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A novel design to allow recording multiple facial measurements without changing subject's position

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ABSTRACT: *Statement of the problem:* Research on the human face has seen a surge, especially with rapidly developing new concepts of dynaesthetics. Besides dentistry, medical specialties like surgery, forensics and ophthalmology have found renewed interest in studies on human face. In dentistry, specialists from the field of orthodontics, prosthodontics, orthognathic surgeons and aesthetic dentists have done considerable research on various landmarks of human face especially measurements between different landmarks. While researchers have focussed on different methods of measuring, none seemingly has focussed on the significance of stabilizing the subject on which measurements are made or the device with which measurements are made.
Purpose: To review the literature related to the methods used to measure facial parameters.
To design a new device that firmly stabilizes subject as well as measuring device.
Materials and methods: An innovative device was first designed from data obtained from measurements of average head sizes of various races. Thirty dentulous and thirty edentulous subjects were then selected on whom the reliability of the instrument was verified. For dentulous subjects three different observers measured predetermined facial parameter whereas for edentulous subjects, vertical dimensions were measured on the newly designed device called Subject stabilizing device. Vertical dimensions incorporated in the denture were approved in a two stage procedure.
Results: Distances between various different landmarks of the human face were measured without the subject having to move his/her head and without ever removing the measuring calliper from the device.
Conclusion: The device is reliable in measuring different clinical landmarks and can be particularly useful in research where measurements need to be standardized when large populations are studied.

KEYWORDS: facial parameters, vertical dimensions of face, facial midline, interpupillary line, vernier calliper.

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1 INTRODUCTION

Evidence of measuring faces in humans can be seen even in a sketch in Windsor Castle by Leonard da Vinci [1] showing the use of various facial measurements as an aid when drawing face. Human face has been a subject of study since ages and many disciplines of medical sciences like general anatomy, ophthalmology, ENT (ear, nose and throat), forensic medicine and dentistry, pediatrics, psychology (science of human expression), genetic engineering, cosmetic and plastic surgery has contributed enormously to its existing knowledge. In dentistry, specialties like orthodontics, oral surgery, Pedodontics, Prosthodontics and cosmetic dentistry have done research, which involves measuring various parameters of the face in order to understand the dynamic relation between structures and at the same time develop new methods or techniques. The dynamic parameters of the face and its relations with surrounding structures have also led to the development of new equipment's, machines, devices and appliances. Landmarks like midline of face, interpupillary line, base of the nose, angle of the mouth, tragus of the ear and so on, are not new to any field of dentistry since researchers have used these landmarks or parameters to expand solutions. One problem that has acquired more attention from researchers, especially in the field of Prosthodontics and orthodontics, is establishing correct vertical dimensions of occlusion (VDO) when it is lost, altered, distorted or even misused. In dentistry, facial measurements have been more extensively used especially since 1887, when Ivy [2] mentioned the role in determining the lost vertical dimensions.

Since then, this critical step has prompted many prosthodontist's to find a constant anthropometric measurement within the face. [3] To make matters more difficult, face shows infinite variety of dynamic patterns. [4], [5] the problem with measurements on face magnify once the subject is rendered edentulous as the 'sinking-in' of the lips, loss of tissue support, [6] along with facial wrinkles complicate measurements. Amongst many procedures, determination of the VDO is an important procedure in the treatment of the edentulous patient. [7], [8], [9]

Methods described in literature to restore lost vertical dimensions that utilizes facial measurements [10-21] directly on the subject are to be recorded multiple times and mostly average of multiple readings is taken into consideration. Various devices like jaw relator, [13] Willis gauge, [14] Dakometer [19] and simple dividers, [22] have been used to record facial measurements. The accuracy of such instruments has been established. [19], [23], [24], [25] Other mechanical methods that have been advocated include use of a Bimeter that measures biting force, [26], [27] strain gnathodynamometer that measures increase in closing forces, [28] a central bearing device through which patient's tactile sense verifies the correct VDO [29] and a jig to determine interocclusal distance. [30]

To eliminate the errors introduced by measuring soft tissues, the significant role of cephalometric radiographs, [31] introduced first as a Broadbent Boltan cephalometer [32] and since then has been extensively used for studying vertical dimensions of occlusion. Radiographs have been used to verify the reliability of various facial measurements [33], [34], [35], [36] Pre extraction methods for VDO determination include mounted diagnostic casts, [37] making of transparent vacuum formed template [38] and use of existing dentures [39], [40]

When multiple measurements are done on subjects face, it is important that the subject and the measuring device remain in constant relation to each other. This article in the form of innovation has designed a new instrument that has the basic feature of a cephalostat which has been modified to hold the measuring digital calliper at its end. For descriptive purpose the device has been named as Subject stabilizing device (SSD)

2 SUBJECT STABILIZING DEVICE (SSD)

A device that would allow the observer/ operator to measure distances between various landmarks was based on the principle that the device should be heavy, allow the circumference of the head to fit within the device, should carry a measuring device to any part of the face, including the lateral surfaces and be inexpensive, resist wear and minimize incorporation of errors due to the subject, observer or because of its own function and be universally applicable and acceptable. With the above principles in mind, the first step of such designing was to collect data of different human races. This data comprised of various measurements of human head like length, width of face, circumference of head at different points, distances of anterior part of the face from the shoulder and neck, width of the human shoulders, the angle of the chin with the neck in various facial relations and the distance of the bridge of the nose from the surface of the face in various races. After analysis of the data, a blue print of the device was designed that could accommodate the size of any human subject. (**Fig 1)**

Structure:

The Subject stabilizing device comprises of following parts:-

1- Horizontal Platform or base with four plastic adjustable pins.
2- Chin rest (adjustable)
3- "U" shaped frame connected to the base.
4- Head positioner.
5- Horizontal arm, which is attached to one side of the "U"-shaped frame. It has 3 components:-

a) A swivelling arm, which has 4 detachable, movable and adjustable short horizontal components (**Fig. 2**)
b) Attachment for vernier or any other measuring device connected to the rest through a ball and socket joint.
c) Magnetic disc.

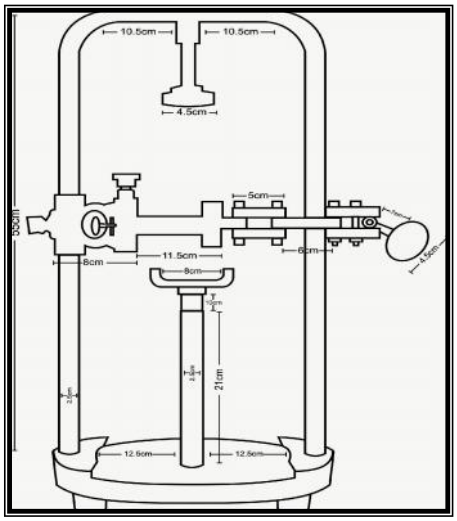

Figure 1: Schematic diagram of the device with various dimensions

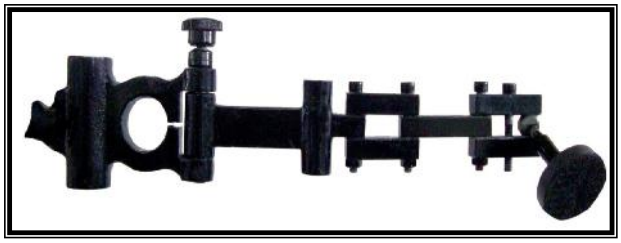

Figure 2: Design and components of swivelling arm

Horizontal Platform: - The horizontal platform or base of the device is made of heavy metal so as to self-resist destabilizing forces as a result of subject's movement of the head or while the observer is moving the horizontal arm. The platform consists of four plastic adjustable cylinders that are connected through a screwed pin. Rotation of the plastic cylinders clockwise or anticlockwise allows the base to be adjusted parallel to the floor on which the device is placed. Aligning the base in such a manner prevents the binding of the subject's head within the device and allows the head positioner to adapt properly to the contour of the subject's head. Extension of the screw to permanently clamp the whole device to any working table if and when the device is to be used for the permanent research area is also incorporated. Such a feature is advantageous in institutes where large population has to be studied. The horizontal platform carries two components on its superior surface. The position of these two components is designed according to the most comfortable position of the subject and the observer. The platform is oval shaped with a maximum width of 40 centimetres on one side and 30 centimetre's maximum on the other side. The rest of the borders are tapered towards each other.

Chin Rest: - Measurement of individual parameter does not consume much time for the person who is recording, but in a study where many such measurements are taken for many parameters it is important that the subject is comfortable. One such feature of comfort is the chin rest. The chin rest is a simple plastic holder which can be further customized e.g. a leather

or foam casing, according to the individual need. The chin rest is designed to be vertically adjustable with a simple double hollow cylinder design, wherein the diameter of one cylinder is slightly less than the other. The subject superior aspect of the head has to contact the head positioner and the chin rest has to be adjusted accordingly. Once the vertical height is adjusted the vertical rest is locked, thereby stabilizing the head. Between the head positioner and the chin rest the subject's head is comfortably stabilized and not allowed to move.

"U" Shaped Frame: - is a hollow cylindrical rod of 1" diameter that has a uniform bend, the two sides of which are fastened within the horizontal platform and is permanently fixed to the base. The length of each leg of this frame is about 22 inches. One leg of the frame carries the horizontal arm, which can be adjusted in a vertical direction according to the convenience of the observer and the subject. A vertical extension towards the horizontal platform at the mid portion is the head positioner. The horizontal arm attachment can be loosened or tightened with a screw.

Head Positioner: - This is a vertical extension which carries a plastic disc about 4 cms in diameter, at its end that is concave from down inside. This allows the surface contour of the parietal portion of the subjects head to fit snugly into the subject and device stabilizing device (SSA) without causing any discomfort to the subject. This component is permanently fixed to the u shaped frame.

Horizontal Swivelling Arm (Fig.2): - The "U" shaped frame also carries the horizontal swivelling arm on its one side which can be detached from the main device. The horizontal arm is broken into four flexible joints that allow the arm to be freely adjusted in horizontal direction. This feature also extends the length of the arm so that the device that is attached at the end can be aligned on the left side of the subject's face to measure any parameter. In order to bring the device on the right side of the subject's face, the first joint is short and can be moved away from the face, which brings the device holder towards the right side of the subject's face. The second and the third joint is just a split extension of the arm so that it can be adjusted in any part of the face. At the end of this horizontal arm is attached an attachment for measuring device i.e. a digital vernier or any other measuring device. At this junction is attached a magnetic disc, which is connected with ball and socket arrangement. This feature allows the free positioning of the vernier in not only vertical and horizontal direction, but it can also move inward and outward with this arrangement (**Fig.3**). The entire feature allows the observer to place the vernier on any part of the subject's face. The subject and device stabilizing device (SSA) is designed to allow the observer to measure distance between any two points on the face without changing his position or the subject's position, a feature unique to this device. The horizontal arm can swivel around 360 degrees as well as move vertically along the entire length of the subject's face. This feature again allows the horizontal arm to be brought to the right and the left of the subject. Observers, who are left handed and would like to manipulate the digital vernier with their left hand, just have to use the horizontal arm on the other side.

Figure 3: Subject stabilizing device

3 MATERIALS AND METHODS

Following the fabrication of the device, its reliability was checked clinically by measuring the chin, nose distance that is used to measure the vertical dimension of occlusion in completely edentulous patients. Sixty complete dentures were fabricated using the above mentioned device by various post graduate students under the supervision of experienced staff in the field of removable prosthodontics. The supervisors were not told that the vertical dimensions incorporated in the prosthesis were recorded using the device. Out of sixty patients, only two post graduates were told to alter the recorded vertical dimensions of occlusion. For the same subjects interpupillary distance was measured on the device following which the same distance was verified with the optometrist. Among all subjects, three subjects had different values which were within a fraction of a millimetre.

4 DISCUSSION

There is enough literature that shows the use of mechanical devices like simple gauge, simple to digital callipers and in some instances different types of scales that have been used to measure two distant points on the face. Though the reliability of such instruments cannot be questioned, but the manner in which they have measured raised doubts about the reliability of the results. The holding of the instrument in hand and placing the instrument on the face cannot be relied as both the subject, one who is measuring and the other on whom the measures are taken are not stable and fixed and as a result error is incorporated.

Subject Stabilizing Device (SSA) eliminates the drawbacks and errors in measurements between two points as a result of handheld devices for measuring along with unstable head position of the subject as given in the past literature. The stabilization of subjects had at one place along with the fixation of the measuring device to the same instrument eliminates all the errors arising through movements of subjects head and neck, variable pressure applied by the observer on the device, transfer of device to a measuring scale and frequent shifting of subject as well as observer while recording different points

within the same face. The horizontal arm of the device is dynamic in nature as well as entire horizontal arm can be adjusted vertically as well as could be kept fixed in one place. The joints within horizontal arms allows the measuring device to record all five measurements (three times each) without the subject moving his/her head even once. This makes any measurement on face accurate, less time consuming and convenient for the observer and the patient. The ball and socket joint allows free movement of the entire digital vernier calliper which gives the observer the freedom of placing either the external or internal jaws without changing the subject between various measurements.

5 CONCLUSION

Correct determination of vertical dimensions is important when using facial measurements for research and clinical purpose. A detailed review of literature regarding the methods used to determine vertical dimensions of occlusion has been described along with a new instrument that has been designed to overcome the flaws with previous methods of measuring with callipers. The instrument is extremely beneficial where a large data is to be collected in a short time. The feature of the instrument is its flexibility to measure any point on face without moving the subject or the operator.

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