Journal of Oral and Maxillofacial Surgery, Medicine, and Pathology 27 (2015) 764–769

Contents lists available at ScienceDirect

Journal of Oral and Maxillofacial Surgery, Medicine, and Pathology

journal homepage: www.elsevier.com/locate/jomsmp

Original Research

Quantitative analysis of frontal facial asymmetry for patients with hemifacial microsomia

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ARTICLE INFO

Article history:
Received 3 September 2013
Received in revised form 1 February 2015
Accepted 13 March 2015
Available online 27 May 2015

Keywords:
Hemifacial microsomia
Craniofacial anomaly
Mandibular asymmetry
Jaw deformity

ABSTRACT

Background: Facial asymmetry, which is often due to asymmetry of the mandible, is a naturally occurring phenomenon in patients with hemifacial microsomia (HFM). Only a few attempts have been made to develop specific quantitative diagnostic criteria for the mandibular asymmetry of HFM. This pilot study was designed to determine the soft-tissue and skeletal characteristics of patients perceived to have HFM and the factors affecting objective assessment of mandibular asymmetry.
Methods: Frontal facial photographs and frontal cephalograms of twelve patients who had HFM with mandibular asymmetry were analyzed. Landmarks and reference lines were determined on the basis of frontal photographs and cephalographic analysis. Linear measurements of the right and left sides were performed to assess the degree of asymmetry of the mandible. The differences between the affected side and the unaffected side were calculated and analyzed statistically.
Results: Significant differences were found for linear measurements of the gonion distance (GoD), full marginal distance (FMD), external marginal distance (EMD), and gonion-menton distance (Go-MeD) in the hard tissue and sFMD, sEMD, sGo-MeD in the soft tissue but not for the gonion distance in soft tissue (sGoD). The differences in sEMD and EMD were significantly correlated, and represented a valid factor affecting the mandibular asymmetry in soft and hard tissues.
Conclusions: The results of this study suggest that appropriate measurements affecting the outline of the mandible such as sEMD and EMD taken from frontal facial photographs and frontal cephalograms provide a useful, objective means of assessing mandibular asymmetry for patients with HFM.

1. Introduction

Hemifacial microsomia (HFM) is a common craniofacial anomaly, variably affecting structures derived from the first and second pharyngeal arches [1]. The reported incidence varies between one in 4000 and 5600 live births, and it is the second most common congenital craniofacial malformation, after cleft lip and palate [2,3]. One of the primary features of HFM is unilateral failure of formation or underdevelopment of the mandibular ramus, condyle, or both and the associated muscles of mastication, which is often because of mandibular asymmetry. HFM also causes other disorders in the ear, maxilla, malar bone, or zygomatic arch. Unilateral microtia, or ear abnormality, has been suggested as a mandatory feature of HFM. Moreover, there are often other anomalies in HFM, including ocular, vertebral, cardiac, and renal problems [4]. Therefore, HFM is also called oculoauriculovertebral spectrum.

There are not as yet any effective measurement landmarks for the frontal facial asymmetry of HFM patients, though several prominent diagnostic norms such as the Pruzansky classification and the orbit, mandible, ear, nerve, soft tissue (O.M.E.N.S.) classification have been reported [5–8].

☆ Asian AOMS: Asian Association of Oral and Maxillofacial Surgeons; ASOMP: Asian Society of Oral and Maxillofacial Pathology; JSOP: Japanese Society of Oral Pathology; JSOMS: Japanese Society of Oral and Maxillofacial Surgeons; JSOM: Japanese Society of Oral Medicine; JAMI: Japanese Academy of Maxillofacial Implants.

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http://dx.doi.org/10.1016/j.ajoms.2015.03.008
2212-5558/

Furthermore, only a few attempts have thus far been made to develop specific quantitative diagnostic criteria for assessing maxillofacial asymmetry [9–12]. If a diagnostic norm for the congenital anomaly of HFM is established, quantitative evaluation of the frontal face in patients with jaw deformity and facial asymmetry who have been treated with orthognathic surgery will be possible.

The purpose of this study was to establish some quantitative diagnostic items for mandibular asymmetry in patients with HFM.

2. Patients and methods

We conducted retrospective analysis of patients with hemifacial microsomia involving microtia who visited the Department of Oral Surgery, Sapporo Medical University Primary Hospital between April 2007 and March 2011. The study was approved by the Clinical Institutional Ethical Review Board of the Medical Institute of Bioregulation, Sapporo Medical University, Japan. Data were gathered by reviewing medical records and measuring posteroanterior cephalometric radiographs and standardized frontal facial photographs taken at the same time. The photographs were taken under the same conditions. The patients were seated upright on a special chair with which is was possible to adjust height of patient and to maintain a precise distance from the camera to it, with the Frankfort plane parallel to the floor, and looked directly at the camera lens in the occlusal rest position. Microtia was confirmed for all patients in this study. The measurements were done using a special apparatus with a headrest without ear rods but which allowed us to fix the head in a particular position. This made it possible to fix the position of the head and regulate revolution in the FH plane and the vertical axis direction and take reproducible frontal facial photographs and cephalometric radiographs. The special chair was fixed on the floor to keep the distance between the camera and subject at 150 cm, and the lighting conditions were fixed. We controlled the location of the head of each patient to ensure the reproducibility and accuracy of the pictures. The color photographs were printed individually on size A4 paper. All frontal cephalograms were conventionally taken using a cephalostat.

Twelve patients (9 males, 3 females) were eligible and the patients' mean age at enrollment was 8.3 years, with a range of 3–12 years. The inclusion criteria were the following: (1) patients with unilateral HFM, (2) the mandible objectively deviated from the facial midline and (3) the maxilla did not visually show any deformities. The exclusion criteria included: (1) patients with bilateral HFM and (2) patients with complicated congenital disorders such as cleft lip and palate.

The soft-tissue and hard-tissue landmarks and reference lines used in this study are described in Figs. 1a and 2a, respectively. A horizontal reference line passing through the right and left extokanthions (Ex) was defined as the X-axis of soft tissue. A vertical reference line perpendicular to the X-axis passing through the midpoint between the right and left entokanthions (En) was defined as the Y-axis of soft tissue (Fig. 1a). A horizontal reference line passing through the right and left latero-orbitales (Lo) was defined as the X-axis of hard tissue. A vertical reference line perpendicular to the X-axis passing through the crista galli was defined as the Y-axis of hard tissue (Fig. 2a). For all measurement points, an apostrophe refers to the affected side as opposed to the unaffected side. A lower-case "s" refers to a soft tissue landmark as opposed to a hard tissue landmark. Linear measurement items for soft tissue and hard tissue are shown in Tables 1 and 2, respectively.

Linear measurement items for soft tissue used to analyze the middle face and lower face are shown in Fig. 1b and c, respectively. In the middle face, the distance between Ex and the intersection of the X-axis and Y-axis was defined as Ex-Y. In the lower face, the segment vertically lower than sGo in the Y-axis was defined as the soft tissue gonion distance (sGoD). The segment connecting sGo with sMe was defined the soft-tissue gonion-menton distance (sGo-MeD), the distance between the Y-axis and the outline of the mandible that perpendicularly passed the middle point of sGo and sMe was called the soft tissue full marginal distance (sFMD), the distance between the middle point of sGo and sMe and the outline of the mandible perpendicularly passing the middle point of sGo and sMe was called the soft tissue external marginal distance (sEMD).

Table 1
Definitions of landmarks, reference lines and linear measurements in soft tissue.

i. Landmarks of soft tissue	
• Ex, Ex'	Lateral end of palpebral fissure (extokanthion)
• En, En'	Medial end of palpebral fissure (entokanthion)
• sMe	The most inferior point in the chin (soft tissue menton)
• sGo, sGo'	The most lateral extent of the outline of the mandible (soft tissue gonion)
ii. Reference lines of soft tissue	
• X-axis	Horizontal reference line: The line connecting the right and left extokanthion (Ex, Ex')
• Y-axis	Vertical reference line: Perpendicular to X-axis that passes the midpoint of the line where En is connected with En'
iii. Linear measurement of soft tissue to analyze middle of face	
• Ex-Y, Ex'-Y	Distance between (Ex, Ex') and intersection of X-axis and Y-axis
iv. Linear measurements of soft tissue to analyze lower of face	
• sGoD, sGoD'	Segment vertically below (sGo, sGo') in Y-axis (soft tissue gonion distance)
• sGo-MeD, sGo'-MeD	Segment that connects (sGo, sGo') with sMe (soft tissue gonion-menton distance)
• sFMD, sFMD'	Distance between Y-axis and outline of the mandible perpendicular to the line that passes the midpoint of (sGo, sGo') and sMe (soft tissue full marginal distance)
• sEMD, sEMD'	Distance between midpoint of (sGo, sGo') and sMe and outline of mandible perpendicular to the line that passes the midpoint of (sGo, sGo') and sMe (soft tissue external marginal distance)

Table 2
Definitions of landmarks, reference lines and linear measurements in hard tissue.

i. Landmarks of hard tissue	
• Lo, Lo'	The bilateral intersection of the oblique orbital line with the lateral contour of the right and left side orbits (latero-orbitales)
• CG	The point of constriction of the cervical part of the crista galli (crista galli)
• Me	The most inferior point in the symphysis (menton)
• Go, Go'	The most lateral extent of the outline of the mandible (gonion)
ii. Reference lines of hard tissue	
• X-axis	Horizontal reference line: The line connecting the right and left latero-orbitales (Lo, Lo')
• Y-axis	Vertical reference line: The line perpendicular to the X-axis passing through the crista galli (CG)
iii. Linear measurement of hard tissue to analyze middle of face	
• Lo-Y, Lo'-Y	Distance between (Lo, Lo') and intersection of X-axis and Y-axis
iv. Linear measurements of hard tissue used to analyze lower of face	
• GoD, GoD'	Segment vertically below (Go, Go') in Y-axis (hard tissue gonion distance)
• Go-MeD, Go'-MeD	Segment that connects (Go, Go') with Me (hard tissue gonion-menton distance)
• FMD, FMD'	Distance between Y-axis and outline of the mandible perpendicular to the line that passes the midpoint of (Go, Go') and Me (hard tissue full marginal distance)
• EMD, EMD'	Distance between the midpoint of (Go, Go') and Me and outline of mandible perpendicular to the line that passes the midpoint of (Go, Go') and Me (hard tissue external marginal distance)