IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 17, Issue 01 Ver. VI January. (2018), PP 56-61
www.iosrjournals.org

3dcephalometric Norms With new CBCT Imaging Protocol

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Date of Submission: 27-12-2017 Date of acceptance: 16-01-2018

I. Introduction

Cephalometric analysis has been a key element in diagnosis and treatment planning for orthodontic, orthognathic and orthopedic patients for more than fifty years. Cephalometric radiography was introduced in 1931 by Broadbent and H. Hofrath[1], who developed simultaneously and independently standardized methods for the production of cephalometric radiograph. Since the introduction of cephalometrics, there were many shortcomings of the technology that orthodontists had to accept as superimposition of anatomical structures, magnification problems and errors in landmark identification due to two dimensional representation of three dimensional objects.

Cone Beam Computed Tomography (CBCT) made the dream of three dimensional diagnosis and treatment planning come true. Since the early 2000s CBCT has grown greatly paving the way for far more accurate diagnosis through actual reflection of three dimensional objects in life sized 3D images offering identification of landmarks in the three planes.The era of CBCT is a fact, it is the natural next step in orthodontic diagnosis and virtual treatment planning. Now all parts of the skull are clearly visible in CBCT images except for the occlusal anatomy of the teeth. The current CBCT imaging protocols produceblended occlusal anatomy due to imaging subjects in maximum intercuspation which hinders the x-rays to reach the occlusal anatomy. Accurate representation of the occlusal anatomy is tremendously important for virtual 3D treatment planning either in orthodontic or orthognathic cases, it is impossible with the current imaging protocol to properly separate dental arches hindering digital simulation of orthodontic treatment.A new imaging protocol[2]offering minimum acceptable inter-occlusal separation during CBCT imaging using a radiolucent splint that guarantees reproducibility, undisrupted facial form, centric condylar position concurrently with feasibility for separation of the maxillary and mandibular teeth and hence digital simulation of the orthodontic treatment was introduced. So our aim was togenerate 3D cephalometric normative data for adult Egyptians taking the advantage of this new imaging protocol..

II. Materials And Methods

A cross sectional observational study was performed on 37 Egyptian adult subjects (25 males and 12 females) with an age range from 18-25 years having balanced facial proportions and Angle Class

I skeletal, molar and canine relationship. All subjects had a full permanent dentition with the exception of the third molars. Arch length discrepancy ranged from 1 to 3 mm in each jaw within the three dimensions (vertical, anteroposterior and transverse), 2 to 3 mm overjet, 20-30% overbite and coincidental facial and dental midlines. Subjects with craniofacial deformities, pregnant female subjects, those who had been exposed to x-ray radiation within the last six months and those who had received previous orthodontic treatment were excluded from the study.First visit, impression taking was performed. Splint fabrication was done using 2 mm thickness hard vacuum sheets and the thickness was checked with the digital caliper to ensure 1-1.2 mm thickness of the sheet after fabrication.Thirty seven CBCT images were collectedusing the i-CAT CBCT machine. The subject`s head was oriented before imaging in the natural head position. The three-dimensional assessment was performed by **In Vivo DentalAnatomage**5.3 software. The inter- and intra-observer reliability was confirmed after the 3D landmarks identification for randomly selected 10% of the sample by two observers, the researcher (observer1) and a colleague (observer2), and only for the researcher to do it twice with a gap of seven days between them.

Nasion landmark (N point) was the point of origin where the three main reference planes (x, y, z) intersectdue to its high accuracy and reproducibility[3, 4,5, 6, 7]. Reference planes were parallel to those of the machine representing the True spatial planes as found in previous studies[8,9].“3D Analysis” was based on thirty six cranial, maxillary and mandibular base landmarks located on each CBCT image, thirty two angular and linear measurements between the different anatomical landmarks which were projected to the main reference system. (Fig. 1)

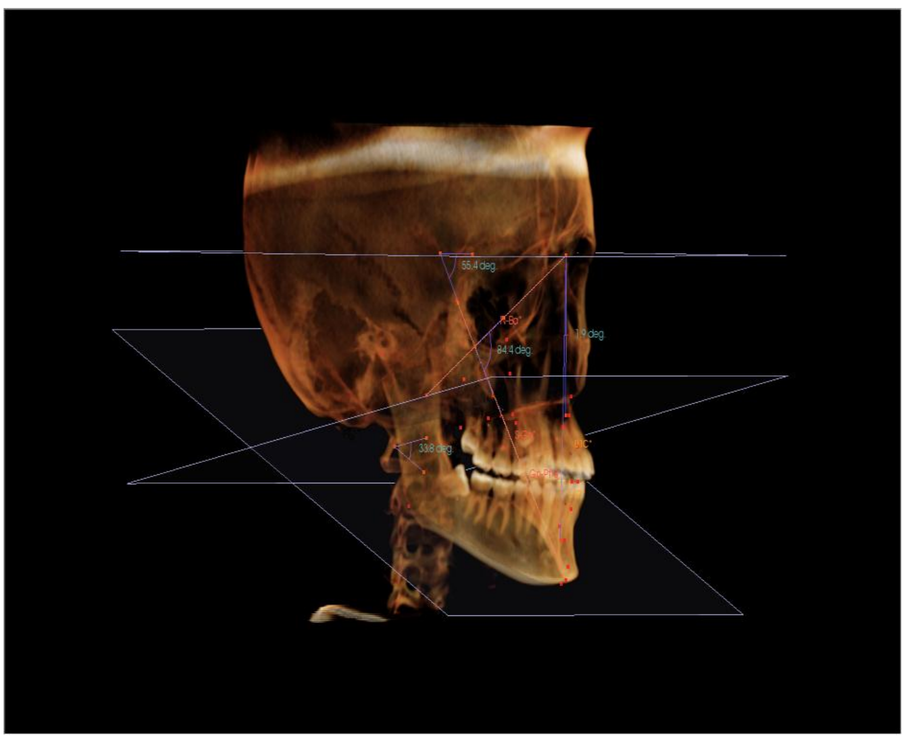

Figure 1 3D Cephalometric Analysis

III. Results

3.1 Error of the method

The intra-observer reliability for cranial base, maxillary base and mandibular base landmarks showed high concordance with identical ICC and CCC values exceeding 0.998 for all points except for J Point_R and UR6_Center that had a relatively low (0.594&-0.598 respectively) intraobserver reliability in the Y (midsagital) plane. There was no statistical significant difference between the two observations. The inter-observer paired sample t-test and limits of agreement were calculated between the two observers. The paired samples test indicated excellent reliability, non-statistically significant difference between the observers, with the upper and lower limits of agreement not surpassing 1mm difference that lies within the range of clinical acceptance in the three spatial axes.

3.2 Maxillary Base Measurements

Regarding the antero posterior relation of maxilla to cranium, the means of was 82.9° ± 3.4° , while the effective maxillary length and maxillary basal length means were 87mm ± 4.2mm and 51.8 mm ± 3.1mm respectivelty (Table 1).The mean maxillary tipping relative to the cranium (PP-SN) were 8.4° ± 3.9° (Table 1).

3.2 Mandibular Base Measurements:

Anteroposterior relation of the mandible to the cranium (SNB) had a mean of 79.5° ± 3.4° , while the effective mandibular length and the mandibular basal length means were 116.3 mm ± 6.4mm and 73.6 mm ± 4.4mm respectively (Table 1).The mean mandibular rotation relative to the cranium (MP-SN) were 33.6° ± 4.9° (Table 1).

3.3 Skeletal Profile Measurements

Regarding anteroposterior relation of maxilla to mandible (ANB, MXMD difference and A-B difference) means were 3.6° ± 2°, -29.9 mm ± 3.8mm and 4.4 mm ± 3.5mm respectively (Table 1).Vertical jaw relation mean was 25.2° ± 4.9°, while the S.Gn-N.Ba means were 86.9° ± 3°. (Table 1).

3.4 Skeletal Vertical Measurements

The means of Anterior Upper Facial Height (AUFH), Anterior Lower Facial Height (ALFH), Anterior Total Facial Height (ATFH), Posterior Total Facial Height (PTFH) and Posterior Lower Facial Height (PLFH) were found to be 52.6 mm ± 3.1mm, 66.5 mm ± 5.3mm, 119.1 mm ± 6.6mm, 78.4 mm ± 7.2mm and 36.1 mm ± 4.9mm respectively (Table 1).

3.5 Skeletal Vertical Measurements Ratios

The mean Jarabak ratio was found to be 70% while, PLFH/ALFH and ALFH/ATFH ratios were 50 % and 60 % respectively (Table 2).

3.6 Dento-Alveolar Measurements

Maxillary and Mandibular alveolus means were 85.7° ± 3.4° and 82.2° ± 3.4° respectively (Table 2).

3.7 Dental Measurements

Regarding the maxillary central incisor inclination and vertical position the means were 113.6° ± 6° and 17.1mm ± 2.3mm respectively, while the mandibular central incisor inclination and vertical position means were 95.5° ± 5.2°and 30.8 mm ± 2.8mm respectively (Table 2). The interincisal angle mean was 125.7° ± 7.7° (Table 2).The mean maxillary (right and left) first molar anteroposterior position in relation to PTV was 20 mm while, its vertical position in relation to the palatal plane was 13.5 mm (Table 2).

Table 1 3D Cephalometric Norms

		Abbreviation			95% CI	
			Mean	SD	Lower	upper
A. Maxillary Base Measurements	Antero-posterior relation to Cranium	**SNA°**	**82.9**	3.4	81.8	84.0
	Effective Maxillary Length	**CD-A (mm)**	**87.0**	4.2	85.7	88.4
	Maxillary Basal Length	**$A\text{-}J_{Mid}$**	**51.8**	3.1	50.8	52.8
	Maxilla Rotation (Tipping)	**PP-SN°**	**8.4**	3.9	7.1	9.7
B. Mandibular Base Measurements	Antero-posterior relation to Cranium	**SNB°**	**79.5**	3.4	78.4	80.6
	Mandibular Basal Length	**$Me\text{-}Go_{Mid}$**	**73.6**	4.4	72.2	75.0
	Effective Mandibular Length	**CD-Gn (mm)**	**116.3**	6.4	114.2	118.3
	Mandibular Rotation (Tipping)	**MP-SN°**	**33.6**	4.9	32.0	35.2
C. Skeletal Profile Measurements	Antero-posterior Jaw Relation	**ANB°**	**3.6**	2.0	2.9	4.2
		MXMD Difference (mm)	**-29.3**	3.8	-30.5	-28.1
		A-B Difference (mm)	**4.4**	3.5	3.3	5.6
	Vertical Jaw Relation	**MMA°**	**25.2**	4.9	23.7	26.8
	Facial Skeleton	**S.Gn-N.Ba°**	**86.9**	3.0	85.9	87.8
D. Skeletal Vertical Measurements	Anterior Upper Facial Height (AUFH)	**N-ANS (mm)**	**52.6**	3.1	51.6	53.6
	Anterior Lower Facial Height (ALFH)	**ANS-Me (mm)**	**66.5**	5.3	64.8	68.2
	AnteriorTotal Facial Height (ATFH)	**N-Me (mm)**	**119.1**	6.6	116.9	121.2
	PosteriorTotal Facial Height (PTFH)	**S-Go (mm)**	**78.4**	7.2	76.0	80.7
	Posterior Lower Facial Height (PLFH)	**$PMP._{Mid}\text{-}Go._{Mid}$ (mm)**	**36.1**	4.9	34.5	37.7

Table 2 3D Cephalometric Norma (Cont'd)

		Abbreviation			95% CI	
			Mean	SD	Lower	upper
E. Skeletal Vertical Measurement Ratios	Posterior TFH/ Anterior TFH	**S.Go/N.Me**	**0.7**	0.0	0.6	0.7
	Posterior LFH / Anterior LFH	**PMP.$_{Mid}$-Go.$_{Mid}$ / ANS-Me**	**0.5**	0.1	0.5	0.6
	Anterior LFH / Anterior TFH	**ANS-Me / N-Me**	**0.6**	0.0	0.6	0.6
F. Dento-Alveolar Measurements	Maxillary Alveolus	**S-N-Pr°**	**85.7**	3.4	84.6	86.7
	Mandibular Alveolus	**S-N-Id°**	**82.2**	3.4	81.1	83.2
G. Dental Measurements	Maxillary Incisor Inclination	**U1-PP °**	**113.6**	6.0	111.7	115.5
	Maxillary Incisor Vertical position	**U1C-PP (mm)**	**17.1**	2.3	16.3	17.8
	Maxillary Right First Molar Antero-posterior position	**UR6-PTV (mm)**	**20.0**	3.2	19.0	21.1
	Maxillary Left First Molar Antero-posterior position	**UL6-PTV (mm)**	**19.9**	2.9	19.0	20.9
	Maxillary Right First Molar Vertical position	**UR6-PP (mm)**	**13.5**	2.0	12.9	14.2
	Maxillary Left First Molar Vertical position	**UL6-PP (mm)**	**13.4**	2.1	12.8	14.4
	Mandibular Incisor Inclination	**L1-MP°**	**95.5**	5.2	93.9	97.2
	Mandibular Incisor Vertical position	**L1C-MP (mm)**	**30.8**	2.8	29.9	31.7
	Inter-Incisal Angle	**U1-L1°**	**125.7**	7.7	123.2	128.1

IV. Conclusion

A three dimensional skeletal cephalometric analysis was established. Normative cephalometric data for adult Egyptians in centric relation was generated which can be used in orthodontic diagnosis and treatment planning.

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Shady Abd El-Salam Rizk, "3dcephalometric Norms Withnew CBCT Imaging Protocol." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 17, no. 1, 2018, pp. 56-61.