Journal of Medical Diagnostic Methods

ISSN: 2168-9784

Elisabetta et al., J Med Diagn Meth 2013, 2:4
DOI: 10.4172/2168-9784.1000135

Research Article Open Access

Cephalometric Diagnosis with Cbct: Algorithm of Correlation between Sagittal and Vertical Dimensions

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Abstract

Purpose: The purpose of this study is to analyze and classify a sample size of CT Cone Beam of 201 patients and to identify the correlation between the various cephalometric dimensions.

Material and methods: A sample of 201 patients was randomly selected from an archive of about 650; these patients underwent CT Cone beam technique performed with I-Cat Classic®. The CBCT of selected subjects were analyzed according to the three-dimensional cephalometry of the School of Milan with the software Materialise Mimics®. The results contrast with the samples of populations of Class II Malocclusion reported in the literature (2001, Angle, 1907), in which it is reported that the 2nd deep-vertibite Classes are the most representative of the normo and openvertibite. Statistical comparison was performed with the unpaired *t-tests*.

It was therefore decided to study the sample of 61 subjects with 2nd class normovertibite with a mathematical algorithm developed by the School of Milan. This algorithm allows correlation of the sagittal and vertical dimensions, especially designed to adapt to the potential of calculation and cephalometric measurement of the Materialise Mimics® software.

Results: The results show that by correcting the sagittal dimension, 40 subjects of 61 become deepvertibite, while 21 remain normovertibite, thus obtaining a sample of Class II Malocclusion consistent with data reported in the literature.

Conclusion: The various dysmorphic disorders rarely occur in one direction of space, and finding a pure form malocclusion is rare: dentofacial abnormalities often coexist, involving three-dimensional anatomical structures developed in all directions of space.

Keywords: CBCT; Cephalometric diagnosis; Deep bite; II Class Malocclusion; Algorithm

Introduction

The results of instrumental analysis, in particular radiographic results, aim to identify the alterations of dental-skeletal structures and perform an orthognatodontic diagnosis not solely based on observing the patient's medical history and symptoms [1].

The introduction in the late 90's CT Cone Beam together with the increasingly high calculation speed of computers, has allowed the wide spread use of this device in many areas of dentistry, such as orthodontics [2,3].

The three-dimensional cephalometry performed on CT Cone Beam is a simple and repeatable method that uses the aid of computers and it is relatively uninfluenced by human error method [4,5]. CT Cone Beam is a low dose CT with a 360 degree swing radius of a cone shape, which provides a real representation of reality without distortion, eliminating the problem of perspective, because it works directly using three dimensions, therefore eliminating the problem of overlapping anatomical structures [6-8].

The various dysmorphic disorders rarely occur in one direction of space and this is why finding a malocclusion in pure form is rare: Three-dimensional dento facial changes involving different anatomical structures often coexist [9].

The purpose of this study is to analyze and classify a sample size of CT Cone Beam of 201 patients and to identify the correlation between the various cephalometric dimensions.

Material and Methods

A sample of 201 patients who underwent CT Cone beam technique performed with I-Cat Classic® (Imaging Science International) was randomly selected from an archive of 650 CT Cone Beam.

These patients were all treated at the dental clinic of the Department of Orthodontics, University of Milan: both genders, aged between 4 and 67.

The CBCT of selected subjects were analyzed according to the three-dimensional cephalometry of the School of Milan with the software Materialise Mimics® [10,11].

3 groups are identified [12] from the analysis carried out according to sagittal reports:

- GROUP 1, Steiner I skeletal Class (ANB 2° ± 2): 79 subjects 39%

- GROUP 2, Steiner II skeletal Class (ANB>4°): 115 subjects 57%

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Received July 20, 2013; **Accepted** August 27, 2013; **Published** August 30, 2013

Citation: Elisabetta B, Alessandro Z, Francesca B, Giampietro F (2013) Cephalometric Diagnosis with Cbct: Algorithm of Correlation between Sagittal and Vertical Dimensions. J Med Diagn Meth 2: 135. doi:10.4172/2168-9784.1000135

- GROUP 3, Steiner III skeletal Class (ANB<0°): 7 subjects 4%

Based on the vertical relationships, each group was divided into normo, deep and open vertibite using the proportion between the upper front vertical dimension and the lower front vertical dimension. (N-SNA=45%, SNA-Me=55% of the sum of the two) [13].

Within group 2, Steiner skeletal Class II (ANB>4°), we selected a sample of 92 subjects aged between 8 and 20, that divided according to vertical relationships consists of:

- Group 2.1, Steiner II skeletal normovertibite Class: 61 subjects 66%

- Group 2.2, Steiner II skeletal openvertibite Class: 24 subjects 26%

- Group 2.3, Steiner II skeletal deepvertibite Class: 7 subjects 8%

The previous results contrast with the samples of populations of II Class Malocclusion reported in literature (2001, Angle, 1907), in which it is reported that the II Classes deepvertibite are more representative than the normo and openvertibite.

It was therefore decided to study the sample of 61 subjects with II Class normovertibite with a mathematical algorithm developed by the School of Milan, which allows correlation of the sagittal and vertical dimensions, especially designed to adapt to the potential of calculation and cephalometric measurement of the Materialise Mimics® software.

The group of 61 subjects with Steiner II normovertibite skeletal Class (group 2.2) was analyzed with the addition of further cephalometric data (Figure 1).

The points and measurements needed to calculate the algorithm of correlation between vertical and sagittal dimensions were:

A: (sub spinal point) point falling on the frontal plane of the concavity of the maxilla between SNA and alveolar process.

B: (supra mental-point) point falling on the frontal plane of the concavity of the mandible between the alveolar process and pogonion osseous.

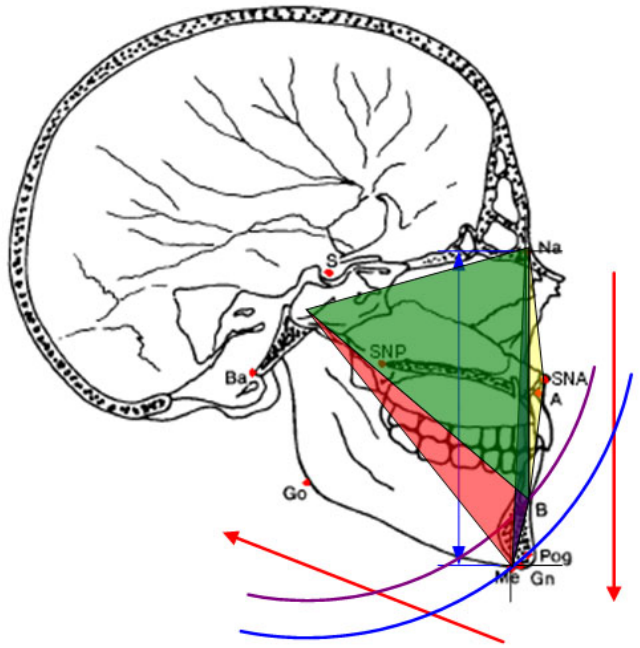

Figure 1: The angles and segments considered for the design of the algorithm.

B ‘: projection of point B on the segment Go-Me.

Cd: the highest point of the mandibular condyle.

Go: (gonion) meeting point of the posterior-inferior margin of the body of the mandible with the bisector of the angle formed by two straight lines drawn from the PC point to the most salient point in the frontal plane of the posterior margin of the mandible and from the point Me to the lowest point on the horizontal plane, of the lower edge of the mandible.

Me: (Menton) midpoint on the lower contour of the chin of the mandibular symphysis.

N: (nasion) midway point on the median sagittal plane, of the fronto-nasal suture.

PC: (condylar point) meeting point of the posterior margin of the mandible with the occipital pyramid.

B-B ‘: distance of the point B from the line through Me-Go.

Cd-A: distance between the point Cd and the point A.

Cd-B: distance between the point Cd and point B.

Cd-I: distance between the point Cd and point Me.

Cd-N: distance between the point Cd and the point N.

Go-Me: distance between the point Me and the point Go.

Go-B ‘: distance between the point Go and the point B’.

N-A: distance between the point N and the point A.

N-Me: distance between point N and point Me, indicates the total vertical size.

ΔN-Me: variations of N-Me.

var.ANB: value to which you want to bring the ANB angle, indicating the relative position of the two maxillary and mandibular bases in the sagittal plane. Its average-statistical value in free facial structural abnormalities models (Steiner skeletal Class I) is 2 ± 2.

New N-Me: the new values corresponding to the variations of the ANB angle.

The algorithm was then integrated into a Microsoft Excel 2007© spreadsheet, a user interface that was as familiar and simple as possible also chosen in order to minimize the possibility of errors during data input.

Descriptive statistics (mean values and standard deviations) were calculated for all measures. Significant differences between the cephalometric variables (N-Me differential and ANB) were tested with unpaired t-tests. All statistical data were processed using SPSS 14.00 (Table 1).

Results

After entering the additional cephalometric data in the spreadsheet, we calculated the new values of N-Me corresponding to variations of the angle ANB.

In order to calculate how many patients were actually II Class normovertibite and not deepvertibite masked by the II Class Malocclusion , we decided to lead ANB angle to the value of 2°, typical

A	B	C	D	E	F	G	H	I	J	K
Caphalometric Parameters	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B-B'	17,22	14,43	18,76	12,34	16,07	17,21	16,74	16,63	17,78	15,79
Cd-A	91,305	79,96	94,135	93,27	95,265	93,285	94,58	90,555	95,02	88,635
Cd-B	108,635	90,935	106,425	103,16	101,92	101,88	106,635	100,27	108,98	98,725
Cd-Me	119,115	93,875	115,055	108,02	106,4	104,68	113,78	104,255	116,15	104,885
Cd-N	92,045	78,185	96,305	95,04	93,66	93,34	92,585	90,06	92,14	88,96
Go-Me	82,085	64,225	78,405	76,505	75,61	74,18	76,635	76,185	81,09	74,3
Go-B'	82,005	63,57	75,89	74,04	73,16	69,435	72,925	75,43	78,325	71,26
N-A	59,75	48,65	59,58	57,05	51,52	50,1	54,49	46,34	53,66	51,7
N-Me	121,98	95,47	117,01	109,39	100,58	102,77	110,41	99,33	113,66	102,66
ΔN-Me	-3,544788	-6,090935	-3,847293	-9,515755	-11,03601	-8,35836	-7,358901	-7,57502	-8,043475	-5,68258
Var.A-N-B	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0	2,0
New NME	118,4	89,4	113,2	99,9	89,5	94,4	103,1	91,8	105,6	97,0

Table 1: Screenshot of Excel interface, used for the calculation program.

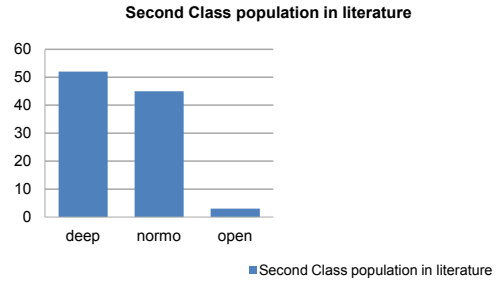

Figure 2: Second class population in literature.

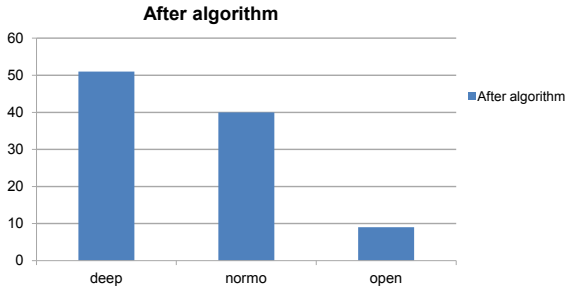

Figure 3: After Algorithm.

of a I Class, to get true values of the vertical dimension through the correction of the sagittal dimension.

We obtained the following data (Table 2).

Discussion

Having obtained the new values, the group was divided according to vertical relationships with the proportion used before between the upper front vertical dimension and lower front vertical dimension. (N-SNA=45%, SNA-Me=55% of the sum of the two).

The results in the table below show that, after correction of sagittal dimension, 40 subjects of 61 become deepvertibite, while 21 remain normovertibite, thus obtaining a sample of II Class Malocclusion in agreement with data reported in the literature (Proffit, 2001, Angle, 1907) (Figure 2 and 3).

This shows that the various dysmorphic disorders rarely occur in one direction of space and that finding of a malocclusion in pure form is rare: different dentofacial abnormalities, more or less marked, often coexist and involve three-dimensional anatomical structures in all the directions of space (Table 3).

Conclusion

Orthognatodontic diagnosis aims to identify the alterations of dental-skeletal structures not only by observing patient's medical history and symptoms but also through the results of instrumental analysis, first of all radiographic ones [14].

With the introduction of CBCT and three-dimensional cephalometric data a simple, repeatable, and relatively uninfluenced by human error method has been found, which relies on the use of computers [15,16]. CT Cone Beam provides an actual representation of reality without distortion, eliminating perspective problems, because it works directly using the three dimensions, eliminating overlapping of anatomical structures [17,18].

Various dysmorphic disorders rarely occur only in one direction

IdPz	original ANB	algorithm ANB	N-Me original	N-ME algorithm	N-ME Variations
1	4,89	2	121,98	118,4	-3,5
2	4,26	2	117,01	113,2	-3,8
3	7,27	2	109,39	99,9	-9,5
4	6,65	2	95,47	89,4	-6,1
5	7,71	2	100,58	89,5	-11,08
6	6,28	2	102,77	94,4	-8,37
7	6,17	2	110,41	103,1	-7,31
8	6,54	2	99,33	91,8	-7,53
9	6,81	2	113,66	105,6	-8,06
10	5,24	2	102,66	97	-5,66
11	4,95	2	101,62	95,3	-6,32
12	5,46	2	108,83	102,5	-6,33
13	5,71	2	95,17	88,9	-6,27
14	7,56	2	114,9	105,2	-9,7
15	5,52	2	98,32	93,3	-5,02
16	4,25	2	86,13	83,3	-2,83
17	5,57	2	100,99	95,2	-5,79
18	5,15	2	105,33	101,2	-4,13
19	4,97	2	95,93	91	-4,93
20	7,3	2	101,73	94,1	-7,63
21	5,02	2	102,9	98,6	-4,3
22	5,4	2	102,91	97,6	-5,31
23	5,63	2	103,14	97,4	-5,74
24	5,59	2	102,86	96,5	-6,36
25	4,46	2	102,92	99,2	-3,72
26	6,56	2	107,5	100,3	-7,2
27	4,81	2	103,85	99,5	-4,35
28	8,48	2	106,52	97,3	-9,22
29	6,6	2	113,12	106,5	-6,62
30	4,58	2	103,67	98,3	-5,37
31	5,26	2	115,14	109,2	-5,94
32	5,67	2	109,54	103,7	-5,84
33	8,16	2	121,66	112,4	-9,26
34	6,74	2	119,26	111,3	-7,96
35	4,29	2	104,71	101	-3,71
36	4,1	2	105,82	102	-3,82
37	5,41	2	102,65	98,2	-4,45
38	7,31	2	110,25	102,5	-7,75
39	5,6	2	100,93	95,9	-5,03
40	7,61	2	110,12	100,4	-9,72
41	6,46	2	106,81	99,5	-7,31
42	7,98	2	110,88	102,6	-8,28
43	6,93	2	101,77	93,1	-8,67
44	4,76	2	112,78	108,3	-4,48
45	6,4	2	117,64	110,6	-7,04
46	4,57	2	104,68	100,7	-3,98
47	5,59	2	90,92	85,7	-5,22
48	5,4	2	123,68	117,6	-6,08
49	4,94	2	102,32	98,8	-3,52
50	4,15	2	103,77	100,9	-2,87
51	8,45	2	112,61	101,4	-11,21
52	8,75	2	100,44	87,5	-12,94
53	5,79	2	117,06	109,3	-7,76
54	5,79	2	113,88	105,4	-8,48
55	5,66	2	107,58	101,7	-5,88
56	5,6	2	104,84	100,8	-4,04
57	4,87	2	118,74	114,2	-4,54
58	4,01	2	110,97	107,8	-3,17
59	6,05	2	102,33	94,5	-7,83
60	14,07	2	107,92	90,4	-17,52
61	5,67	2	96,29	91,4	-4,89

Table 2: N-Me corresponding to variations of the angle ANB.

IdPz	% H. upper f.	% H. lower f.
1	44,61	55,39
2	47,13	52,87
3	51,10	48,90
4	48,01	51,99
5	51,33	48,67
6	47,10	52,90
7	46,58	53,42
8	46,21	53,79
9	46,42	53,58
10	47,29	52,71
11	48,14	51,86
12	45,73	54,27
13	49,13	50,87
14	47,83	52,17
15	45,48	54,52
16	46,97	53,03
17	48,16	51,84
18	45,48	54,52
19	47,43	52,57
20	46,97	53,03
21	45,67	54,33
22	47,18	52,82
23	45,98	54,02
24	47,19	52,81
25	46,92	53,08
26	45,73	54,27
27	46,38	53,62
28	48,03	51,97
29	46,75	53,25
30	45,68	54,32
31	46,35	53,65
32	49,41	50,59
33	48,93	51,07
34	46,06	53,94
35	44,51	55,49
36	48,16	51,84
37	45,99	54,01
38	48,57	51,43
39	46,38	53,62
40	46,88	53,12
41	47,53	52,47
42	49,50	50,50
43	48,32	51,68
44	46,44	53,56
45	46,75	53,25
46	44,96	55,04
47	45,62	54,38
48	46,52	53,48
49	48,08	51,92

50	47,06	52,94
51	49,90	50,10
52	52,01	47,99
53	45,77	54,23
54	50,22	49,78
55	46,92	53,08
56	46,82	53,18
57	45,87	54,13
58	47,90	52,10
59	47,98	52,02
60	54,32	45,68
61	46,67	53,33

Table 3: In yellow the subjects passing from normo to deep vertibite.

of space and finding of a malocclusion in pure form is rare: different dentofacial abnormalities often coexist and involve three-dimensional anatomical structures in all the directions of space.

Sagittal relationship between the jaws depends on several structural features, such as the vertical dimension, which is one of the elements involved. In case of simultaneous presence of Steiner II Class Malocclusion and a skeletal "deep bite", the extent of progress of the mandibular body not only depends on the value of ANB but also on the extent of "deep bite": the greater the increase in terms of verticality, the greater the need to simultaneously advance the mandible. These circumstances are problematic because the most common orthodontic therapies of malocclusion dimensional carriers compensate each other at times, even though imperfectly, by concealing the presence of some of them so they can be aggravated by the treatment chosen.

In case of II Class Malocclusion deep bite is disguised because of the slack between of mandible and anterior nasal spine. This algorithm enables us to clean out the effect of II Class Malocclusion and to assess the "real" verticality of the specific case. Based on this role played by vertical plane, the treatment of Deep II Class Malocclusion needs to address verticality in order to resolve sagittal situation. In surgical cases the correction must be pursued with forward and post-rotated movements rather than only by advancements.

The University of Milan has analyzed the problem in order to achieve an algorithm that creates a functional relationship between two variables "ANB angle" and "total vertical dimension of N-Me", of the same subject who had the power to describe the kinematic changes of provided therapy and provide knowledge of the value of one depending on the other.

The purpose of this study was to provide a method for cephalometric diagnosis that, based on the use of Cone Beam Tc, is able to provide reliable diagnostic results quickly and simultaneously by elaborating data with computerized calculation programs [19].

Today scientific research is geared towards speed and accuracy, and the School of Milan is developing virtual gipsotecas, customized *equipment* and the orthodontic-surgical programming through the use of computers and CT Cone beam in order to reach these objectives [20,21].

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