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A Comparison of Soft Tissue Face Analysis Measurements with Face Analysis Measurements in 3-D Modelling

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ABSTRACT

Objective: The face is the most important factor determining the physical appearance of individuals. Measurements of facial beauty have continuously been made and evaluated on two-dimensional, photographs. As an alternative method, the evaluation of facial morphology could be better determined using 3D technology. The aim of this study was to assist in facial analysis by measuring the soft tissue facial ratios in our society in order to compare these values with the proportions and measurements of the 3D facial model of the patient.

Materials and Methods: A total of 24 (10 male, 14 female) subjects' faces and their 3D masks were measured to compare the results of each measurement.

Results: There was a significant difference between the soft tissue measurements and 3D measurements of only the dorsal width measurements of male patients (p=0.019) and columellar length and upper lip width measurements of women (p=0.021, p=0.035), while other facial analysis measurements showed no significant differences. Additionally, no significant difference other than the upper width, nasolabial angle, and lateral intercantal distance measurements were noted in the 3D mask (p=0.026, p=0.022, p=0.042).

Conclusion: This study examined the compatibility of the 3D-printed models and soft tissue measurements. We found no significant difference except for the dorsal width measurements of male patients and the columellar length and upper lip width measurements of female patients. These results suggest that modelling with 3D printing is technologically safe and advantageous and has great potential in facial aesthetics and surgical interventions.

Keywords: Facial analysis, three-dimensional printing, facial aesthetics

INTRODUCTION

The face is the most important factor determining the physical appearance of individuals (1). The aesthetic appearance of our face comprises complex interaction of the viscera-cranium skeletal morphology and the soft tissue structures above it (2). Various methods have been continuously tested for the analysis of facial morphology and the examination of the proportions and measurements of the face (3, 4).

To date, traditional 2D photographs have been used for the analysis of facial morphology. In addition to being limited to one side of the face, an examination with 2D photographs has some disadvantages, such as various sensitivities pertaining to the adjustment of the picture, problems with patient compliance, and difficult metric measurements. Therefore, the evaluation of facial morphology in 3D may be a better alternative method. After the face has been scanned, the 3D technology allows any necessary adjustments of the facial structures and enables the use of natural and linear measurements with angular and linear measurements.

The efficiency of planning treatments may increase with 3D technology; however, it should be noted that it does not guarantee an ideal or perfect result, and that, despite its many advantages, it cannot replace the surgeon's decision or technical skill (5).

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The aim of this study was to assist in facial analysis and to facilitate the evaluation of facial differences and abnormalities and to measure the soft tissue facial ratios in our society in order to compare these values with the proportions and measurements of the 3D facial model of the patient.

MATERIAL AND METHODS

A total of 24 subjects were included in the study with 10 males and 14 females. The age range was between 19 and 41. Subjects were selected on a voluntary basis in that the first 24 subjects to apply without any exclusion criteria were accepted into the study. The exclusion criteria were previous rhinoplasty, previous facial surgery, previous maxillofacial trauma with plate/screw reconstruction and subjects under the age of 18 or over the age of 65.

Every subject then underwent a scan using the Meshmixer programme (Autodesk, Inc.) and a 3D version of their face was created. The 3D face was then uploaded to the Zortrax M200 3D printer (Zortrax S.A) and a model was created (Figure 1, 2). Both the 3D model and the subjects' faces were then subject to the same measurements made with the same calliper. The measurements were as follows (Figure 3);

Forehead: Trichion to the glabella (FH)

Dorsal Length: Nasion to the tip (DL)

Dorsal Width: Width of the radix (DW)

Intercanthal distance: Medial canthus (right) to medial canthus (left) (ICDm)

Lateral canthus (right) to medial canthus (left) (ICDl)

Columellar length: Tip to the subnasal (CL)

Alar width: Alar base (AW)

Upper lip: Subnasale to the labrale superior (UL)

Chin: Menton to the labrale inferius (C)

The nasofrontal angle, nasolabial angle and nasomenlal angle were also included in the measurements (Figure 4).

Measurements of the subjects' faces and their 3D masks were then compared to analyse the correlation between the two measurements.

Table 1: Patient characteristics

		Mean.±SD	Min-Max
Age		±	
		n	%
Gender	Male	10	41.7
	Female	14	58.3

Statistical analysis

The SPSS 15.0 program (IBM SPSS Corp., Armonk, NY, USA) was used for statistical analysis. Descriptive statistics for the numerical variables were given as the mean, standard deviation, minimum, maximum, median and 95% CI. As the numerical variables did not meet the normal distribution conditions, both independent groups were compared using the Mann–Whitney U test. The statistical significance level was set as $p<0.05$.

Ethical committee approval

This study was approved by Acıbadem University Ethics Committee (ATADEK) on 12/09/2019 with the approval number 2019-14/71.

This study was conducted according to the Helsinki Declaration.

RESULTS

Of the patients that were entered for the study, 41.7% of the patients were male (10) and 58.3% were female (14). The mean age of our patients was ± (Table 1).

When the facial and 3D measurements of the male patients were compared, there was a significant difference in the dorsal width measurements ($p=0.019$). However, there was no statistically significant difference in the other facial analysis measurements (Table 2).

When the facial and 3D measurements of the female patients were compared, a significant difference was found in the columellar length and upper width measurements ($p=0.021$, $p=0.035$). However, there were no statistically significant differences in other facial analysis measurements (Table 3).

When the normal and 3D measurements of male and female patients were compared, a significant difference was found in the measurements of the upper width, the nasolabial angle and the lateral intercantal distance in the 3D mask ($p=0.026$, $p=0.022$, $p=0.042$). However, there were no statistically significant differences in other facial analysis measurements (Table 4)

DISCUSSION

Taking photographs of patients is an important element in terms of patient follow-up, communication with the patient, medical-legal necessity and surgical planning. However, patients are often unable to understand the nature of their medical condition on screen or in two-dimensional photographs, which may lead to disappointment and poor results after treatment. 3D modelling, on the other hand, is an effective tool for demonstrating the relationship between facial structures. The 3D modelling process consists of 5 main components: analysis, planning, virtual surgery, 3D printing and comparison with the actual planned results (5-7).

Table 2 : Statistical analysis of normal values and 3D values of male patients in facial analysis measurements

	Male						
	Normal			3D			
	Mean±SD	Min-Max	Median	Mean±SD	Min-Max	Median	p
Forehead	6.07±0.8	4.5-7.3	6.2	6.19±0.7	4.6-7.3	6.4	0.522
Dorsal length	5.48±0.6	4.2-6.5	5.6	5.22±0.9	3.7-6.8	5.3	0.481
Dorsal width	1.25±0.2	0.8-1.8	1.2	1.94±0.7	0.9-3.2	1.9	0.019
Intercanthal-M	3.33±0.7	2.6-5.1	3	3.34±1.2	1.9-5.9	3.2	0.912
Intercanthal-L	10.78±1.3	8.8-13	10.7	11.5±1.5	9.6-14	11.4	0.28
Columellar length	1.93±0.3	1.3-2.7	2	2.22±0.8	1.1-3.9	2	0.631
Alar width	3.75±0.5	2.6-4.7	3.9	3.82±1	2.3-5.7	3.7	0.912
Upper width	1.87±0.4	1.1-2.8	1.9	2.37±0.8	0.8-3.4	2.5	0.89
Chin	2.85±0.9	2-5	2.6	3.45±1.5	1.8-6.3	3.2	0.481
Nasofrontal angle	142.1±6.9	130-151	141.5	140.3±12.9	123-167	138.5	0.436
Nasolabial angle	122.9±14.6	102-144	126.5	135.2±12.6	119-156	133.5	0.143
Nasiomental angle	137.6±10.8	125-160	133.5	138.6±13.5	120-165	141	0.796

Table 3: Statistical analysis of normal values and 3D values of female patients in facial analysis measurements

	Female						
	Normal			3D			
	Mean±SD	Min-Max	Median	Mean±SD	Min-Max	Median	p
Forehead	5.93±1.2	4.5-8.5	5.7	5.98±1.2	4,5-8.4	5.6	0.839
Dorsal length	4.82±0.9	3-6.1	4.8	5.26±0.9	3.5-7.1	5.3	0.210
Dorsal width	1.47±0.7	0.8-4	1.2	1.89±1	0.9-5	1.7	0.210
Intercanthal-M	3.08±0.5	2.5-4.5	3	3.15±0.9	1.9-4.7	3	1.000
Intercanthal-L	10.44±1.3	7.9-13	10.3	9.9±1.7	7.8-13	9.3	0.210
Columellar length	1.71±0.3	1.2-2.4	1.6	2.94±2.1	1.1-9.8	2.3	0.021
Alar width	3.24±0.6	2.3-4	2.1	3.27±0.9	1.9-4.6	3.3	0.804
Upper width	1.41±0.3	1-2	1.3	2.12±0.8	0.9-4	2.3	0.035
Chin	2.32±0.6	1.7-4	2.1	2.46±0.8	1.3-3.9	2.5	0.769
Nasofrontal angle	146.3±8.6	130-160	147	145.5±19.3	120-178	142.5	0.804
Nasolabial angle	134.8±14.7	105-156	138.5	132.5±17	100-152	136	0.511
Nasiomental angle	138.2±11.6	123-160	135.5	131.7±15.5	100-152	136	0.571

In recent years, there has been an increase in preoperative planning with the 3D printing method. 3D printed models allow surgeons to better understand individual anatomical variations and detect defects that may be difficult to compile from 2D images. In addition, it can be used to facilitate postoperative procedures and to obtain realistic examples of postoperative results (8). It is also thought that patients can manage their expectations more realistically when they can use their sense of touch in a printed model and examine their existing pathologies or conditions (6-9).

Facial appearance plays an important role in the quality of life of individuals. Over time, individuals become sensitive to changes in their facial appearance. Correction of these facial changes require careful and accurate planning, as even subtle changes in facial proportions can strongly effect the original appearance. Therefore, a reliable analysis of facial changes is very important in maximising surgical outcomes that meet patient expectations. Hence, the morphological and genetically objective evaluation of facial features has become increasingly important and, as the face is one of the most complex and variable regions of our face, the use of 3D printing in facial plastics has increased (9-11).

In the past, standard relationships between various parts of the face have been formulated by scientists and painters. Neoclassical laws are well known to surgeons, but the average ratios differ from the commonly used aesthetic standards. Ideal

Table 4: Statistical analysis of male and female ratios in the facial analysis measurements

	Male			Female			
	Mean±SD	Min-Max	Median	Mean±SD	Min-Max	Median	p
Forehead	6.07±0.8	4.5-7.3	6.2	5.93±1.2	4.5-8.5	5.7	0.666
Forehead 3D	6.19±0.7	4.6-7.3	6.4	5.98±1.2	4,5-8.4	5.6	0.437
Dorsal length	5.48±0.6	4.2-6.5	5.6	4.82±0.9	3-6.1	4.8	0.108
Dorsal length 3D	5.22±0.9	3.7-6.8	5.3	5.26±0.9	3.5-7.1	5.3	0.931
Dorsal width	1.25±0.2	0.8-1.8	1.2	1.47±0.7	0.8-4	1.2	0.709
Dorsal width 3D	1.94±0.7	0.9-3.2	1.9	1.89±1	0.9-5	1.7	0.585
Intercanthal-M	3.33±0.7	2.6-5.1	3	3.08±0.5	2.5-4.5	3	0.546
Intercanthal-M 3D	3.34±1.2	1.9-5.9	3.2	3.15±0.9	1.9-4.7	3	0.841
Intercanthal-L	10.78±1.3	8.8-13	10.7	10.44±1.3	7.9-13	10.3	0.625
Intercanthal-L 3D	11.5±1.5	9.6-14	11.4	9.9±1.7	7.8-13	9.3	0.026
Columellar length	1.93±0.3	1.3-2.7	2	1.71±0.3	1.2-2.4	1.6	0.154
Columellar length 3D	2.22±0.8	1.1-3.9	2	2.94±2.1	1.1-9.8	2.3	0.472
Alar width	3.75±0.5	2.6-4.7	3.9	3.24±0.6	2.3-4	2.1	0.064
Alar width 3D	3.82±1	2.3-5.7	3.7	3.27±0.9	1.9-4.6	3.3	0.285
Upper width	1.87±0.4	1.1-2.8	1.9	1.41±0.3	1-2	1.3	0.022
Upper width 3D	2.37±0.8	0.8-3.4	2.5	2.12±0.8	0.9-4	2.3	0.437
Chin	2.85±0.9	2-5	2.6	2.32±0.6	1.7-4	2.1	0.096
Chin 3D	3.45±1.5	1.8-6.3	3.2	2.46±0.8	1.3-3.9	2.5	0.096
Nasofrontal angle	142.1±6.9	130-151	141.5	146.3±8.6	130-160	147	0.212
Nasofrontal angle 3D	140.3±12.9	123-167	138.5	145.5±19.3	120-178	142.5	0.709
Nasolabial angle	122.9±14.6	102-144	126.5	134.8±14.7	105-156	138.5	0.042
Nasolabial angle 3D	135.2±12.6	119-156	133.5	132.5±17	100-152	136	0.886
Nasiomental angle	137.6±10.8	125-160	133.5	138.2±11.6	123-160	135.5	0.886
Nasiomental angle 3D	138.6±13.5	120-165	141	131.7±15.5	100-152	136	0.472

aesthetic proportions, angles and geometric relationships may not be fully seen on beautiful faces and may not be achieved surgically in the general population (12, 13).

Facial analysis dictates that the length of the face is divided horizontally into three parts. The upper part extends from the hairline to the glabella, the middle part extends from the glabella to the subnasal, and the third part at the bottom extends from the subnasal to the menton area (Figure 5). In terms of achieving desired aesthetic harmony, these three parts should be equal; however, they rarely are. As indicated in classical studies, the facial height ratios are compatible at approximately 50%. In accordance with the criteria of facial ratios, the width of the face was divided vertically into five parts; both eye widths formed one section each, and the intercantal distance and nose width is one fifth of the total width (Figure 3). The width of the lips should be approximately 40% of the width of the lower face and should generally be equal to the distance between the medial limbuses (1, 13).

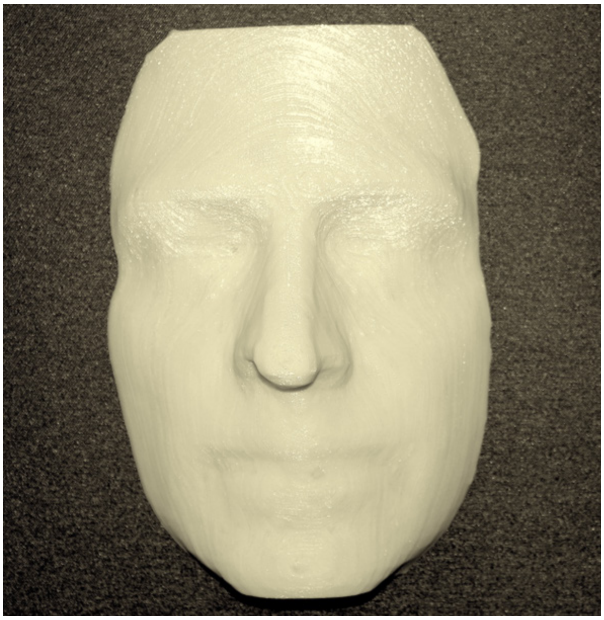

Figure 1: Figure of a 3D-printed mask

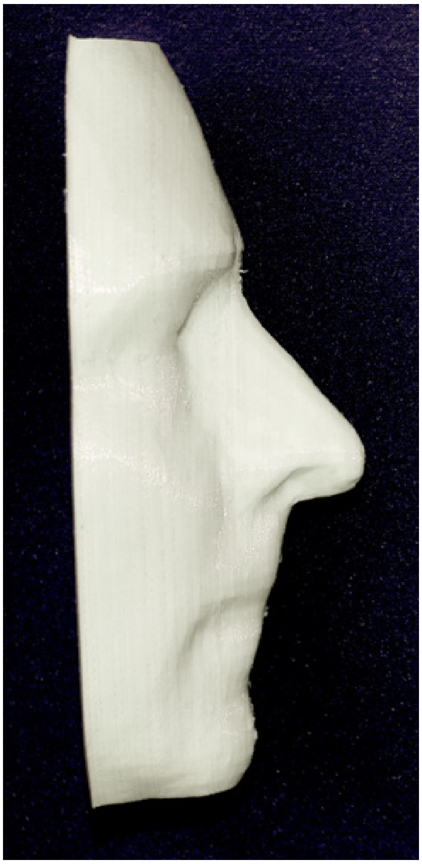

Figure 2: Figure of a 3D-printed mask.

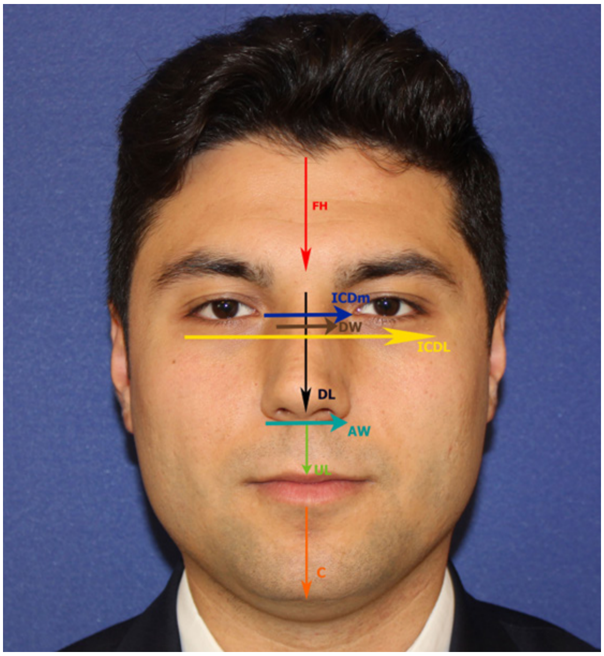

Figure 3: Length measurements made on the face and the 3D mask are depicted. FH: Forehead, ICDm: Intercanthal distance-medial, ICDL: Intercanthal distance-lateral, DW: Dorsal width, DL: Dorsal length, CL: Columellar length, AW: Alar width, UL: Upper lip, C: Chin.

Figure 4: Angle measurements made on the face and the 3D mask. NF: nasofrontal angle, NLA: nasolabial angle, NM: nasomental angle

In order to evaluate the patients' faces, we examined the compatibility of the 3D-printed models and the soft tissue measurements of our patients.

In our results, a significant difference was found between soft tissue measurements and 3D measurements in dorsal width measurements only of male patients (p=0.019) and only in columellar length and upper width measurements of female patients (p=0.021, p=0.035) while no other significant differences were noted (Table 2, Table 3).

In addition, no significant difference was found between male and female measurements except for upper width measurements, nasolabial angles and the lateral intercantal distance measurements in the 3D mask (p=0.026, p=0.022, p=0.042).

These results suggest that modelling with 3D printing is technologically safe and advantageous and shows great potential in facial aesthetics and surgical interventions. As it becomes easier and more widespread in its production, the use of 3D printing will increase in surgical interventions, patient's preoperative evaluations, training simulations and the reconstruction of complex defects. Therefore, further research and development is needed to increase access to this technology.

This research is a basic study on the Turkish population. The results may not represent the Turkish population due to the relatively small sample size.

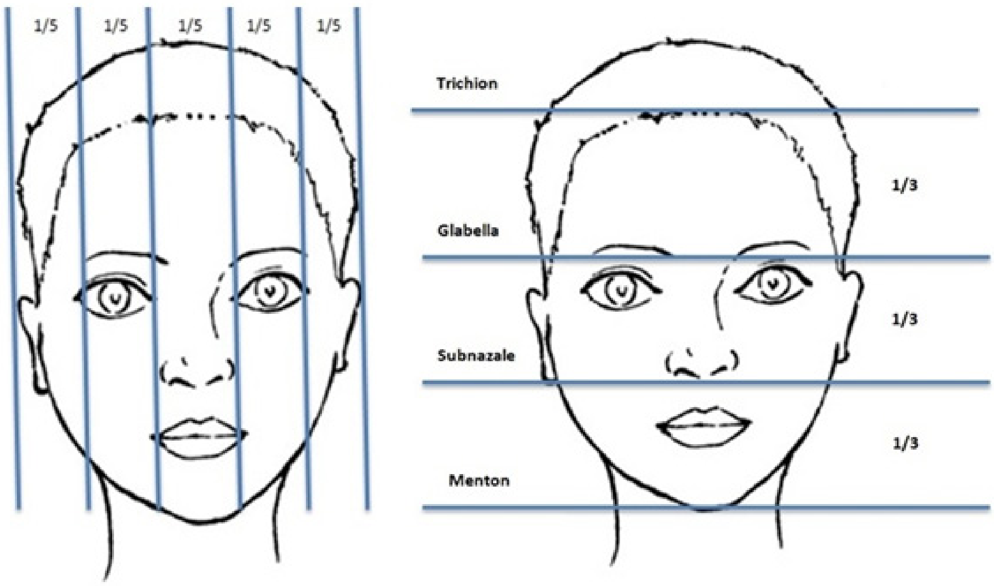

Figure 5: Facial divisions

Ethics Committee Approval: This study was approved by the Acıbadem University Ethics Committee (ATADEK) (Date: 12.09.2019, No: 2019-14/71).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer Review: Externally peer-reviewed.

Author Contributions: Conception/Design of Study- İ.E.E., K.S.K., M.V.K.; Data Acquisition- İ.E.E., K.S.K., M.V.K.; Data Analysis/Interpretation- İ.E.E., K.S.K., M.V.K.; Drafting Manuscript- İ.E.E.; Critical Revision of Manuscript- İ.E.E., K.S.K., M.V.K.; Final Approval and Accountability- İ.E.E., K.S.K., M.V.K.; Technical or Material Support – İ.E.E., K.S.K., M.V.K.; Supervision- İ.E.E., K.S.K., M.V.K.

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