Original Article

Accuracy analysis between digital and clinical measurements of facial features

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ABSTRACT

Introduction: Clinical facial analysis is essential for many specialists, such as plastic surgeons, maxillofacial surgeons, otorhinolaryngologists and other specialties. Clinical facial analysis is not a particular phase of clinical practice or a moment during a patient consultation. It is the largest part of a professional life and a never-ending process. Also obtaining accurate measurements is essential for achieving proper diagnosis, putting accurate treatment plans and following up the clinical outcome of the performed procedures. Obtaining accurate repeatable linear measurements clinically using a ruler between two different points on the face is always difficult, challenging and operator dependent because of different factors.
Material and Methods: This article presents novel technique to obtain accurate and repeatable measurements of linear facial measurements using standardized photos and computer software and compare the results with those obtained with clinically using a ruler.
Results: The inter observer reliability of the new technique was very reliable in comparison with traditional method. The reliability of the new technique was up to 1 while the clinical method was never up to this level of reliability.

Key Words: Facial measurements, maxillofacial, orthodontics, plastic surgery

Received:19 May 2018, **Accepted:**14 August 2018

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ISSN: 2090-097X, May 2018, Vol. 9, No. 2

INTRODUCTION

Review of literature:

Clinical facial analysis (CFA) is the method utilized by physicians for evaluating and judging the patient’s face, to define its proportions, volume, appearance, symmetry, and visible deformities. It is based on direct examination, clinical photographs, and conventional and computerized X-ray imaging[1].

Clinical facial analysis is essential for many specialists, such as plastic surgeons plastic surgeons, maxillofacial surgeons, otorhinolaryngologists, ophthalmic plastic surgeons, head and neck surgeons, cosmetic surgeons, orthodontists, rehabilitative dentists, and dermatologists, and, generally, for any physicians dealing with facial aesthetics and functions.

Clinical facial analysis is not a particular phase of clinical practice or a moment during a patient consultation. It is the largest part of a professional life and a never-ending process. Furthermore, CFA is not separable from everyday activities and we should be able to analyze the face of the patient and, at the same time, answer his or her questions, or illustrate a procedure[1].

Also obtaining accurate measurements is essential for achieving proper diagnosis, putting accurate treatment plans and following up the clinical outcome of the performed procedures.

Linear measurements although not the best way to describe or predict facial changes but still give strong simple descriptive information for the existing conditions so treatments plans can be put upon this information to correct it.

Obtaining accurate repeatable linear measurements clinically using a ruler between two different points on the face is always difficult, challenging and operator dependent because of different factors[2].

A) The face is not a flat surface.

B) It would be impossible to the put the ruler at the exact same points every time the measurements being taken either by the same operator at different times or by different operators at the same or different times.

 DOI: 10.21608/OMX.2018.18826

C) Soft tissue compressibility: because the ruler would rest on the patient skin during recording the different measurements, more pressure would result in a little flatting of the tissues giving false measurements and again this factor can't be standardized between the different measurements obtained whether by the single operator or different examiner.

It becomes more difficult or even impossible to obtain linear measurements during movement of facial structures during different facial expressions. For example, it's impossible to obtain linear measurement during full social smile that can't not be maintained by the patient otherwise it would be paused smile and not the natural movement.

Hence the necessity to develop simple and affordable technique that help to obtain accurate and reliable linear measurements to help in diagnosis, treatment planning, follow ups or even research purposes emerges.

AIM OF THE STUDY

To validate the repeatability and reliability of a new method used for obtaining facial measurements digitally.

MATERIALS AND METHODS

This study was conducted after receiving an ethical clearance from the Research Ethics Committee of Faculty of Dentistry; Ain Shams University, that the study follows the guidelines of the research ethical committee code of practice.

To validate the repeatability and reliability of the new method and compare it with those of the traditional clinical method the following steps were followed:

A) One measurement was chosen:

I) Vermillion Height (during rest): the vertical measurement from the superior border of the vermilion at the Cupid's bow to the inferior border of the upper lip. (Figure 1).

Fig. 1 : Vermillion Height

B) Examiners were recruited: Ten examiners were recruited from different departments of the faculty of dentistry Ain Shams University. Detailed information about the measurements and how to obtain them both clinically and digitally was explained to them as described later.

C) volunteers were recruited: Ten volunteers were recruited to join this research project:

Inclusion criteria:
Any male or female between 18 and 60

Exclusion criteria:
Any volunteer who can't maintain steady position during measurements (I.e: volunteers with Parkinson's disease).

D) Obtaining measurements : The examiners were asked to take the measurement 3 times, each at different times clinically and digitally at each time the measurement was obtained three times and the mean was calculated to be the final result.

Clinical method: A plastic ruler was used to measure the distance between the two points, previously mentioned.

Digital method: The following steps were followed to obtain the measurements.

1-Photo standardization: To obtain standardized photograph, many variables were being fixed every time photos were taken. These variables included:

I) Patient head position in space.
II) Camera position in space and the relationship between camera and the patient.
III) Camera's settings.

The patient head position:

To standardize the patient head position in space every time and avoid any flexion, extension, later flexion or rotation in any direction, a cephalostat device was used.

The patient was asked to stand up upright so his\her head was in between the two ear rods and head clamp. The ear rods were approximated to each other so they fit inside the external auditory meatus so that patient's head was centered between them. This prevented any lateral flexion or rotation of the patient's head. The head clamp was approximated so, it rested on the soft tissue Nasion on the patient's face and the patient was asked to rest his\her forehead on the head clamp. This prevented the patient's head from any flexion or extension. Every time the head clamp was adjusted such that at least one centimeter of graduation on the clamp head ruler is visible which will help in photo standardization. (Figures 2,3)

Fig. 2: Cephalostat (Sirona Orthophos XG 3D).

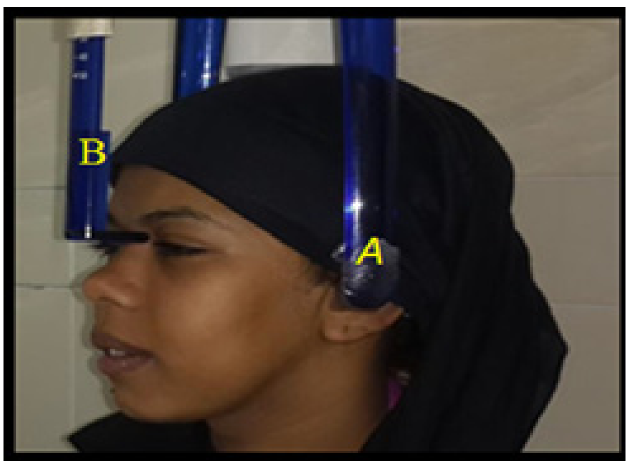

Fig. 3: A) Ear rod. B) Head

Camera position in space and the relationship between camera and the patient:

To standardize the camera position in relation to the cephalostat and to patient's head we put the three permanent marks on the floor. These three permanent marks were used to position the three legs of a tri-pod every time the photos were being taken, this fixed the distance and position of the camera in relation to the cephalostat. (Figures 4,5,6).

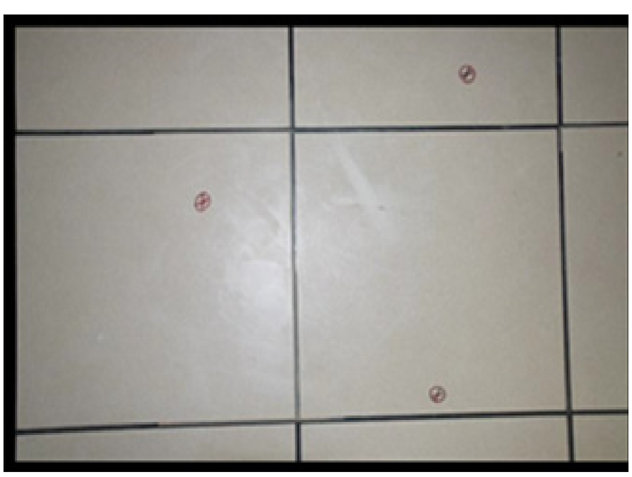

Fig. 4: Three permanent markers on the floor to accurate positioning of the tripod legs every time.

Fig. 5: Tripod Components (Walimex WT-3570 Basic Tripod). A) Quick releasing plate. B) Quick releasing mount plate. C) Horizontal spirit level. D) Round spirit level. E) Crank handle. F) Pan handle. G) Housing of Central column.

Fig. 6: Nikon D5300 with Nikon 18-140mm f3.5-5.5 lens.

To fix the position of the camera in space (horizontal and vertical axis), the camera was connected to the quick releasing plate and then they were connected to the quick releasing mount plate. The pan handle was used to adjust the camera in a horizontal axis by making sure that the air bubble is centered within the horizontal spirit level.

The round spirit level was used to make sure that the camera isn't tilted in relation to the vertical axis and this was adjusted by making sure that the three legs of the tripod were in the same height.

Depending on the height of the patient the cephlostat can be moved up and down from the control panel of the device so that the patient stands upright.
The crank handle was used to control the center column's height to adjust the camera at the same level of the patient head

Camera's settings:

The lens (18-135 mm) was connected to the camera and the focal length was adjusted to minimum which is 18mm for this lens after setting focus mode to manual.

After adjusting photography mode to manual as well, the shutter speed: which is the length of time when the film or the digital sensor inside the camera is exposed to light. The amount of light that reaches the film or image sensor is proportional to the exposure time. 1/500th of a second will let half as much light in as 1/250th.The higher the shutter speed, the more the number of pictures can be taken per second but the amount of light that reach the is low so the pictures would be very dim. The shutter speed was adjusted to be 1\200 sec.[3]

Another setting to adjust was the aperture which is referred to the lens diaphragm opening inside a photographic lens. The size of the diaphragm opening in a camera lens regulates amount of light passes through onto the film inside the camera the moment when the shutter curtain in camera opens during an exposure process. Aperture size is usually calibrated in f-numbers or f-stops. i.e. those little numbers engraved on the lens barrel like f22 (f/22),16 (f/16), f/11, f/8.0, f/5.6, f/4.0, f/2.8, f/2.0, f/1.8 etc.[4]

Aperture controls the sharpness of the photo, the smaller the number, the sharper the photo which means that the boundaries between different color zones can be identified easily and not blurred. So, with zooming in the photo, the boundaries between different anatomical landmarks (teeth, gingival, vermillion and nose) can be identified and pointed easily. But again, decreasing the f -number will decrease the amount of light that pass to the sensor and the photo will be dimmer. The f -number was adjusted to be f\2.5.

To avoid the dimness of the photos that resulted from increasing the shutter speed and decreasing the f-number, the ISO number which is the sensitivity of the sensor to the light was increased too. The higher the ISO number the higher the light sensitivity of the sensor and the camera flash was also used to decrease that dimness.so the ISO was adjusted to be 4000[5].

After Adjusting all the previous variables each patient was asked to stand up upright within the cephalostat device and in rest position and the shutter button was pressed and held down so multiple pictures were taken (24 pictures per second).

2) Obtaining Measurements using Photoshop's software:

The number of pixels mainly depends on the camera's sensor and its ability to capture the details of the photo. The higher the number of pixels, the higher the resolution and the higher the details that can be seen within the photo. Zooming in or out the photo just increases the size or decrease the size of the pixel but the number of pixels within certain area of the photo is fixed for a photo. Based on the previous facts, we used the Photoshop software to measure the previously mentioned measurements by following steps[6]:

Photoshop CS6 was opened

The desired photo was selected and dropped into the window of the program. A straight line was drawn just next to the ruler on the head clamp and extended down vertically along the patient face, this guaranteed to take the measurement at the position every time because the patient head position is fixed within the cephalostat device. To draw that line, right click on the line tool from the tool menu on the right side of the program and increase the width of the line to 5 pixels from the top menu to make the line more visible.

Points were drawn over the line at the start and end of one centimeter on the ruler on the head clamp and on each land mark by using the brush tool from tool menu

Ruler tool was selected from the tool menu and the distance between the two points at the beginning and the end of one centimeter at the ruler pic was measured to detect the number of pixels between the two points. (Figure 7)

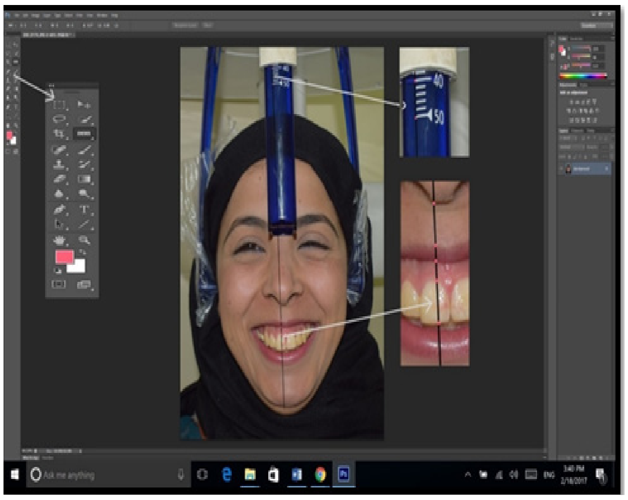

Fig. 7: Obtaining measurements from Photoshop software

The number of pixels between each two points (anatomical land marks to be measured) was detected the same way.

By using simple proportional and cross multiplication (cross matching equation) the exact measurements were obtained.

$$\frac{\text{Number of pixels over 1cm on the ruler on Photoshop } \textbf{(known)}}{\text{1 cm on the physical l ruler on the head clamp } \textbf{(known)}} = \frac{\text{Number of pixels between two points (anatomical land mark to be measured) } \textbf{(known)}}{\text{The exact physical length of the anatomical landmark } \textbf{(unknown)}}$$

The measurements were obtained again after 3 days and after one week by the ten examiners.

E) Analysis of the results:

The collected data was revised, coded, tabulated and introduced to a PC using Statistical package for Social Science (SPSS 15.0 for windows; SPSS Inc, Chicago,IL, 2001). Data was presented and suitable analysis was done according to the type of data obtained for each parameter.

1. Reliability analysis (using Alpha (Cronbach): was a model of internal consistency, allow you to study the properties of measurement scales and the items that compose the scales. Calculate a number of commonly used measures of scale reliability and also provides information about the relationships between individual items in the scale.

P- value: level of significance:

-P>0.05: Non-significant (NS).
-P< 0.05: Significant (S).
-P<0.01: Highly significant (HS).

RESULTS

The study included 10 patients (Caucasian Egyptian patients) between 24 and 31 years old while. The obtained measurements from the ten examiners for the ten volunteers were tabulated in the following table: (Table 1)

The intra observer relibility of the clinical method ranged from 0.79 to 0.89 on Alpha (Cronbach) Reliability analysis which means that it is reliable method for obtaining measurements but not highly reliable. (Table 2)

The intra observer relibility of the digital method ranged from 0.99 to 1 on Alpha (Cronbach) Reliability analysis which means that it is highly reliable method for obtaining measurements up to 100% repeatability. (Table 3)

Alpha (Cronbach) Reliability analysis, **= HR, *= R

Alpha (Cronbach) Reliability analysis, **= HR, *= R .

Table 1: Clinical and digital measurements

Measurements of vermillion height during Rest																															
First, Second, Third volunteers' measurements																															
EX.		1			2			3			4			5			6			7			8			9			10		
Case:		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1st	C	1.4	1.6	1.3	1.1	1.6	1.6	1.2	1.1	1.2	1.6	1.7	1.6	1.6	1.3	1.6	1.6	1.1	1.6	1.6	1.1	1.6	1.4	1.3	1.2	1.1	1.1	1.6	1.2	1.6	1.3
	D	1.5	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
2nd	C	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.4	1.6	1.7	1.3	1.4	1.4	1.3	1.4	1.3	1.3	1.3	1.4	1.6	1.2	1.6	1.4	1.6	1.6	1.7	1.3	1.4
	D	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
3rd	C	1.6	1.6	1.6	1.1	1.3	1.1	1.3	1.3	1.4	1.3	1.5	1.3	1.1	1.6	1.3	1.1	1.3	1.4	1.4	1.6	1.3	1.3	1.8	1.3	1.6	1.7	1.3	1.5	1.4	1.4
	D	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.5
Fourth, Fifth, Sixth volunteers' measurements																															
EX.		1			2			3			4			5			6			7			8			9			10		
Case:		4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
1st	C	2.3	1.7	2.1	2.1	1.6	1.9	2.1	1.7	1.9	2.4	1.4	1.9	2.3	1.8	1.6	1.9	1.3	2	2	1.9	1.6	2.1	1.4	1.7	2	1.7	1.6	2.1	1.7	1.8
	D	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8
2nd	C	2.1	1.9	2	2.2	1.4	1.7	2.3	1.5	1.5	2.1	1.8	2	2	1.7	2	2.3	1.5	2.1	2	1.8	1.7	2	1.8	2	2.2	1.6	1.7	2.2	1.6	2.1
	D	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8
3rd	C	2.2	1.8	1.9	2	1.6	1.9	2.5	1.7	1.7	2.6	1.7	1.5	2.3	1.4	1.9	2	1.4	2	2.1	1.9	1.4	2.3	1.6	1.8	2.3	1.8	1.9	1.9	1.4	2
	D	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.1	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8	2.2	1.6	1.8
Seventh, Eighth, Ninth volunteers' measurements																															
EX.		1			2			3			4			5			6			7			8			9			10		
Case:		7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9	7	8	9
1st	C	1.7	1.7	1.3	1.4	1.8	1.4	1.7	1.4	1.3	1.7	1.7	1.7	1.6	1.4	1.5	1.6	1.5	1.7	1.6	1.7	1.7	1.7	1.5	1.7	1.4	1.7	1.6	1.4	1.7	1.7
	D	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6
2nd	C	1.4	1.4	1.5	1.6	1.4	1.5	1.5	1.7	1.7	1.5	1.5	1.4	1.6	1.5	1.4	1.4	1.7	1.5	1.4	1.4	1.5	1.5	1.7	1.5	1.6	1.4	1.4	1.6	1.4	1.4
	D	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6
3rd	C	1.3	1.8	1.1	1.3	1.5	1.5	1.6	1.5	1.4	1.4	1.4	1.7	1.4	1.4	1.5	1.6	1.5	1.4	1.4	1.5	1.5	1.8	1.6	1.6	1.5	1.5	1.6	1.6	1.4	1.3
	D	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6	1.5	1.6	1.6
Tenth, Eleventh, Twelfth volunteers' measurements																															
EX.		1			2			3			4			5			6			7			8			9			10		
Case:		10	11	12	10	11	12	10	11	12	10	11	12	10	11	12	10	11	12	10	11	12	10	11	12	10	11	12	10	11	12
1st	C	1.6			1.7			1.4			1.3			1.6			1.7			1.3			1.5			1.3			1.7		
	D	1.5			1.5			1.5			1.4			1.5			1.5			1.4			1.5			1.5			1.5		
2nd	C	1.2			1.7			1.4			1.6			1.2			1.3			1.7			1.3			1.4			1.6		
	D	1.5			1.5			1.5			1.4			1.5			1.5			1.4			1.5			1.5			1.4		
3rd	C	1.6			1.6			1.8			1.2			1.3			1.2			1.3			1.4			1.4			1.2		
	D	1.5			1.5			1.5			1.4			1.5			1.5			1.4			1.5			1.5			1.4		

Table 2: Intra-observer Reliability analysis for clinical measurement of vermillion height during rest.

Vermillion height during rest(clinical)	Mean	Min.	Max.	Cronbach's Alpha	*P value*
First Dr.	1.61	1.55	1.67	0.891**	<0.001
Second Dr.	1.57	1.49	1.64	0.874**	<0.001

Third Dr.	1.58	1.55	1.62	0.887**	<0.001
Fourth Dr.	1.62	1.56	1.70	0.854**	<0.001
Fifth Dr.	1.57	1.52	1.63	0.865**	<0.001
Six Dr.	1.56	1.47	1.61	0.832**	0.001
Seventh Dr.	1.59	1.55	1.64	0.843**	<0.001
Eight Dr.	1.59	1.56	1.65	0.815**	0.001
Nine Dr.	1.59	1.52	1.66	0.824**	0.001
Ten Dr.	1.60	1.53	1.63	0.798*	0.002

P- value: level of significance
- *P>0.05:* Non-significant (NS).
- *P< 0.05:* Significant (S).
- *P<0.01:* Highly significant (HS).

Table 3: Intra-observer Reliability analysis for digital measurement of vermillion height during rest.

Vermillion height during rest(digital)	Mean	Min.	Max.	Cronbach's Alpha	*P value*
First Dr.	1.62	1.60	1.63	0.988**	<0.001
Second Dr.	1.630	1.630	1.630	1.0**	---
Third Dr.	1.630	1.630	1.630	1.0**	---
Fourth Dr.	1.63	1.62	1.63	0.998**	<0.001
Fifth Dr.	1.630	1.630	1.630	1.0**	--
Six Dr.	1.630	1.630	1.630	1.0**	--
Seventh Dr.	1.630	1.630	1.630	1.0**	--
Eight Dr.	1.63	1.62	1.63	0.998**	<0.001
Nine Dr.	1.630	1.630	1.630	1.0**	--
Ten Dr.	1.63	1.63	1.64	0.998**	<0.001

DISCUSSION

Obtaining measurements for different facial feature is usually useful for different clinical purposes either for diagnosis, treatment planning or to follow up the results of different procedures. When anthropometric methods were introduced into clinical practice to quantify changes in the craniofacial framework, features distinguishing various races/ethnic groups were discovered. To treat congenital or post-traumatic facial disfigurements in members of these groups successfully, surgeons require access to craniofacial databases based on accurate anthropometric measurements.[7]

Photoshop and other computer programs were used by different researchers to obtain measurements from digital photos like Barman J *et.al*[8], AL-Kaisy N *et.al*[9], Isa ZM *et.al*[10] but the photos from which the measurements were obtained, were not standardized to obtain the same measurements at different .

Obtaining measurements clinically using different types of rulers or calipers has been used for long time with some margin of error making them not highly repeatable and operator dependent most of the time.

Obtaining measurements by naked eyes and using rules can give results on millimeters but obtaining the measurements digitally using software can give measurements with margin of error on range of one tenth or one hundredth of millimeter and the margin of difference between different observers was on this scale which made that there is almost no difference when the measurements were approximated to the nearest millimeter.

The new method of assessment introduced a new way to obtain these measurements with very high repeatability.

CONCLUSION AND RECOMMENDATION

The new method of obtaining measurements has a very high reliability in comparison with the clinical method.

It's recommended to test this new method with other facial measurements for further confirmation if it reliability

It's also recommended to use this method to obtain measurements during dynamic motions of the face for example to examine the range of motion of the upper lip during smiling and test its reliability which is usually challenging to obtain such kind of measurements clinically.

CONFLICT OF INTEREST

There are no conflicts of interest.

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