# ANTERIOR OPEN BITE TREATED WITH PALATINE CRIB: A CASE REPORT WITH CEPHALOMETRIC, SPEECH AND ELECTROMYOGRAPHY ANALYSES

Flávio Mendonça **Copello**[1], Flávia **Viegas**[2,3], Larine Ferreira **Lira**[1], Isabela Contage **Amin**[1], Rodrigo Lopes de **Lima**[1], Katia **Nemr**[3], Margareth Maria Gomes de **Souza**[1*]

[1]Department of Pedodontics and Orthodontics, Universidade Federal do Rio de Janeiro, Brazil
[2]Department Specific Training in Speech and Hearing Pathology, Universidade Federal Fluminense, Rio de Janeiro, RJ, Brazil
[3]Department of Speech and Hearing Pathology, physiotherapy and occupational therapy, Universidade de São Paulo, SP, Brazil

**Palavras-chave**: Mordida Aberta. Ortodontia Interceptativa. Fala. Eletromiografia.

**RESUMO**
**Objetivo:** Este relato de caso descreve um tratamento interceptivo da mordida aberta anterior (MAA) com grade palatina fixa usando dados clínicos, cefalométricos, eletromiográficos e de fala. **Relato do caso:** Menina de 8 anos de idade apresentando maloclusão Classe I de Angle e MAA. A documentação ortodôntica completa foi obtida e os músculos periorais foram avaliados pela eletromiografia durante as atividades de sopro, sucção e sorriso, antes e após o tratamento. A avaliação acústica da fala foi realizada através das frequências dos formantes para avaliar a posição da língua. **Resultados:** O MAA foi corrigida em seis meses com redução do transpasse vertical, diminuição dos ângulos cefalométricos 1: NA e 1: NB e aumento do ângulo interincisivo. Durante o movimento do sorriso, foi possível observar a diminuição da atividade muscular do músculo orbicular superior e o aumento da atividade muscular do orbicular inferior. No movimento do sopro, houve uma tendência a diminuir a atividade muscular. Direções opostas foram observadas no momento da instalação da grade nas frequências dos formantes. Quando a grade foi removida, a língua foi abaixada e posteriorizada em relação ao tempo de instalação inicial do aparelho. Quando comparados os momentos final e inicial, observou-se predomínio da posição inferior da língua, além de posteriorização em algumas vogais e anteriorização em outras. **Conclusão:** Após o uso da grade palatina fixa como tratamento interceptivo para a MAA, a mordida foi fechada e foi possível observar harmonia no perfil da paciente e melhora da musculatura periorbital e posicionamento da língua.

**Keywords**: Open Bite. Interceptive Orthodontics. Speech. Electromyography.

**ABSTRACT**
**Objective**: This case report describes an interceptive treatment of anterior open bite (AOB) with fixed palatine grid using clinical, cephalometric, electromyographic and speech analysis data. **Case report**: An 8-year-old girl, Angle Class I malocclusion presenting AOB. The complete orthodontic documentation was obtained and the perioral muscles were evaluated using the electromyography during blowing, sucking and smiling activities, before and after treatment. Speech acoustic evaluation was performed through the frequencies of the formants to assess the position of the tongue. **Results**: The AOB was corrected in six months with reduction of vertical transpass, decrease of cephalometric Angles 1: NA and 1: NB and increase of interincisal angle. During the smile movement, it was possible to observe the decrease of the muscular activity of the superior orbicularis muscle and the increase of the muscular activity of the inferior orbicularis. In the blow movement, there was a tendency to decrease muscle activity. Opposite directions were observed at the time of installation of the grid in the frequencies of the formants. When the grid was removed, the tongue was lowered and posteriorized in relation to the installation time. When compared the final and initial moments, it was noted a predominance of tongue lower position, besides posteriorization in some vowels and anteriorization in others. **Conclusion**: After the use of the fixed palatine crib as an interceptive treatment for AOB, the bite was closed and it was possible to observe an harmony in the patient profile and improvement in periorbital musculature and tongue positioning.

Submitted: May 13, 2020
Modification: May 25, 2020
Accepted: July 23, 2020

***Correspondence to:**
Margareth Maria Gomes de Souza
Department of Pedodontics and Orthodontics, Universidade Federal do Rio de Janeiro, Brazil (UFRJ)
Address: Avenida Professor Rodolpho Rocco, 325, Ilha do Fundão, Rio de Janeiro-RJ, Brazil
Zip Code: 21941-617
Email: margasouzaster@gmail.com

# INTRODUCTION

The anterior open bite (AOB) is characterized by the lack of vertical contact between upper and lower front teeth and it is one of the malocclusions with the greatest aesthetic and functional influence.[1,2] Its prevalence is associated with age and ethnicity[2] and, in the primary dentition it occurs from 31.1% to 36.8%.[3] It is also reported that the prevalence of the AOB reduces in the mixed dentition (13.5%-18.6%).[2]

This type of malocclusion is usually caused by habits such as sucking finger, low tongue posture or tongue/lip thrusting (during speech or swallowing) and these habits are commonly associated with relapses after the treatment of AOB.[4,5] It is known that is important to interrupt the negative habit so the correction of AOB may happen spontaneously if the patient has a good facial growth patter[2] once soft tissue pressure is a factor that influences craniofacial growth and development.[6] Furthermore, it is related that early treatment of AOB increases the stability of morphologic correction.[7]

The speech acoustic evaluation includes consonants and vowels, however, this analysis is commonly used for vowels, as observed in some studies[8,9,10] The articulation of the consonants can be directly affected by orthodontic appliances and it may cause some estimation errors, thus, it is not common when compared to the vowels analysis.[10]

One of the most common appliance used for the treatment of AOB is the palatal crib and it works as an obstacle to the fingers when non-nutritive sucking occurs and maintains the tongue in a better position when problems with tongue posture is present, preventing its interposition between the incisors.[11] Thus, the aim of this work is to report the case of one patient diagnosed with AOB and treated with a fixed palatine crib and, besides that, show a more detailed evaluation of the functional aspects of speech and muscle activity.

# CASE REPORT

## Diagnosis and aetiology

A 8-year-old girl was referred to the Orthodontic Clinic at the Federal University of Rio de Janeiro, Brazil, for orthodontic treatment due to the patient presented AOB. The mother reported that the patient had digital sucking habit. In order to make it possible to publish this case report, it was approved by the Research Ethics Committee of the Research Institute and Collective Health of the Federal University of Rio de Janeiro, under the number N062011N282010.

A clinical evaluation revealed that the patient was in mixed dentition, Angle Class I malocclusion, negative overbite (-5.5mm) besides inadequate phonation and lingual interposition. The patient also presented a slight unilateral crossbite (top-to-top bite) due to transverse maxilla deficiency caused by the digital sucking habit and the wrong tong position.

The orthodontic documentation was composed by extra-oral clinical photographs (front rest, front smile and profile) (Figure 1; A and B) and intra-oral (front, right lateral, left lateral, upper occlusal and lower occlusal) (Figure 1 C); study casts and cephalograms (Figure 2).

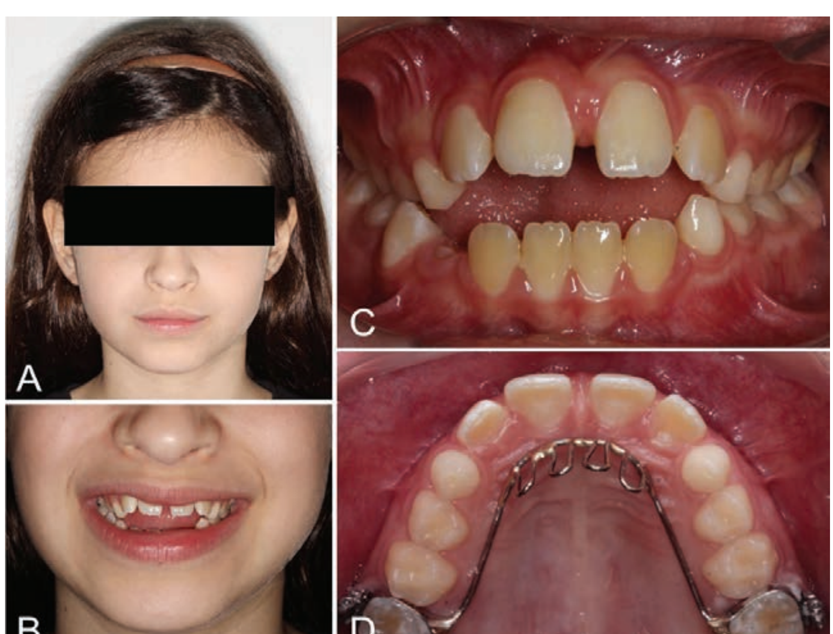


***Figure 1**: Facial initial aspect (A and B), malocclusion (C) and the palatal grid installed to interrupt parafunctional habit (D).*

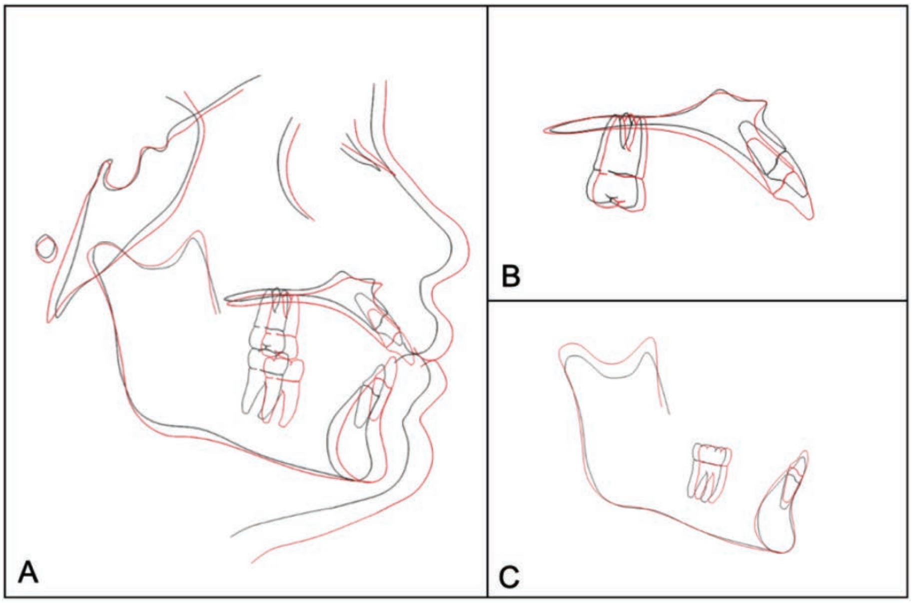


***Figure 2**: Superimposition of the initial cephalometric tracings (black) and one year after malocclusion correction (red). It is possible to observe the bite closure and facial growth (A), and, the dental effects of extrusion caused by the interruption of the habit on the upper (B) and lower (C) incisors.*


***Figure 3**: Extraoral and intraoral characteristics immediately after malocclusion correction (A.1, A.2 and A.3) and one year after removing the fixed palatal grid (B.1, B.2 and B.3).*

## Treatment Plan

The treatment plan was: 1) To help interrupt lingual interposition and digital suctioning habits a fixed palatal grid was installed in the upper arch made with 0.8 wire (Morelli, Sorocaba, SP, Brazil) fixed in bands (American Orthodontics, USA) in the first permanent molars. This stage lasted six months until the overbite was positive in both patients. 3) The fixed palatal grid was removed after three months under clinical evaluation since it was found that the treatment results were stable. 4) One year after the retention stage the patient returned for follow-up (Figure 3) and new radiographic, electromyography and speech examinations were performed. It is important to mention the multidisciplinary approach of this case, the patient underwent regular speech therapy in a private office before, during and after all orthodontic treatment.

***Table 1**: Frequencies means (M) and standard deviations (SD) of the first and second portuguese formants ($F_1$ and $F_2$) in three moments of evaluation (M0, M1 and M2).*

| Parameters | | Initial Evaluation (M0) | | Evaluation after the appliance installation (M1) | | Evaluation after appliance removal (M2) | |
|---|---|---|---|---|---|---|---|
| | | Frequencies (Hz) | (±SD) | Frequencies (Hz) | (±SD) | Frequencies (Hz) | (±SD) |
| [a] | F1 (Hz) | 786 | 53.74 | 993 | 11.58 | 933 | 9.83 |
| | F2 (Hz) | 1589 | 58.53 | 1780 | 115.00 | 1813 | 35.32 |
| [ε] | F1 (Hz) | 716 | 21.65 | 664 | 28.56 | 732 | 33.40 |
| | F2 (Hz) | 2240 | 127.74 | 2560 | 27.32 | 2583 | 101.23 |
| [e] | F1 Hz) | 400 | 29.71 | 342 | 15.10 | 496 | 14.08 |
| | F2 (Hz) | 2821 | 79.88 | 2618 | 96.93 | 2755 | 29.40 |
| [i] | F1 (Hz) | 414 | 21.69 | 513 | 44.00 | 332 | 3.00 |
| | F2 (Hz) | 3083 | 105.64 | 2323 | 230.76 | 3268 | 23.47 |
| [ɔ] | F1 (Hz) | 739 | 34.63 | 737 | 12.69 | 787 | 51.49 |
| | F2 (Hz) | 1085 | 26.80 | 1176 | 27.08 | 1043 | 50.83 |
| [o] | F1 (Hz) | 578 | 26.11 | 436 | 39.76 | 467 | 46.38 |
| | F2 (Hz) | 1214 | 104.81 | 781 | 11.27 | 995 | 97.40 |
| [u] | F1 (Hz) | 488 | 47.23 | 633 | 22.37 | 340 | 33.12 |
| | F2 (Hz) | 927 | 72.00 | 891 | 34.29 | 854 | 77.91 |

***Table 2**: Electromyographic results before and after treatment.*

| | SMILING | | | | BLOWING | | | | SUCKING | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *SO | | *IO | | SO | | IO | | SO | | IO | |
| | I | F | I | F | I | F | I | F | I | F | I | F |
| ***RMS** | 50.3 | 30.6 | 94.5 | 132 | 54.2 | 78.3 | 78.9 | 116 | 108 | 64.8 | 79.4 | 38.6 |
| **Max. Value** | 233 | 209 | 802 | 788 | 233 | 551 | 336 | 556 | 690 | 380 | 690 | 189 |
| **Min. Value** | -192 | -197 | -648 | -653 | -206 | -431 | -429 | -563 | -648 | -326 | -648 | -238 |

*Note: * RMS: root mean square; SO: superior orbicular muscle; IO: inferior orbicular muscle; I: inicial; F: final.*

***Table 3**: Cephalometric angle measurements before and after treatment.*

| CEPHALOMETRIC MEASUREMENTS | NORMAL VALUE | INICIAL VALUE | FINAL VALUE |
|---|---|---|---|
| **1:NA** | 22° | 39.3° | 36.2° |
| **1:NB** | 25° | 34.2° | 32.8° |
| **1:1** | 131° | 105.7° | 123° |
| **GoGn:SN** | 32° | 30.5° | 27.7° |

# Orthodontic documentation and complementary exams

## Cephalometric Analysis

Cephalograms were requested to verify if there were skeletal factors involved with the AOP. To analyse this, the GoGN-SN angle was evaluated to verify the vertical and horizontal growth pattern of the patient. It was found that the patient presented a horizontal growth pattern (GoGn-SN angle near the normal value of 32º), thus, the open bite was caused only by the habit of digital suction, atypical phonation and lingual interposition. Through the cephalograms it was also possible to observe the influence of dental positioning on the establishment of the AOB since angular values (1NA, 1NB and 1: 1) were accentuated showing an exaggerated buccal tipping.

## Electromyographic Evaluation

To complement the clinical examination, myoelectric activity evaluation of the perioral muscles during the smile, blowing and sucking (upper and lower orbicularis) was performed to verify the influence of muscle activity on this malocclusion. EMG System® electromyography EMG 500 model with 4 channels for EMG was used. To standardize the capture of EMG data, the patient was asked to make the movements of smiling and blowing for 10 seconds, and, for the suction movement, the patient sucked 100ml of water using a straw. The electromyography was connected to a portable computer that provided the graphic image of the EMG signal being possible analysis the RMS value (root mean square value or root mean square value, which corresponds to a measure derived from the amplitude of the EMG signal).

## Speech Analysis

The acoustic evaluation of formats frequencies was performed to infer the tongue position and it was based on methodology described by Viegas.[9] Phonatory samples were recorded in a quiet room using the open-source software Praat, version 6.0.16 (P. Boresma and D. Weenink, University of Amsterdam, Netherlands, available at http://www.fon.hum.uva.nl/praat/), in mono channel, with a sampling rate of 22.050 Hz and in "wav" format. An HP notebook computer (Hewlett-Packard, USA) with a Windows 10 operating system and a Shure microphone, model SM 58 (Shure, USA), placed at a distance of 10cm from the lips of the patient, were used for the recordings.

To record the speech signals, the patient was asked to say a carrier phrase ("Say ___ for me") that was filled with the words "pápa", "pépe", "pêpe", "pípi", "pópo", "pôpo", and "púpu". Then, segments of the seven tonic vowels were selected from the broadband spectrograms, choosing the best-defined sections of the formant spectrograms and extracting 10ms of the intermediate section of each vowel. Two measurements of each parameter were estimated and the mean of these values was extracted at the end.

## Treatment Results

The results between the initial and final exams (clinical examination, cephalograms, electromyography and speech) can be observed on Figures 1, 2, 3 and Tables 1, 2 and 3. The use of the fixed palatal grid in this treatment was effective and provided the correct tongue positioning, causing correct repositioning of the upper and lower incisors, leading to the correction of the AOB. The correct tongue position also provided the correction of the posterior crossbite as it was slight unilateral crossbite (top-to-top bite).

# DISCUSSION

A comparative study using cephalograms of the patients with and without AOB shows that the inclination angles of the upper and lower incisors (1.1, 1.NA and 1.NB) differ statistically between patients with AOB and patients with normal occlusion[12] and these results are in agreement with the findings obtained in this case report (Table 3).

The AOB can be classified as dental or skeletal, and it requires the correct diagnosis so the treatment plan may be effective and successful [13] shows the importance of cephalograms as a tool for the correct diagnosis of open bite. In the cephalometric measures of the patient (Table 3) it was possible to observe the improvement in the positioning of the upper and lower incisors, reducing buccal tipping (1.1, 1.NA and 1.NB) comparing to the beginning of the treatment.

The lingual interposition may cause, among other problems, changes in speech. Researchers found alterations in several types of phonemes, but did not investigate the frequencies of the formants, so it makes impossible to compare with the present results.[14,15] In AOB cases it is also expected that the tongue tonicity reduce, since there is a tendency to lingual interposition in the anterior area where there is no occlusal contact.

The speech corresponds to the articulation of the voice sounds that are produced in the larynx and modified by the resonance cavities, such as the larynx, pharynx, mouth and nose. These cavities act as a filter, amplifying some frequency bands and damping others. The amplified bands are called frequencies of the formants, and the first two formants (F1 and F2) are the most studied. The frequency of the first formant (F1) is related to the posterior cavity (pharynx) behind the point of maximum lingual constriction, and is influenced by the vertical position of the tongue and degree of mouth opening. This measure is inversely proportional to the height of the tongue position. The frequency of the second formant (F2) is associated to the anterior cavity (oral), lingual constriction and is influenced by the anteroposterior displacement of the tongue. The higher the frequency of F2, the more anterior will be the constriction of the tongue and the lower this value, the more posterior will be the positioning of the tongue during speech.[16, 17]

When is compared the moment that the patient had the appliance installed (M1) with the initial (M0) it was possible to observe that the frequencies of the first formant (F1) were higher in the vowels [a], [i] and [u] (Table 1), and it allows to infer that after the installation of the orthodontic appliance, the tongue presented a lower position, the mandible more opened and there was more constriction of the pharynx when these vowels were spoken[16,17]. However, the vowels [ɛ], [e], [o] presented lower F1 frequencies in M1 (Table 1) than in the initial evaluation, demonstrating a higher tongue position, with a more closed mandible and less pharyngeal constriction.[16,17]The vowel [ɔ] in the two moments (Table 1) of evaluation presented close averages. In the frequencies of F2 (Table 1), higher values were observed for the three vowels [a], [ɛ] e [ɔ] when the appliance was installed (M1) when compared to the initial period (M0), demonstrating an anteriorization of the tongue. These opposite directions at the height of the tongue measured by F1 and anteriorization of the tongue in most vowels measured by F2 (Table 1) can be attributed to the difficulty of adapting the tongue to a new position shortly after the installation of the palatine crib.

When comparing the moments of installation (M1) and the removal of the orthodontic appliance (M2), it was observed that after removal, the tongue presented a lower position in the low and high medium vowels [ɛ], [e], [ɔ] and [o] (Table 1), demonstrated by the increase of F1,[16,17] which can be attributed to the removal of the mechanical barrier. In the anteroposterior direction, when the crib was removed (M2) the frequencies of F2 increased in five vowels [a], [ɛ], [e], [i] e [o] when compared to the moment of installation of the palatal grid (M1) (Table 1). It demonstrated that after removal of the appliance, the tongue presented an anterior posture during the moment of articulation of those vowels.[16,17]

When analysing the data of the initial moments (M0) and final (M2) it was noted that after removal of the palatine grid, four vowels ([a], [ɛ], [e], [ɔ]) presented a lower tongue position, demonstrated by an increase of frequencies of F1 (Table 1). In the horizontal direction, after removal of the crib (M2), posteriorization of the tongue was observed in the vowels [e], [T], [o] and [u] demonstrated by F2 lower values (Table 1).[16,17] The other vowels presented more anterior position of the tongue, which evidenced the need for speech therapy to adapt the tonicity and tongue posture to prevent alterations in dental occlusion after removal of the mechanical barrier.

With the data presented, the importance of the association of orthodontists and speech therapists is essential especially in malocclusions associated with deleterious habits, given that the function of orthodontic appliances is to change the shape of dental arches and prevent lingual interposition, while speech therapy will correct the position of the tongue and lips during swallowing, speech, chewing and usual position.[14]

Changes in the formants' frequencies were also reported in a longitudinal study in which the patients used upper and lower Hawley plaques. The authors observed distortions of the phonemes [s] and [z] in addition to increase of F1 and reduction of F2 in the vowel [i]. These changes were more evident after installation and especially after one week of use. After one month, and especially after the third month, the data were normal in most of the patients.[8] The data in the present study after installation of crib (M1), the tongue presented lower position (higher F1) and posteriorization of the tongue (lower F2) demonstrating, therefore, the same trend during the vowel emission of the vowel [i].

Electromyography is a very useful tool in the study of neuromuscular aspects of the masticatory system; however, in order to obtain a faithful electromyography record, it is imperative to use an adequate technique in order to minimize interference from the external environment.[18,19]

In the processing of the collected signal, the RMS was chosen. This form of analysis presents outstanding advantages, since it quantitatively expresses muscular electrical activity, with the realization of this calculation in a simplified way, through specific software.[19]

The present study demonstrated (Table 2) that the patient showed difference in electromyographic activity as a result of the palatine grid treatment and of the open bite correction, with lower electrical activity of the orbicular muscles after the bite closure during the smile and suction movements. This fact is probably related to the characteristics of this malocclusion, where vestibuloinfraversion of the incisors and negative vertical trespass are observed, which hamper the performance of the basic functions of the orbicularis muscles, generating the need for adaptations. The results obtained were in agreement with previous studies, where the authors observed that individuals with anterior open bite, expend greater effort of the perioral muscles to effect several movements, as well as presented smaller potentials of orbicularis muscle action of the mouth compared to those with occlusion normal.[20,21,22] Also, the correct tongue position also provided the correction of the posterior crossbite as it was slight unilateral crossbite (top-to-top bite) Some studies[14,23] says that in some of these cases the interceptive approach solves, without the need for orthodontic treatment, if the habit is removed before the alveolar atresia occurs in the maxilla. Otherwise, the rapid expansion of the maxilla (REM), should be performed to correct transverse discrepancies of the upper arch of severe skeletal or dental origin. In our case report the slight unilateral crossbite (top-to-top bite) was solved only with de interceptive treatment which indicated that there wasn't any severe skeletal or dental transverse discrepancies.

The persistence of perioral muscle dysfunction pattern after orthodontic treatment may lead to recurrence. The imbalance of the perioral muscles represents an important factor of alteration of the morphology of the arches and the position of the teeth.[24]

## CONCLUSION

Based on the results, it can be inferred that by the change in the upper and lower incisors inclination results in a tendency to improve the perioral musculature tone, the tongue positioning and, consequently, the improvement of speech.

## REFERENCES

1. Skidmore KJ, Brook KJ, Thomson WM, Harding WJ. Factors influencing treatment time in orthodontic patients. Am J Orthod Dentofacial Orthop, v. 129, n. 2, p. 230-8, Feb 2006. ISSN 1097-6752.

2. Worms FW, Meskin LH, Isaacson RJ. Open-bite. Am J Orthod, v. 59, n. 6, p. 589-95, Jun 1971. ISSN 0002-9416.

3. Chevitarese AB, Della Valle D, Moreira TC. Prevalence of malocclusion in 4-6 year old Brazilian children. J Clin Pediatr Dent, v. 27, n. 1, p. 81-85, 2002. ISSN 1053-4628.

4. Borrie FR, Bearn DR, Innes NP, Iheozor-Ejiofor Z. Interventions for the cessation of non-nutritive sucking habits in children. Cochrane Database Syst Rev, n. 3, p. CD008694, Mar 2015. ISSN 1469-493X.

5. Yamaguchi H, Sueishi K. Malocclusion associated with abnormal posture. Bull Tokyo Dent Coll, v. 44, n. 2, p. 43-54, May 2003. ISSN 0040-8891.

6. Proffit WR. Equilibrium theory revisited: factors influencing position of the teeth. Angle Orthod, v. 48, n. 3, p. 175-86, Jul 1978. ISSN 0003-3219.

7. Yang EY, Kiyak HA. Orthodontic treatment timing: a survey of orthodontists. Am J Orthod Dentofacial Orthop, v. 113, n. 1, p. 96-103, Jan 1998. ISSN 0889-5406.

8. Kulak Kayikci ME, Akan S, Ciger S, Ozkan S. Effects of Hawley retainers on consonants and formant frequencies of vowels. The Angle Orthodontist, v. 82, n. 1, p. 14-21, 2012. ISSN 0003-3219.

9. Viegas F, Viegas D, Baeck HE. Frequency measurement of vowel formants produced by Brazilian children aged between 4 and 8 years. Journal of Voice, v. 29, n. 3, p. 292-298, 2015. ISSN 0892-1997.

10. LorenzonI DC. Alterações produzidas na fala por contenções superiores ortodônticas - ensaio clínico randomizado prospectivo. 2016. Tese (Doutorado em Ortodontia e Odontologia em Saúde Coletiva) - Faculdade de Odontologia de Bauru, Universidade de São Paulo, Bauru, 2016. doi:10.11606/T.25.2016.tde-07112016-104154.

11. Leite JS, Matiussi LB, Salem AC, Provenzano MG, Ramos AL. Effects of palatal crib and bonded spurs in early treatment of anterior open bite: A prospective randomized clinical study. Angle Orthod, v. 86, n. 5, p. 734-9, Sep 2016. ISSN 1945-7103.

12. Stuani AS, Stuani Andréa S, Stuani MB, Saraiva MCP, Matsumoto MAN. Anterior open bite: cephalometric evaluation of the dental pattern. Braz. Dent. J., Ribeirão Preto , v. 17, n. 1, p. 68-70, 2006

13. Henriques JFC, Janson G dos RP, Almeida RR de, Dainesi EA, Hayasaki SM. Mordida aberta anterior: a importância da abordagem multidisciplinar e considerações sobre etiologia, diagnóstico e tratamento. Apresentação de um caso clínico. Revista Dental Press de Ortodontia e Ortopedia Facial, v. 5, n. 3, p. 29-36, 2000.

14. Maciel CT, Leite IC. Etiological aspects of anterior open bite and its implications to the oral functions. Pro-fono: revista de atualizacao cientifica, v. 17, n. 3, p. 293-302, 2005. ISSN 0104-5687.

15. Berwig LC, Silva AMT da, Busanello AR, Almeida FL de, de Paula BG. Alterações no modo respiratório, na oclusão e na fala em escolares: ocorrências e relações. Revista CEFAC, v. 12, n. 5, p. 795-802, 2010. ISSN 1516-1846.

16. Kent RD, Read C. Análise acústica da fala. Cortez Editora, 2015. ISBN 8524923857.

17. Barbosa PA, Madureira S. Manual de fonética acústica experimental: aplicações a dados do português. Cortez editora, 2015. ISBN 8524924217.

18. Pruzansky S. The application of electromyography to dental research. The Journal of the American Dental Association, v. 44, n. 1, p. 49-68, 1952. ISSN 0002-8177.

19. Soderberg GL, Knutson LM. A guide for use and interpretation of kinesiologic electromyographic data. Physical therapy, v. 80, n. 5, p. 485-498, 2000. ISSN 0031-9023.

20. Baril C, Moyers R E. An electromyographic analysis of the temporalis muscles and certain facial muscles in thumb-and finger-sucking patients. Journal of dental research, v. 39, n. 3, p. 536-553, 1960. ISSN 0022-0345.

21. Gustafsson M, Ahlgren J. Mentalis and orbicularis oris activity in children with incompetent lips: an electromyographic and cephalometric study. Acta Odontologica Scandinavica, v. 33, n. 6, p. 355-363, 1975. ISSN 0001-6357.

22. Nieberg LG. An electromyographic and cephalometric radiographic investigation of the oro-facial muscular complex. 1959.

23. Capelozza Filho L, SILVA Filho OG. Expansão rápida da maxila: considerações gerais e aplicação clínica. Parte I. Rev Dental Press Ortod Ortop Maxilar, v. 2, n. 3, p. 88-102, 1997

24. Camargo PC, Zampini S, Betachini L. Considerações sobre o perfil vocal de operadores de telemarketing e estudo da relação das alterações vocais com os distúrbios da respiração. Fono Atual, n 11, p.32-45, 2000.