A review of the use of CT in the study of facial soft tissue in patients affected by hemifacial microsomia

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Corresponding Author:
Dr. Benedetta Toni,
Doctor, Department of Oral and Maxillo-facial Sciences Sapienza University of Rome, via roma 82, 05100 - Italy

Submitting Author:
Dr. Benedetta Toni,
Doctor, Department of Oral and Maxillo-facial Sciences Sapienza University of Rome, via roma 82, 05100 - Italy

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Author(s): Toni B

Abstract

Hemifacial microsomia (HFM) is a craniofacial disorder characterized by a wide spectrum of anomalies, including conductive hearing loss due to external and middle ear deformities. Hemifacial microsomia is the second most common developmental craniofacial anomaly after cleft lip and palate. For the pre-surgical evaluation of this anomaly, diagnostic imaging and classification of the facial structures, based on OMENS classification, is of prime importance.. The management of this developmental malformation is multidisciplinary.

Introduction

Over time, instrumental diagnostics in patients with hemifacial microsomia have been focused on an exact measurement of the entity of skeletal hypoplasia, but few studies have been carried out on the morphological assessment of the masticatory muscles and soft tissues[1-2]. In patients affected by hemifacial microsomia the masticatory muscles on the affected side clinically present various degrees of hypoplasia or are even completely absent. In the past, muscle hypoplasia in patients affected by HFM was assessed through the use of qualitative methods such as clinical palpation[3], while the evaluation of muscle functionality was carried out quantitively by means of electromyography[4]. Today diagnostic methods utilized in the analysis of soft tissue include CT imaging[5-6-7], ultra-sound and magnetic resonance imaging (MRI): the few studies written up which analyze masticatory muscle hypoplasia in patients with HFM have involved the use of 3D-CT.

Review

Radiographic imaging methods for the evaluation of skeletal hypoplasia have been perfected over time, passing from a two-dimensional assessment by means of classic radiographic examinations, such as orthopantomography and tele-cranium - with latero-lateral as well as posterior-anterior projection - to arrive at the three-dimensional assessments which can be obtained through computerized exams, such as the 3D-CT, either using the MDCT multi-layered tecnique or CBCT cone-beam method[2.Â] There are various control-case and case report studies[2] which list the advantages of computerized multi-layered tomography (MDCT) in the diagnosis and management of craniofacial malformations. Such imaging technology permits a more accurate assessment of cranio-facial defects, of asymmetries and of congenital cervical defects often associated with craniofacial anomalies. In addition, this imaging allows high-resolution study of the inner ear, which can assist the surgeon in reducing the risk of facial nerve lesions and in determining if an endosteal accustic aid should be implanted[2]. Marsh et al., 1989[5-8], and Kane et al.[8], 1997, were the first to utilize the MDCT with 3D riconstruction to show the existence of a relationship between the masticatory muscle volumes and the mandibular shape. They assert that in hemifacial microsomia the hypoplasia of specific masticatory muscles tends to determine skeletal hypoplasia, supporting the theory according to which there exists an epigenetic regulation of the bone by neuromuscular tissue. According to these authors the entity of the muscle deficit permits a forecast of the extension of bone-level dysplasia; however they do not assert the contrary, i.e., that hypoplasia of both facial bone structure and masticatory muscles are always correlated and that the former is necessarily an indicator of the occurence of the latter or its entity[5]. The study by Marsh et al. supports the hypothesis that the form and dimensions of cranial bones depend on the muscles which originate from and are attached to these bones, even if some exceptions have been encountered. The limits of this study are the range of age of the patients (1 year/36 years), the lack of a control group, the absence of an objective validation of the volumetric measurements (owing to the difficulty in isolating and precisely calculating the volume of a specific muscle) as well as the inherent difficulty in comparying linear bone measurements, based on two-dimensional bone riconstructions, and three-dimensional volumetric muscle measurements. In 2001, using MDCT with 3D riconstruction, Fisher et al.[8] assessed the correlation between masticatory muscle hypoplasia and bone malformation in patients with HFM, using a control group for comparison. The masticatory muscles analyzed were: masseter, temporal and internal and external pterygoids. The study found a relationship between craniofacial bone malformation and hypoplasia of the masticatory muscles: in particular, this relationship is strongly evident in the case of the masseter and temporal muscles while less so in the case of the mediale and lateral pterygoid muscles. This study contests the point of view of Kane et al., as the authors affirm that there does not exist a direct correlation between neuromuscular deficit and bone deficit, since not always is muscle hypoplasia associated with the same degree of bone hypoplasia. In this study the volume of the masticatory muscles on the unaffected side is however less than that recorded in the control group and does not present an increase in compensatory volume compared to the affected side. This means that there is an overall limitation to the masticatory function in patients with HFM. Takashima et al. 2003[9] instead studied muscle morphology by means of MDCT imaging with 3D riconstruction. The study was carried out on 10 patients with hemifacial microsomia for the purpose of assessing , for the first time, a quantitive measurement of the irregularity of the masticatory muscle morphology, previously examined solely from a qualitative point of view (Murray et al., 1984; Kane et al., 1997). The muscles considered were the masseter, temporal and internal and external pterygoids. Moreover, the study analyzes the difference in volume in masticatory muscles on the affected and unaffected sides, to determine which specific muscles are most affected by hypoplasia, as well as the relation existing between the severity of the mandibular, dental and ear anomalies and the entity of the masticatory muscle volume differential between the affected and unaffected sides. This study found a significant reduction in masticatory muscle volume on the affected side in subjects stricken by hemifacial microsomia, which agrees with the preceding findings of Marsh et al.[5-8], 1989 and Kane et al., 1997. In addition these findings highlight: that involvement is general and spread equally among the masticatory muscles, as all of these evidence a reduction in volume compared to the unaffected side; that hypoplasia of the masseter, lateral pterygoid, mediale pterygoid and temporal muscles on the affected side is a primary component of the ME phenotype and that there is no significant relationship between the severity of the mandibular, dental and ear anomalies and the entity of the volume differential in the masticatory muscles between affected and unaffected sides. We underline that even this study finds no correlation between the degree of muscle hypoplasia and the degree of mandibular hypoplasia. 3D-MDCT is a powerful diagnostic tool and offers many advantages: volumetric reproduction of the cranium and of soft tissue without the superposition of anatomic elements which limit visibility of the structures, elevated precision, image guarantees and a permanent reproducible reference system[10]. The only disadvantages are the patient's horizontal position during the examination which can distort the position of facial soft tissues (due to such artefacts there is a lack of precision regarding occlusion), as well as cost of the procedure and exposure time, both of which exceed that of other imaging techniques. Calvacanti has examined the precision of the 3D-MDCT , comparing results of linear measurements on 3D images with physical measurements carried out on skulls. He has concluded that the difference between the two measures was minimal and that the 3D images are highly precise. Therefore, computerized three- dimensional tomography, MDCT, permits carrying out linear and volumetric measurements of cranial bones, highlighting their shape and, moreover, in the same scan - assessing the thickness, volume and shape of the masticatory muscles[11-12-13]. All the above-mentioned studies demonstrate the usefulness of 3D-MDCT in the study of the morphology of masticatory muscles, the measurement of their thickness by means of linear measures, and the quantification of their volume on the 3D reconstructions. While there is not universal accord on the correlation between bone and muscle deficit, there is agreement that masticatory muscle thickness is less on the microsomic side compared to the healthy side. Furthermore, thanks to the use of MDCT it is possible to measure the areas of masticatory muscle cross sections in a live subject (Weijs and Hillen, 1984-1985). However, an obstacle to large-scale use of 3D-MDCT to obtain muscle cross-sections is the radiation dosage which can be as high as 30mGy per scan (Jones and Garret, 1985); this obstacle could be overcome nowadays thanks to the use of the cone beam method CBCT, which is gaining increasing popularity. In craniofacial pathology clinical practice, use of the modern cone beam technique has been recommended for the assessment of differing types of craniofacial malformations, both acquired and congenital, such as hemifacial microsomia or cleft palate, facial trauma, radicular fractures, inflammatory bone alterations and benign and malignant lesions[2]. In particular, in orthognathic surgery sophisticated 3D virtual software has been developed for making a diagnosis, planning the treatment and assessing the results. Moreover, future development will probably allow us to overcome the current limit of a static diagnosis and provide the means of obtaining a dynamic diagnosis capable of simulating various functional activities[2].

Conclusions

On the whole, CBCT has several advantages compared to MDCT technique: images of optimal quality despite a lower dosage of radiation (comparable to radiation dosages delivered by endobuccal or orthopantomogram X-rays), briefer scan time, compatability with other radiographic formats, permitting the exportation of images (orthopantomogram and cephalometric X-rays), and ease of installing the unit in the dental clinic. The metromorphic assessment of 3D riconstructions of craniofacial structures is able to provide information on longitudinal changes in bilateral facial asymmetry and to assist in the formulation of a plan of othodontic treatment[4]. Advanced CBCT software also permits the superposition of digital models and 3D images, permitting the viewing of three-dimensional changes in hard and soft tissues, the teeth as well as the airways, so that these can be studied. The disadvantages of CBCT regard insufficient contrast for soft tissue assessment and the possibility of errors when interarch occlusal (overbite and overjet)[2] assessments are carried out. At the moment agreed-upon guidelines for the use of CBCT in clinical practice are still lacking, but it is recommended and already widely utilized in the study of the craniofacial complex and in the assessment of surgical cases. What are needed are large-scale clinical studies as well as control randomized double-blind clinical studies to determine the real potential of CBCT in various craniofacial and dental clinical applications[2]. However, at the moment there is no research utilizing CBCT in soft tissue study or in the measurement of masticatory muscles in patients affected by hemifacial microsomia.

References

1) Marsh JL, Baca D, Vannnier MW. Facialmuscoloskeletalasymmery in hemifacial microsomia; Cleft Palate J 1989; 26:292-302

Â 2) PJ Anderson, R Young, TL surman, ZA Rajion, S Ranjitkar; Application of three-dimensional computed tomography in craniofacial clinical practice and research; Australian dental journal 2014; 59(1suppl):174-185

3) CE Huisinga-Fischer*,1,2, JM Vaandrager3, FW Zonneveld4 and B Prahl-Andersen1,2Precision and accurancy of CT-based measurements of masticatory muscles in patients with hemifacialmicrosomia. DentomaxillofacialRadiology (2004) 33, 12â€“16

4) Grabb WC. The first and second branchial arch syndrome. PlastreconstrSurg 1965;36:485-506

5) Kane AA, Lo LJ, Marsh JL, et al.The relationship between bone and muscle of mastication in hemifacialmicrosomia; PlastReconstrSurg 1997;99:990-997

6) Nakata S, Mizuno m, Koyano K, et al. Functional masticatory evaluation in hemifacialmicrosomia. Eur J Orthod1995;17:273-280

7) Marsh JL, Baca D, Vannnier MW. Facialmuscoloskeletalasymmery in hemifacial microsomia; Cleft Palate J 1989; 26:292-302

8) Clara E. Huisinga-Fisher, DDS; Frans W. Zonneveld, phD; J. MichielVaandrager, MD; BirtePrahl-Andresen, DDS, PhD. Relationship in hypoplasia between the masticatory muscles and the craniofacial skeleton in hemifacial microsomia, as determined by 3-d ct imaging. The journal of craniofacial surgery/vol 12, numero1: 31-40, 2001.

9) Takashima et al. Volume and shape of masticatory muscles in patients with hemifacialmicrosomiaCleft Palateâ€“Craniofacial Journal, January 2003, Vol. 40 No. 1: 6-12

10) S.Saccomanno; F.greco;Role of 3d-ct for orthodontic and ent evaluation in goldenhar syndrome. Actaotorhinolaryngolital 2014;34:283-287

11) Silvestri A. Accivile E. La terapia funzionale nel trattamento delle fratture condilari della mandibola. Mondo Ortodontico 1986; 2:45-55

12) Vargervik K, Miller AJ. Neuromuscolar patterns in hemifacialmicrosomia. Am J Orthodont 1984; 86:33-42

13) CE Huisinga-Fischer*,1,2, JM Vaandrager3, FW Zonneveld4 and B Prahl-Andersen1,2Precision and accurancy of CT-based measurements of masticatory muscles in patients with hemifacial microsomia. Dento maxillofacial Radiology (2004) 33, 12â€“16