ОРТОДОНТІЯ

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CEPHALOMETRIC SKELETAL COMPARATIVE ANALYSIS BETWEEN LEFT AND RIGHT SIDE OF SKULL FOR TWO AGE GROUPS PATIENTS WITH CLASS ONE MALOCCLUSION BY THREE DIMENSIONAL CONE-BEAM COMPUTED TOMOGRAPHY

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Introduction

Cephalometric analysis is an important orthodontics diagnostic tool for evaluation of dentofacial morphology, treatment plan and follows up. It provides a clear image of the skeletal changes that occur in the process of growth and treatment of patients. But the 2D lateral cephalometric isn't used to give us clear idea for comparison between two sides of face and symmetry of skull in which the analysis usually from one (right) side with two plane. In the lateral cephalogram the patient head is positioned with the left side of face next to the image receptor, with the midsagittal plane parallel to the image receptor and the Frankfort plane parallel to the floor. An X-ray beam should be collimated (from right side) to the size of receptor at left side. Because of the projection geometry, structure away from the receptor will be magnified more than the structure close to receptor. Magnification is calculated by dividing the distance from the source of radiation to the image receptor (SID) by the distance from the source to the object of interest (SOD). Based on this calculation, it is easy to see that the right and left sides of the skull will be different sizes in a lateral cephalogram [1].

In the United States, lateral cephalograms are conventionally taken with the left side of the patients head closest to the film. In Europe, however, the convention is to place the right side of patient head closest to film [2]. According to in vitro study of B. Callouel, the result from 2 techniques isn't the same, because of the divergent nature of x-ray, the structure of the craniofacial complex that are the farthest from the film will be magnified more than those that are closer to the film.

Shortly after the discovery of x-rays by Wilhelm Conrad Roentgen (1895) the use of the first facial and cranial radiographs was reported as early as 1896 by Rowland and later by Ketcham and Ellis. B. H. Broadbent used lateral cephalograms in his private practice in 1921 [3].

First registration for roentgenograms of head was made in 1896; Ketchman published first lateral roentgenograms of the head in 1919 [4].

The development and introduction in medical practice of the computed tomography (CT) were represented as an important contribution to the orthodontic radiological diagnosis by Sir Godfrey Hounsfield in 1971, overcoming the limits of the previous methods, while the cone-beam computed tomography began to appear more late 1990 [5].

During the last few years the 3D cephalometric analysis able to describe anatomical landmarks both on hard and soft tissues has been introduced [6]. CBCT is currently being used with orthodontic patients since it offers three-dimensional craniofacial imaging as an alternative to conventional radiography and computed tomography (CT). Moreover, the images produced with CBCT are not magnified; CBCT may replace some of the diagnostic tools used in orthodontics, such as two-dimensional (2D) cephalometry. Today, the most clinicians are replacing conventional radiographic records with CBCT. It can provide a series of slides which are then reconstructed in 3D, which give us much more information of the structures studied [7].

Facial asymmetry is commonly observed in the most population and it is an individualized characteristic, asymmetry refers to the bilateral difference between such components [8]. A perfect bilateral symmetry almost never exists in the human body where it in soft tissues or hard tissues, with old or young age. Computed tomography is considered an optimal diagnostic method for asymmetry assessment [9].

The purpose of this study were to conduct comparative cephalometric analysis between left and

right side of head (lateral, frontal) and evaluate the skeletal facial symmetry in patients with class one malocclusion by using 3D CBCT. Two age groups were aid to known if there are differences in craniofacial growth between left and right side for young samples as increase of the brain during prenatal and early postnatal life that thrusts the calvarial bony plates outward and the midface forward and downward [10].

The cranial cavity achieves 87% of its adult size of 2 years, 90% of 5 years and 98% from 8 to 15 years. Between 15 years and adulthood the growth changes are the mostly secondary to the pneumatization of the frontal sinuses and thickening of the anterior part of the frontal bone [11].

Materials and Methods

Twenty 3D CBCT for patients (7 males, 13 females) with age ranging from 8 to 34 year were screened for the following criteria.

- All subjects have normal skeletal relation.
- Good facial symmetry/proportion was shown.
- None of the subjects should have undergone any orthodontic or maxillofacial/plastic surgery in the past.
- Cases were chosen for inclusion only on the basis of balance of facial parts, and quality of parts (skin color, beautiful eyes, hair style or color) was disregarded.
- Handwork measurement analysis (without software analysis program was used) except the landmarks determination.
- Ethical Approval and acquisition of Informed Consent was obtained for all cases.

All cases had not undergone previous orthodontic treatment; they came to Orthodontic Department of Ukrainian Medical Stomatological Academy for orthodontics consultation. Two different age groups of patients were from May 2017 to January 2019: 10 subjects in group A (age ≤14 'yr') and 10 subjects in group B (age >14 'yr'). 3D CBCT (advanced 3d-imaginag software Ez3d2009) was used for all cases. It was recorded by the same operator and taken in Natural Head Position (NHP) and simultaneously in centric occlusion and lips in repose. The measurement was used with 11 angular (anteroposterior - frontal) and 4 liner as shown in (tables 2). The cephalometric analysis was recorded from right and left.

Unilateral and bilateral landmarks parameters were used for comparative reasons between right and left side of the head (table 1).

Table (1) landmarks definitions

Variables	Definition
Nasion (Na point)	The anterior point of the intersection between the nasal and frontal bones.
Pogonion (Pog)	The most anterior point on the contour of the chin.
S point	The midpoint of the cavity of sella turcica or the center of pituitary fossa.
Isi–Incision Superius Incisalis	Incision superius incisalis is the incisal tip of the most anterior maxillary central incisor.
Isa–Incision Superius Apicalis	The upper incisor apex is the root apex of the most prominent upper incisor.
Iii–Incision inferius incisalis	The incision inferius is the incisal tip of the most labial mandibular central incisor.
Iia–Incision inferius apicalis	The lower incisor apex is the root apex of the most prominent lower incisor.
Gonion (Go)	The bilaterial midpoint of the contour connecting the ramus and mandibular body.
Gnathion (Gn)	The center of the inferior point on the mandibular symphysis.
Anterior nasal spine (ANS)	The most anterior point of the nasal floor tip of pre-maxilla on mid-sagittal plane.
A point	The deepest midline point on the premaxilla between the anterior nasal spine and prosthion.
Menton (Me)	The most inferior point on the mandibular symphysis.
Condylon (Cd)	The upper midpoint of the mandibular condyle.
B point	Innermost point on the contour of the mandible.
Zygomaticofrontal suture (Z)	The bilateral, anatomic, hard tissue PA cephalometric landmark at midpoint in the Zygomaticofrontal suture.
Porion (Po)	Bilateral most superior points of auditory meatus.
Orbital (Or)	Bilateral the lowest point on the lower margin of each orbit. It is identified by palpation and is identical to the bony orbitale.
Mx–Maxillare	The bilateral, anatomic, hard tissue PA cephalometric landmark, Maximum concavity on the contour of the maxilla between the first molar and malare.
Ag–Antegonion	The bilateral, anatomic, hard tissue PA cephalometric landmark. As it highest point in the antegonial notch (left and right).
In-or infraorbital	Bilateral anatomic hard tissue at the center of inrfaorbital foramen.

The following reference planes were used:

- Frankfort Horizontal Plane (FHP)
- Mandibular Plane (MP): A plane connecting the points Gonion and Menton.

Seven skeletal cephalometric angular measurements, ANB, Z-GO-ME, PO-GO-ME, FMA, FH-A, FH-Z-GO. and one dental cephalometric angular measurement (Inter incisal) were used from both sides for right and left central incisors.

Four skeletal frontal angular measurement, AG-

AG to midline, inOR-inOR to midline, MX-MX to midline, Z-Z to midline were used of frontal view (table 2) (figure 3).

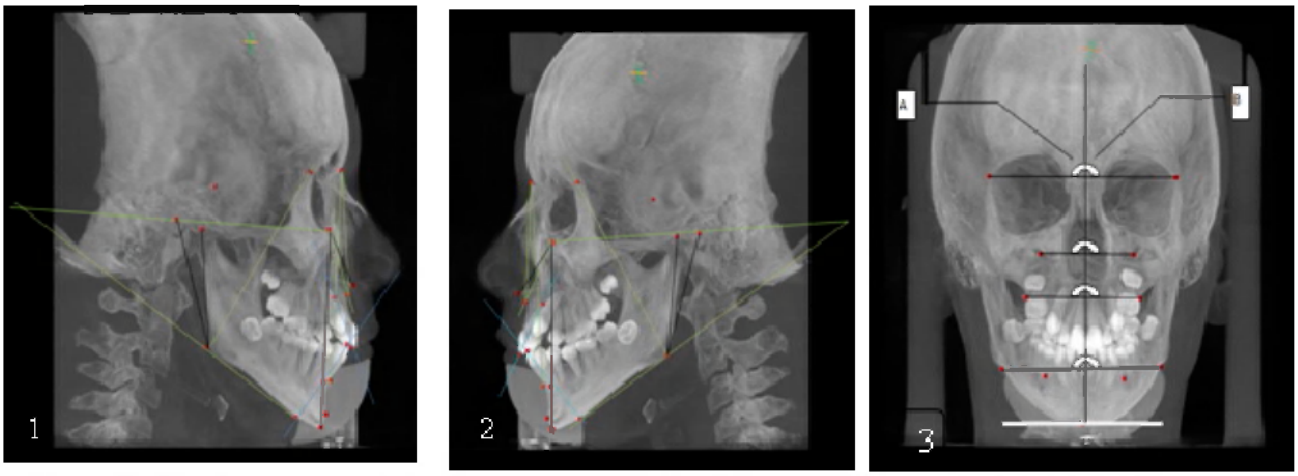
Four linear measurements were used from right and left side as following.

- Posterior mandibular height (CD-GO): The linear distance from condyle (CD) to Gonion (GO).
- PO-GO: The linear distance from porion (PO) to Gonion (GO).
- OR-GN: The linear distance between Orbital (OR) and Gnathion (GN).
- OR-ANS: The linear distance between Orbital (OR) and Anterior nasal spine (ANS).

The results were statistically analyzed to establish norms for the right side as well as to compare them with the findings of left side for whole sample and subsamples.

Table (2) angular measurements

Angle	Definition
ANB	The angle formed between A point, nasion, B point.
Z-Go-Me	Angle formed between the Z-Go line and the line drawn along Go and Me
Po-Go-Me	Angle formed between the Po-Go line and the line drawn along Go-Me
FH-M OR FMA	The Frankfort-mandibular plane angle is formed by the intersection of the Frankfort horizontal plane and the mandibular plane.
FH-A	Angle is formed by the intersection of the Frankfort horizontal plane and A-point
FH-Z-Go	Superior angle that formed by the intersection of the Frankfort horizontal plane and the line drawn along Z-Go.
Inter incisal	Angle formed between the long axes of upper and lower incisors.
Z-Z to midline	Angles (left ,right) is formed by the intersection of the vertical midline to horizontal Z-Z line from frontal view.
inOr-inOr to midline	Angles (left, right) is formed by the intersection of the vertical midline to horizontal infraorbitals fossae line from frontal view.
Mx-Mx to midline	Angles (left, right) is formed by the intersection of the vertical midline to horizontal Mx-Mx line from frontal view.
Ag-Ag to midline	Angles (left, right) is formed by the intersection of the vertical midline to horizontal Ag-Ag line from frontal view.



Figures (1) right side parameters (A)yellow color represent the skeletal plane of angles ANB, Z-GO-ME, PO-GO-ME, FMA, FH-A, FH-Z-GO.(B) black color represent the liner measurements mm CD-GO, PO-GO, OR-GN, OR-ANS. (C)blue color represent the dental plane of interincisal angle. (2) left side parameters .(3) skeletal frontal angular measurement from (A) right and (B)left, depend on intersection of midline with planes of AG-AG, inOR-inOR, MX-MX; Z-Z

Results

Normal values were calculated as mean, standard deviation (SD) for reference in the treatment procedure. Significance of the difference between the both sides was tested with Chi -test. Statistical analysis showed that the two side were similar in the most but not in all measurements.

As shown in the result tables the dental factors (interincisal angle) showed a higher value differences from left to right, while frontal view factors showed a lower value differences The remaining means were not statistically different between them.

Comparisons between the right and left side of skull for whole sample.

As shown in (table 3) from anteroposterior measurements the difference in the ANB angle between the right and left sides (-0.183) where it at right 4.238095 with SD 1.68 while it at left side 4.42 with SD 1.74 . p-value ($p < 0.99$) were not statistically significant, ANB angle represent relationship of both arches to frontal bone (unilateral landmarks).from the result the most symmetric angle for both side it was inOR-inOR where the DF= 0.

Comparisons between the right and left side of skull for group A contains younger age sample.

Table 3 for whole sample	RIGHT		LEFT			According to chi squire
parameters measurement	Mean	SD	Mean	SD	DF	p
skeletal anteriopostеor (angle)						
ANB	4.238095	1.685854	4.421053	1.74215	-0.183	0.999997
Z-GO-ME	82.71429	4.740642	83.21053	5.127041	-0.496	1
PO-GO-ME	132.1905	6.247339	132	7.25718	0.1905	1
FH-M or FMA	25	5.385165	24.31579	5.426812	0.685	0.983666
FH-A	113.0476	4.511843	115.1053	4.433393	-2.0577	0.999993
FH-Z-GO	121.8571	2.225582	120.8421	2.339591	1.015	1
skeletal vertical sagital (mm)						
OR-ANS	23.66667	2.966677	24.21053	3.06556	-0.54386	0.999997
OR-GN	72.61905	8.09122	72.10526	7.615005	0.51379	1
PO-GO	54.42857	6.676747	54.15789	7.033753	0.27068	1
CD-GO	47	6.818876	47.84211	6.743418	-0.84211	0.999931
dental vertical (angle)						
Inter incisal	133.6667	11.88788	128.1579	13.84142	5.5088	0.920826
skeletal frontal view (angle)						
AG-AG to midline	90.04762	1.393385	89.94737	1.393385	0.10025	1
inOR-inOR to midline	90	1.527525	90	1.527525	0	0.999999
MX-MX to midline	90.19048	1.118688	89.84211	1.118688	0.34837	1
Z-Z to midline	89.71429	0.805682	90.15789	0.83421	-0.4436	1
P<0.05 ,significant; p>0.05 not significant. DF= DEFFERANCES. SD=STANDARD DEVIATION						

As shown in (table 4), were statistically no significantly, as the higher value of differences in the skeletal measurement angles was FMA (1.1) and FH-A (-1.6). While, the least difference value was Z-Go-Me (-0.1). The group A young sample comparison result show highest differences value between left and right side then with group B sample and others subsamples in relation to dental measurement angle where inter incisal DF = 7.1.

Comparisons between the right and left side of skull for group B contains older age sample.

Table 4 for A group	RIGHT		LEFT			According to chi squire
parameters measurement	Mean	SD	Mean	SD	DF	p
skeletal anteriopostеor (angle)						
ANB	4.6	1.837873	4.8	1.873796	-0.2	0.999415
Z-GO-ME	84	3.681787	84.1	5.173651	-0.1	0.999746
PO-GO-ME	134.7	5.2079	134.9	7.125073	-0.2	0.998528
FH-M or FMA	26.2	4.491968	25.1	5.237684	1.1	0.728344
FH-A	113.4	5.316641	115	4.082483	-1.6	0.996776
FH-Z-GO	121.7	2.406011	121	2.309401	0.7	0.999993
Skeletal sagital or vertical (mm)						
OR-ANS	22.6	2.590581	22.7	2.668749	-0.1	0.997681
OR-GN	68.8	6.214678	68.5	5.602579	0.3	0.999988
PO-GO	51.3	4.738729	51.1	4.771443	0.2	0.999986
CD-GO	44.4	4.812022	44.7	5.638164	-0.3	0.999857
Dental vertical (angle)						
Inter incisal	130.8	7.067924	123.7	7.732328	7.1	0.626432
Skeletal frontal view (angle)						
AG-AG to midline	90.1	1.66333	89.9	1.66333	0.2	0.999122
inOR-inOR to midline	89.9	1.66333	90.1	1.66333	-0.2	0.999134
Mx-Mx to midline	90.2	1.229273	89.8	1.229273	0.4	0.999915
Z-Z to midline	89.8	0.421637	90	0.471405	-0.2	1
P<0.05 ,significant; p>0.05 not significant. DF= DEFFERANCES. SD=STANDARD DEVIATION						

As shown in (table 5), the older sample more symmetrical than A sample younger sample. The higher value of differences in the skeletal measurement angles from right to left was FH-A (-1.8) and FH-Z-GO (1.2). While, the least difference value was AG-AG (0).

Table 5 B sample parameters measurement	RIGHT Mean	RIGHT SD	LEFT Mean	LEFT SD	DF	According to chi squire p
skeletal anterioposteor (angle)						
ANB	3.777778	1.481366	4	1.581139	-0.22222	0.996123
Z-GO-ME	81.55556	5.637178	82.22222	5.190804	-0.66666	0.999279
PO-GO-ME	129.3333	6.344289	128.7778	6.260547	0.5555	0.999959
FH-M or FMA	23.66667	6.22495	23.44444	5.811865	0.22223	0.99248
FH-A	113.3333	3.741657	115.2222	5.044249	-1.8889	0.998534
FH-Z-GO	121.8889	2.14735	120.6667	2.5	1.2222	0.999968
Skeletal sagital or vertical (mm)						
OR-ANS	24.77778	3.073181	25.88889	2.666667	-1.11111	0.999036
OR-GN	76.33333	8.381527	76.11111	7.801353	0.22222	0.999979
PO-GO	57.77778	7.084804	57.55556	7.812028	0.22222	0.999069
CD-GO	50	7.745967	51.33333	6.363961	-1.33333	0.95363
Dental vertical (angle)						
Inter incisal	135.2222	15.81754	133.1111	17.64543	2.1111	0.919729
Skeletal frontal view (angle)						
AG-AG to midline	90	1.118034	90	1.118034	0	0.999915
inOR-inOR to midline	90.11111	1.452966	89.88889	1.452966	0.22222	0.99934
Mx-Mx to midline	90.11111	1.054093	89.88889	1.054093	0.22222	0.999943
Z-Z to midline	89.66667	1.118034	90.33333	1.118034	-0.66666	0.999884
P<0.05 ,significant; p>0.05 not significant. DF= DEFFERANCES. SD=STANDARD DEVIATION						

Discussion

There are numerous factors which should be considered when applying the results of this investigation. The accuracy of measurement distances may be affected by a reduction in image quality due to tissue attenuation, metallic artifacts, patient motion and variation in scanning protocol. Therefore, it would be expected that during selection of cases was consider the normal symmetry of face at smiling, mouth opening and profile appearance. 3-mm asymmetry was considered abnormal for smiling. Asymmetry was recognized when both the eyebrow and oral commissure have more than a 3-mm difference [12].

This study showed that the right side measurements not exactly equal and symmetry the left side measurement but there were little differences, that also, depend on the age and sex .The young sample show less symmetry than olde. There were the dental factors (inter incisal) least symmetric especially at mixed dentition while, the frontal skeletal factor most symmetrical.

The female patients show less symmetry than male. The frontal view show more symmetrical than lateral anteroposterior view. The dental angle measurement at all sample show highest value differences between left and right side. The angles that formed by Unilateral landmarks (ANB) show more symmetrical result than the angle that formed by bilaterial landmarks. The infraorbital bilateral landmark it was the most symmetrical point for whole sample, where inOR-inOR to midline angle = 90◦ from both side.

Extra-cranial reference line was used instead of an intracranial reference line, which is essential for cephalometric analysis based on NHP because patients have considerable biological variations in inclination.

In this study manual measurement analysis were used rather than software programs analysis, because here used new and different parameters like, Z-GO-ME or FH-Z-GO. The software programs that used in orthodontics cephalometric analysis measurements are not statistically significant mostly with manual analysis measurements [13].

Also, many studies have compared available cephalometric analysis software programs and found no clinically significant difference between the measured values [14].

In this study was considered relation of facial bone growth to above landmarks selection, where the maxillary complex is surrounded by a system of sutures that allows the growth and displacement of the various bones both anteroposteriorly and laterally. The circummaxillary suture system includes the zygomaticomaxillary, frontozygomatic, sphenopalatine, and palatomaxillary sutures [15]. The frontozygomatic bilaterial landmark point (Z) was used as criteria for comparison of both side and its angulation with mandibular and maxillary bone (Z-GO-ME, Z-Z to midline).

The growth on the head of the condyle occurs in an upward and backward direction. Mandibular growth is expressed as a downward and forward displacement. The growth at the condyles compensates for the vertical displacement of the mandible and accommodates for the eruption of the teeth vertically. On the other hand, the bone resorption at the anterior border and deposition at the posterior border of the two rami account for the anteroposterior growth of the mandibular rami and body [16].

The CD-GO liner distances of right was compared with left that represent the vertical height of posterior of mandibular, while the PO-GO measure the mandibular angle to portion point of partial bone from both sides. Also, the OR-ANS and OR-GN liner distances may represent the anterior vertical growth of half lower face of both sides. Also, the selection of two age groups was allowed to make a comparison between them and identified ratio of symmetry of both side.

According to Bjork [17] the bone change direction (7-19 years old) was related to (SN plane) downward and forward. But the scientist did not specify or mention any differences between left and right side bone change with large individual variation.

Conclusion

Measurements of skeletal analysis performed by 3D CBCT cephalograms from right side were found to be similar to left side. So, we can use the left analysis for orthodontics diagnosis as right side. Also, the both side analysis can be used for symmetric analysis reasons.

Compliance with Ethical Standards

Ethical approval: All procedures performed in this study involving human participants (3D tomography x-ray) were in accordance with the ethical standards of the institutional and/or national research committee in 1964 in Helsinki.

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Summary

Objective: The purpose of our research was to study comparative cephalometric analysis between left and right sides of head and evaluate the skeletal facial symmetry in patients with class 1 malocclusion by 3D Cone-beam computed tomography (CBCT). Materials and Methods: Pre-treatment by 3D Cone-beam computed tomography radiographs for 20 patients of two age groups with class 1 malocclusion was undergone for 11 angular and 4 liner measurements from right and left sides, anteroposterior, vertical and frontal view by hand except the hard landmarks determination. Chi-test was used to compare the result of both sides ($P < 0.05$). Results: No difference was found between left and right analysis for linear measurements as for the angular cephalometric measurements. Conclusion: Measurements of skeletal analysis by 3D CBCT cephalograms from right side were found to be similar to left side. So, we can use the left analysis for orthodontics diagnosis as right side. Also, the both sides analysis can be used for symmetric analysis reasons.

Key words: Cephalometric, analysis, symmetry, cone-beam computed tomography, measurement, orthodontics.

Резюме

Мета дослідження – порівняти цефалометричні показники лівого й правого боків черепа в пацієнтів із І класом ЗЩА за допомогою конусно-променевої комп'ютерної томографії (CBCT). Матеріали і методи: на 3D-рентгенограмах 20 пацієнтів двох вікових груп із І класом ЗЩА було проведено 11 кутових і 4 лінійні вимірювання з правого й лівого боків. **Результати:** статистично достовірної різниці між лівою й правою половинами не виявлено. **Висновки:** аналіз вимірювань скелета за допомогою 3D-цефалограм із правого й лівого боку в пацієнтів із І класом ЗЩА статистично не відрізняється. Отже, при І класі ЗЩА можна використовувати і лівий, і правий боки для цефалометричного аналізу.

Ключові слова: цефалометричний, аналіз, симетрія, конусно-променева комп'ютерна томографія, вимірювання, ортодонтія.

Резюме

Цель исследования – сравнить цефалометрические показатели левой и правой сторон черепа у пациентов с I классом ЗЧА с помощью конусно-лучевой компьютерной томографии (CBCT). **Материалы и методы:** на 3D-рентгенограммах 20 пациентов двух возрастных групп с I классом ЗЩА были проведены 11 угловых и 4 линейные измерения с правой и левой сторон. **Результаты:** статистически достоверной разницы между левой и правой половинами не обнаружено. **Выводы:** анализ измерений скелета с помощью 3D-цефалограмм с правой и левой стороны у пациентов с I классом ЗЧА статистически не отличается. Следовательно, при I классе ЗЧА можно использовать и левую, и правую стороны для цефалометрического анализа.

Ключевые слова: цефалометрический, анализ, симметрия, конусно-лучевая компьютерная томография, измерения, ортодонтия.