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Intra- rater Reliability of facial markers placement Utilizing Moiré Topography: pilot study

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ABSTRACT

Objective: The purpose of this study is to test intra rater reliability of placement of facial markers for calculation of facial angles utilizing moiré topography. Design: randomized non experimental design. Setting: Faculty of Physical Therapy, Cairo University. Materials and Methods: Twenty five healthy subjects were randomly selected from both gender, They were participated in the study after signing institutionally approved consent form prior to data collection .Five facial angles were measured at both sides of the face which done by five muscles includes: (frontalis, orbicularis oculi, levatorangulioris, zygomaticus major , buccinators) after putting twenty two passive reflective markers made of plastic balls of 5mm in diameter on the face of the subjects then asked each subject to raising eye brow then relax and after light eye closure then smiling then kissing and finally blowing to measure each angle two times at one day apart between each measurement by using Moiré topography. Results: There was a strong positive correlation between first and second readings for all the five angles of the face right and left side at one day apart measurements by using moiré topography, these angles were including: (raising, closing, smiling, kissing and blowing angles). Conclusions: There was a strong correlation between first and second reading of each angles of the five angles of the face that repeated two times at a separate one day by using moiré topography that is accurate and reliable methods to measure facial movements. Keywords: Moiré Topography, Intra rater- reliability, facial markers, healthy.

INTRODUCTION

Facial motion measurement is a topic that receives important contributions from different sciences, since facial emotions give information

about personality, mood, internal state and behavior of human beings. ^(1,2) It is very important to evaluate facial movements adequately in the diagnosis, planning of treatment, prognosis and surgical outcomes of

patients, trauma, malignant tumor, neurological disease. In such clinical situations, facial movements have been conventionally evaluated and treatment methods have been selected by an observer or an operator subjectively. ⁽³⁾

The Moiré Topography method is an optic measure which enables the visualization of the facial contour in three dimensions, creating stria as a map of contours with a high degree of accuracy. The Moiré frame occurs when a latticed frame is placed in front of the face and a light is illuminated from one side, a shadow of the lattice is generated on the face. This shadow is curved according to the shape of the face, and waved contour lines are generated on the face. This phenomenon is the Moiré effect. ^(4,5,6) It is used by non-specialized staff, it can also allow to establish a certain degree of asymmetry. This aspect contributes to its applications in the population healthcare program for the early detection of the illnesses. ⁽⁷⁾

The term reliability in research is defined as “the degree with which repeated measurements, or measurements taken under identical circumstances will yield the same result.” ⁽⁸⁾ This definition also assumes that while the measurements are being made, no change is being effected to the measured subject. In essence, reliability looks the “randomness of the measurement process itself.” ⁽⁹⁾ Reliability can also be defined as “the precision or internal consistency of a test, and does not require comparison with an external standard.” ^(10,11,12)

Soft tissue facial characteristics have been evaluated in multiple ethnic groups and races using a variety of methods, such as anthropometry, ^(13,14) cephalometry, ^(15,16) two dimensional photogrammetry, ^(17,18,19) three dimensional imaging ^(20,21) and video imaging. ⁽²²⁾ Each of these techniques has certain disadvantages, including, clinical time needed for anthropometry, radiation exposure and limitation to profile outline in cephalometry, cost of 3D imaging systems, and image distortion and limited visibility of landmarks with indirect methods. ^(23,24,25) Values for measurements derived from different methods of soft tissue evaluation are not as reliable as those taken with the same method due to different sources of error for each technique. ^(26,27,28)

There is limited evidence about the reliability of facial soft tissue landmarks, especially intra-examiner and inter examiner reliability. ^(26,29,30) Intra-examiner reliability of facial landmarks is important when attempting to quantify changes during treatment, whereas inter-examiner reliability is important when quantitatively comparing individuals to standards from predefined facial analyses. Further investigation into the variation of identification error varies between photograph landmarks and the effect of examiner bias is needed. Therefore, better evidence about the reliability of soft tissue landmarks is needed before a reliable facial analysis can be constructed. ⁽³⁰⁾ Much attention

has been given to the reliability of facial measurements. Repeatability of facial landmark measurements is a more suitable method for evaluating the reliability than comparing absolute values to other methods of facial evaluation.

Reliability is evaluated by repeating measurements twice within a short period of time. A short time period is ideal due to possible changes in facial dimensions over an extended period of time due to environmental factors, such as body mass index, temperature and humidity. These environmental factors may cause measurable soft tissue changes that affect reliability of quantifying growth and treatment changes.⁽¹³⁾

The reliability of markers placement is of most importance because linear and angular measurements are affected by points used for the measurements. Photograph was found to have good repeatability, though measurements obtained from photographs were more variable than anthropometric measurements. The resolution of the images used for photograph, have an effect on the reliability of landmark identification. There has been less attention given to the reliability of measurements from video-images. The high level of accuracy and reliability of measurements on three dimensional images combined with the benefits of indirect measurements are clear benefits of these techniques for facial measurements.⁽²⁸⁾ So The purpose of this study is to analysis the intra-rater

reliability of facial markers placement utilizing moiré topography.

MATERIAL AND METHODS:

Subjects

Twenty five subjects were randomly selected from both gender, they were participated in the study after signing institutionally approved consent form prior to data collection they were recruited from the students, employees and the out clinic of Faculty of Physical therapy. Inclusive criteria are all normal subjects, exclusive criteria are Neuromusculo-skeletal diseases, Burn face, Facial trauma, Face skin disease, History of neurologic disorders, Facial plastic surgery.

Procedure:

The moiré topography apparatus specially designed for calculation of facial angles consisted of:

1-The frame:

It was a rectangular aluminum frame with 40X30 cm dimension, 30cm width and 40cm height, the frame was attached with transparent screen which divided horizontally with an equal spaced back lines that were separated by a distance equal to their thickness (2mm) i.e. the diameter of each line and the space between each two lines were both (2mm).The frame could be raised or lowered in order to facilitate the investigation of subjects of various heights ,the frame were supported on an adjustable aluminum frame and the identification of subject.

2- A studio light

A studio light with an intensity of 800 watt after adjustment with light meter was used as a light source , it was fixed to its tripod at a distant 50cm apart from the camera and it was on a level with the central of the moiré topography frame .⁽³¹⁾

3- The camera:

The camera used was (Nikon, D3200 24MP camera, 4 FS) the distance between the light source, the camera and moiré frame was 170 cm horizontally,^(5,6) while the distance between the light source and the camera was 50cm vertically measured by tape measurement ,the camera was supported on its tripod to adjust its height .⁽³²⁾

4- Skin markers and Double face adhesive plaster :

Twenty two passive reflective markers made of plastic balls of 5mm diameter, coated with reflective material were used as face surface markers for this study as in figure 1 .The markers were attached bilaterally to both side of the face for each subject with a well defined anatomical landmarks with double faced adhesive tape to ensure proper fitting on the face. The adhesive plaster was used to ensure good contact of the dots to the skin and we used three markers on the frame to make standardization of the head position.⁽³³⁾

Testing procedure:

The Subjects were given a full explanation about the study protocol and we described each movement of the face in front of the

subjects and then allowed the subjects to perform each movement.

Marker placement^(34,35)

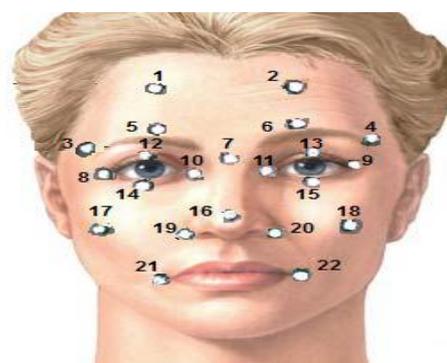


Figure 1:the markers placement. The facial landmarks of the upper face :1, rightfrontal; 2, left frontal; 3, right external eyebrow; 4, left external eyebrow; 5, right middle eyebrow; 6, leftmiddle eyebrow; 7, nasium point; 8, right externalcanthus; 9, left external canthus; 10, right internalcanthus; 11, left internal canthus; 12, right uppereyelid; 13, left upper eyelid; 14, right lower eyelid;15, left lower eyelid. The facial landmarks of thelower face: 16, middle nasal point; 17, rightzygomaticus; 18, left zygomaticus; 19, rightnasogenian; 20, left nasogenian; 21, rightcommissure; 22, left commissure.^(34,35)

We measured the angle of each movement for each side (right and left) two times. To make standardization to the position of the head, the chin of the subject was parallel to the middle marker on the frame of the screen. The distance between the light source, the camera and moiré frame was 170cm. horizontally, while the distance

between the light source and the camera was 50cm. vertically.^(5,6,29) The subjects were instructed to sit comfortably and remain as still as possible while fully performing the facial expression, then to relax after each expression was performed. The subject began motion after a verbal signal from the examiner (go) until the end of the session. To record the upper face expression, subjects were instructed to close and open the eyes (not blinking) and to lift the eyebrows and relax. To smile with the mouth closed, with their lips together, and then allowing the lips to return to a

resting state, they were then asked to draw the angle of the mouth straight upward and relax finally the subjects were asked to make blowing and then relax. Two measurements were done by the same investigator at two different times (one day apart) for each movement. The parameters studied on both sides of the face were the amplitude of the selected facial angles including: raising, closing, kissing, smiling and blowing angles during static position. The analysis of the angles was done by AutoCAD 2009 Program as computer software as in fig.2.

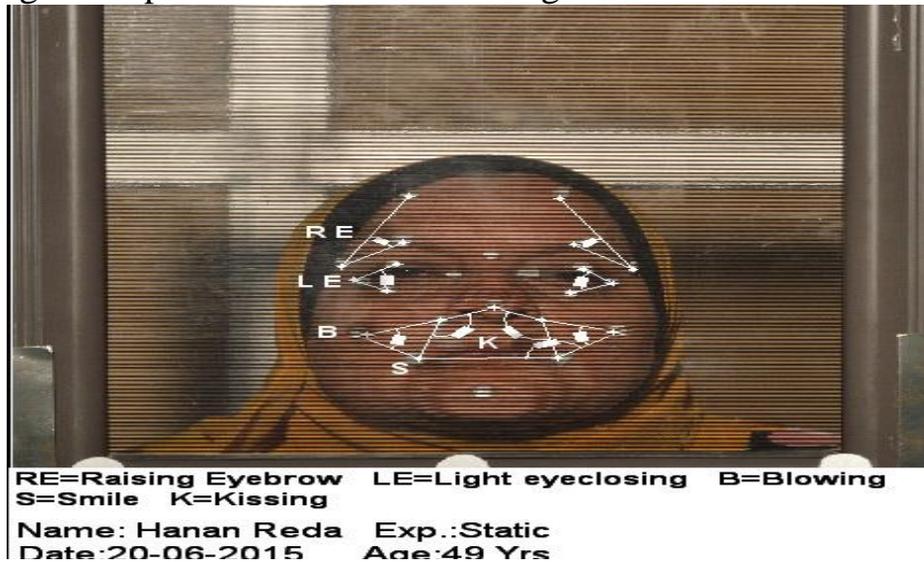


Figure 2: Main facial plots used for determination of Facial angles among landmarks during static position including: -Raising angle (R E) -Closing angle (L E) -Smiling angle(S) -kissing angle (K) -Blowing angle (B)

Statistical analysis:

Data were analyzed using a Statistical Package for Social Sciences (SPSS) version 15.0. Correlation coefficient to test intra rater reliability of markers placement on the face to

compare between the two readings of each facial angles at two different periods (one day apart) by the same investigator. Level of significance for the test was set at 0.05.

Twenty five subjects were participated in the study after signing institutionally approved consent form prior to data collection; they were recruited from the

RESULTS

students, employees and the out clinic of Faculty of Physical Therapy, Cairo University. We found that there was a strong positive significant correlation

between first and second reading for all the five angles of the face right and left side measurements as occurred in table1.

Table 1. Correlation between first and second reading of facial motion:

	r value	p value	Sig
Raising right eyebrow	0.81	0.0001	S
Raising left eyebrow	0.84	0.0001	S
Light closing of right eye	0.8	0.0001	S
Light closing of left eye	0.81	0.0001	S
Smiling on right side	0.84	0.0001	S
Smiling on left side	0.8	0.0001	S
Kissing on right side	0.79	0.0001	S
Kissing on left side	0.74	0.0001	S
Blowing on right side	0.79	0.0001	S
Blowing on left side	0.81	0.0001	S

r value: Correlation coefficient value **p value:** Probability value **S:** Significant

DISCUSSION

This study was conducted to test the intra rater reliability of placement of facial markers utilizing moiré topography. The results indicated that there was a strong significant correlation for all the five angles of the face right and left side measurements when the measurements were done a one day apart. Facial appearance and our expressive behaviors have a major impact on how we perceive ourselves and how others in society perceive us. For an individual with a facial functional impairment and/or disfigurement, however, these interactions and associated perceptions may be very different. To aid in the diagnosis, treatment planning, and outcome assessment for these individuals, it is important that objective and quantitative methods are

available to measure the severity of impairment and to compare the effectiveness of different operative or medical procedures.^(35,36)

Facial movements have been conventionally evaluated and treatment methods have been selected by an observer or an operator subjectively.⁽³⁾ Given the varied treatment modalities, objective, quantitative measures of facial movement by zone and measures of synkinesis are more critical in permitting health care providers to assess the efficacy of their therapies. Objective measures will also help guide therapeutic decision making by quantifying the disordered facial movement prior to intervention.⁽³⁷⁾ So this study was conducted to test the intra rater reliability of placement of facial markers utilizing moiré topography. The findings of this study

proved that there was a strong correlation for all the five angles of the face right and left side measurements when the measurements were done a one day apart. These findings confirm with the preliminary results of other studies that proved that moiré topography is an excellent method of determining the extent of facial palsy, as it is faster and more economic technique than the traditional one used in the diagnosis of asymmetries in patients' faces.⁽⁷⁾

The Moiré Topography method is an optic measure which enables the visualization of the facial contour in three dimensions, creating stria as a map of contours with a high degree of accuracy. Moiré is the interference pattern that is generated when more than two periodical patterns are overlapped. When a latticed frame is placed in front of the face and a light is illuminated from one side, a shadow of the lattice is generated on the face. This shadow is curved according to the shape of the face, and wavy contour lines are generated on the face. This phenomenon is the Moiré effect.⁽³⁸⁾

The moiré topography is a faster and more economic technique than the traditional one used in the diagnosis of asymmetries in patients and can be used by non-specialized staff. It allows the evaluation and quantification of parts of the human body, such as the face, the back, the legs and the sole of the foot. The MT method has the advantages of being a non-invasive technique as it does not involve radiation as occurs in x ray exams⁽⁷⁾ it

does not require a highly trained professional to apply the method,^(7,39) it allows for fast evaluation of a large number of subjects in a short time period.⁽⁷⁾ It is a reproducible⁽⁴⁰⁾ and low-cost^(7,39), technique that can either substitute X-ray examination or be applied as a complementary diagnostic technique.^(7,40)

This finding comes in agreement with Voepel-Lewis et al,2010⁽⁴¹⁾ who mentioned that clinical feasibility, or the ability to readily adapt an instrument for routine assessment and documentation, may depend on a tool's compatibility with other tools used in the clinical setting, as well as on the ability to use the tool across settings or populations of patients. Another way of measuring facial movements is to use facial point systems. Movements of selected points are representative of the movements of the particular face expression. The simplest technique is to hold a hand-held ruler against the patient's face to measure distances. Frey et al,1994⁽⁴²⁾ used hand-held calipers to measure the distances between fixed landmarks. By this way, the caliper does not provide the direction of movement of the facial point and the angle of movement is very difficult to determine.

Isono et al,1996⁽⁴³⁾ presented a landmark-based system in which 24 reflective markers were placed on the face before recording with a video camera at a rate of 10 frames for computer analysis. The resulting data were expressed both as a graphic representation and as a ratio of mean

right versus left facial movements. The time lag between capture of the visual movement, digitization, and graphic display is a temporary delay and, again, no 3-D facial movement is showed. So the reliability of three dimensional analysis of moiré topography is very important of facial movements and according to this study moiré topography is more reliable and accurate methods to measure the facial symmetry.⁽⁴³⁾

Renders the reliability measurements of the head and face difficult to accurately assess. Since no gold standard and a large variation between individuals in the size of their facial structures exist, the only way to accurately measure a given facial structure is to correctly identify the bony/soft tissue points that comprise it. Any method developed to assess facial structures needs to show high intra-rater and inter-rater reliability so that accurate measurements can be completed. Thus, an accurate identification of the facial points comprising the afore-mentioned structures is necessary.

In order for measurements to be accurate, an important aspect is the training of the examiner. Farkas, 1996⁽⁴⁴⁾ states that even extensive training is sometimes insufficient for examiner to provide reliable and accurate measurements. He also states that the two main components for good accuracy are “the ability to locate the facial landmark and to have a set of high-quality measuring tools.” He adds also the cooperation of the examinee as a necessary factor for high

accuracy. Farkas, 1996 tried to distinguish between the two components of reliability – accuracy and precision. In his description, the former pertains to the bias in measurement while the latter is related to the repeatability of a certain measurement. The author suggests that while mistakes are made when the two components are combined, minimizing the possible errors is a way of reducing “unreliable measurements.” Accuracy errors are due to examiner’s bias and Farkas suggests that can be minimized via training while precision errors are due to the patient and obtaining a large data set can minimize those.⁽⁴⁴⁾

Most studies have concentrated on reliably measuring distances between chosen anthropometric points on the 3D-generated images against corresponding points on live subjects.^(45,46,47) as a form of validation. Some studies use complex mathematics to derive and analyze shapes.^(48,49) Recently, attempts have been made to analyze the dynamic face by linear measurement between points.⁽⁵⁰⁾ and facial polygons.⁽⁵¹⁾ Error studies to measure accurate facial soft tissue reproducibility are rare. Only one study to date has attempted this, but the small sample consisted of adults, and the images were averaged before measuring between times.⁽⁵²⁾ This potentially amalgamates all errors during the averaging process (eg, cancellation of positive and negative errors) and might not give a true picture of reproducibility. No study to date has measured the reliability of placement of facial marks by using

moiré topography so this study found that there was a high intra rater reliability of the examiner when replacing the facial markers at two different times (a day apart) by using moiré topography.

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الملخص العربي

مدى مصداقية وضع علامات عاكسة على الوجه لقياس الزوايا باستخدام الموير توبوجرافى

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الهدف: هو اختبار مدى مصداقية وضع علامات عاكسة على الوجه لقياس الزوايا بواسطة استخدام الموير توبوجرافى. **التصميم:** دراسة قياسات متكررة. **المواد والطرق:** 25 اشخاص اصحاء تمت اختيارهم بطريقة عشوائية من الجنسين وشاركوا فى هذه التجربة بعد الموافقة كتابيا على مشاركتهم فى هذه الدراسة و تم قياس 5 زوايا للوجه لكلا الجانبين التى تتم بواسطة خمس عضلات للوجه بعد وضع 22 علامات سلبية عاكسة مصنوعة من البلاستيك كملى على وجه كل شخص بعد ذلك قام كل شخص اولا برفع الحاجب ثم الاستراحة بعد ذلك يقوم بغلق العينين ثم الابتسام ثم التقبيل وفى النهاية النفخ تم الاستراحة بعد كل حركة وتمت قياس كل زاوية مرتين مع فرق يوم بين القرائتين للخمس زوايا لكلا الجانبين. **النتائج:** هناك علاقة طردية قوية بين اول وثان قراءة لكل زاوية من الخمس زوايا الوجه لكلا الجانبين عند قياس الزوايا مرتين مع فرق يوم واحد بين القرائتين باستخدام الموير توبوجرافى. **الخلاصة:** هناك علاقة طردية قوية بين اول وثان قراءة لكل زاوية من خمس زوايا الوجه عند قياسها مرتين يوم واحد فرق بين القرائتين باستخدام الموير توبوجرافى لكلا جانبيين الوجه وهو اكثر دقة ومصداقيه لقياس حركات الوجه.

الكلمات الدالة: الموير توبوجرافى، المصداقية، علامات الوجه، اصحاء