The relation between mandibular symphysis and the Angle class in orthodontic treatment

Ricardina Nobre, Saúl Matos de Castro, Maria João Ponces, Jorge Dias Lopes, Afonso Pinhão Ferreira

Abstract

Objectives. Facial perception depends on the different components of the face. The chin is a striking anatomical structure in the individual’s identity and mandibular symphysis (MS) shape influences the adjacent soft tissue, determining facial harmony. In lateral cephalometry, the MS corresponds to the image of the mandibular body in its anterior curvature. Its shape, inclination and thickness provide valuable information for orthodontic diagnosis and prognosis. Since facial features are associated with malocclusions, the present investigation aims to relate the height, thickness and inclination of the MS using Angle’s Class.

Methods. 495 lateral incidence cephalograms of an orthodontic population were analyzed using a previously developed and tested software. The sample was randomly selected and the height, thickness and inclination of the MS were measured. The values were statistically analyzed (p ≤ 0.05).

Results. The distribution according to Angle’s Class was 48.9% for Class I, 34.7% for Class II Division 1, 7.4% for Class II Division 2 and 8.9% for Class III. The MS height did not show significant differences between the three dental classes. The MS thickness was significantly increased in Class II Division 2 and Class I subjects (p = 0.037). The MS inclination was significantly less in Class III subjects when compared to Class I and Class II Division 1 (p ≤ 0.001).

Conclusions. The MS presented variations, which may be associated with a natural compensation against malocclusion, influencing the position of the teeth and their relationship with the other dento-craniofacial structures and with consequences on the facial harmony.

Keywords: mandibular symphysis, chin, angle class, orthodontic treatment, facial aesthetics

Background and aims

The perception of the face is based on the recognition of the different subcomponents of the face [1,2]. Among the most relevant anatomical areas for addressing orthodontic problems, the mandible stands out due to the importance that this skeletal structure plays in the composition of facial balance and also the aesthetic perspective [3-5].

The term symphysis is reserved to define a certain type of suture or bone joint with special characteristics, such as immobility, which distinguish it from other joints in the body. Anatomically, it is the structure that establishes the union between the two halves of the mandibular bone in the anterior region, coinciding with the sagittal plane [6,7]. It is present in the lower 1/3 of the face and, therefore, it is relevant in terms of aesthetics and facial harmony [1,4,8]. In harmonious faces, the lower third is equivalent in size to the middle third and the upper third [9-11]. Symphysis, mentum, chin, mentonian symphysis, mental symphysis and chin...
bone are some of the various designations used in the literature for this structure.

Lateral teleradiography and the respective cephalometry are one of the oldest and most important elements of study in orthodontics [12,13]. Cephalometric analysis allows us to assess the relationship between the different craniofacial structures, fundamentally with regard to their shape, dimension and position. In lateral cephalometry, the mandibular symphysis (MS) corresponds to the anterior region of the mandibular bone, which serves as the base for the incisor teeth. It presents itself in an image well delineated by the cortical bone that demarcates it with a very characteristic “drop” shape. This structure corresponds to the image of the mandibular body in its anterior curvature.

When analyzing the MS, we must take into account its shape, dimension and inclination, as these provide important information for the orthodontic diagnosis and prognosis of the treatment plan. In this context, the main objective of the study was to relate the height, thickness and inclination of the mandibular symphysis using the Class of Angle. As secondary objectives, this study intends to evaluate factors that influence mandibular symphysis morphology, as well as to establish the importance of incorporating symphysis analysis in orthodontic treatment.

**Methods**

The present study is observational, cross-sectional, exploratory and descriptive.

Three thousand randomly selected individuals from a population of orthodontic cases from an orthodontic clinic in Northern Portugal were analyzed. From these, we obtained a final sample of 495 individuals who met the inclusion criteria.

Inclusion criteria: patients with initial records that: have not been subjected to any type of orthodontic treatment; protocol photographs; panoramic radiography and lateral teleradiography of the face; orthodontic exam. The lateral cephalograms had to have the mandibular symphysis clearly visible.

Exclusion Criteria: poor definition and quality of teleradiography; no cephalometric tracing; major oral rehabilitations; edentulous patients; absence of upper and/or lower central incisors.

The DOLPHIN IMAGING® program was used for observation and calibration of teleradiographies and execution of the cephalometric tracing (according to Ricketts) and the MB RULER® program for measuring angles (in degrees - °) and distances (in millimeters - mm). These values were properly filled in an Excel® document for further statistical analysis.

The symphysis variables analyzed were:

- Height: vertical distance between point Is and the horizontal line that passes through Mentum Point (Me).
- Width: distance between points Pogonion (Pog) and the most posterior point of the symphysis (L-Pog).
- Inclination: Angle that the line [Midpoint-Mentum Point] makes with the mandibular plane.

Figures 1, 2 and 3 show how the symphysis variables were measured.

Statistical analysis was performed using IBM® SPSS® version 25.0. The ANOVA methodology was used to compare the measures, and when significant differences were detected, Tukey’s multiple comparison tests were used. The decision rule used consisted of detecting significant statistical evidence for probability values less than 0.05.

Ethical considerations: to carry out this study, facial cephalograms already existing in a clinical file were used, so the present study does not present any risk, since nothing was carried out in patients. During the research, all the ethical rules described in the current legislation were considered, namely regarding the treatment and storage of data, where the confidentiality of all information was guaranteed, and the data used are not identifiable to the patient.

Taking these facts into account, approval was requested from the Ethics Committee, from which a positive response was obtained.

**Figures 1, 2 and 3.** Symphysis variables (1-Height, 2-Width, 3- Inclination).
Results

Statistical analysis of measurement error: to verify the degree of systematic difference between the measurements of the pair by the same examiner at two times, preceded by verification of the normal distribution, the t-student test for paired samples was used in 10% of a sample randomly selected from the set of 495 valid cases. The results are shown in table I. According to the results of the t-student test for paired samples, there are no significant differences in the mean values of the measurements at the two times.

Table I. Student t-test results for measurement error evaluation.

|          | t     | gl  | p value | Result      |
|----------|-------|-----|---------|-------------|
| MS height| 1.934 | 59  | 0.058   | Not significant |
| MS width | -0.143| 59  | 0.887   | Not significant |
| MS inclination | -0.300 | 59  | 0.201   | Not significant |

The total sample consists of 495 cases, of which 140 are male (28.3%) and 355 are female (71.7%), aged between 7.06 and 68.02 years.

Individuals from all Angle Classes were present in the sample: 224 Class I subjects (45.3%), 159 Class II Division (Div.) 1 subjects (32.2%), 34 Class II Div.2 (6.9%), 42 Class III individuals (8.5%) and 36 undefined individuals (it was not possible to define their dental class).

Table II presents the sample characterization data in relation to the symphysis measures variables according to the Angle Class.

To compare symphysis measurements according to Angle Class, the ANOVA methodology was used to compare mean values between groups, and when significant differences were detected, Tukey’s multiple comparison tests were used. The results are summarized in table III.

Table III. ANOVA results according to Angle Class.

|          | gl  | F    | p value | Result      |
|----------|-----|------|---------|-------------|
| MS height| (4.488)| 2.821| 0.025   | Significant |
| MS width | (4.488)| 2.691| 0.031   | Significant |
| MS inclination | (4.488)| 10.452| <0.0001 | Significant |

Tukey’s multiple comparison tests for significant results are shown in table IV.

From the results shown in table IV, significant differences were detected in the mean values in the pairs marked with (*). The profile graphs in figures 4, 5 and 6 illustrate these results.

The height of the symphysis did not show significant differences between the three dental classes.

The symphysis width was significantly greater in Class II Div.2 subjects.

The symphysis inclination was significantly lower in Class III subjects when compared to Class I subjects, and Class II Div.1 individuals had the highest MS inclination value.

Table II. Summary statistics for measures according to Angle Class.

| Angle Class        | N    | Mean | Standard Dev. | Min. | Max. |
|--------------------|------|------|---------------|------|------|
| **MS height**      |      |      |               |      |      |
| Class I            | 226  | 31.49| 3.59          | 21.46| 43.13|
| Class II Div.1     | 159  | 31.31| 3.74          | 22.68| 38.69|
| Class II Div.2     | 34   | 31.81| 2.97          | 23.48| 38.82|
| Class III          | 41   | 31.91| 4.32          | 24.64| 40.86|
| Undefined          | 35   | 33.55| 3.96          | 25.25| 42.07|
| Total              | 495  | 31.64| 3.72          | 21.46| 43.13|
| **MS width**       |      |      |               |      |      |
| Class I            | 226  | 14.05| 1.85          | 8.82 | 23.56|
| Class II Div.1     | 159  | 14.18| 1.95          | 9.72 | 19.78|
| Class II Div.2     | 34   | 15.05| 1.64          | 11.12| 18.56|
| Class III          | 41   | 14.26| 2.20          | 10.22| 23.36|
| Undefined          | 35   | 13.65| 1.92          | 10.64| 18.86|
| Total              | 495  | 14.15| 1.92          | 8.82 | 23.56|
| **MS inclination** |      |      |               |      |      |
| Class I            | 226  | 76.00| 5.46          | 62.44| 89.13|
| Class II Div.1     | 159  | 77.61| 6.82          | 26.96| 89.03|
| Class II Div.2     | 34   | 73.95| 5.24          | 66.08| 87.57|
| Class III          | 41   | 71.57| 5.33          | 62.00| 82.80|
| Undefined          | 35   | 74.05| 6.08          | 56.85| 84.39|
| Total              | 495  | 75.87| 6.18          | 26.96| 89.13|
Table IV – Multiple comparisons according to the Angle Class.

| (I) Angle Class | (J) Angle Class | mean difference (I-J) | p value |
|-----------------|-----------------|-----------------------|---------|
| Class I         | Class II Div.1   | 0.17119               | 0.992   |
|                 | Class II Div.2   | -0.32445              | 0.989   |
|                 | Class III        | -0.42805              | 0.960   |
|                 | Undefined        | -2.06558*             | 0.019   |
| Class II Div.1  | Class II Div.2   | -0.49564              | 0.954   |
|                 | Class III        | -0.59925              | 0.887   |
|                 | Undefined        | -2.23677*             | 0.011   |
| Class II Div.2  | Class III        | -0.10361              | 1.000   |
|                 | Undefined        | -1.74113              | 0.289   |
| Class III       | Undefined        | -1.63753              | 0.305   |

MS height (mm)

| (I) Angle Class | (J) Angle Class | mean difference (I-J) | p value |
|-----------------|-----------------|-----------------------|---------|
| Class I         | Class II Div.1   | -0.12469              | 0.970   |
|                 | Class II Div.2   | -0.99735*             | 0.037   |
|                 | Class III        | -0.20609              | 0.969   |
|                 | Undefined        | 0.40519               | 0.769   |
| Class II Div.1  | Class II Div.2   | -0.87266              | 0.111   |
|                 | Class III        | -0.08140              | 0.999   |
|                 | Undefined        | 0.52988               | 0.570   |
| Class II Div.2  | Class III        | 0.79126               | 0.381   |
|                 | Undefined        | 1.40254*              | 0.020   |
| Class III       | Undefined        | 0.61128               | 0.632   |

MS width (mm)

| (I) Angle Class | (J) Angle Class | mean difference (I-J) | p value |
|-----------------|-----------------|-----------------------|---------|
| Class I         | Class II Div.1   | -1.60818              | 0.071   |
|                 | Class II Div.2   | 2.04689               | 0.336   |
|                 | Class III        | 4.42607*              | 0.000   |
|                 | Undefined        | 1.95096               | 0.373   |
| Class II Div.1  | Class II Div.2   | 3.65507*              | 0.011   |
|                 | Class III        | 6.03425*              | 0.000   |
|                 | Undefined        | 3.55914*              | 0.013   |
| Class II Div.2  | Class III        | 2.37918               | 0.421   |
|                 | Undefined        | -0.09593              | 1.000   |
| Class III       | Undefined        | -2.47511              | 0.371   |

*significant differences for a 5% significance level.

Figure 4. Mean values of symphysis height and respective 95% CI according to Angle’s Class.
Figure 5. Mean values of symphysis width and respective 95% CI according to Angle’s Class.

Figure 6. Mean values of symphysis inclination and respective 95% CI according to Angle’s Class.

Table V presents the sample characterization data regarding the variables of the symphysis measurements, by sex (male and female) and in totality.

To assess whether there are differences in the mean measurements of male and female individuals, a t-test was performed for the independent samples. The results of these tests are summarized in Table VI.

According to these results, in terms of mean values, men have a significantly higher mean value than women in terms of symphysis thickness.
Discussion

When analyzing the MS, its shape, dimension and inclination should be taken into account. Within the limits of variation, these are influenced by various factors, such as genetic factors, ethnicity, lower incisor inclination, and facial type [14-20].

The total sample consisted of 495 cases, with 71.1% females and 28.3% males. Regarding sexual dimorphism in the mandibular symphysis, men had a higher mean value for symphysis width than women (Table V), which is in agreement with the results obtained in other studies in which this parameter was analyzed [6,15,18,21-30]. In this research, men had an average width of 14.66 mm against 13.95 mm for females.

In the research by Yaser Khan et al. [11] the reported values were 13.00 mm for men and 11.81 mm for women, corroborating the existence of sexual dimorphism in terms of width. According to Formby [31], in general, females showed lesser growth changes than males, and the latter have more changes in the total depth of the skeleton in the pogonion area, thus justifying the higher values of symphysis thickness. Lesrel et al. [32] justify the differences in width in relation to gender by a compensatory bone phenomenon (remodeling) [25]. On the other hand, Iuliano-Burns [33] justifies the bone dimorphism in MS by the later growth in males and claims that the differences in bone width are partially established before puberty [34].

Regarding to height, although the difference was not statistically significant, there was also a difference among values, which was bigger in men than in women (Table V). In the present study, we obtained mean values of 32.22 mm for men and 31.43 mm for women. Compared with a study by Yaser Hamed Khan et al. [11] that evaluated the dimensions of the chin, and where the same method to analyze the height of the symphysis was used, the results they obtained were 28.95 mm for men and 28.31 mm for women. Both studies found a higher height symphysis in males compared to females.

Between the three dental classes, the height of the symphysis did not show significant differences, even though class III individuals were the ones with higher values. These results are in agreement with the results of other studies, which report that these individuals present greater vertical growth and that it is associated with an increase in cortical bone thickness [35,36].

Regarding the Angle Class, the height of the mandibular symphysis did not show significant differences between the three dental classes (Table IV, Figure 4). The symphysis width was significantly larger in Class II Div.2 individuals (Table IV, Figure 5). The inclination of the symphysis was significantly lower in individuals with dental Class III when compared to individuals with Class I. Individuals with Class II Div.1 had a bigger

Table V. Summary measurements of the symphysis measurements.

|                | Male      | Female    | Total   |
|----------------|-----------|-----------|---------|
| **MS height**  |           |           |         |
| Mean           | 32.22     | 31.43     | 31.65   |
| Median         | 32.74     | 31.49     | 31.73   |
| Standard Deviation | 4.51 | 3.37     | 3.74    |
| Minimum        | 22.84     | 21.46     | 21.66   |
| Maximum        | 43.13     | 42.43     | 42.73   |
| **MS width**   |           |           |         |
| Mean           | 14.66     | 13.95     | 14.30   |
| Median         | 14.57     | 13.82     | 14.00   |
| Standard Deviation | 2.08 | 1.81     | 1.91    |
| Minimum        | 8.82      | 9.68      | 9.26    |
| Maximum        | 23.36     | 23.56     | 23.41   |
| **MS inclination** |        |           |         |
| Mean           | 76.42     | 75.63     | 75.97   |
| Median         | 76.63     | 75.97     | 76.05   |
| Standard Deviation | 5.94 | 6.28     | 6.10    |
| Minimum        | 56.85     | 26.96     | 26.96   |
| Maximum        | 88.57     | 89.13     | 89.31   |

Table VI. Results of the t-student test for symphysis measurements according to sex.

|                | t     | gl  | p value          | Result   |
|----------------|-------|-----|------------------|----------|
| **MS height**  | 1.871 | 203.358 | 0.063            | Not significant |
| **MS width**   | 3.756 | 492 | <0.0001          | Significant |
| **MS inclination** | 1.279 | 492 | 0.201            | Not significant |
The shape of mandibular symphysis is influenced by several factors and due to dental malocclusion, symphysis varies.

This highlights the importance of incorporating mandibular symphysis analysis when planning orthodontic treatment.

References
1. Prokopakis EP, Vlastos IM, Picavet VA, Nolst Trenite G, Thomas R, Cingi C, et al. The golden ratio in facial symmetry. Rhinology. 2013;51:18-21.
2. Hashim PW, Nia JK, Taliercio M, Goldenberg G. Ideals of facial beauty. Cutis. 2017;100:222-224.
3. Grehs RA. Morphological, dimensional and positional characteristics of the human mandibular symphysis, under a radiocephalometric approach. Thesis - Campinas State University; 1979.
4. Sella Tunis T, Hershkovitz I, May H, Vardimon AD, Sarig R, Shpack N. Variation in Chin and Mandibular Symphysis Size and Shape in Males and Females: A CT-Based Study. Int J Environ Res Public Health. 2020;17:4249.
5. Sella Tunis T, May H, Sarig R, Vardimon AD, Hershkovitz I, Shpack N. Are chin and symphysis morphology facial type-dependent? A computed tomography-based study. Am J Orthod Dentofacial Orthop. 2021;160:84-93.
6. Al-Khateeb SN, Al Maaitah EF, Abu Alhaija ES, Badran SA. Mandibular symphysis morphology and dimensions in different anteroposterior jaw relationships. Angle Orthod. 2014;84:304-309.
7. Breeeland G, Akta A, Patel BC. Anatomy, Head and Neck, Mandible. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2022 Jan.
8. Torgut AG, Akan S. Mandibular symphysis morphology in different skeletal malocclusions and its correlation with uvulo-glossopharyngeal structures. Cranio. 2021;39:533-540.
9. Turk T, Cakmak F, Sumer M. Advancement of mandibular symphysis with distraction osteogenesis. Am J Orthod Dentofacial Orthop. 2009;135:232-240.
10. Câmara P. Aesthetics in orthodontics: dental (DRED) and facial (DREF) aesthetic reference diagrams. Dental Press Magazine of Orthodontics and Facial Orthopedics. 2006;11:130-156.
11. Beckmann SH, Kuitert RB, Prahl-Andersen B, Segner D, The RP, Tuinzing DB. Alveolar and skeletal dimensions associated with lower face height. Am J Orthod Dentofacial Orthop. 1998;113:498-506.
12. Molina-Berlanga N, Llopis-Perez J, Flores-Mir C, Puigdollers A. Lower incisor dentoalveolar compensation and symphysis dimensions among Class I and III malocclusion patients with different facial vertical skeletal patterns. Angle Orthod. 2013;83:948-955.
13. Ricketts RM. Cephalometric synthesis: An exercise in stating objectives and planning treatment with tracings of the head roentgenogram. American Journal of Orthodontics.
14. Guerino P, Marquezan M, Mezomo MB, Antunes KT, Grehs RA, Ferrazzo VA. Tomographic Evaluation of the Lower Incisor’s Bone Limits in Mandibular Symphysis of Orthodontically Unreated Adults. Biomed Res Int. 2017;2017:9103749.

15. Gracco A, Luca L, Bongiorno MC, Siciliani G. Computed tomography evaluation of mandibular incisor bony support in untreated patients. Am J Orthod Dentofacial Orthop. 2010;138:179-187.

16. Meredith HV. Change in the profile of the osseous chin during childhood. Am J Phys Anthropol. 1957;15:247-252.

17. Horowitz SL. Osborne RH, DeGeorge FV. A cephalometric study of craniofacial variation in adult twins. Angle Orthod. 1960;30:1-5.

18. E BC. A longitudinal cephalometric study of growth of the human mandibular symphysis. Northwestern University Bulletin. 1968;68(11):6-14.

19. Garn SM, Lewis AB, Vicinus JH. The inheritance of symphyseal size during growth. Angle Orthod. 1963;33:222-231.

20. Schudy FF. Vertical growth versus anteroposterior growth as related to function and treatment. Angle Orthodontist. 2009;34:75-93.

21. Khan YA, Kishore SV, Bukhari A, Rachala MR, Sashidhar BA. Alveolar and Skeletal Chin Dimensions Associated with Lower Facial Height Among Different Divergent Patterns. J Clin Diag Res. 2016;10:ZC75-ZC80.

22. Swasty D, Lee J, Huang JC, Maki K, Gansky SA, Hatcher D, et al. Cross-sectional human mandibular morphology as assessed in vivo by cone-beam computed tomography in patients with different vertical facial dimensions. Am J Orthod Dentofacial Orthop. 2011;139(4 Suppl):e377-e389.

23. Merrot O, Vacher C, Merrot S, Godlewski G, Frigard B, Goudot P. Changes in the edentate mandible in the elderly. Surg Radiol Anat. 2005;27:265-270.

24. Burstone CJ. The integumental profile. Am J Orthod. 1958;44:1-25.

25. Uysal T, Yagci A, Ozer T, Veli I, Ozturk A. Mandibular symphysis bone density according to various skeletal types. Contemp Clin Dent. 2011;2:200-206.

26. Vasseur L. Racial differences in mandibular symphyseal and soft tissue chin. Dental Press J Orthod. 2021;26:e2119347.

27. Linjawi AI, Afify AR, Baeshen HA, Birkhed D, Zawawi Z. Evaluation of mandibular morphology in different facial types. Contemp Clin Dent. 2011;2:200-206.

28. Resti PE, Takahashi O, Kanazawa E. A quantitative approach for measuring crowding in the dental arch: Fourier descriptors. Am J Orthod Dentofacial Orthop. 2004;125:716-725.

29. Juliano-Burns S, Hopper J, Seeman E. The age of puberty determines sexual dimorphism in bone structure: a male/ female co-twin control study. J Clin Endocrinol Metab. 2009;94:1638-1643.

30. Alves JM. Study to define a new formula for craniofacial skeletal classification: Thesis - Faculty of Medicine of Porto University; 2012.

31. Gousman J, Park JH, Chae JM. Evaluating mandibular symphysis bone density according to various skeletal patterns with CBCT. Orthod Craniofac Res. 2021;24:70-77.

32. Jain S, Puniyani P, Saifee A. Mandibular symphysis morphology and lower incisor angulation in different anteroposterior jaw relationships and skeletal growth patterns - a cephalometric study. Med Pharm Rep. 2020;93:97-104.

33. Watnick SS. Inheritance of craniofacial morphology. Angle Orthod. 1972;42:339-351.

34. Salemi F, Farhadian M, Ebrahimii M. Anatomical Variations of the Mandibular Symphysis in a Normal Occlusion Population Using Cone-Beam Computed Tomography. Maedica (Bucur). 2021;16:230-238.

35. Wehrbein H, Bauer W, Diedrich P. Mandibular incisors, alveolar bone, and symphysis after orthodontic treatment. A retrospective study. Am J Orthod Dentofacial Orthop. 1996;110:239-246.

36. Yu Q, Pan XG, Ji GP, Shen G. The association between lower incisal inclination and morphology of the supporting alveolar bone--a cone-beam CT study. Int J Oral Sci. 2009;1:217-223.

37. Yamada C, Kitai N, Kakimoto N, Murakami S, Furukawa T, Takada K. Spatial relationships between the mandibular central incisor and associated alveolar bone in adults with mandibular prognathism. Angle Orthod. 2007;77:766-772.

38. Jones JD. The eruption of the lower incisor and the accompanying development of the symphysis and point B. Angle Orthod. 1966;33:222-231.

39. Lin H, Zhu P, Lin Q, Huang X, Xu Y, Yang X. Comprehensive Analysis of Mandibular Residual Asymmetry after Bilateral Sagittal Split Ramus Osteotomy Correction of Menton Point Deviation. PLoS One. 2016;11:e0161601.

40. Torres HM. Radiographic evaluation of the influence of mentoplasty on the pharyngeal air space in patients undergoing maxillomandibular advancement. 2014.91f. Thesis - Goias Federal University; 2014.
45. Al-Ani MH, Mageet AO. Extraction Planning in Orthodontics. J Contemp Dent Pract. 2018;19:619-623.

46. Bolas-Colvee B, Tarazona B, Paredes-Gallardo V, Arias-De Luxan S. Relationship between perception of smile esthetics and orthodontic treatment in Spanish patients. PLoS One. 2018;13:e0201102.

47. Moreira A. Optimization of aesthetics in orthodontic treatments and orofacial rehabilitation. Thesis - Faculty of Dental Medicine of Porto University; 2013.

48. Gkantidis N, Christou P, Topouzelis N. The orthodontic-periodontic interrelationship in integrated treatment challenges: a systematic review. J Oral Rehabil. 2010;37:377-390.

49. Blatz MB, Chiche G, Bahat O, Roblee R, Coachman C, Heymann HO. Evolution of Aesthetic Dentistry. J Dent Res. 2019;98:1294-1304.

50. Ricketts RM. The keystone triad: I. Anatomy, phylogenetics, and clinical references. American Journal of Orthodontics. 1964;50:244-264.