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Length and depth of the hard palatine and its relationship with facial growth type in adolescents (CBCT Scan Study).

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□ ABSTRACT □

It is generally agreed that growth in palatine results from bone formation at the palatine sutures and lengthening of the alveolar processes, but the extent to which these two sites contribute to the depth and length of the hard palate remains unsolved. Hence, professionals should use quantitative assessments of the hard palate, which allow more accuracy in the diagnosis and assessment of this structure.

Aim investigating the relationship between the length and depth of the skeletal hard palatine with facial growth type in adult subjects using CBCT scan.

Materials and methods: 20 Caucasian patients (8 males, 12 females) from 18 to 23 years of age, (mean age of 22.13 years), were chosen from pretreatment patients undergoing orthodontic evaluation at the Department of Orthodontics and Dentofacial Orthopedics at Tishreen University. They were ordinarily undergoing CBCT scan for non-orthodontics and not for otolaryngology purpose. Cephalometric growth study was performed according to Jarabak. *Pearson's Correlation Coefficient* was calculated to investigate the relation between the hard palatine length and depth with facial growth type.

Results: The studied CBCT hard palatine measurements have no statistical significance between the two genders; CBCT hard palatine length and depth have no relationship with facial type growth.

Conclusion: Palatine depth and length do not seem to obey any specific growth type.

Key Words: Length and depth of the skeletal hard palatine, Facial growth cephalometric evaluating by Jarabak, Hard palatine CBCT.

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دراسة بواسطة الطبقي المحوري المحوسب لطول وعمق قبة الحنك الصلب وعلاقتهما مع نموذج النمو الوجهي لدى البالغين(دراسة بواسطة الطبقي المحوري المخروطي)

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□ ملخّص □

من المعلوم إنه نمو الحنك عموماً هو نتيجة للتشكل العظمي للدروز الحنكية وتطاول النتوءات السنخية، إلا إنه من غير المعروف بدقة مدى العلاقة المتبادلة ما بين عمليتي النمو هاتين، وبين عمق وطول قبة الحنك الصلب، من هنا فإنه يتوجب على الإختصاصيين اللجوء إلى تقييم قبة الحنك الصلب قابل للقياس مما يسمح بوضع تشخيص أكثر دقة ويساعد الممارس في تقييم أفضل لهذه البنية التشريحية.

هدف البحث: دراسة العلاقة بين طول وعمق قبة الحنك الصلب مع النمو الوجهي وذلك لدى أفراد من البالغين باستخدام التصوير الطبقي المخروطي.

مواد وطرق البحث: أفراد العينة 20 بالغ من العرق قوقازي (8 ذكور،12 أنثى) بعمر ما بين 18 إلى 23 (متوسط العمر 22.13 سنة) من مراجعي قسم تقويم الأسنان والفكين بكلية طب الأسنان بجامعة ولم يخضعوا لمعالجة تقويمية سابقة حيث تم انتقائهم من مرضى كانوا تلقائياً بصدد إجراء تصوير طبقي محوري مخروطي لأسباب لا تتعلق بمشاكل تقويمية أو بأمراض الأنف والأذن والحنجرة، تم إجراء دراسة سيفالومترية للنمو الوجهي وفق جاراباك، ومن ثم تحليل معامل ارتباط بيرسون لدراسة العلاقة بين طول وعمق قبة الحنك الصلب مع النمو الوجهي مع القياسات السيفالومترية المحددة للنمو الوجهي حسب جاراباك.

النتائج: لا توجد فروقات ذات دلالة إحصائية في قياسات الطبقي المحوري المخروطي لقبة الحنك الصلب المدروسة بين الجنسين في العينة المدروسة، طول وعمق قبة الحنك الصلب لا يمتلكان علاقة ذات دلالة إحصائية مع النماذج النمو الوجهي.

الخلاصة: كلا من طول وعمق قبة الحنك الصلب لا يرتبطان مع نموذج نمو وجهي محدد.

الكلمات المفتاحية: طول وعمق قبة الحنك الصلب، نمو وجهي محدد حسب جاراباك، تصوير طبقي محوري مخروطي لقبة الحنك الصلب.

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Introduction:

Mouth Cavity Proper roofed in by the hard and soft palates, while the greater part of the floor is formed by the tongue. Hard Palatine (Hard Palate) is the anterior vaulted (concave) part; this space is filled with the tongue when it is at rest. Hard palatine (covered by a mucous membrane) is formed by the palatine processes of the maxillae and the horizontal plates of the palatine bones. The suture between the maxillae and palatine bones is Transverse Palatine Suture. The suture between the maxillae on the palate is the Median Palatine Suture. Median Palatine Suture is a linear raphe covered by a dense structure, formed by the periosteum and mucous membrane of the mouth, which are intimately adherent [1].

It is generally agreed that growth in palatine height and width results from bone formation at the palatine sutures and lengthening of the alveolar processes, but the extent to which these two sites contribute to the depth and breadth of the palate remains unsolved [2].The palate is sometimes subject to morphologic variations that may be the result of pathologic conditions [3], studies regarding palatal height and width assessment have focused on craniofacial syndromes [4 - 6]

The development of hard palatine and occlusion should be considered also as a result of interactions between the genetically defined factors of development and external and internal environmental factors, including orofacial function [7 - 11]. However, if the hard palate is morphologically altered, the functions and resting position depending on this structure may have been adapted. In view of this, the careful anatomical examination is indispensable. Hence, professionals should use quantitative assessments of the hard palate, which allows more accuracy in the diagnosis and assists the clinician in the assessment of this structure [12]. Furthermore, it is well known that morphologic variations of hard palate may be as a result of malocclusion and different facial types [13]. Patient's face growth type is important for orthodontic diagnosis and treatment factor, since certain procedures performed during the orthodontic treatment may attenuate or accentuate facial morphology, and it is extremely important to respect the facial growth type of the patient in adjusting orthodontic treatment mechanics, thus drawing a prognosis and, consequently, obtain a greater control of the outcome [14 - 23].

Korkhaus suggested that evaluating subsequent development of the roof of the palate could be recognized on any good model of the upper arch [24], several studies regarding palatal dimension used models of upper arch.[13, 24 -26]. Clinical examination, panoramic and cephalometric radiographs have limitations when assessing the amount of bone tissue in the palate [27]. More advance method of diagnosis such as CT and CBCT Scan can provide more accurate evaluating of the skeletal hard palatine because of the thickness of the palatine mucosa which decreased from lateral to median and from anterior to posterior regions [28]. Besides, the thickness of the palatine bone itself is not equal, palatine thinned progressively from anterior to posterior and from medial to lateral [29].

Study Objectives

The aim of this study is to investigate the relationship between the length and depth of the skeletal hard palatine with facial growth type in adult subjects using CBCT scan.

MATERIALS AND METHODS

-Subjects.

Sample's subjects were selected from patients who were ordinary undergoing CBCT scan for non-orthodontics nor for otolaryngology purpose.

The criteria for selecting the subjects were taken as follows:

1)No history of speech-language pathology and/or orthodontic and/or orthopedic treatment

2) patient with tongue thrust, upper respiratory tract infections, mouth breathing, and snoring were excluded.

3)No history of trauma to the dento-facial structures.

4)Each subject must have fully erupted permanent dentition up to second molar tooth.

5)No supernumerary tooth / supplementary tooth / missing tooth / impacted tooth.

6)Exclusion criteria were subjects with congenital anomalies/ evident signs of neurological impairment and/or syndromes and/or dentoskeletal asymmetries and/or craniofacial malformation.

To exclude patient upper respiratory tract infections, mouth breathing, and snoring, patients were examined by one and the same otolaryngologist.

Sample estimation

To determine the minimum sample size to be statistically significant, a pilot study was realized on 20 subject (who were selected according to the criteria of selecting this study`s sample). It has been found that descriptive statistics results follow the normal distribution; therefore, determining the minimum sample size to be statistically significant was according to the following formula:

$$n = \frac{Z^2.\sigma^2}{(e)^2}$$

(N): is the sample size ;.(z): is the value corresponding to a confidence level, estimated at 99% (Z = 2.58) (i.e. significance level is 0.019), (σ): highest Standard Deviation value within the all the variables (σ = 7.25)

(e): Margin of error (maximum acceptable error in mean estimate) (e=5)

Thus:

$$n = \frac{(2.58)^2(7.25)^2}{5^2} \approx 13.6$$

According to this pilot study, we determined that to get an exact estimate about the mean of patients' results, and the error in his estimate does not exceed 5 of the mean, with a significance level of 99% requires a sample size (n) of 13.6 patients as minimum.

The size of this study's sample was 20 Caucasian patients (8 males, 12 females) from 18 to 23 years of age, (mean age of 22.13 years: Males average age was 20.1; Females average age was 22.4) with no history of prior orthodontics treatment

- *CBCT study:*

Data were obtained using a 3D cone-beam volume scanner (i-CAT Cone Beam 3-D Imaging System, PA.). The following settings were used:

- 30 cm field of view (in the coronal plane).
- 120 kV.
- 47mA.
- Exposure time 30 s.
- slice thickness 0.5 mm.

Orientation was established (as was recommended by Baratieri [30] and Alves [31]) by three reference planes: 1- the axial plane, passing through the right and left Orbitale

points as well as the right and left Porion accordingly; 2- the coronal plane, passing through the left and right Porion perpendicular to the chosen axial plane; 3- the sagittal plane, passing through the Nasion point, perpendicular to the chosen axial and coronal planes.

CBCT hard palatine measurements:

All CBCT hard palatine measurements are liner and they were performed by one and the same author (in mm) digitally using the CBCT software, CBCT digital measurements accurate to the nearest 0.01 mm. The CBCT hard palatine liner measurements were as follows:

L: hard palatine length, defined as distance between the most labial point of the central incisors and the point bisecting the line joining the distal midpoints of the first maxillary molars [32]

D: indicates hard palatine depth, we define it as the liner distance between the deepest point on the oral surface of the hard palatine to the line connects left and right lingual alveolar crests. This Deepest point could be located almost in the middle of the hard palatine

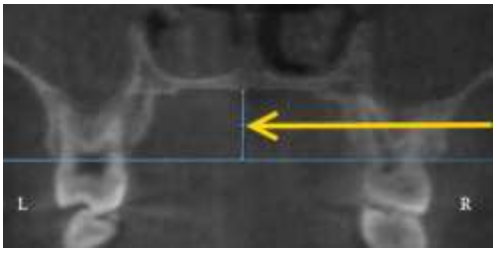

Figure 1 the deepest point of the hard palatine located at the median palatine suture.

Alternatively, deepest point of the hard palatine can be located to the left (Fig4) or to the right (Fig5) of the median palatine suture.

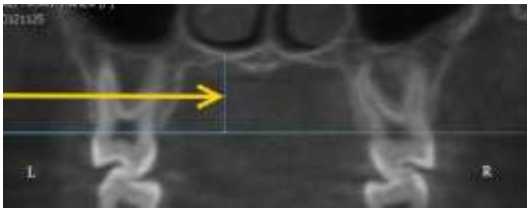

Figure 2 the deepest point of the hard palatine located to the left of the median palatine suture.

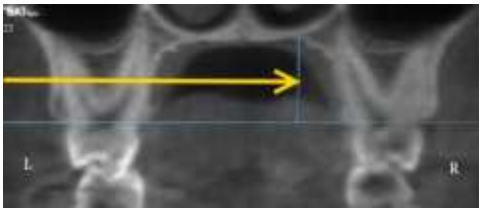

Figure 3 the deepest point of the hard palatine located to the right of the median palatine suture.

-lateral cephalometric analysis:

Lateral cephalometric radiographs were obtained in centric occlusion with the head in the natural head position and lips in the rest position lateral cephalograms has been scanned into JPEG digital format at 300 dpi and an 8-bit greyscale using scanner with 1600 dpi imaging 40 800 pixels per line and 48-bit color depth, and displayed on 15-inch LCD

screen Notebook with resolution of 1366 X 768, high-pixel resolution with pixel pitch of 0.297 mm, a contrast ratio of 450:1, and a brightness of 250 cd/m 2, with 32-bit color. The digital tracing of the lateral cephalogram was done using Dolphin Imaging Software Version 11 (Dolphin Imaging). All digital cephalometric measurements were performed by one and the same author (angles measurements in degrees).

Cephalometric evaluating facial growth was performed as recommended Jarabak [20, 23] by using Height Ratio (FHR) and sumangle (SA). As sumangle (SA) is a sum of angles (Saddle angle + Articular angle + Gonial angle) this angles were also calculated beside the Upper Gonial angle (AR-GO-ME), and Lower Gonial angle (N-GO-ME) according to Jarabak.

In order to reduction, Saddle angle well be mentioned as (S), Articular angle (S-AR-GO) well be mentioned as (R), Gonial angle well be mentioned as (R), Upper Gonial angle well be mentioned as (Go1), Lower Gonial angle well be mentioned as (Go2).

−Error of method:

All cephalometric and CBCT hard palatine measurements were repeated twice with a month interval, by the same calibrated examiner, the initial measurements and the repeated measurements were compared by using a paired t-test at $\alpha = 0.05$ to check any systematic error. The t-test did not show any statistical significance.

Statistical method:

Using Microsoft Excel of Microsoft office 2013, Pearson's Correlation Coefficient was calculated to investigate:

1. The strength of a linear association of the hard palatine length (L) with Facial Height Ratio (FHR) of Jarabak, Jarabak sumangle (SA), Saddle angle, Articular angle, Gonial angle, Upper Gonial angle and Lower Gonial angle.
2. The strength of a linear association of the hard palatine depth (D) with Facial Height Ratio (FHR) of Jarabak, Jarabak sumangle (SA), Saddle angle, Articular angle, Gonial angle, Upper Gonial angle, and Lower Gonial angle.

RESULTS:

Descriptive statistics for CBCT hard palatine measurements of male subjects are presented in Table 1.

Table 1 Descriptive statistics for CBCT hard palatine measurements of male subjects.

	L	*D*
Standard Deviation	1.81	1.94
Sample Variance	3.28	3.78
Median	40.40	11.90
Minimum	37.70	9.40
Maximum	43.30	16.00
Count	8	8

Descriptive statistics for CBCT hard palatine measurements of female subjects are presented in Table 2

Table 2 Descriptive statistics for CBCT hard palatine measurements of female subjects.

	L	*D*
Standard Deviation	2.26	1.76
Sample Variance	5.11	3.08
Median	39.23	12.30
Minimum	35.00	9.40
Maximum	42.80	15.50
Count	12	12

Descriptive statistics for CBCT hard palatine measurements of both genders are presented in Table 3.

Table 3 Descriptive statistics for CBCT hard palatine measurements of both genders.

	L	*D*
Standard Deviation	2.21	1.78
Sample Variance	4.88	3.18
Median	40.00	12.25
Minimum	35.00	9.40
Maximum	43.30	16.00
Count	20	20

CBCT hard palatine measurements were compared between males and females using a t-Test: Two-Sample Assuming Unequal Variances at $\alpha = 0.05$ that did not show any statistical significance between the two genders (shown in Table 4).

Table 4 P value of t-Test for comparing CBCT hard palatine measurements between males and females.

	L	*D*	α=0.05
P	0.08	0.90	

Descriptive statistics for cephalometric measurements estimated facial growth according to Jarabak (male, female, both gender) are shown in Table 5.

Table 5 Descriptive statistics for cephalometric measurements estimated facial growth according to Jarabak (male, female, both gender).

		S	*Ar*	*Go*	*Go1*	*Go2*	*SA*	*FHR*
Mean	♂	127.33	143.08	125.16	51.45	73.71	395.56	64.61
S.D.		1.66	5.88	7.24	3.50	6.83	7.56	4.92
S.V.		2.76	34.61	52.35	12.27	46.70	57.17	24.19
Count		8	8	8	8	8	8	8
Mean	♀	123.53	144.64	127.11	52.98	74.13	395.28	63.85
S.D.		4.71	7.80	7.48	5.04	4.18	4.44	3.96
S.V.		22.15	60.82	55.92	25.36	17.46	19.71	15.69

Count		12	12	12	12	12	12	12
Mean	♂&♀	125.05	144.02	126.33	52.37	73.96	395.39	64.15
S.D.		4.18	6.97	7.25	4.45	5.23	5.70	4.26
S.V.		17.49	48.58	52.62	19.80	27.36	32.49	18.14
Count		20	20	20	20	20	20	20

Pearson's Correlation test was performed to test the relationship between the hard palatine length (L), hard palatine depth (D) with Height Ratio (FHR) of Jarabak, Saddle angle (N-S-AR), Articular angle (S-AR-GO), Gonial angle (AR-GO-ME), Upper Gonial angle (AR-GO-ME), Lower Gonial angle (N-GO-ME) and Jarabak sumangle (SA) among male, and female. Results of this test are presented in Table 6.

Table 6 Pearson's Correlation test between CBCT hard palatine measurements and the cephalometric measurements determined according to Jarabak's analysis for estimating facial growth of sample's subjects (according to gender).

	L♂	*L*♀	*D*♂	*D*♀
S	0.46 ▲	0.48 ▲	-0.12▼	-0.13▼
Ar	0.27 ▲	-0.44▼	-0.02▼	0.15 ▲
Go1	-0.13▼	0.48 ▲	0.11 ▲	-0.24▼
Go2	-0.05▼	-0.01▼	0.25 ▲	-0.45▼
Go	-0.11▼	0.32 ▲	0.29 ▲	-0.41▼
SA	0.21 ▲	0.26 ▲	0.23 ▲	-0.55▼▼
FHR	-0.27▼	-0.50▼▼	-0.24▼	0.54 ▲▲

▲: Positive **weak** strength of correlation, ▲▲: Positive **Moderate** strength of correlation.

▼: Negative **weak** strength of correlation, ▼▼: Negative **Moderate** strength of correlation.

Pearson's Correlation test was performed to test the relationship between the hard palatine length (L), hard palatine depth (D) with Height Ratio (FHR) of Jarabak, Saddle angle (N-S-AR), Articular angle (S-AR-GO), Gonial angle (AR-GO-ME), Upper Gonial angle (AR-GO-ME), Lower Gonial angle (N-GO-ME) and Jarabak sumangle (SA) among all subjects (regardless of gender). Results of this test are presented in Table 7.

Table 7 Pearson's Correlation test between CBCT hard palatine measurements and the cephalometric measurements determined according to Jarabak's analysis for estimating facial growth of sample's subjects (regardless of gender).

	L	*D*
S	0.55▲▲	-0.12▼
Ar	-0.27▼	0.10▲
Go1	0.22▲	-0.11▼
Go2	-0.04▼	-0.07▼
Go	0.11▲	-0.12▼
SA	0.21▲	-0.12
S-GO	-0.28▼	0.34▲
N-ME	0.08▲	0.32▲
FHR	-0.34▼	0.18▲

▲: Positive **weak** strength of correlation, ▲▲: Positive **Moderate** strength of correlation.
▼: Negative **weak** strength of correlation.

DISCUSSION

This study showed that CBCT hard palatine measurements have no statistical significance between the two genders (Tab4); this was contrary to Woo [33], who found that males have a greater absolute size of the hard palate than do the females. In Esteves's study [13], the palatine depth appeared to be bigger in males than females but not the palatine length. Tsai [26] suggested that the height of the palatal vault may increase with age and that the vaults in males may be a little higher than those in females of comparable ages. Tsai recommended a further study to confirm this hypothesis.

Differences in researcher's results could be due to the altered way of assuming and measuring hard palatine dimensions, beside the different ways of sampling.

However, assessing correlation test between CBCT hard palatine measurements and the cephalometric measurements determined according to Jarabak's analysis for estimating facial growth were not the same among male and female subjects (Tab6), but anyway, they were statically unimportant, for the reason that the strength of the correlation statically were always weak.

Exclusion was the correlation of Jarabak sumangle (SA) with the hard palatine depth (D) was moderate and negative in females subjects (were as it was week and positive in males). Facial height ratio (FHR) correlation with hard palatine length (L) was moderate and negative in females subjects (were as it was week and positive in males), (FHR) correlation with hard palatine depth (D) was positive and moderate in females subjects (were as it was week but negative in males). Having stronger strength of a linear association amongst females subjects could be explained due to the fact that females in this study were older than males which mean females have more mature facial growth degree, Additionally, correlation between CBCT hard palatine measurements and the cephalometric measurements determined according to Jarabak's analysis for estimating facial growth did not have the same direction of correlation, further longitudinal studies with bigger samples is required to clarify this consequence.

Pearson's Correlation test showed weak strength (with different direction) of correlation between CBCT hard palatine measurements and the cephalometric measurements determined according to Jarabak's analysis for estimating facial growth of sample's subjects regardless of gender (Tab7). However, weak strength means that the CBCT hard palatine length and depth have no relationship with facial type growth.

Esteves [13] evaluating the palatine depth (beside the dimensions of the upper dental arch) in patients with malocclusion and different facial types found no statistically significant differences between these measurements considering the facial types, except for the palatine depth, that was smaller in brachyfacial group than dolichofacial group.

As we have seen, palatine depth and length do not seem to obey any specific growth type.

CONCLUSION

1. The present study ravel that CBCT hard palatine measurements have no statistical significance between the two genders.

2. Both genders have almost week strength (with different direction) of linear association between the CBCT hard palatine measurements and facial type growth, but females showed stronger association comparing with males.

3. CBCT hard palatine length and depth have no relationship with facial type growth.

REFERENCES:

1. GRAY H. *Anatomy of the Human Body. Philadelphia*: Lea & Febiger, 1918; Bartleby.com, 2000.

2. MERZ M.L., ISAACSON R.J., GERMANE N., RUBENSTEIN L.K. *Tooth diameters and arch perimeters in a black and a white population*. Am J Orthod Dentofacial Orthop. 1991 Jul;100(1):53-8.

3. VIDIC B. *Morphologic variations of the transverse palatine suture in Yugoslav skulls*. J Dent Res.1967;46(6):1473.

4. KILIARIDIS S, KATSAROS C. *The effects of myotonic dystrophy and Duchenne muscular dystrophy on the orofacial muscles and dentofacial morphology*. Acta Odontol Scand.1998;56(6):369–374.

5. WESTLING L, MOHLIN B, BRESIN A. *Craniofacial manifestations in the Marfan syndrome: palatal dimensions and a comparative cephalometric analysis.* J Craniofac Genet Dev Biol.1998;18(4): 211–218.

6. PANCHON-RUIZ A., JORNET-CARRILLO V., SANCHEZ DEL CAMPO F. *Palate vault morphology in Down syndrome*.J Craniofac Genet Dev Biol.2000;20(4):198–200.

7. ADRIANOPOULOS, M. V.; HANSON, M. L. *Tongue-thrust and stability of overjet correction.* Angle Orthod., Appleton, v. 57, no. 2, p. 121-35, Apr. 1987

8. KORKHAUS G. *Present orthodontic thought in Germany: jaw widening with active appliances in cases of mouth breathing*. Am J Orthod. 1960; 46: 187–206

9. VIDIC B. *Morphologic variations of the transverse palatine suture in Yugoslav skulls*. J Dent Res.1967;46(6):1473.

10. HANSON, M. L.; COHEN, M. S. *Effects of form and function on swallowing and the development dentition*. Am. J. Othod., St. Louis, 1973, v. 64, no. 1, p. 63-81,.

11. RAKOSI T., GRABER T.M. *Orthodontic and dentofacial orthopedic treatment*. Georg Thieme Verlag, Suttgart, 2009. pp.27.

12. BERWIG L.C., SILVA A.M.T., CÔRREA E.C.R., MORAES A.B., MONTENEGRO M.M., RITZEL R.A. *Hard palate dimensions in nasal and mouth breathers from different etiologies.* J Soc Bras Fonoaudiol. 2011;23(4):308-14

13. ESTEVES A., BOMMARITO S. *Avaliação da profundidade do palato e das dimensões do arco dentário superior em indivíduos com má oclusão e diferentes tipos faciais*. Rev. Dent. Press Ortodon. Ortop. 2007, vol.12, n.4.

14. BJÖRK A. *Variations in the growth pattern of the human mandible: longitudinal radiographic study by the implant method*. J Dent Res 1963;42:400-11.

15. BJÖRK A. *Facial Growth in Bilateral Hypoplasia of the Mandibular Condyle: A Radiographic, Cephalometric Study of a Case, Using Metallic Implants*. In: Kraus BS, Riedel RA editor. Vistas in Orthodontics. Philadelphia: Lea & Febiger, Publishers; 1962.

16. BJÖRK A. *Prediction of mandibular growth rotation*. Am J Orthod 1969;55:585-99.

17. BJÖRK A, SKIELLER V. *Facial development and tooth eruption: an implant study at the age of puberty*. Am J Orthod 1972;62:339-83.

18. BJÖRK A. *The role of genetic and local environmental factors in normal and abnormal morphogenesis*. Acta Morphol Neerl Scand 1972;10:49-58

19. BJÖRK A., SKEILLER V. *Normal and abnormal growth of the mandible: A synthesis of longitudinal cephalometric implant studies over a period of 25 years*. Eur J Orthod 1983;5:1-46.

20. JARABAK JR, FIZZELL JA. *Technigue and treatment with lightwire edgewise appliance*. St Louis: CV Mosby 1972:15-18.

21. JARABAK J. R. *Die morphologie und behandlung des deckbisses*. Journal of Orofacial Orthopedics Fortschritte der Kieferorthopädie Volume 36 issue 4 1975.

22. JARABAK J. R. *Open bite*. Journal of Orofacial Orthopedics Fortschritte der Kieferorthopädie 44 issue 2 1983.

23. SIRIWAT PP, JARABAK JR *Malocclusion and Facial Morphology Is there a Relationship?* Angle Orthod l985;SS: 127-3 8

24. KORKHAUS G. *Present orthodontic thought in Germany: jaw widening with active appliances in cases of mouth breathing*. Am J Orthod. 1960; 46: 187–206

25. YOUNES S., EL ANGBAWI M.F., AL DOSARI A.M. *A comparative study of palatal height in a Saudi and Egyptian population*. J Oral Rehabil. 1995 May;22(5):391-5.

26. TSAI H.H., TAN C.T. *Morphology of the palatal vault of primary dentition in transverse view*. Angle Orthod. 2004 Dec;74(6):774-9.

27. WEHRBEIN H., MERZ B.R., DIEDRICH P. *Palatal bone support for orthodontic implant anchorage a clinical and radiological study*. Eur J Orthod. 1999 Feb;21(1):65-70

28. MARQUEZAN M., NOJIMA LI, FREITAS A.O., BARATIERI C., ALVES JÚNIOR M., NOJIMA MDA C., ARAÚJO M.T. *Tomographic mapping of the hard palate and overlying mucosa*. Braz Oral Res. 2012 Jan-Feb;26(1):36-42.

29. GRACCO A., LUCA L., COZZANI M., SICILIANI G. *Assessment of palatal bone thickness in adults with cone beam computerised tomography*. Aust Orthod J. 2007 Nov;23(2):109-13.

30. BARATIERI C, NOJIMA LI, ALVES MJ, SOUZA MMG, NOJIMA MCG. *Transverse effects of rapid maxillary expansion in Class II malocclusion patients: a cone-beam computed tomography study*. Dental Press J Orthod. 2010 set-out; 15(5):89-97.

31. ALVES M JR, BARATIERI C, NOJIMA LI. *Assessment of mini-implant displacement using cone beam computed tomography*. Clin Oral Implants Res. 2011 Oct 22(10):1151-6.

32. SETO B.H., GOTSOPOULOS H., SIMS M.R., CISTULLI P.A. . *Maxillary morphology in obstructive sleep apnoea syndrome* . Eur J Orthod . 2001 ; 23 (6): 703 - 714 .

33. WOO J. *Direction and type of the transverse palatine suture and its relation to the form of the hard palate*. Am. J. Phys. Anthropol. September, 1949. 7: (N.S.) 385-399.