# Study Regarding the Applications of Imaging Technology in Cranial Base Morphology in Angle Class II Division 1 and 2 Malocclusions

**RONEN BOIANGIU[1], ANGELICA BENCZE[1]*, ELINA TEODORESCU[1], STEFAN MILICESCU JR.[2], VIORICA TARMURE[3], MARIANA PACURAR[4], ECATERINA IONESCU[1]**

[1] Carol Davila University of Medicine and Pharmacy, Faculty of Dental Medicine, Department of Orthodontics and Dentofacial Othopedics, 37 Dionisie Lupu Str.,020021, Bucharest, Romania

[2] Carol Davila University of Medicine and Pharmacy, Faculty of Dental Medicine, Department of Fixed Prosthodontics, 37 Dionisie Lupu Str., 020021, Bucharest, Romania

[3] Iuliu Haieganu University of Medicine and Pharmacy, Faculty of Dental Medicine, Department of Orthodontics, 8 Victor Babes Str., 400012,Cluj Napoca, Romania

[4] Iuliu Haieganu University of Medicine and Pharmacy, Faculty of Dental Medicine, Department of Dentofacial Orthopedics, 38 Gh. Marinescu Str., 540139 Tirgu Mures, Romania

*The aim of the research is to investigate the characteristics of cranial base morphology in class II division 1 and class II division 2 malocclusions. The study group consisted of 40 patients aged 11 years treated at the Orthodontic Department of "Carol Davila" University. Both gender and both malocclusion types were equally represented. Lateral cephalograms were traced and 22 linear and angular cephalometric parameters were calculated: four parameters for the cranial base (N-S-Ba, N-Op-Ba angles, N-S, S-Ba lengths) and 18 parameters for the maxillofacial complex Nsa-Nsp, Go-Gn, Kdl-Go, S-Nsp, N-Nsa, Nsa-Gn, N-Gn, Nsp-Go, SNA angle, ANB angle, SN – NsaNsp angle, SN-GoGn angle, N-Nsa-Gn angle, S-Nsp-Go angle, N-Nsa-Pg angle, gonial angle, FMA angle, NsaNsp – GoGn. Statistical significant differences between cranial base parameters in the two malocclusions groups were depicted, in particular for feminine gender. Regardless of gender, the sphenoidal angle values were mainly increased in both malocclusion groups, when compared to normal population values. The S-Ba lengths were decreased in both malocclusion groups, regardless of gender. More significant alterations of cranial base morphology were depicted in patients with Class II Division 2 malocclusions then in patients with Class II Division 1 malocclusion. The study's results sustain the existence of some cranial base alterations in Class II malocclusions.*

*Keywords: cranial base morphology, lateral cephalograms, cephalometric parameters, Class II Division 1 malocclusion, Class II Division 2 malocclusion*

The dental radiography nowadays is an indispensable exam in order to obtain a correct diagnosis [1,2].

Previous published studies demonstrated correlations between cranial base configuration and facial morphology in different types of malocclusions. Enlow [3] stated that quantitative and qualitative evolution of the skull base directly affects the position of the jaw bases. He demonstrated that increasing the skull base flexion (reducing the angle formed between the anterior and middle cranial fossa) determines most anterior mandibular positioning, so the trend of development towards Class III Angle malocclusions. Conversely, reducing the skull base flexion would facilitate posterior mandibular positioning and evolution trend towards Class II Angle malocclusions. The results published by Anderson and Popovich [4] argue that in Class II Angle malocclusions mandibular angle values correlate mainly with angular parameters of the skull base and large cranial base angles were associated with Class II malocclusions. The study published by Renfroe [5] found no correlation between the cranial base angle and Angle's Class I or Class II malocclusions. In 1983, Firu [6] advocated that alterations in the skull base ossification lead to changes in maxillary and mandible dimensions and positions. In view of the conflicting bibliographical results [7], a retrospective study was conducted to further explore the characteristics of cranial base morphology in Class II division 1 and Class II division 2 malocclusions.

The main purpose of this study was to investigate, in a cross-sectional sample, whether the cranial base morphology, as illustrated on lateral cephalometric radiographs, shows modifications in Class II malocclusions.

## Experimental part

*Materials and methods*

This study targeted the Class II skeletal jaw relationships and it aimed to investigate cranial base characteristics in Division 1 and Division 2 malocclusions. To achieve these goals, a group of 40 patients aged 11 years, treated at the Bucharest University Orthodontic Department, was selected. The sample consisted of 20 patients with Class II Division 1 malocclusions and 20 patients with Class II Division 2 malocclusions. All patients were 11 years old, both genders being equally represented.

Patients presented skeletal Class II jaw relationship and dental Class II malocclusions [8]. Class II Division 1 patients presented maxillary incisors protrusion. From the study were excluded subjects with genetic syndromes and metabolic diseases. The patients' legal guardians expressed their informed consent regarding the study. Among orthodontic records, required prior to orthodontic treatment, each patient effectuates cephalometric radiograph. The cephalometric records were collected and analyzed.

From each radiograph, 14 landmarks were retained: Nasion (N), Sella (S), Basion (Ba), Opisthion (Op), Anterior Nasal Spine (Nsa), Posterior Nasal Spine (Nsp), Down's A point (A), Down's B point (B), Pogonion (Pg), Gnathion (Gn), Orbitale (Or), Porion (Po), Gonion (Go), Condylion

** email: dr_abencze@yahoo.com; Phone: +40213147710* *All authors contributed equally*

(Kdl). These cephalometric points are exemplified on figure 1.

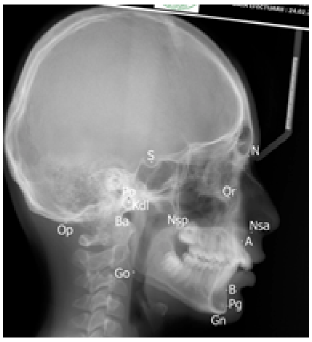


Fig. 1. The cephalometric landmarks recorded for the study, exemplified on the radiograph of male patient D.P., 11 years, 4 month old, Class II Division 1 malocclusion

From these cephalometric points, 22 linear and angular cephalometric parameters were calculated (4 for cranial base and 18 for maxillofacial complex):

-Cranial base angles: N-S-Ba, N-Op-Ba angles;
-Cranial base lengths: N-S, S-Ba;
-Jaw lengths: Nsa-Nsp, Go-Gn, Kdl-Go;
-Facial heights: S-Nsp, N-Nsa, Nsa-Gn, N-Gn, Nsp-Go;
-Jaw positions: SNA, ANB angles;
-Maxillofacial angles: Sella Nasion to Palatal Plane angle (SN – NsaNsp), Sella Nasion to Mandibular Plane angle (SN-GoGn), convexity angles (N-Nsa-Gn, S-Nsp-Go, N-Nsa-Pg), gonial angle, FMA angle, Palatal Plane to Mandibular Plane angle (NsaNsp - GoGn).

Descriptive statistical analysis was performed. The mean and standard deviations were estimated for each cephalometric variable in each group.

The error of the method (EM) was assessed according to the Dahlberg formula (1940, quoted by [11]:

$$EM = \sqrt{\frac{\Sigma d^2}{2N}},$$

where *d* is the difference between two measurements, and N is the number of variables.

Using the cephalometric mean values, graphical representations of craniofacial skeleton pattern were computed for each gender and type of malocclusion.

All collected data were stored in tables, created in Excel Word. The statistical analysis was performed with the PSPP free statistical package. The group variable means were compared with normal population values (as stated by [9]) and comparison between groups was realized with an independent t-test. The Pearson correlation parametric test was used to explore statistical correlations between cranial base parameters values and maxillofacial parameters values. The minimum probability level for accepting significance between the means was set at 5% [12].

In figure 2 are presented the graphical cephalometric representation for feminine gender in Class II Division 1 malocclusions (a) and in Class II Division 2 malocclusions (b). The blue segments represent parameters with decreased average values compared to population norms [11].

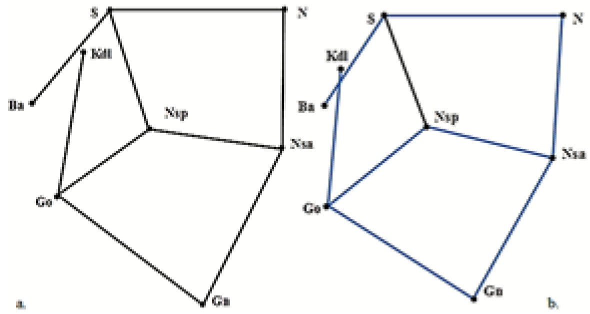


Fig. 2. Graphical cephalometric representation for feminine gender: (a) in Class II Division 1 malocclusions and (b) in Class II Division 2 malocclusions

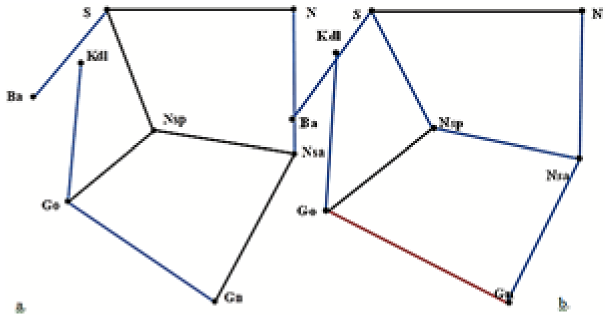


Fig. 3. Graphical cephalometric representation for masculine gender: (a) in Class II Division 1 malocclusions and (b) in Class II Division 2 malocclusions

In figure 3 is presented the graphical cephalometric representation for masculine gender: in Class II Division 1 malocclusions (a) and in Class II Division 2 malocclusions (b). The blue segments represent parameters with decreased average values; the red segment represents parameter with increased average values compared to population norms [11].

## Results and discussions

Comparing the cranial base parameters for feminine gender, we noticed that patients with Class II Division 1 malocclusions presented normal average parameters values, except for the increasing cranial base flexure angle (N-S-Ba). The Class II Division 2 malocclusions group was characterized with normal sphenoidal angles, but decreased cranial base lengths and N-O-Ba angle values (table 1).

For masculine gender, more alterations of cranial base morphology were depicted: in Class II Division 1 malocclusions group the sphenoidal angle increases with reduced N-O-Ba angular values and reduced S-Ba length. In Class II Division 2 malocclusion both cranial base angular values were increased and S-Ba length decreased (table 2).

The differences between genders regarding sphenoidal angle values were not statistically significant in both

**Table 1**

CRANIAL BASE PARAMETERS VALUES FOR FEMININE GENDER (BOLD-ITALIC – MEAN VALUES ABOVE THE NORMAL POPULATION MEANS, BOLD – MEAN VALUES UNDER THE NORMAL POPULATION MEANS, [11]; * - STATISTICAL SIGNIFICANT DIFFERENCES – ONE SAMPLE T TEST

| Variable | Class II, Division 1 | | | | Class II, Division 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Min. | Max. | Mean | SD | Min. | Max. |
| ∡ N-S-Ba (°) | ***132.39****(p=0.026) | 5.13 | 124.0 | 138.0 | 126.63 | 3.10 | 124.0 | 131.5 |
| ∡ N-Op-Ba (°) | 18.67 | 4.57 | 11.0 | 27.0 | **12.0** *(p < 0.001) | 1.31 | 10.0 | 13.0 |
| S-Ba (mm) | 42.44 | 3.84 | 38.5 | 49.0 | **37.88** *(p < 0.001) | 1.66 | 35.5 | 39.5 |
| S-N (mm) | 65.56 | 5.38 | 60.0 | 76.0 | **62.38** *(p = 0.009) | 3.51 | 57.0 | 65.5 |

malocclusions groups. The values of N-Op-Ba angles, S-Ba lengths were significantly higher for male patients then for female patients in Class II Division 2 malocclusions group (p=0.004, respectively p= 0.001, one sample t test). The values of S-N lengths were significantly higher for all male patients then for female patients (p=0.007, one sample t test).

The maxillofacial development of female patients presented specific characteristics:

-in Class II Division 1 malocclusion group - normal average linear parameters values, reduced facial convexity angle values, and the following parameters were increased: ANB angles, Sella Nasion to mandibular plane angles, palatal plane to mandibular plane angles, FMA angles;

-in Class II Division 2 malocclusion group – reduced average linear parameters values (except for S-Nsp), reduced facial posterior convexity angles, increased ANB angles, palatal plane to mandibular plane angles.

For masculine gender, the results of the study demonstrated:

-in Class II Division 1 malocclusion group – decreasing of some linear parameter values (mandibular lengths Go-Gn, KDL-Go, facial heights N-Nsa, N-Gn), decreased facial convexity angles, increased SNA and ANB angles;

-in Class II Division 2 malocclusion group – reduced linear parameter values (except for normal posterior facial height Nsp –Go and increasing of Go-Gn length), reduced Sella Nasion to mandibular plane angles, facial convexity angles, FMA angles, increased ANB angles values.

Graphical representations of cranial skeleton (3/4 ratio) in the two malocclusion groups are illustrated in figure 2 for feminine gender and in figure 3 for masculine gender.

Applying the Pearson correlation test over all cephalometric recorded values, we found a positive correlation, statistically significant, between cranial base lengths (N-S and S-Ba) in both malocclusions groups: r = 0.32* (p = 0.024) in Class II Division 1 malocclusions group; r = 0.66* (p < 0.001) in Class II Division 2 malocclusions group.

Regarding correlations between cranial base parameters and maxillofacial ones, the most significant results are presented in table 3 for Class II Division 1 malocclusions and in table 4 for Class II Division 2 malocclusions.

Statistical significant differences between cranial base parameters in the two malocclusions groups were depicted:

-sphenoidal angle values were in average with 5.76° larger in female patients with Class II Division 1 malocclusions then in female patients with Class II Division 2 malocclusions (p=0.015, one sample t test);

-N-Op-Ba angle values were in average with 6.67° narrower in female patients with Class II Division 2 malocclusions then in female patients with Class II Division 1 malocclusions (p=0.001, one sample t test);

-S-Ba lengths were in average with 4.57 mm reduced in female patients with Class II Division 2 malocclusions then in female patients with Class II Division 1 malocclusions (p=0.007, one sample t test).

Our results showed:

-A tendency of increased sphenoidal angles in both malocclusion groups, regardless of gender, compared to normal population values. This result is similar with the conclusions of Anderson and Popovich [4]. Other studies [13,14] failed to demonstrate any differences in cranial base flexure in Class II division 1 malocclusion compared to Class I malocclusions.

-A tendency of reduced S-Ba lengths in both malocclusion groups, regardless of gender. Other cephalometric studies have reported elongation for the posterior cranial base for Class II patients: Salehi and Danaie 2006 [15]; Behbehania et al. 2006 [16].

-More significant alterations of cranial base morphology in patients with Class II Division 2 malocclusions then in patients with Class II Division 1 malocclusion. This result can be due to malocclusion's etiology, mostly hereditary for the first group [17].

In both Class II malocclusions groups the investigated linear maxillary parameters showed positive, statistically significant, correlations with one or both cranial base lengths. Regarding angular maxillary parameters, mandibular plane angles were positively correlated with cranial base angular values in Class II Division 1 malocclusions group. This result partially agrees with data published by Anderson and Popovich [4].

The anterior facial convexity angle (N-Nsa-Gn) is positively correlated with S-N length in Class II Division 1 group and negatively correlated with both cranial base lengths in Class II Division 2 group. The SNA angle values were negatively correlated with S-N length in both malocclusion groups and with sphenoidal angle in Class II Division 2 malocclusion group. The ANB angle values showed negative correlation with sphenoidal angle values in Class II Division 2 malocclusion group.

Errors were comparable to other cephalometric studies [10].

The negative moderate correlation between cranial base angle (N-S-Ba) and SNA in Class II Division 2 malocclusion group was similar to the results reported by other studies [18-20]. This result suggests that as the cranial base angle reduces, the maxilla tends to protrude, and angle SNA increases. The values of ANB angles were also negatively correlated with the values of sphenoidal angles, in contradiction with other studies results, which advocated a positive correlation between these two angular values: Kerr and Adams 1988 [21]; Agrawal et al. 2014 [13].

The correlation analysis suggests a relationship between maxillofacial linear parameters and cranial base linear parameters for both malocclusion groups, and a relationship between mandibular position and the magnitude of cranial

**Table 2**

CRANIAL BASE PARAMETERS VALUES FOR MASCULINE GENDER (BOLD-ITALIC – MEAN VALUES ABOVE THE NORMAL POPULATION MEANS, BOLD – MEAN VALUES UNDER THE NORMAL POPULATION MEANS, [11]; * - STATISTICAL SIGNIFICANT DIFFERENCES – ONE SAMPLE T TEST

| Variable | Class II, Division 1 | | | | Class II, Division 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Min. | Max. | Mean | SD | Min. | Max. |
| ∡ N-S-Ba (°) | ***132.7*** *(p < 0.001) | 2.05 | 130.0 | 135.0 | **128.0** | 4.73 | 122.0 | 132.0 |
| ∡ N-Op-Ba (°) | **14.2** | 4.82 | 8.0 | 18.0 | **19.5** | 7.52 | 13.0 | 29.0 |
| S-Ba (mm) | **40.10** *(p = 0.003) | 2.04 | 36.5 | 41.5 | ***42.0*** | 5.59 | 35.0 | 47.0 |
| S-N (mm) | 68.4 | 5.03 | 62.0 | 76.0 | 70.0 | 4.47 | 65.0 | 75.0 |

| Variable | | ∡ N-S-Ba | ∡ N-Op-Ba | S-Ba | S-N |
|---|---|---|---|---|---|
| Nsa-Nsp | r | 0.15 | -0.11 | 0.51 * | 0.58 * |
| | p | n.s. | n.s. | <0.001 | <0.001 |
| Go-Gn | r | -0.03 | -0.01 | 0.51 * | 0.52 * |
| | p | n.s. | n.s. | <0.001 | <0.001 |
| S-Nsp | r | -0.3 * | -0.02 | 0.70 * | 0.38 * |
| | p | 0.032 | n.s. | <0.001 | 0.06 |
| N-Gn | r | 0 | 0.26 | 0.64 * | 0.41 * |
| | p | n.s. | n.s. | <0.001 | 0.003 |
| Nsp-Go | r | -0.13 | 0.07 | 0.45 * | 0.45 * |
| | p | n.s. | n.s. | 0.001 | 0.004 |
| Kdl-Go | r | -0.24 | -0.05 | 0.56 * | 0.40 * |
| | p | n.s. | n.s. | <0.001 | 0.004 |
| ∠ SN-GoGn | r | 0.37 * | 0.32 * | -0.10 | -0.33 * |
| | p | 0.008 | 0.025 | n.s. | 0.002 |
| ∠ N-Nsa-Gn | r | -0.11 | -0.16 | -0.02 | 0.44 * |
| | p | n.s. | n.s. | n.s. | 0.002 |
| ∠ SNA | r | -0.24 | -0.32 | 0.12 | -0.40 * |
| | p | n.s. | n.s. | n.s. | 0.004 |
| ∠ ANB | r | 0.18 | 0.06 | 0.01 | -0.09 |
| | p | n.s. | n.s. | n.s. | n.s. |
| ∠ FMA | r | 0.32 * | 0.28 * | 0.06 | -0.46 * |
| | p | 0.026 | 0.045 | n.s. | 0.001 |
| ∠ NsaNsp-GoGn | r | 0.22 | 0.24 | -0.08 | -0.29 * |
| | p | n.s. | n.s. | n.s. | 0.039 |

**Table 3**
MOST IMPORTANT CORRELATION COEFFICIENTS IN CLASS II DIVISION 1 GROUP (* = STATISTICALLY SIGNIFICANT RESULT, N.S. = NOT SIGNIFICANT)

| Variable | | ∡ N-S-Ba | ∡ N-Op-Ba | S-Ba | S-N |
|---|---|---|---|---|---|
| Nsa-Nsp | r | 0.05 | 0.47 * | 0.62 * | 0.50 * |
| | p | n.s. | 0.001 | <0.001 | <0.001 |
| Go-Gn | r | 0.20 | 0.16 | 0.41 * | 0.50 * |
| | p | n.s. | n.s. | 0.003 | <0.001 |
| S-Nsp | r | -0.42 * | 0.36 * | 0.62 * | 0.52 * |
| | p | 0.002 | 0.011 | <0.001 | <0.001 |
| N-Gn | r | -0.23 | 0.57 * | 0.77 * | 0.58 * |
| | p | n.s. | <0.001 | <0.001 | <0.001 |
| Nsp-Go | r | 0.10 | 0.21 | 0.41 * | 0.51 * |
| | p | n.s. | n.s. | 0.003 | <0.001 |
| Kdl-Go | r | -0.15 | 0.21 | 0.23 | 0.58 * |
| | p | n.s. | n.s. | n.s. | <0.001 |
| ∠ SN-GoGn | r | 0.15 | 0.14 | -0.13 | -0.22 |
| | p | n.s. | n.s. | n.s. | n.s. |
| ∠ N-Nsa-Gn | r | 0.10 | -0.64 * | -0.43 * | -0.46 * |
| | p | n.s. | <0.001 | 0.002 | 0.001 |
| ∠ SNA | r | -0.61 * | -0.18 | -0.16 | -0.45 * |
| | p | <0.001 | n.s. | n.s. | 0.001 |
| ∠ ANB | r | -0.34 * | 0.20 | -0.15 | -0.24 |
| | p | 0.015 | n.s. | n.s. | n.s. |
| ∠ FMA | r | -0.01 | 0.08 | 0.1 | -0.38 * |
| | p | n.s. | n.s. | n.s. | 0.007 |
| ∠ NsaNsp-GoGn | r | 0.05 | 0.09 | -0.09 | -0.31 * |
| | p | n.s. | n.s. | n.s. | 0.030 |

**Table 4**
MOST IMPORTANT CORRELATION COEFFICIENTS IN CLASS II DIVISION 2 GROUP (* = STATISTICALLY SIGNIFICANT RESULT, N.S. = NOT SIGNIFICANT)

base flexure in Class II Division 2 malocclusion group. In both malocclusion groups, little correlation was evident between ANB angle values and cranial base parameters. Dhopatkar et all. [22], appreciate that cranial base angle alone does not appear to play an important part in the malocclusion's etiology. Errors were comparable to other cephalometric studies [10].

In the Class II Division 1 malocclusion group, the values of sphenoidal angle presented a moderated positive correlation with the values of the mandibular plane angles (SN GoGn angle, Tweed angle). This finding is in agreement with those of Klocke et al. [23]. The described correlations suggest that increase in the cranial base flexure can cause a clockwise rotation of the mandible.

The values of sphenoidal angle N-S-Ba presented no statistically significant differences between genders; this result agrees with previous studies [24-26], while in general, the linear measurements of the cranial base were found larger in males than females, and this was also in agreement with previous studies [27].

## Conclusions

Some results of our study correlate with previously published articles, and others present contradictory data. The differences between the results of this study and other studies may be attributed to the differences in the case selection procedure.

It is difficult to include in clinical studies all possible factors that influence the occurrence of a malocclusion. The results of the study suggest that the opening of the cranial base flexure can result in a skeletal Class II jaw relationship.

The negative correlation between cranial base angle (N-S-Ba) and SNA in Class II Division 2 malocclusions suggests the influence of the cranial base on the position of the maxilla.

For female patients, the values of sphenoidal angles, N-Op-Ba angles and S-Ba lengths registered in Class II Division 1 malocclusions group were significantly higher than those registered in Class II Division 2 malocclusions group.

No statistical significant differences were depicted for male gender between the two malocclusions group.

Further studies are required to explore these discrepancies.

Acknowledgment: All authors contributed equally in the elaboration of the study

## References

1.STANA AH, STANA GAG OL, CIOBANU G, PORUMB A, CIOBAN CG, POPOVICI RA, MOGA A, Rev. Chim.(Bucharest), **68**, no.5, 2017, p. 1130

2.BALAN G, PELIN AM, MACOVEI LA, PLESEA CONDRATOVICI A, PLESEA CONDRATOVICI C, BUSILA C, Rev. Chim.(Bucharest), **68**, no. 3, 2017, p. 608

3.ENLOW DH. Facial Growth. 3rd edition. Philadelphia: Saunder, 1990

4.ANDERSON D, POPOVICH F. Am J Phys Anthropol, 1983; 61:181-187

5.RENFROE EW. Angle Orthod, 1948;18:12-15

6.FIRU P. Bucureþti: Ed. Didactica si Pedagogica, 1983

7.POLAT Ö, KAYA B. Orthod Craniofacial Res, 2007; 10:216-221

8.JONES ML, OLIVER RG. W&H orthodontic notes. 6th edition, Oxford: Wright, 2000

9.JACOBSON A, JACOBSON RL. Radiographic Cephalometry. Chicago: Quintessence Publishing Co, 2006

10.GRAVELY JF, BENZIES PM. Br J Orthod, 1974; 1:95-101

11.MILICESCU V, DUDUCA-MILICESCU I. Bucuresti: Ed. Viaþa Medicala Româneascã, 2001: 136-141

12.BeGOLE E. In: VANARSDALL RL, VIG KWL, GRABER TM. Current Principles and Techniques. (4th edition). St. Louis: Elsevier, Mosby, 2005: 391-405

13.AGRAWAL A, PANDEY H, BAJAJ K, PANDEY L. J Int Oral Health, 2013; 5(1):39-42

14.WILHELM BM, BECK FM, LIDRAL AC, VIG KW. Am J Orthod Dentofac Orthop, 2001; 119(4):401-405

15.SALEHI P, DANAIE MSh. J Dent, 2006; 3:92-99

16.BEHBEHANIA F, HICKSB EP, BEEMANC C, KLUEMPERD GT, RAYENSE MK. Angle Orthod, 2006; 76:406-411

17.BOBOC G. Bucuresti: Ed. Didacticã, 1974

18.HOPKIN GB, HOUSTON WJ, JAMES GA. Angle Orthod, 1968; 38:250-255

19.FATEHULLA KS. College of Dentistry, University of Sulaimania, 2009

20.KASAI K, MORO T, KANAZAWA E, IWASAWA T. Eur J Orthod, 1995; 17(5):403-410

21.KERR WJ, ADAMS CP. Am J Phys, 1988; 77:213-220

22.DHOPATKAR A, BHATIA S, ROCK P. Angle Orthod, 2002; 72(5):456-463

23.KLOCKE A, NANDA RS, KAHL NIEKE B. Am J Orthod Dentofacial Orthop, 2002; 122:386-391

24.ROTHSTEIN T, YOON-TARLIE C. Am J Orthod Dentofac Orthop, 2000; 117(3):320-332

25.FREITAS MR, SANTOS MA, FREITAS KM, JANSON G, FREITAS DS, HENRIQUES JF. J Appl Oral Sci, 2005; 13(2):198-203

26.OBAIDI HA. Al-Rafidain Dent J, 2007; 7(1):6-13

27.YASSIR AY. J Bagh Coll Dentistry, 2008; 20(2):88-92

Manuscript received: 15.02.2017