as time consuming method. Even though LS3DM took slightly longer time than measurement using digital caliper (30 minutes digitizing time + 3 minutes measurement with Mimics software), the process of digital measurement was very easy especially to determine the arch depth. The arch depth required the examiner to determine the 90-degree angle in which the tool in Mimics software enables this measurement to be done swiftly.

Conclusion

In conclusion, LS3DM obtained from Next Engine laser scanner device is a reliable, valid and time effective method to analyze metrically dental casts of UCLP patients. This finding emphasizes the inclusion of high technology methods in research as well as clinical treatment planning.

Authors' Contributions: SH, MFK and MKA designed the study, performed the data collection, data analysis and interpretation, wrote the manuscript and reviewed the manuscript. SH, MFK, MKA and WMAWA performed the data collection, data analysis and interpretation, and wrote the manuscript. All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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Conflict of Interest: The authors declare no conflicts of interest.

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