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Evaluation Study

THE DIAGNOSTIC RELIABILITY OF THE FRANKFORT HORIZONTAL PLANE, EVALUATED BY 3D CEPHALOMETRY

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ABSTRACT

Many maxillofacial malformations can modify the Frankfort horizontal plan making it unusable in orthodontic clinical diagnosis. This study aims to evaluate the position of the cephalometric points that determine the Frankfort horizontal plane on individualised craniofacial CT reconstructions using the foramen occipital line (Basion-Opisthion) on the midline sagittal axis as a reference. Thirty patients (15 males and 15 females aged between 10 and 76, mean of 36.4 years) were selected among those undergoing maxillofacial CT. Three multiplanar reconstructions were performed; the first was positioned at the craniofacial midline level, and a line was drawn passing from the Basion and Opisthion craniometric points; the second and third reconstructions were positioned on the right and left side, respectively, with a postero-anterior and latero-medial inclination to observe two parasagittal planes suitably inclined on which a line was drawn between the craniometric points Porion and Orbitale of the respective hemiface. The following parameters were evaluated: 1. angles between Basion-Opisthion and right and left Frankfort horizontal plane and the difference between them; 2. the minimum vertical distance on the individualised multiplanar reconstructions between the Porion and Orbitale points on the left and the right side, and the line passing through Basion-Opisthion; 3. the difference between the minimum vertical distance of the right and left Porion and Orbitale; 4. the difference between the minimum vertical distance of the right and left Orbitale point. The difference between the left and right Frankfort horizontal plane ranged from 0° to 7° with a mean value of 2°23'. The difference between the vertical position of the right and left Porion points ranged between 0 and 12 mm, with a mean value of 3.35 mm. The difference between the vertical position of the right and left Orbitale points ranged between 0 and 7.5 mm, with a mean value of 2.35 mm. The Frankfort horizontal plane is questionable in patients with craniofacial asymmetries and malformations.

KEYWORDS: *cephalometry, orthodontics, CT, malformation, asymmetry*

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INTRODUCTION

The cephalometric analysis allows the clinician to quantify the relationships between facial and dental structures and establish how much the patient's dental and facial morphological characteristics differ from the norm.

The Frankfort horizontal plane (FhP), drawn from the highest point of the upper edge of the external acoustic meatus Porion point (Po) to the lowest point of the lower edge of the Orbit point (Or), was born as a reference plane for studying dry skulls by of anthropologists and anatomists. It was then used in orthodontics for the cephalometric study (1). A comparison of two-dimensional radiography and three-dimensional computed tomography for cephalometric measurements was made by different authors in the last years (2-11).

Many maxillofacial malformations can modify the FhP, making it unusable for orthodontic diagnosis (12-15). Due to the position of the skeletal structures that determine the cephalometric points of the FhP, the poor reliability of the FhP with respect to sella-nation as a facial reference plane was highlighted by Incisivo et al. (16).

This study aims to evaluate the position of the cephalometric points that determine the FhP on individualised craniofacial CT reconstructions using the foramen occipital Basion (Ba) and Opisthion (Op) line on the midline sagittal axis as a reference.

MATERIALS AND METHODS

Thirty patients (15 males and 15 females aged between 10 and 76, mean of 36.4 years) were selected among those undergoing maxillofacial CT. Patients with fractures, tumors and craniofacial malformations were excluded. Twenty-two patients with skeletal class I, 4 with class II and 4 with class III were detected after evaluation of the ANB angle.

The radiological examinations were performed using 64 Slices SOMATOM CT (Siemens, Erlangen - Germany) with volumetric acquisition according to the usual protocol for maxillofacial structures: fields of view (FoV) 14 cm, 120 Kv, 90 mAs, scan time about 9" with 1 mm slices. In addition, the DICOM files were analysed using the eFilm Workstation 2.0 reconstruction software (Merge Healthcare Inc., Hartland, WI - USA).

Three multiplanar reconstructions were performed. The first was positioned at the craniofacial midline level, and a line passing from the Ba and Op craniometric points was drawn; the second and third were positioned on the right and left side, with a postero-anterior and latero-medial inclination to visualise two parasagittal planes suitably inclined, on which a line was drawn between the craniometric points Porion (Po) and Orbitale (Or) of the respective hemiface (Fig. 1).

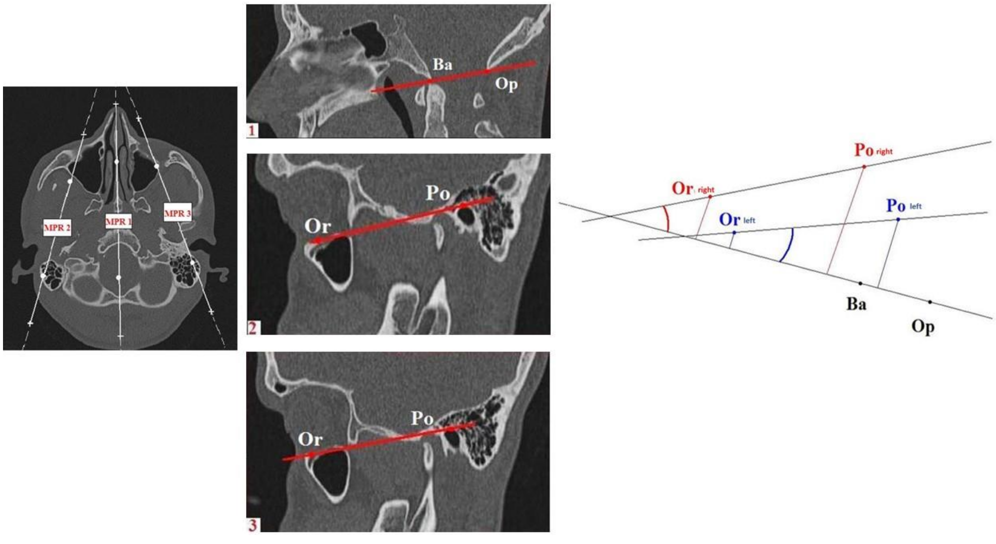

Fig. 1. *On the left the Multiplanar Reconstruction (MPR) reconstructions on axial plane; in the middle the MPR1 passing through Ba-Op, the MPR 2 passing through the right FHP, the MPR 3 passing through the left FHP; on the right the angles and distances measured.*

The following parameters were evaluated:

the angles between Ba-Op and right and left FhP and the difference between them;

the minimum vertical distance on the MPRs between the Po and Or points on the left and right side, and the line passing through Ba-Op;

the difference between the minimum vertical distance of the right and left Po;

the difference between the minimum vertical distance of the right and left Or.

RESULTS

Results are summarized in Table I.

Table I. *Summary of the results.*

Patient	Skeletric class	Left FHP^Ba-Op	Right FHP^Ba-Op	Minimum vertical distance between Left Po and Ba-Op	Minimum vertical distance between Right Po and Ba-Op	Minimum vertical distance between Left Or and Ba-Op	Minimum vertical distance between Right Or and Ba-Op
1	I	4°	4°	19 mm	17.5 mm	15 mm	13.5 mm
2	I	10°	6°	18 mm	12.5 mm	9 mm	7.5 mm
3	III	7.5°	8°	12.5 mm	18 mm	6.5 mm	11.5 mm
4	I	12.5°	13°	3 mm	10 mm	-6 mm	-1 mm
5	II	6°	5°	16.5 mm	15 mm	11 mm	10 mm
6	II	4.5°	4.5°	14 mm	14 mm	18 mm	18 mm
7	III	1°	3.5°	12.5 mm	17.5 mm	11.5 mm	14 mm
8	I	7°	4°	15 mm	13.5 mm	10 mm	9 mm
9	III	2.5°	1°	19 mm	28 mm	20 mm	26.5 mm
10	I	0°	1.5°	12 mm	16 mm	11.5 mm	19 mm
11	I	6°	4°	15 mm	18 mm	11 mm	15 mm
12	I	5°	2°	29 mm	17 mm	19 mm	15.5 mm
13	III	10°	10°	19 mm	19 mm	6.5 mm	6.5 mm
14	I	8.5°	8.5°	9 mm	9 mm	6 mm	6 mm
15	I	8°	5°	17 mm	16.5 mm	9 mm	11.5 mm
16	I	3°	4.5°	17.5 mm	23 mm	14 mm	18 mm
17	II	18.5°	15°	17 mm	12.5 mm	-1 mm	-3 mm
18	II	13°	16°	17 mm	21 mm	2.5 mm	4 mm
19	I	9°	11°	12 mm	16 mm	3 mm	6 mm
20	I	9.5°	2.5°	17 mm	13 mm	7 mm	5 mm
21	I	4°	9°	16 mm	20 mm	12 mm	10 mm
22	I	0°	0°	17.5 mm	18.5 mm	17.5 mm	18.5 mm
23	I	6.5°	5°	22 mm	18 mm	15.5 mm	13 mm
24	I	4°	1°	17.5 mm	13 mm	15 mm	13 mm
25	I	2.5°	2.5°	18 mm	18 mm	15 mm	15 mm
26	I	5°	2°	21 mm	15 mm	16 mm	13 mm
27	I	4.5°	10°	11 mm	18 mm	7 mm	9 mm
28	I	7.5°	1.5°	17.5 mm	14 mm	11 mm	12 mm
29	I	5°	6°	19 mm	21 mm	13.5 mm	14.5 mm
30	I	14°	12.5°	22 mm	21.5 mm	7 mm	9 mm

The difference between left and right FHP ranged from 0° to 7° with a mean value of 2°23'; The difference between the vertical position of the right and left Po ranged between 0 and 12 mm with a mean value of 3.35 mm; the difference between the vertical position of the right and left Or ranged between 0 and 7.5 mm with a mean value of 2.35 mm.

DISCUSSION

The diagnostic possibilities of a 3D cephalometric technique based on a volumetric acquisition in order to avoid distortions typical of a two-dimensional X-ray have been evaluated by numerous authors in recent years (2-11). Although the sample examined is not very large, the measurements performed are reliable since they are performed on the MPRs of a dedicated CT exam.

In the cephalometric analysis used in this study, discrepancies are uncorrected if reference points are more anterior or posterior in the sagittal plane than the contralateral ones.

The FhP was found to be symmetrical only in 20% of cases; in 50% of cases, the discrepancy was less or equal to 2° and in 13.3% of cases, it was greater or equal to 4°. The Po and the two Or points were symmetrical only in 4 cases (13.3%). In most cases (87%), the most significant difference in height between the right and left sides concerned the Po more than the Or point.

The difference between the right and left landmarks was so high that tracing a reliable FhP on a lateral cephalometric radiograph was impossible. Thus cephalometrics that base their analysis on FhP, particularly those of Ricketts and McNamara, cannot be performed; this cephalometric analysis would be even more inadequate in case of craniofacial asymmetries and malformations.

CONCLUSIONS

Our data showed that only in 20% of examined cases there is a symmetry in respect to the FhP.

Author contributions

DM acquired clinical and imaging data and interpreted the data; FC drafted the manuscript; MDG revised the manuscript; LB gave final approval of the version to be published.

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