Original article

Clinical Accuracy of Structured-Light vs Active-Illumination Multi-View Stereo 3D Facial Scanners: A Comparative Study

Danaiya Supakanjanakanti* Teepawat Witeerungrot* Nattawat Patanalertpiboon** Kanokporn Santavalimp*

Abstract

Background: Three-dimensional facial scanners are widely used in medical and dental fields for diagnostics, treatment planning, and postoperative evaluations. While scanner specifications provide nominal accuracy, actual clinical accuracy may vary due to facial complexity. **Objective:** This study aimed to evaluate and compare the clinical accuracy of two 3D facial scanners with different technologies: the structured light system (Artec® Space Spider, Artec 3D, Luxembourg) and the active illumination multi-view stereo system (Lumio® 3D, Lumio 3D Corporation, Thailand). **Materials and methods:** Fourteen participants underwent simultaneous 3D facial scanning using both scanners. An examiner measured distances and displacements between imaginary lines defined by anatomical landmarks, both directly on the participants' faces and on their 3D models. Measurements were categorized into three groups and analyzed using one-way ANOVA and the Kruskal-Wallis test. Deviations in displacements and distances between each scanner's data and the direct measurements were evaluated using paired *t*-tests and Wilcoxon signed-rank tests ($P < 0.05$). **Results:** No statistically significant differences were found among the three measurement groups overall. However, a significant difference in displacement deviation was observed between the two scanners in the orbital and nasal regions. **Conclusion:** Artec® space spider and Lumio® 3D scanners showed no significant difference in facial scanning accuracy compared to the direct measurement method. However, significant discrepancies were noted in the eye and nose region, likely due to anatomical complexity and movement. These areas may require special attention for improved scanning precision.

Keywords: Facial scan, Accuracy, Structure light, Active illumination multi-view stereo

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Introduction

Orthognathic surgery is a procedure used to correct malocclusions and enhance facial esthetic. A precise extra-and intraoral examination is required for accurate surgical planning for the best results. In practice, facial measurements with a ruler or a Vernier caliper, as well as facial photographic analysis from various angles, are used. Unfortunately, these methods may result in discrepancies due to a variety of factors, such as different measures, low-quality measuring tools, or patients moving their faces during the examination. Furthermore, even if these two-dimensional photographs are recorded, they cannot be measured repeatedly, making data collection complicated.[1]

Modern dentistry and surgery have greatly benefited from technology, particularly the use of computers. Surgery planning and simulation using a three-dimensional computer system is known as computer-aided surgical simulation (CASS).[2] Real face measuring and photographic analysis have been substituted in the preoperative data gathering by three-dimensional data collection methods like 3D facial scans and extra- and intraoral scans. Moreover, the data can be measured as distance, representing surface based measurement, and displacement, representing straight line measurement. These two types of data are essential for various facial analyses in both 2D and 3D formats and are used in orthodontic treatment as well as bone and soft tissue surgery. These data are more precise and are independent of both individual measurements and other variables.[3,4] Additionally, the collected data can be continuously measured at any moment. The virtual surgical planning is more accurate when combined with the 3D skull model from computed tomography, which affects the surgical outcome in many ways, particularly the facial esthetic and patient satisfaction.[5,6]

On the market, 3D facial scanners come in a variety of systems and brands. Each one has a unique capture technique and a unique nominal accuracy, which is the accuracy determined by the factory. The majority of 3D scanners utilized in the medical field are non-contact systems including photogrammetry, active wavefront sampling, and structured light. Due to the fact that, unlike contact groups, they do not change an object's surface as a result of probe pressure.[7-9] Artec® Space Spider 3D (Artec 3D, Senningerberg, Luxembourg) is a non-contact scanner based on the Structured Light principle, which is widely used today. It has a light source and is equipped with a receptor on the scanner's body to pick up reflex light. The examiner may need some practice to adjust the distance between the subject and receptor because of the form of the handheld scanner. An average facial scan takes 5 to 10 minutes to complete.[10] Lumio®3D (Lumio 3D corporation, Bangkok, Thailand) is a brand-new 3D facial scanner from Thailand that features a desktop design and an active illumination multi-view stereo system. Multiple captures from 8-12 cameras in various positions are rendered to generate a 3D model. The scan should take between 2-3 minutes. These facial scanners have 0.05 and 0.10 millimeters of nominal accuracy, respectively.[11] Because the structure of a human face is more complex than that of a geometric object, the practical accuracy, or the accuracy used in practice, may differ from the nominal accuracy.[12]

This study's goal was to determine and compare the accuracy of two 3D facial scanners, the Artec® Space Spider 3D and Lumio®3D. This study may aid in selecting the appropriate facial scanner for medical use, enhance the performance of the surgeon, and lower unnecessary costs.[13-15]

Materials and methods

Study design

This study was a non-randomized clinical trial. The study was approved by the Human Research Ethics Committees of the Faculty of Dentistry, Prince of Songkla University (EC6402-013 and registered in the Thai Clinical Trials Registry (TCTR20210927005).

Sample size calculation was performed by G*Power 3.1 software (Heinrich Heine University Düsseldorf, Germany). Based on the study by Zhao YJ et al.,[12] an effect size were determined. Using a two-tailed *t*-test with a significance level (α) of 0.05 and a power ($1-\beta$) of 0.80, the minimum required sample size was calculated to be 12 participants. Accounting for a 20 percent potential dropout rate, the final sample size was increased to 14 participants. Two scanners, Artec® Space Spider (Artec 3D, Senningberg, Luxembourg) and Lumio® 3D (Lumio 3D corporation, Bangkok, Thailand) were the testing devices (figure 1).

Subjects

Participants aged between 18 and 50 years who voluntarily consented were included in the study. Individuals were excluded if they presented with head and neck infections, maxillofacial trauma, or dentofacial anomalies such as cleft lip and palate or hemifacial microsomia. Further exclusion criteria included inability to follow instructions during facial scanning, such as maintaining a still position with a neutral facial expression. Volunteers with excessive facial hair, facial tattoos, permanent cosmetic markings, or neurovascular conditions affecting facial movement were also excluded due to potential interference with scan accuracy.

The volunteers were informed about the details of the study and were consent and signed before enrollment.

Scanning and rendering the 3D facial models.

Participants were instructed to undergo scanning with both scanners in random order on the same day by the same examiner, while maintaining a relaxed head position and facial expression, keeping their eyes closed, and remaining still during the scan. Each scanner recorded five captures from each participant. The scanning time from the posture adjustment to the completion of the scanning process was recorded.

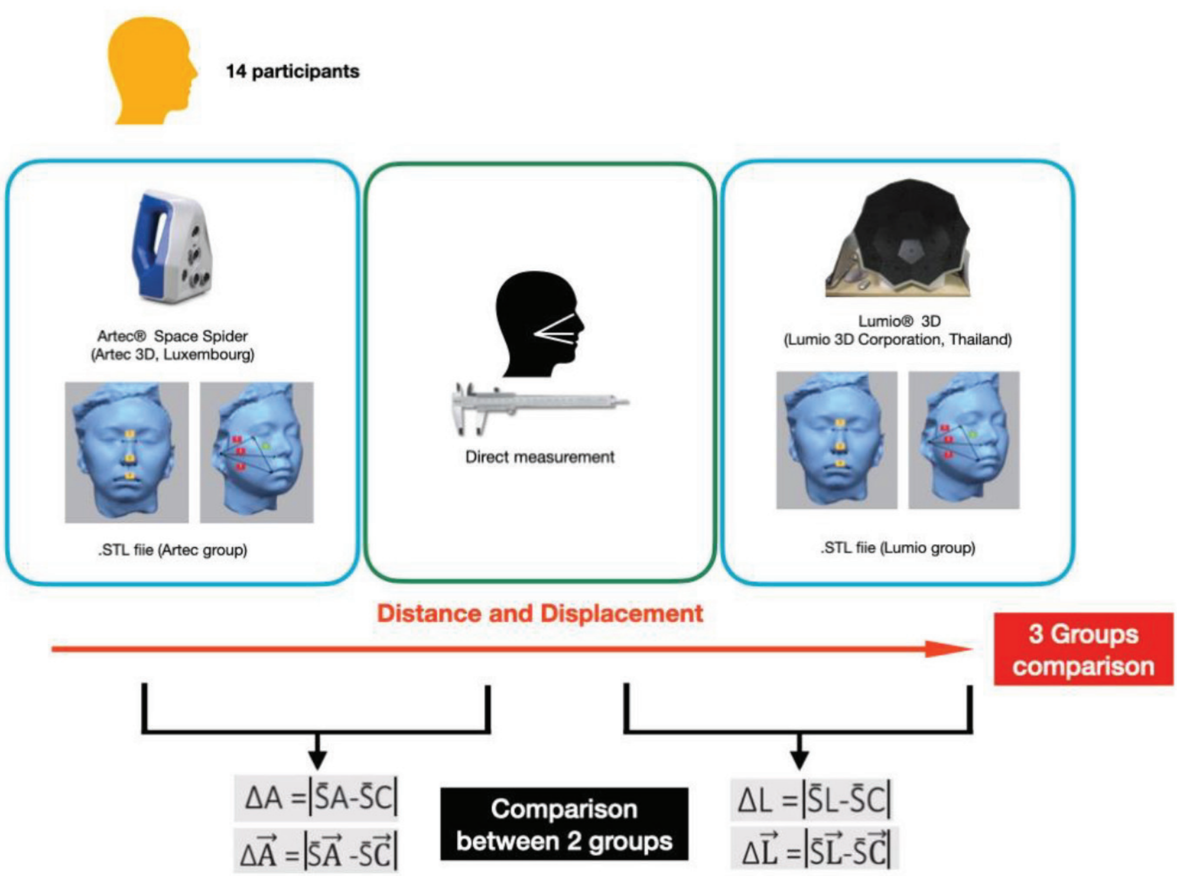

Figure 1 The study framework includes the scanning, measuring, and comparing of data.

The scanned images were rendered in the standard triangular language (STL) format.

Establishing and measuring anatomical landmarks

The imaginary lines on the frontal view and the right lateral view of the faces as shown in Figure 2 were measured. There were 3 horizontal lines on the frontal views. Line 1(Intercanthal line, IC) extended from the right to the left medial canthal points. Line 2 (Interalar line, IA) extended from the right to the left alar bases. Line 3 (Intercommissural line, IM) extended from lip commissures from right to left. There were 1 vertical line and 3 horizontal lines on the lateral of the face: Line 4, the vertical line (V), connected the right lateral canthal to the right lip commissure, Line 5 (Lateral canthus-tragus, LT) connected the right tragus to the right lateral canthal point, Line 6 (Alar-tragus, AT) was drawn from the right tragus to the right alar base, Line 7 (Lip commissure – tragus, MT) connected the right tragus to the right lip commissure (figure 2). The direct measurement of the distance (c) of each line was performed in millimeters by using dental floss attached to the surface of the face and calculated using a ruler with 1 decimal. The displacement ($\vec{c}$) of each line was measured in millimeters with 1 decimal by using a Vernier caliper. Each measurement was taken five times and calculated the average of distance and displacement.

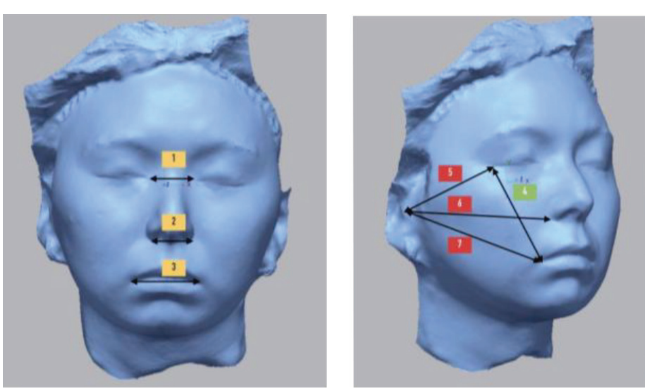

Figure 2 Actual faces and three-dimensional models both had seven lines placed on the frontal and lateral views.

3D model measurement

The 3D models were imported into Geomagic Control X version 2018.1.0 (3D Systems, Morrisville, NC, USA). The anatomical landmarks, representing actual facial measurements, were manually identified, and the seven designated imaginary lines were subsequently constructed. The distance of each line was measured using surface-based techniques, while the displacement was evaluated using straight-line measurements. The average of distance and displacement from the Artec group and the Lumio group were measured by a different examiner, who was blinded to the scanner source of each dataset and was independent of the examiner conducting the scans.

Statistical analysis

Demographic data and scanning times were analyzed using descriptive statistics. One-way ANOVA and the Kruskal-Wallis test were used to determine statistically significant differences among the direct measurement group, the Artec group, and the Lumio group, with a significance level set at P value < 0.05. The Scheffé test was planned for post hoc analysis to identify significant differences between individual pairs of groups. The amount of the deviation of distance and displacement in absolute value between the Artec group ($\Delta A, \Delta\vec{A}$), the Lumio ($\Delta L, \Delta\vec{L}$) and the direct measurement at each line was calculated and compared between 2 groups with the paired t-test and Wilcoxan signed-rank test. For the computation, SPSS Statistics (SPSS® 25.0, SPSS Inc.) was utilized. The study confirmed measurement reliability with an intraclass correlation coefficient of 0.91, assessed after one month.

Result

There were 14 participants, 12 females and 2 males, with a mean age of 29.57 ± 2.87 years. The average scanning time of Artec® Space Spider 3D scanner and Lumio®3D scanner is 95.86 ± 18.19 and

27.25 ± 7.76 seconds, respectively.

Although there was no statistically significant difference in distance and displacement among the three groups (Table 1 and Table 2), a significant difference was observed in the amount of displacement deviation for line 1 (Intercanthal line, IC) and line 2 (Interalar line, IA), as shown in Table 4. However, the difference in distance between the 2 groups was not statistically significant (Table 3).

Table 1 Distance values from direct Measurement, Artec, and Lumio Groups for Each Line.

Line	Measurement	Mean (SD)	Median (IQR)	Min-Max	95 % CI (lower, upper)	*P* value
Line 1 (IC)	Direct	40.00 (4.24)	39.70 (5.22)	31.10-46.90	37.55, 42.45	0.923[a]
	Artec	39.96 (3.53)	40.35 (4.41)	33.82-47.44	37.92, 42.00	
	Lumio	39.48 (3.58)	39.95 (5.34)	32.67-46.62	37.41, 41.55	
Line 2 (IA)	Direct	36.87 (4.33)	36.85 (5.63)	28.30-44.00	34.37, 39.37	0.895[a]
	Artec	37.18 (4.15)	37.33 (6.00)	30.32-44.34	34.79, 39.57	
	Lumio	37.60 (3.79)	37.77 (5.65)	30.22-41.76	35.41, 39.79	
Line 3 (IM)	Direct	58.48 (6.27)	59.75 (7.57)	41.50-67.30	54.86, 62.10	0.257[k]
	Artec	61.18 (6.19)	62.95 (7.25)	44.04-68.41	57.60, 64.75	
	Lumio	60.88 (5.67)	62.79 (8.54)	46.11-66.63	57.61, 64.15	
Line 4 (V)	Direct	75.33 (5.29)	74.95 (9.53)	68.70-85.00	72.27, 78.38	0.752[a]
	Artec	76.71 (5.23)	76.28 (6.89)	67.29-87.00	73.69, 79.73	
	Lumio	75.62 (4.65)	74.77 (6.34)	68.15-84.18	72.93, 78.30	
Line 5 (LT)	Direct	83.98 (5.67)	83.55 (7.78)	75.50 - 96.90	80.71, 87.25	0.745[a]
	Artec	82.43 (5.32)	81.20 (8.05)	75.76-94.59	79.36, 85.50	
	Lumio	83.16 (4.96)	81.85 (7.54)	75.33-93.47	80.29, 86.02	
Line 6 (AT)	Direct	121.99 (5.58)	122.20 (10.07)	112.40-129.40	118.76, 125.21	0.877[k]
	Artec	122.62 (4.57)	123.84 (6.85)	113.91-128.45	119.98, 125.26	
	Lumio	121.92 (4.55)	122.88 (5.31)	112.46-126.59	119.29, 124.55	
Line 7 (MT)	Direct	113.94 (5.38)	115.90 (9.15)	103.80-120.00	110.83, 117.05	0.909[k]
	Artec	113.51 (4.20)	114.46 (7.53)	105.88-119.54	111.08, 115.93	
	Lumio	113.39 (4.81)	114.60 (8.24)	104.88-120.46	110.62, 116.17	

[a] one-way ANOVA test

[k] Kruskul-Wallis test

IC = Intercanthal line, IA = Interalar line, IM = Intercommissural line, V = vertical line, LT = lateral canthus to tragus line, AT = Alar to tragus line, MT = Lip commissure to tragus line

Table 2 Displacement values from direct Measurement, Artec, and Lumio Groups for Each Line.

Line	Measurement	Min-Max	Mean	Median (IQR)	95 % CI (lower, upper)	*P* value
Line 1 (IC)	Direct	29.00-36.60	31.89 (1.96)	31.80 (2.13)	30.75, 33.02	0.097[a]
	Artec	28.14-36.29	32.10 (2.27)	32.01 (3.32)	30.79, 33.40	
	Lumio	29.67-38.29	33.56 (2.25)	33.89 (3.34)	32.26, 34.86	
Line 2 (IA)	Direct	24.00-35.00	31.11 (3.29)	32.00 (4.45)	29.21, 33.01	0.106[k]
	Artec	22.36-35.40	32.01 (3.48)	32.71 (3.69)	30.00, 34.02	
	Lumio	23.60-37.14	33.34 (3.56)	33.92 (3.46)	31.28, 35.39	
Line 3 (IM)	Direct	36.60-56.80	50.98 (4.87)	51.75 (5.03)	48.17, 53.79	0.484[k]
	Artec	42.26-56.14	52.16 (3.82)	52.48 (5.67)	49.96, 54.37	
	Lumio	40.96-57.13	52.53 (4.31)	53.36 (4.69)	50.04, 55.02	
Line 4 (V)	Direct	66.20-79.80	71.09 (4.30)	70.65 (6.48)	68.61, 73.58	0.455[k]
	Artec	67.02-70.47	72.50 (4.35)	72.02 (7.35)	69.99, 75.02	
	Lumio	67.59-80.56	72.51 (4.31)	71.58 (6.85)	70.02, 75.01	
Line 5 (LT)	Direct	72.00-82.70	76.61 (3.73)	76.45 (6.83)	74.46, 78.77	0.847[a]
	Artec	69.13-81.71	76.21 (3.63)	76.11 (5.29)	74.12, 78.31	
	Lumio	72.07-82.80	77.00 (3.47)	77.21 (5.21)	75.00, 79.01	
Line 6 (AT)	Direct	96.80-111.40	105.62 (4.62)	107.35 (6.28)	102.95, 108.29	0.594[k]
	Artec	96.04-110.96	105.64 (4.09)	107.01 (3.97)	103.28, 108.01	
	Lumio	97.24-113.72	106.93 (4.57)	107.67 (4.83)	104.29, 109.57	
Line 7 (MT)	Direct	97.10-109.90	104.63 (3.59)	105.30 (5.48)	102.56, 106.70	0.764[a]
	Artec	96.16-109.72	104.77 (3.55)	104.94 (4.88)	102.72, 106.82	
	Lumio	97.60-111.65	105.59 (4.00)	106.74 (5.22)	103.28, 107.89	

[a] one-way ANOVA test

[k] Kruskul-Wallis test

IC = Intercanthal line, IA = Interalar line, IM = Intercommissural line, V = vertical line, LT = lateral canthus to tragus line, AT = Alar to tragus line, MT = Lip commissure to tragus line

Table 3 Distance deviation of the Artec and Lumio Groups from the direct measurement (Control Group).

Line	Deviation value	Mean (SD)	Min-Max	Median (IQR)	95 % CI (lower, upper)	*P* value
Line 1 (IC)	Artec (ΔA)	1.87 (1.06)	0.27-3.57	1.98 (1.97)	1.26, 2.47	0.182^{p}
	Lumio (ΔL)	2.33 (1.63)	0.10-5.01	1.95 (3.02)	1.39, 3.27	
Line 2 (IA)	Artec (ΔA)	1.14 (0.81)	0.13-2.65	0.90 (1.42)	0.67, 1.60	0.595^{p}
	Lumio (ΔL)	1.27 (0.87)	0.01-2.77	1.34 (1.62)	0.77, 1.77	
Line 3 (IM)	Artec (ΔA)	3.05 (1.10)	1.08-4.91	3.00 (1.35)	2.42, 3.68	0.807^{p}
	Lumio (ΔL)	2.95 (1.18)	0.30-4.61	3.24 (1.63)	2.27, 3.63	
Line 4 (V)	Artec (ΔA)	2.11 (1.12)	0.11-3.58	2.13 (1.65)	1.46, 2.75	0.292^{p}
	Lumio (ΔL)	1.71 (0.99	0.17-3.28	1.69 (1.72)	1.14, 2.28	
Line 5 (LT)	Artec (ΔA)	1.64 (0.93)	0.18-3.54	1.50 (1.31)	1.10, 2.17	0.810^{p}
	Lumio (ΔL)	1.57 (1.02)	0.35-3.43	1.21 (1.86)	0.98, 2.16	
Line 6 (AT)	Artec (ΔA)	2.01 (1.58)	0.01-6.15	1.85 (1.33)	1.10, 2.92	0.925^{w}
	Lumio (ΔL)	2.11 (2.03)	0.06-6.59	1.66 (2.64)	0.93, 3.28	
Line 7 (MT)	Artec (ΔA)	1.62 (0.84)	0.09-2.72	1.71 (1.27)	1.13, 2.10	0.826^{w}
	Lumio (ΔL)	1.54 (1.53)	0.26-5.29	1.12 (1.45)	0.66, 2.42	

^{p} paired-t test
^{w} Wilcoxan-signed rank test
IC = Intercanthal line, IA=Interalar line, IM = Intercommissural line, V = vertical line, LT = lateral canthus to tragus line, AT = Alar to tragus line, MT = Lip commissure to tragus line

Discussion

Three-dimensional facial scanner is commonly employed, particularly for capturing and assessing the proportions of the face before and after surgery. Due to the abundance of brands and systems on the market, the accuracy, convenience, realistic pricing, and scanning time should all be considered as selection criteria.[7] The accuracy of each scanner is impacted by the operating system, manufacturing processes, light source, light propagation, and light reflection.[16]

Although direct facial measurements using tools like Vernier calipers and fine-scale rulers are still commonly used in many hospitals, they are increasingly considered less precise due to potential human error. Previous research has demonstrated that stereophotogrammetry and structured-light system offers the higher accuracy in facial scanning.[17,18] However, the high cost of these scanners limits their accessibility and widespread use. Therefore, identifying a more affordable and accurate alternative to the direct measurement method would be highly beneficial for clinical practice.

This study aimed to compare the accuracy of the Artec® Space Spider 3D and Lumio® 3D scanners in capturing human facial images. The findings indicate that there is no statistically significant difference in both distance and displacement measurements between the two scanners and direct measurements taken from

Table 4 Displacement deviation of the Artec and Lumio Groups from the direct measurement (Control Group).

Line	Deviation value	Mean (SD)	Min-Max	Median (IQR)	95 % CI (lower, upper)	*P* value
Line 1 (IC)	Artec ($\Delta \vec{A}$)	0.82 (0.71)	0.16-2.92	0.78 (0.77)	0.41, 1.23	0.006[w]
	Lumio ($\Delta \vec{L}$)	1.74 (0.97)	0.14-3.55	1.82 (1.52)	1.18, 2.30	
Line 2 (IA)	Artec ($\Delta \vec{A}$)	1.39 (0.70)	0.01-2.37	1.65 (1.05)	0.99, 1.79	0.035[w]
	Lumio ($\Delta \vec{L}$)	2.30 (1.22)	0.07-3.63	2.91 (1.99)	1.59, 3.00	
Line 3 (IM)	Artec ($\Delta \vec{A}$)	1.53 (1.47)	0.06-5.66	1.36 (1.62)	0.68, 2.38	0.683[w]
	Lumio ($\Delta \vec{L}$)	1.66 (1.40)	0.05-4.36	1.19 (2.74)	0.85, 2.46	
Line 4 (V)	Artec ($\Delta \vec{A}$)	1.50 (2.31)	0.14-9.28	0.73 (1.26)	0.17, 2.84	0.972[w]
	Lumio ($\Delta \vec{L}$)	1.51 (2.11)	0.16-8.55	0.85 (1.01)	0.30, 2.73	
Line 5 (LT)	Artec ($\Delta \vec{A}$)	1.23 (0.88)	0.01-2.87	1.31 (1.20)	0.72, 1.74	0.152[w]
	Lumio ($\Delta \vec{L}$)	0.75 (0.62)	0.07-1.83	0.52 (1.17)	0.40, 1.11	
Line 6 (AT)	Artec ($\Delta \vec{A}$)	1.35 (0.88)	0.33-3.12	1.39 (1.46)	0.84, 1.86	0.753[p]
	Lumio ($\Delta \vec{L}$)	1.45 (1.02)	0.28-3.79	1.22 (1.66)	0.86, 2.04	
Line 7 (MT)	Artec ($\Delta \vec{A}$)	1.22 (0.83)	0.12-2.92	1.00 (1.23)	0.74, 1.70	0.605[p]
	Lumio ($\Delta \vec{L}$)	1.41 (0.83)	0.06-2.93	1.45 (1.08)	0.93, 1.89	

[p] paired-*t* test

[w] Wilcoxan-signed rank test

IC = Intercanthal line, IA = Interalar line, IM = Intercommissural line, V = vertical line, LT = lateral canthus to tragus line, AT = Alar to tragus line, MT = Lip commissure to tragus line

the human face. The results of this study are consistent with those of Zhao et al.,[12] which found no significant differences in the accuracy of three different facial scanner types: line laser, stereophotogrammetry, and structured light. Conversely, Amornvit and Sanohkan., discovered that the best accuracy is provided by a structured-light scanner, with stereophotogrammetry coming in second.[15]

When comparing the scanner measurements with the direct method, this study found significant differences in displacement at line 1 (IC) and line 2 (IA), which correspond to the orbital and nasal regions, respectively. These discrepancies can be attributed to several factors that affect the accuracy of facial scanning. According to the study of Zhao et al., the skin's surface characteristics, skin texture, reflectivity, roughness, presence of hair follicles and pores, as well as micro-movements caused by breathing, muscle twitching, emotional expression, and facial asymmetries, can all impact scan accuracy. Additionally, the scanning technique particularly the lighting system used, may influence involuntary facial movements.[12]

LED light emitted during scanning has been reported to induce blinking and facial movement, potentially leading to distortion in the captured data.[19] Different scanning systems use varying light emission patterns, which may have differing impacts on patient response. For example, the Lumio® 3D scanner emits a single flash of light during image capture, minimizing prolonged visual stimulation. In contrast, the Artec® Space Spider emits continuous flashes throughout the entire scanning process, which may increase the likelihood of blinking or subtle facial movements. These involuntary responses can lead to distortions, particularly in dynamic facial regions such as the eyes, thereby reducing the accuracy and reliability of the final 3D facial model.

The orbital and nasal regions present greater anatomical complexity compared to other areas of the face. These regions contain multiple slopes, skin creases, and undercut areas, which can pose challenges for optical scanning systems. Such complexity may reduce scanning accuracy due to difficulties in light reflection and surface detection. In contrast, a study by Zhao et al., reported high accuracy in facial scanning when using stereophotogrammetry and structured-light systems, particularly in the midface region. This improved performance was attributed to the facial contours in that area, which facilitated better registration across multiple image captures.[12]

The scanning time is one of the factors that influences accuracy. The Artec® space spider requires approximately four times as much Lumio® 3D, according to the study. The prolonged scanning time could affect the patient's tendency to move during the scanning. However, this study did not evaluate the relation between scanning time and accuracy. Additionally, the handheld design, which requires the user to move around the object at a limited distance, occasionally results in many captures that overlap. In the global registration step, multiple captures diminish precision.[20,21] Furthermore, since no headrest or stabilization device was used during the scanning procedure, slight head movements may have occurred during data acquisition. This was particularly relevant for scanners with longer scanning durations, such as the Artec® Space Spider, which may have contributed to reduced accuracy. Despite this potential limitation, no significant differences were observed among the three groups.

The study was carried out by photographing a human face with the muscle of facial expression active at all times, depending on emotion and external stimulation.[22] This introduces potential confounding variables that may affect the accuracy and consistency of the scans. To minimize such variables, the 3D-printed solid facial models were proposed. These models provide a stable and repeatable surface for evaluation, helping to control for muscle movement and facial expression.[15] However, while this approach improves standardization, it may involve higher costs and lacks direct applicability in routine clinical settings.

The accuracy of facial scanning is crucial, particularly for 3D planning in orthognathic surgery. Since soft tissue simulation significantly impacts treatment outcomes which are the primary concern for patients. The misalignment of the facial surface scan and the soft tissue profile can lead to discrepancies affecting both planning and outcomes. Not only the surgical planning, but the accurate facial profile documentation is also important to assess the treatment of patients undergoing orthognathic surgery or orthodontic treatment alone. Unlike 2D photos, which lack of surface texture and three-dimensional shape, 3D imaging provides a more comprehensive assessment of soft tissue changes.[23] From our study, these two 3D facial scanners are the appropriate tools for the treatments mentioned above. However, despite significant differences in the orbital and nasal areas, users should be cautious, particularly when measuring the degree of asymmetry between these areas.

This study was conducted on subjects who were not orthognathic surgery patients and generally exhibited a skeletal Class I relationship. In contrast, clinical cases, particularly in orthodontic treatment and orthognathic surgery, often involve patients with abnormal jaw relationships, asymmetry, and other conditions such as cleft lip and palate or hemifacial microsomia. These variations could potentially influence the results of the study.

For more applicable findings in clinical treatment, future research should include patients with abnormal skeletal and soft tissue frameworks. Additionally, further studies should compare the soft tissue profiles obtained from CBCT with the underlying bone structure to validate the results of this study. Moreover, the scanners can be utilized as a tool in research to evaluate treatment, particularly in orthodontic and orthognathic procedures.

Conclusion

Artec® space spider and Lumio® 3D scanners showed no significant difference in facial scanning accuracy compared to the direct measurement method. However, significant discrepancies were noted in the eye and nose region, likely due to anatomical complexity and movement. These areas may require special attention for improved scanning precision.

Author contributions

DS: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data Curation, Writing-Review & Editing, Visualization, Project administration, Funding acquisition; TW: Validation, Writing-Review & Editing, Visualization, Supervision; NT: Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing-Original Draft, Funding acquisition; KS: Writing-Review & Editing, Visualization

Ethical statement

The research protocol was approved by the Ethics Committee of the Faculty of Dentistry, Prince of Songkla University (No. EC6402-013).

Disclosure statement

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