EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 69, 1:8, JANUARY, 2023
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
ORTHODONTICS, PEDIATRIC AND PREVENTIVE DENTISTRY
Submit Date : 28-09-2022 • Accept Date : 29-11-2022 • Available online: 1-1-2023 • DOI : 10.21608/edj.2022.165820.2274

CONE-BEAM COMPUTED TOMOGRAPHY SCANS VERSUS STUDY MODELS TO ASSESS THE TOTAL MAXILLARY ARCH CONSTRICTION IN PATIENTS WITH UNILATERAL CLEFT LIP AND PALATE

Eman Hossameldin Elabbassy*

ABSTRACT

Objective: To evaluate the reliability of using cone-beam computed tomography (CBCT) scans instead of study models to assess the total maxillary arch constriction using the modified Huddart Budenham (MHB) scoring system in patients with unilateral cleft lip and palate

Materials & Methods: The study models of fifty-six patients with non-syndromic surgically repaired complete UCLP were used to assess the total maxillary arch constriction using the MHB scoring system. The CBCT scans of the same patients were used to assess the same scoring system again. Three examiners scored the study models and the CBCT scans independently using the MHB scoring system and repeated the scoring one month later. Cronbach's alpha reliability coefficient and Intra-Class Correlation Coefficient (ICC) were used to assess intra and inter-observer agreement, as well as agreement between the study models and CBCT measurements. Spearman's (ϱ) correlation coefficient was used to determine the correlation between study models and CBCT measurements.

Results: There was a very good level of intra-observer agreement for both the study models and the CBCT measurements. Cronbach's alpha values measuring inter-observer agreement were above 0.74 and 0.76, respectively, for all examiners. There was a statistically significant correlation between the study models and the CBCT measurements in all cases (*P*-value <0.001). The results showed no significant difference between the scores of the study models and the CBCT scans.

Conclusions: CBCT scans provide a reliable method that can substitute the study models to assess the total maxillary arch constriction in patients with UCLP using the MHB scoring system.

KEY WORDS: Unilateral cleft lip and palate, total maxillary arch constriction, Modified Huddart Budenham scoring system.

* Orthodontic Department, Faculty of Dentistry, Ain Shams University, Cairo, Egypt

INTRODUCTION

Cleft lip and/or palate (CLP) is the fourth most common congenital birth defect with an incidence of 1 in every 700 births worldwide.[1,2] Children born with CLP have numerous problems including hearing, speech, nutritional, psychological and dental problems, all of which need a professional team work to reach a high standard of cleft care.

Early closure of the lip and palatal defects during childhood is mandatory to improve feeding and speech. However, it results in muscular contraction forces leading to three-dimensional (3D) maxillary collapse and variable degrees of maxillary arch constriction.[3]

Evaluation of the treatment outcome of early surgical closure of the lip and palatal defects is an integral part of the global standard of care of cleft patients. Dental arch relationships are one of the surgical outcome measures that have been used to evaluate the quality of care. Several occlusal indices have been introduced to assess the dental arch relationships in surgically operated cleft patients: Goslon Yardstick, 5-Year-Old's Index, Eurocran Yardstick, Huddart Budenham (HB) and modified Huddart Budenham (MHB) indices.[4]

The MHB scoring system has been recommended by the World Health Organization (WHO) to be the best and most versatile index for assessment of treatment outcome in cleft care.[4] It is a modification from the original HB scoring system that was introduced in 1972, so that it can be used in the mixed dentition.[5] It scores the antero-posterior (AP) relationship between every two opposing teeth, which are then totaled for every set of models to give the total maxillary arch constriction. The higher the negative score, the greater the amount of maxillary arch constriction, indicating poor surgical outcomes.[6,7]

Study models have been commonly used as the gold standard to score the MHB scoring system. However, dental impressions have been always an annoying and uncomfortable dental procedure for cleft patients due to difficult lip manipulation resulting from the stretching muscular forces of the upper lip scarring, in addition to the sensitive gag reflexes that heighten the anxiety in some patients.[8] Moreover, proper cast articulation into proper occlusion usually represents a problem specially with the numerous dental anomalies in patients with CLP.

Intra-oral scanning has been recently used as a 3D method to assess the total maxillary arch constriction using the MHB scoring system in cleft patients. It proved to be a valid and reliable method that can substitute the dental impressions and the study models.[9] However, the cost of the scanner and the lack of its availability in every clinic, the long scanning time, and the discomfort stated by some patients due to limited tissue retraction caused by the scarring effect specially in the young age, were reported as limitations to intra-oral scanning in cleft patients.[10]

Cone-beam computed tomography (CBCT) has been used as a routine diagnostic tool for patients with CLP.[11] It collects all the necessary radiographs needed to localize anatomic structures and to evaluate the dentition in only one quick scan, with very high resolution and accuracy and low radiation exposure.[12] It is also used to assess the alveolar cleft width and volume which is important to evaluate before alveolar cleft grafting. Moreover, the study models obtained from the scans can be rotated in 3D to perform various methods of cast analysis needed for diagnosis and treatment planning.[13] It solves the problem of difficult cast articulation as the mouth is the best articulator. In addition, the lack of aspiration risk of impression material in cleft patients is another benefit from using the CBCT instead of the study models.

Therefore, using the already available CBCT scans to assess the MHB scoring system can decrease the burden of the dental impression, the

long scanning time and the limited tissue retraction that are needed for accurate intra-oral scanning. However, it has never been used to assess dental arch relationship as an indicator for the treatment outcome in cleft patients.

Thus, the idea of this study had aroused to assess the reliability of using the CBCT scans, that are already available as a part of the patient's pre-treatment records, to assess the total maxillary arch constriction in patients with CLP, using the MHB scoring system.

MATERIAL AND METHODS

This retrospective study was carried using the pre-treatment diagnostic records of 56 patients (43% boys, 57% girls) with non-syndromic surgically repaired complete UCLP, treated in the Cleft Care Center (CCC) affiliated to the Oral and Maxillofacial Surgical Department, Faculty of Dentistry, XXXX University. They were all in the mixed dentition and aged from 9-13 years. None of the patients had performed any previous orthodontic treatment including maxillary expansion. All the diagnostic records were collected at the same time before the start of treatment by residents of the department. Approval for the study was obtained from the local ethics committee.

The stored dental study models of those selected patients were used in the study. All the study models were of good quality; poured in hard dental stone and accurately trimmed.

The scoring system that was modified to be used in the mixed dentition (MHB) was assessed using the dental study models.[6,7] It requires that all the teeth from the first permanent molar forward to be given a score. No direct measurements are taken in this scoring system, but all maxillary teeth are scored from -3 to +1 according to their buccolingual relationship to the corresponding mandibular tooth (Fig. 1), except for the lateral incisors, which may be missing or in an abnormal position in CLP subjects.[6] The scores are then added to give a total score that gives an indication about the amount of total maxillary arch constriction.

All the modifications of the HB scoring system were applied; premolars were scored in the same way as primary molars. In case of missing central incisor, the other central incisor was scored. When a canine was unerupted, its score was determined by the mid-point of the maxillary alveolar ridge. When a premolar was absent, a score was allocated equivalent to the adjacent premolar, if erupted. If no

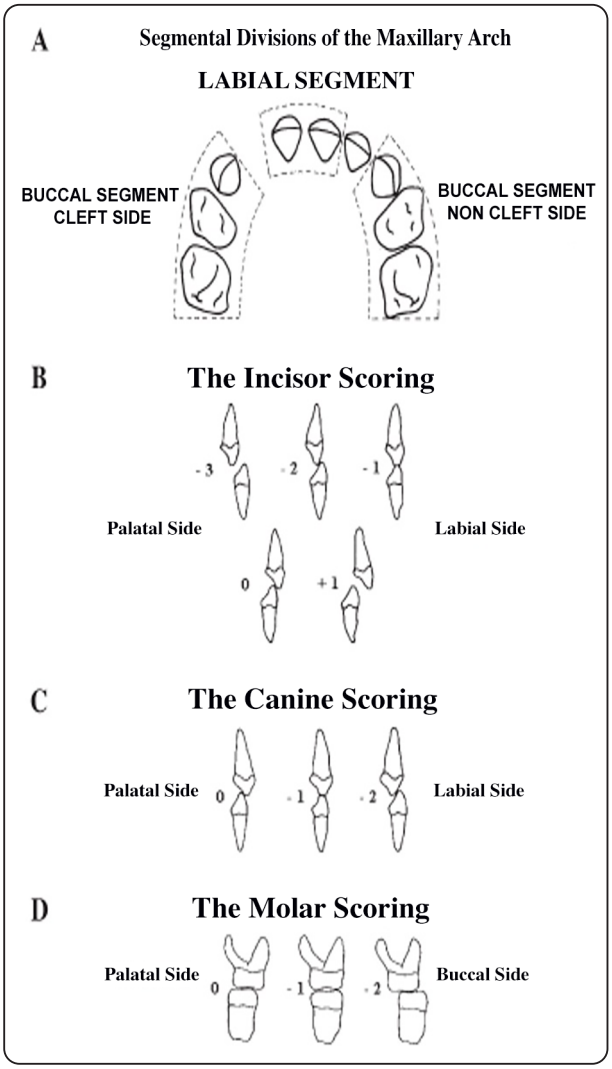

Fig (1) The Huddart/Bodenham scoring system. (a) Segmental divisions of the maxillary arch. (b) Incisor scoring. (c) Canine scoring (d) Molar scoring. Reproduced from the Cleft Palate Journal 1972;9:194-209.

premolars were erupted, the score was determined by the mid-point of the maxillary alveolar ridge.[7]

The CBCT scans of the selected patients, stored on the PC of the CCC were used to assess the MHB score again. All images were acquired using i-CAT Next Generation CBCT machine (Imaging Sciences International, Hatfield, PA). Patients were positioned as described in the i-CAT operations manual. They were guided to close in centric occlusion with lips in relaxed posture. The vertical and horizontal laser-positioning guides were used to guide the proper orientation and position of each patient, with the horizontal laser beam representing the Frankfurt plane which was adjusted parallel to the floor and the vertical laser beam representing the midsagittal plane that is adjusted perpendicular to the floor. Scans were interpreted and evaluated using the i-CAT Vision software utilizing the implant screen (Fig. 2). The arch curve was adjusted to be passing within the mandibular arch between the buccal and lingual cortical plates to accurately create the reconstructed panorama. The vertical ruler on the reconstructed panorama was drawn to the examined tooth to be displayed as a cross-sectional image. The cross-sectional cuts were used to assess the relation between the maxillary and mandibular teeth, each tooth separately. Then, the MHB score was given based on the demonstrated relation.

The 3D model displayed on the lower left side of the screen also helped to determine the score by rotating it in all directions exactly like the study models, to detect the exact buccolingual relationship of each opposing teeth.

Three examiners scored the study models and the CBCT scans independently using the MHB scoring system. They were all consultant orthodontists experienced in the treatment of cleft patients, working with the MHB scoring in their routine clinical practice. They were given a reference guide which described the scoring protocol and gave details of modifications to the scoring system (Fig. 1). The examiners repeated the scoring one month later under similar conditions, to calculate the intra and inter-observer reliability and minimize the possible influence of memory on the results.

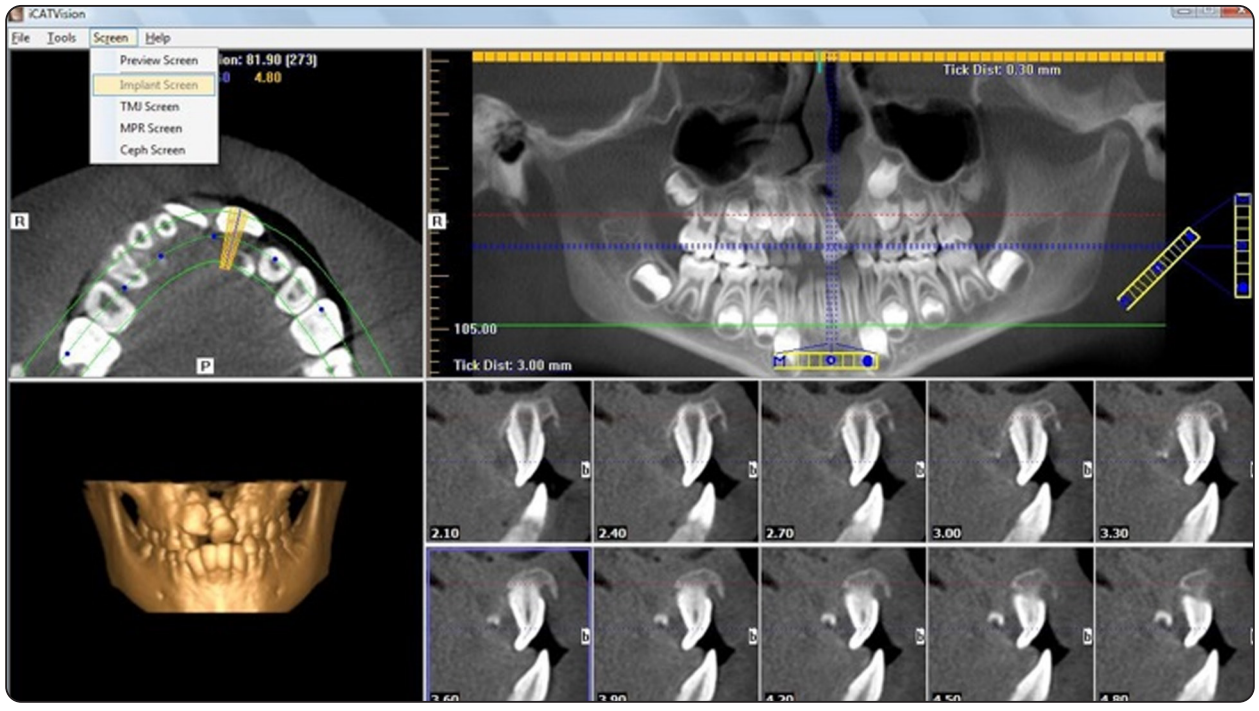

Fig. (2). Implant screen derived from the CBCT scans.

Statistical Analysis

Statistical analysis was performed utilizing SPSS software (version 23.0; IBM, Armonk, NY). Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). The MHB scores data showed non-normal (non-parametric) distribution. Data were presented as mean and standard deviation (SD) values. Cronbach's alpha reliability coefficient and Intra-Class Correlation Coefficient (ICC) were used to assess intra-observer and inter-observer agreement, as well as agreement between study models and CBCT measurements. Spearman's (ϱ) correlation coefficient was used to determine the correlation between the study models and CBCT measurements. The significance level was set at $P \leq 0.05$.

RESULTS

Intra-observer agreement

Table 1 shows the aggregate values of the Cronbach's alpha reliability coefficient and ICC derived from the first and second ratings of the three examiners. As regards study models measurements, there was very good intra-observer agreement regarding all measurements with Cronbach's alpha values ranging from 0.781 for incisors to 0.915 for premolars. As regards the total MHB score; there was also very good intra-observer agreement with Cronbach's alpha = 0.922.

Similarly, for CBCT measurements, there was very good intra-observer agreement regarding all measurements with Cronbach's alpha values ranging from 0.757 for molars to 0.952 for canines. As regards the total MHB score; there was also very good intra-observer agreement with Cronbach's alpha = 0.915.

TABLE (1): Results of Cronbach's alpha reliability coefficient and Intra-Class Correlation Coefficient (ICC) for intra-observer agreement regarding study models and CBCT measurements.

Tooth type	Study models		CBCT	
	Cronbach's alpha	ICC	Cronbach's alpha	ICC
Incisors	0.781	0.635	0.878	0.783
Canines	0.787	0.649	0.952	0.909
Premolars	0.915	0.843	0.931	0.871
Molars	0.805	0.673	0.757	0.683
Total score	0.922	0.856	0.915	0.843

Inter-observer agreement

The inter-observer agreement considered the average scores from each examiner over the two scoring occasions compared with the other examiners (Table 2).

TABLE (2): Results of Cronbach's alpha reliability coefficient and Inter-Class Correlation Coefficient (ICC) for inter-observer agreement regarding study models and CBCT measurements.

Tooth type	Study models		CBCT	
	Cronbach's alpha	ICC	Cronbach's alpha	ICC
Incisors	0.741	0.588	0.857	0.750
Canines	0.964	0.930	0.769	0.625
Premolars	0.957	0.918	0.940	0.886
Molars	0.918	0.848	0.808	0.677
Total score	0.953	0.910	0.933	0.875

As regards study models measurements, there was very good inter-observer agreement regarding all measurements with Cronbach's alpha values ranging from 0.741 for incisors to 0.964 for canines.

TABLE (3): Results of Spearman's (P) correlation coefficient and Cronbach's alpha reliability coefficient for correlation and agreement between study models and CBCT measurements

Tooth type	Study models		CBCT		Correlation coefficient (*P*)	*P*-value	Cronbach's alpha
	Mean	SD	Mean	SD			
Incisors	-2.59	0.68	-2.59	0.68	1	NC**	1
Canines	-1.61	0.57	-1.61	0.57	1	NC**	1
Premolars	-1.34	0.57	-1.33	0.57	0.965	<0.001*	0.987
Molars	-0.32	0.51	-0.32	0.51	1	NC**	1
Total score	-14.32	4.44	-14.36	4.49	0.991	<0.001*	0.998

: Significant at P ≤ 0.05, NC**: Not computed because the variable is constant

As regards the total MHB score; there was also very good inter-observer agreement with Cronbach's alpha = 0.953.

Similarly, for CBCT measurements, there was very good inter-observer agreement regarding all measurements with Cronbach's alpha values ranging from 0.769 for canines to 0.940 for premolars. As regards the total MHB score; there was also very good inter-observer agreement with Cronbach's alpha = 0.933.

Correlation and agreement between study models and CBCT measurements

Results from Spearman's (ϱ) and Cronbach's alpha reliability correlation coefficients are shown in Table 3. Scores of incisors and canines were the same regarding study models and CBCT measurements, so the correlation coefficient was (ϱ = 1) and there was perfect agreement between the two methods with Cronbach's alpha value = 1.

As regards premolar scores; there was statistically significant direct correlation between study models and CBCT measurements (ϱ = 0.965, *P*-value <0.001). There was very good agreement between the two methods with Cronbach's alpha value = 0.987.

Scores of molars were the same regarding study models and CBCT measurements, so the correlation coefficient was (ϱ = 1) and there was perfect agreement between the two methods with Cronbach's alpha value = 1.

As regards total score; there was statistically significant direct correlation between study models and CBCT measurements (ϱ = 0.991, *P*-value <0.001). There was very good agreement between the two methods with Cronbach's alpha value = 0.998.

DISCUSSION

The wide variation in the cleft care surgical standards including the surgical techniques, timing and number of surgeries, led to the introduction of different methods to assess the surgical treatment outcome in operated patients with CLP, aiming to follow up and improve the quality of care. These outcome measures include facial esthetics, nasal shape, the presence of fistula, and the amount of maxillary arch constriction.[14] Study models have been used as the standard method to assess the dental arch relationships using various scoring systems.[15] Unfavorable surgical outcome results in maxillary collapse and constriction[16], and therefore success or failure can be related to the dental arch relationships and the frequency with which crossbites occur. The MHB scoring system, which measures the frequency of crossbites of the dental occlusion to evaluate maxillary arch constriction, was found to be an objective and reliable method of assessment of

surgical outcome being more sensitive and versatile to inter-arch discrepancies.[7]

In the electronic era we are living now, there is a general move towards digital records. In Orthodontics this includes digital photography, radiography and study models. Cone Beam Computed tomography (CBCT) scans that are routinely ordered for every cleft patient to assess the skeletal and dental relationships as well as to evaluate the size and the volume of the alveolar and palatal defects, were thought to be used as a new 3D tool to assess the surgical outcome in cleft patients using the MHB scoring system.

Digital photographs have been used previously to assess dental arch relationships in patients with CLP, as considered to be a more economic and convenient approach. Previous cleft care studies [15,17-19] determined "Good" to "Very Good" levels of intra and inter-observer agreement for plaster models with photographs using the interpretation suggested by Altman.[20] Although the validity and reliability of the photography method proved to be good, yet, some difficulties were reported during assessing the overjet, particularly in borderline cases because the examiners were unable to assess the overjet in various directions.[18] Moreover, the information gained from the lingual view that is sometimes needed to ensure the correct AP relationship cannot be acquired from this method. On the other hand, no difficulties were mentioned by any of the three examiners in the scoring procedure using the cross-sectional cuts and the 3D models of the CBCT scans.

Intra-oral 3D scanning has been recently introduced as another digital method to assess dental arch relationships in patients with CLP. Like the CBCT scans, the 3D image of the intra-oral scans can be easily manipulated in all directions to give the correct score. Although it showed good reliability in cleft patients, however, it has some limitations. In addition to the cost of the scanner, it is difficult to achieve adequate soft tissue retraction that is needed throughout the whole scanning procedure for proper acquisition of the entire dentition and recording the bite, due to the stretching and scarring of the previously surgically operated lip and palate. [10] Moreover, it requires some degree of patient cooperation for a relatively long scanning time which represents a problem, specially with the anxiety present in most of the cleft patients. Yet, it was preferred by subjects with UCLP to dental impressions and was recommended as a reliable digital alternative for study models to the assess dental arch relationships in cleft patients.[9] Further studies can be carried to compare between the reliability of the two digital 3D methods: Intra-oral scans and CBCT scans.

CBCT scans have not been used before to assess dental arch relationships in cleft care. They proved to be valid and reliable as indicated by the perfect agreement with the study models, except in the premolar region which showed very good agreement, which might be explained by the buccal occlusion being less well defined in the mixed dentition (Table 3). The CBCT scans also showed very good intra and inter-observer reliability (Table 1 & 2). The examiners reported that the cross-sectional cuts obtained from the reconstructed panorama, together with the virtual 3D image of the study models, allowed them to determine the correct scoring as easy as the manual process of assessing the actual study models. It was reported to be a simple_and convenient method to assess the inter-arch relationships using the CBCT scans that are already available as a part of the patient's record, all of which can allow for easier inter-center comparisons which can improve the quality of care for cleft patients.

LIMITATIONS

Because of the issue of radiation exposure associated with the CBCT scans, this study does not recommend ordering a CBCT from each cleft patient just to assess the total maxillary arch constriction. However, it is recommended to be used as a reliable method whenever the CBCT is already available for

other diagnostic purposes. This will eliminate the burden of the dental impressions on cleft patients as well as the extra armamentarium and cost needed to take intra-oral scans.

CONCLUSION

CBCT scans provide a valid and reliable method to assess the total maxillary arch constriction in patients with UCLP using the MHB scoring system. Whenever they are available as a part of the patient's pre-treatment records, they can substitute the dental impressions and the study models, and therefore decrease the burden they represent to the cleft patients and their families.

ACKNOWLEDGEMENT

The author would like to thank Dr.Noha Ezzat Sabet for her valuable advices and comments, Dr. Marwah Salah and Dr. Sara El-Gawily for their kind help as examiners.

REFERENCES

1. Borçbakan C. An analysis of 1000 cases of cleft lip and palate in Turkey. Cleft Palate J. 1969;6(3):210-12.
2. Cobourne MT. The complex genetics of cleft lip and palate. Eur J Orthod. 2004;26(1):7-16.
3. Graber TM. A cephalometric analysis of the developmental pattern and facial morphology in cleft palate. Angle Orthod.1949;19:91-100.
4. Altalibi M, Saltaji H, Edwards R, Major P, Flores-Mir C. Indices to assess malocclusions in patients with cleft lip and palate. Eur J Orthod. 2013;35:772-82.
5. Huddart AG, Bodenham RS. The evaluation of arch form and occlusion in unilateral cleft palate subjects. Cleft Palate J. 1972;9:194-209.
6. Mossey PA, Clark JD, Gray D. Preliminary investigation of a modified Huddart/Budenham scoring system for assessment of maxillary arch constriction in unilateral cleft lip and palate subjects. Eur J Orthod. 2003;25:251-57.
7. Gray D, Mossey PA. Evaluation of a modified Huddart/ Bodenham scoring system for assessment of maxillary arch constriction in unilateral cleft lip and palate subjects. Eur J Orthod. 2005;27:507-11.
8. Kravitz ND, Growth C, Jones PE, Graham JW, Redmond WR. Intraoral digital scanners. J Clin Orthod. 2014;48:337-47.
9. Chalmers EV, McIntyre GT, Wang W, Gillgrass T, Martin CB, Mossey PA. Intraoral 3D scanning or dental impressions for the assessment of dental arch relationships in cleft care: Which is superior? Cleft Palate Craniofac J. 2016;53(5):568-77.
10. Grunheid T, McCarthy SD, Larson BE. Clinical use of direct chairside oral scanner: an assessment of accuracy, time, and patient acceptance. Am J Orthod Dentofacial Orthop. 2014;146:673-82.
11. Elabbassy EH. The use of cone-beam computed tomography (CBCT) for orthodontic elaborate;on of Egyptian cleft lip and palate patients (master's thesis). Cairo, Egypt: Ain Shams University; 2012
12. Hatcher DC. Three-dimensional dental imaging. In: McNamara JA, Kapila SD, editors. Digital radiography and three-dimensional imaging. Monograph 43. Craniofacial Growth Series. Ann Arbor: Center for Human Growth and Development; University of Michigan 2006. p.1-22.
13. Zaky AM. Comparison between dental arch measurements on conventional plaster models and cone-beam computed tomography imaging system. (Master's thesis). Cairo, Egypt: Ain Shams University; 2012.
14. Shaw WC. Intercentre clinical audit for cleft lip and palate- a preliminary European investigation. In: Jackson IT, Sommerland BC (eds) Recent advances in plastic surgery. Churchill Livingston, Edinburgh. 1992:1-29.
15. Ali SA, Mossey P, Gillgrass T. A study model based photographic method for assessment of surgical treatment outcome in unilateral cleft lip and palate patients. Eur J Orthod. 2006;28:366-72.
16. Semb G. A study of facial growth in patients with unilateral cleft lip and palate treated by Oslo cleft team. Cleft Palate Craniofac J. 1991;28(1):1-21.
17. Nollet PJ, Katsaros C, van't Hof MA, Semb G, Shaw WC, Kuijpers-Jagtman AM. Treatment outcome after two-stage palatal closure in unilateral cleft lip and palate: a comparison with Eurocleft..Cleft Palate Craniofac J. 2005;42:512-16.
18. Liao YF, Huang CS, Lin IF. Intraoral photographs for rating dental arch relationships in unilateral cleft lip and palate. Cleft Palate Craniofac J. 2009;46:415-19.
19. McAuliffe NJ, Jones AP, Cumberbirch VC, Russell JI. The use of the 5-years-old' index: comparison between study models and intra-oral photographs. Cleft Palate Craniofac J. 2010;48:526-31.
20. Altman DG. Practical statistics for medical research. Chapman and Hall, London.1991.