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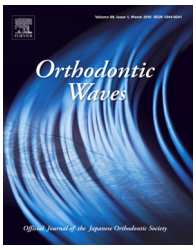

Original article

Evaluation of facial asymmetry measurements on simulation model

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ABSTRACT

Objective: To study the correlation between 3 types of facial deformation and 2 groups of measurements using (1) ratio parameters and (2) center of mass based parameters, in asymmetric computerized simulation models.

Materials and methods: Three groups of facial deformation were constructed which were (1) proportion deformation, (2) shearing deformation and (3) rotation deformation. Computerized facial models were divided into 3 zones which were (1) total zone (maxillo-mandibular complex), (2) upper zone (maxilla) and (3) lower zone (mandible). Three ratio parameters: (1) area ratio, (2) compactness ratio, (3) perimeter ratio, and 4 center of mass based parameters: (1) difference center milieu, (2) Ci milieu, (3) difference milieu and (4) difference vertical milieu were used to measure incremental deformation figures. The results were evaluated using SPSS program. Slope and coefficient of determination (R^2) values were obtained. Correlation of deformation amount and 7 measurements were considered high and significant if R^2 was greater than 0.8 with p-value less than 0.05.

Results: For the proportion deformation and shearing deformation, the center of mass based parameters and area ratio were highly and significantly correlated with the deformation amount. However, difference vertical milieu was the only measurement with significant R^2 in the rotation deformation group for all 3 facial zones.

Conclusion: The correlation of the ratio and the center of mass based parameters can be differently influenced by type of deformations and facial anatomical zones. Center of mass based parameters may be used in conjunction with ratio parameters in order to differentiate type of asymmetry.

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1. Introduction

Asymmetry has been shown to be one of the main factors used to evaluate facial attractiveness. Asymmetry evaluation is also important for orthodontics and orthognathic surgery because treatment may have the potential of changing facial asymmetry. It is therefore necessary for the orthodontist to have a reliable method for evaluating and quantifying this discrepancy.

Human faces are naturally asymmetric. Since the classic study of Woo [1], asymmetry has been the subject of numerous studies, for example, cross sectional [2,3], longitudinal [4–6], soft tissue [7,8] and hard tissue [9–11]. In orthodontics the classic way for evaluating asymmetry is by postero-anterior (P-A) cephalometry [10–14]. However, cephalograms has some discrepancies, mainly due to difficulty in landmark identification [14]. Furthermore P-A cephalometrics could only assess the skeletal elements and the correlation between skeletal and soft tissue asymmetry was not high [15].

Another method to assess asymmetry was soft tissue evaluation. Measurements on frontal pictures could be performed using landmark to reference line or by measuring the deviation or canting of the soft tissue anatomical points in relation to the facial midline [8,16,17]. This method could acceptably quantify asymmetric conditions to some extent. However, any methodology using photographic measurement may encounter problems of distortion due to patient's posture as frequently happened when taking postero-anterior cephalometric films. This problem should be controlled by using standardized photographic procedures.

Recently another method using ratio of area, perimeter, compactness and moment instead of points selection had been proposed for assessing asymmetry [18–23]. The method showed high repeatability both with frontal picture and P-A cephalometry. It could give repeatable measurements and thus detect changes in the severity of the asymmetry. However, the method was still not able to characterize type of deformation. Consequently, this technic had been used mainly for research with limited application as a clinically diagnostic tool.

Due to complex nature of facial asymmetry which can occur in 3 planes of space and may involve rotation of maxilla and mandible [24,25], it would be interesting to expand the existing information by focusing on the soft tissue measurements validity. Were there any other measurements that could better differentiate type of facial asymmetry was our research questions.

The aim of this study was to study the correlation of the ratio and the center of mass based measurements in 3 types of asymmetry simulation models.

2. Methods and materials

2.1. Simulation model construction

Firstly, a symmetric drawing of a face was created. A frontal picture at rest of a patient with good facial proportion and without obvious facial asymmetry was chosen. The image manipulating software; the GIMP (version 2.6.11 Spencer Kimball, Peter Mattis and the GIMP Development Team: http://www.gimp.org) was used to draw the outline of the face. The drawing was then cut in two halves along the facial midline and only the right side was kept. A mirror image of it was created using the command: flip horizontally tool. The original and mirror right side were then joined together to obtain a perfectly symmetric face. Points of one pixel in size were drawn on each side of the junction along the length of the nose midline, thus enabling us to visualize the axis of symmetry. The dimension of the final image was 692 × 504 pixels. Three types of deformation were then created as follows.

2.1.1. *Proportion deformation (PD) (Fig. 1A)*

The left side of the drawing was selected and the scaling tool was used. Incremental scaling in the horizontal dimension of 1% was performed ranging from 1% to 14%. Each increment of the deformation was saved as a picture (jpg file). The number of deformed facial figures created was 14.

2.1.2. *Shearing deformation (SD) (Fig. 1B)*

The lower third of the face was selected with a rectangle, defined vertically by nose (N), menton (ME) (Fig. 2) and horizontally by the marks made on the outline of the face at the level of N. A shearing deformation was applied in the horizontal dimension by increment of 1 pixel ranging from 1 pixel to 30 pixels. After the deformation, reestablishment of the continuity of the drawing was performed. The number of deformed facial figures created was 30.

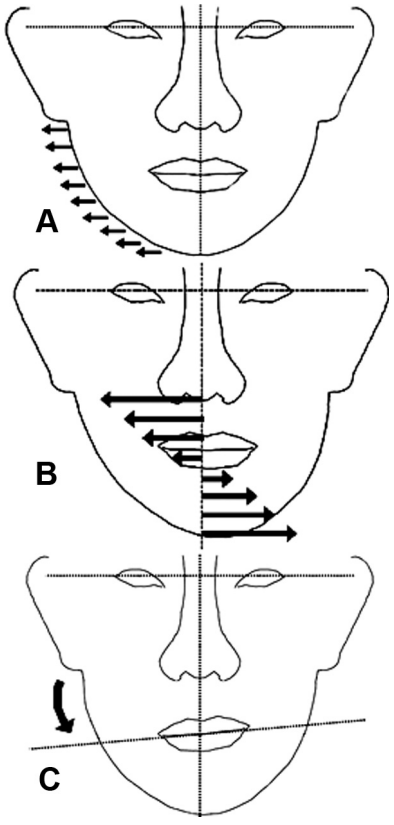

Fig. 1 – The three facial asymmetry simulation models. (A) Proportion deformation, (B) shearing deformation and (C) rotation deformation