Lingual function in children with anterior open bite: A case-control study

Paola Botero-Mariaca\textsuperscript{a,*}, Valentina Sierra-Alzate\textsuperscript{a}, Zulma Vanessa Rueda\textsuperscript{b}, Difariney Gonzalez\textsuperscript{c}

\textsuperscript{a}Cooperative University of Colombia, Envigado, Colombia
\textsuperscript{b}Pontifical Bolivarian University, Colombia
\textsuperscript{c}National School of Public Health, Colombia

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Summary

The position of the tongue during phonation and swallowing can modify the position of the teeth and even the growth of the jaws.

Objective: To determine the association between the position of the tongue and phonation among individuals with normal vertical overbite (NVO) and anterior open bite (AOB).

Materials and methods: This was a case-control study of 132 students with AOB and 132 controls with NVO between the ages of 8 and 16 years old. The presence of AOB was determined during a clinical examination using a Boley gauge, phonation (speech) was assessed with an articulation test, which was analysed using a classification table of Spanish consonants spoken in Colombia, and tongue contact during swallowing was determined with the Payne test. Associations were determined between AOB and the position of the tongue upon swallowing and during speech (Chi\textsuperscript{2} test of independence, Fisher’s exact test, and Mann-Whitey U test, \(P < 0.005\)). Finally, a logistic regression model was performed, with AOB as the dependent variable.

Results: We found associations between AOB and the presence of lingual interposition, distortion, lingual thrust, protrusion of the tongue, contact with palatine rugae, and type of dentition (\(P < 0.05\)). According to the logistic regression model, the presence of lingual thrust (odds ratio (OR): 0.067; 95\% confidence interval (CI): 0.009–0.518) and contact with the palatine rugae (OR: 0.420; 0.216–0.818) behave as protective factors.
associated with the presence of AOB, and the presence of distortion was found to be a risk factor (OR: 10.751; 95%CI: 5.658–20.427).

Conclusion: Lingual thrust, interposition, and protrusion are associated with AOB. Lingual thrust and contact of the tongue with the palatine rugae behave as protective factors, and the presence of distortion acts as a risk factor.

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Keywords
• Open bite.
• Phonation.
• Swallowing.

Introduction

Anterior open bite (AOB) is considered to be a difficult-to-treat malocclusion, and the stability of the correction obtained may not be sustainable over time due to the complexity of eliminating the etiological factors involved [1,2]. The position of the tongue at rest and during function can modify the position of the teeth and the growth of the jaws, including the shape and size of the arch [3,4]. The literature reports that a low position of the tongue at rest expands the lower dental arch and causes collapse of the upper arch [3,5]. Phonation [speech] may also be affected in individuals with AOB due to the close relationship between the lips, tongue, and palate during the articulation of the sounds that construct language. Of the individuals with AOB, 77.4% present some alteration in phonation, the most frequent being distortion, with the greatest alteration in the phoneme /d/ in 62.9% and in the phoneme /t/ in 51.5% [6]. Alterations such as omission and substitution are common up to 7 years of age according to normal language development, whereas distortion can be perpetuated to older ages [6].

Although the relationships between tongue and teeth, lips, palate, palatine rugae, and oropharynx are altered in the presence of AOB, functional adaptations may be present during swallowing, chewing, and breathing that make it difficult to establish a direct relationship between an altered function and the presence of AOB [7]. An altered function can generate changes in the anatomical forms of the skeletal and dental structures, which can lead to aesthetic problems that generate greater difficulty in performing the basic functions of the stomatognathic system [1,2].

Knowledge of the relationship between form and function is fundamental for the orthodontist since it permits directing the

Key points

- Anterior open bite is a difficult-to-treat condition.
- The position of the tongue at rest can expand the lower dental arch.
- Alterations in phonation are common in AOB.
- Functional adaptations can persist.

Mots clés
• Béance.
• Phonation.
• Déglutition.

Introduction

La béance antérieure (BA) est considérée comme une malocclusion difficile à traiter, et à stabiliser dans le temps, en raison de la complexité à éliminer les facteurs étiologiques impliqués [1,2]. La position de la langue au repos et durant la fonction peut modifier la position des dents et la croissance des mâchoires, ainsi que la forme et la taille des arcades [3,4]. La littérature rapporte qu’une position basse de la langue au repos élargit l’arcade dentaire mandibulaire et entraine un rétrécissement de l’arcade maxillaire [3,5]. La phonation peut également être affectée chez les individus présentant une malocclusion de type béance antérieure en raison des relations étroites qui existent entre les lèvres, la langue et le palais durant l’articulation des sons qui construisent le langage. Au total, 77,4 % des personnes en Colombie présentant une béance antérieure ont des troubles de la phonation, la plus fréquente étant la distorsion, avec l’altération la plus forte pour le phonème /d/ dans 62,9 % des cas et du phonème /t/ dans 51,5 % des cas [6]. Les altérations telles que l’omission et la substitution sont courantes jusqu’à l’âge de 7 ans, selon le développement normal du langage, alors que la distorsion peut se perpétuer à des âges plus avancés [6].

Bien qu’en cas d’infraclusion antérieure, les relations de la langue avec les dents, les lèvres, le palais, les crêtes palatines et l’oropharynx soient altérées, des adaptations fonctionnelles peuvent s’établir durant la déglutition, la mastication et la ventilation, d’où la difficulté à établir une relation directe entre dysfonction et béance antérieure [7]. Une trouble dysfonctionnel peut produire des changements anatomiques des structures squelettiques et alvéolodentaires avec comme conséquence des problèmes esthétiques qui génèrent des difficultés encore plus importantes lors des fonctions essentielles du système stomatognathique [1,2].

La connaissance des relations entre la forme et la fonction est essentielle pour l’orthodontiste étant donné qu’elle permet de
diagnosis precisely, successfully, and efficiently. A suitable functional rehabilitation in search of the modification of the oral and perioral muscular functions permits the normal development of the jaws and preserves the obtained orthodontic results [8]. The research hypothesis is that there is an association between the position of the tongue and phonation among individuals with normal vertical overbite (NVO) and AOB.

**Materials and methods**

A case-control study was conducted in a school population in 6 public schools [9], with prospective recruitment between August 2012 and June 2013. The study was approved by the Bioethics Committee of the Cooperative University of Colombia (Universidad Cooperativa de Colombia) (act 0800-0020) and was explained to the parents, who signed the informed consent.

Children between 8 and 16 years of age with presence or absence of AOB who had their 4 upper incisors erupted without the presence of posterior crossbite were included in the study. Exclusion criteria were children with a mental or systemic syndrome that would alter normal skeletal development, children undergoing interceptive or corrective orthodontic treatment, children with previous orthodontics, children in speech therapy, and children with the presence of habits other than those of the tongue (parafunctions).

A sample size of 132 cases and 132 controls was determined, taking into account the population of the municipality (22,955 inhabitants), a 2% prevalence of AOB, a 95% confidence interval (CI), and a sampling error of 7% [9]. Cases were defined as children with AOB and controls as children with NVO.

Prior to the data collection and the evaluation of the children, a standardization of the collection instruments was performed by conducting a pilot test to calculate the intra- and inter-observer errors of the clinical analysis and of the Payne technique. Five children who met the inclusion and exclusion criteria of the orthodontic service of the Cooperative University of Colombia (Universidad Cooperativa de Colombia) were selected (the Kappa indexes were 0.95 for inter-observer error and 0.99 for intra-observer error).

The presence of AOB was determined when the anterior teeth did not reach the occlusion line and did not contact the antagonists by at least 1 mm, measured from the incisal edge of the upper to the incisal edge of the lower teeth [1]. Children with NVO were those in whom the incisal edges were in contact with the palatine surface of the maxillary incisors, with a third of the crown of the lower incisors covered. The magnitude of AOB was classified as mild (up to 1 mm), formulating a diagnostic precise for an optimisation therapeutic. Une réhabilitation fonctionnelle adaptée recherchant la modification des fonctions orales et péribuccales permet le développement normal des mâchoires et préserve les résultats orthodontiques obtenus [8]. L’hypothèse de recherche est qu’il existe une association entre la position de la langue et la phonation chez les personnes présentant une occlusion verticale normale (OVN) et celles qui présentent une bêance antérieure (BA).

Matériels et méthodes

Une étude cas témoin a été menée sur une population d’élcoliers dans 6 écoles publiques [9], avec un recrutement prospectif effectué entre les mois d’août 2012 et juin 2013. L’étude a été approuvée par le Comité d’éthique de l’université coopérative de Colombie (Universidad Cooperativa de Colombia) (act 0800-0020), les notes d’informations et les consentements éclairés ont été dûment signés par les enfants et les parents.

Les enfants âgés de 8 et 16 ans avec ou sans BA, dont les 4 incisives avaient fait leur éruption et sans occlusion croisée postérieure, ont été inclus dans l’étude. Les critères de non-inclusion étaient les suivants : troubles mentaux ou systémiques pouvant altérer le développement squelettique normal, traitement orthodontique interceptif ou correcteur en cours, antécédents de traitement orthodontique, traitement orthophonique en cours, et habitudes parafonctionnelles autres que linguales.

Un échantillon de 132 cas et de 132 témoins a été établi, en prenant en compte la population de la municipalité (22,955 habitants) avec une prévalence de 2 % de BA, un intervalle de confiance de 95 % (IC), et une erreur d’échantillonnage de 7 % [9]. Les cas ont été répartis en deux groupes : un groupe d’enfants avec une bêance antérieure (BA) et un groupe témoin d’enfants avec une occlusion verticale normale (OVN).

Avant le recueil des données et l’évaluation des enfants, nous avons effectué une standardisation des instruments de collecte de données en menant un test pilote pour calculer les erreurs intra- et inter-examineurs de l’analyse clinique et de la technique de Payne. Cinq des enfants qui remplissaient les critères d’inclusion et de non-inclusion du département orthodontique de coopérative de Colombie (Universidad Cooperativa de Colombia) ont été sélectionnés (les indices Kappa étaient de 0,95 pour l’erreur inter-examineurs et de 0,99 pour l’erreur intra-examineurs).

La présence d’une BA a été établie lorsque les dents antérieures n’atteignaient pas le plan occlusal et que la bêance antérieure était d’au moins 1 mm, mesurée du bord incisif des dents maxillaires au bord incisif des dents mandibulaires [1]. Les enfants présentant une OVN avaient le bord libre de leurs incisives en contact avec la face palatine des incisives maxillaires, avec un recouvrement d’un tiers de la couronne des incisives inférieures. L’importance de la BA était
moderate (1 to 5 mm), and severe (> 5 mm) according to the
degree of separation between the incisors [10].

The presence or absence of AOB was determined by clinical
examination using a Boley gauge. Speech was assessed
through the articulation test and analysed by the classification
table of Spanish consonants spoken in Colombia to avoid
misinterpretation or incorrect analysis of the data [6]. An
evaluation of articulation points was performed as follows:

- place of articulation: bilabial: /m/p/b/;
- labiodental: /f/v/;
- interdental: /n/;
- alveolar: /s/z/r/l/r/rr/;
- palatal: /l/y/ll/ch/n~/;
- velar: /k/g/j/x/.

Mode of articulation:
- occlusives /p/b/t/d/k/;
- fricatives: /f/v/s/y/ll/g/j/;
- affricates: /ch/x/;
- nasals: /m/n/n~/;
- lateral: /l/;
- vibrants: /r/rr/.

The phonetic examination was classified as normal, with dis-
tortion because of lingual interposition, and with distortion
because of lingual thrust, substitution or omission [6,11]. The
contact of the tongue during swallowing was evaluated using
the Payne test [12], and the variables derived from this test
were the tongue touches the gingival margin upon swallowing,
the tongue touches at least half of the palatine surface of the
upper and lower teeth, the tongue protrudes completely
between the teeth, the tongue touches the palatine rugae,
and the tongue touches the lower teeth.

Univariate, bivariate, and multivariate statistical analyses
were performed on the variables identified during the evalu-
ations of phonation (speech) and swallowing. The quantitative
variables were tested for normality (Shapiro-Wilk test). The
medians and interquartile ranges were reported for those that
did not comply with the assumption of normality. Relative
frequencies were calculated for the qualitative variables,
and associations between them were identified using the
Chi² test of independence or Fisher’s exact test. To determine
the relationship between quantitative and qualitative vari-
ables, the Mann-Whitney U test was used to compare the
position of the tongue upon swallowing with the magnitude
of the AOB, because the data did not follow a normal
distribution.

The type of dentition was determined according to age as
either mixed dentition (patients between 8 and 12 years of
age) or permanent dentition (patients between 13 and 16 years
of age) to establish if there were differences in phonetics and
the position of the tongue.
To determine if the presence of AOB was associated with alterations in phonetics and swallowing, a logistic regression model was applied, in which the presence of AOB was taken as the dependent variable. Candidate variables included those that met the statistical and clinical criteria, such as age, sex, type of dentition, lingual interposition, lingual thrust, lingual protrusion, distortion, substitution, contact of the tongue with the gingival margin, contact of the tongue with the palatine surface, contact of the tongue with the palatine rugae, contact of the tongue with the lower incisors, and the magnitude of AOB. A significance level of 0.05 was assumed for all statistical tests.

**Results**

The sample consisted of 132 students in the group of cases with AOB and 132 controls with NVO, of which 56.1% were female (26.3% with AOB and 29.8% with NVO). A total of 43.9% were male, (24.4% presented AOB and 19.5% NVO), with an average age of 11.62 years (SD 2.5). There was no association between the presence of AOB and sex and age distribution ($P = 0.216$ and 0.117, respectively, Chi² test of independence). The characteristics of the sample are described in Table 1.

The quantitative variables did not present a normal distribution ($P < 0.05$). The quantity of AOB presented a median of 0 and a range of 5; 37 individuals presented AOBs of 1 and 2 mm (14.1%), 29 individuals showed AOBs of 3 mm (11.1%), and a range of 5; 37 individuals presented AOBs of 3 mm (11.1%), with an average of 1.62 years (SD 2.5). There was no association between the presence of AOB and sex and age distribution ($P = 0.216$ and 0.117, respectively, Chi² test of independence). The characteristics of the sample are described in Table 1. The quantitative variables did not present a normal distribution ($P < 0.05$). The quantity of AOB presented a median of 0 and a range of 5; 37 individuals presented AOBs of 1 and 2 mm (14.1%), 29 individuals showed AOBs of 3 mm (11.1%), and a range of 5; 37 individuals presented AOBs of 3 mm (11.1%), with an average of 1.62 years (SD 2.5). There was no association between the presence of AOB and sex and age distribution ($P = 0.216$ and 0.117, respectively, Chi² test of independence). The characteristics of the sample are described in Table 1.

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**Table I**

Association between anterior open bite (AOB) and normal vertical overbite (NVO) with alterations in phonetics and the position of the tongue upon swallowing.

<table>
<thead>
<tr>
<th></th>
<th>AOB, n (%) / BA</th>
<th>NVO, n (%) / OVN</th>
<th>Total, n (%)</th>
<th>$P$-value$^*$ / Valeur $p^\dagger$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lingual interposition / Interposition linguale</td>
<td>88 (40.5) / 25 (16.7)</td>
<td>151 (57.2)</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Lingual thrust / Propulsion linguale</td>
<td>36 (27.3) / 1 (0.7)</td>
<td>37 (28)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Distortion</td>
<td>105 (39.8) / 24 (9.1)</td>
<td>129 (48.9)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Substitution</td>
<td>1 (0.4) / 0 (0)</td>
<td>1 (0.4)</td>
<td>1.004</td>
<td></td>
</tr>
<tr>
<td>Gingival margin / Gencive marginale</td>
<td>36 (13.6) / 38 (14.4)</td>
<td>74 (28)</td>
<td>0.784</td>
<td></td>
</tr>
<tr>
<td>Protrusion of the tongue / Protrusion de la langue</td>
<td>22 (8.3) / 4 (1.5)</td>
<td>26 (9.8)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Palatine surface / Surface palatine</td>
<td>23 (8.7) / 34 (12.9)</td>
<td>57 (21.5)</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Palatine rugae / Crêtes palatines</td>
<td>64 (24.2) / 100 (37.9)</td>
<td>164 (62.1)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Lower teeth / Dents mandibulaires</td>
<td>2 (1.5) / 8 (6.6)</td>
<td>10 (7.5)</td>
<td>0.053</td>
<td></td>
</tr>
<tr>
<td>Type of dentition / Type de dentition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed / Mixte</td>
<td>99 (37.5) / 67 (25.3)</td>
<td>264 (100)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Permanent / Permanente</td>
<td>37 (14) / 61 (23.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The $P$-values of Table I correspond to the Chi² test of independence between AOB and the variables presented in the table.

**Le tableau I**

Association entre la bêance antérieure (BA) et l’occlusion verticale normale (OVN) avec les altérations phonétiques et la position de la langue durant la déglutition.

Les variables quantitatives ne présentaient pas une distribution normale ($p < 0.05$). La médiane des BA était de 0 avec une étendue de 5 ; 37 patients (14,1 %) présentaient une BA de 1 et 2 mm, 29 patients (11,1 %) une BA de 3 mm,

Pour déterminer si la BA était associée à des troubles de phonation et de déglutition, nous avons appliqué un modèle de régression logistique dans lequel la BA a été considérée comme la variable dépendante. Les variables susceptibles d’être incluses répondaient aux critères statistiques et cliniques, tels que l’âge, le sexe, le type de dentition, l’interposition linguale, la proéminence linguale, la protrusion linguale, la distorsion, la substitution, le contact de la langue avec la gencive marginale, la surface palatine, les crêtes palatines, les incisives inférieures, et l’amplitude de la bêance antérieure. Un seuil de signification de 0.05 a été retenu pour tous les tests statistiques.

Les variables quantitatives ne présentaient pas une distribution normale ($p < 0.05$). La médiane des BA était de 0 avec une étendue de 5 ; 37 patients (14,1 %) présentaient une BA de 1 et 2 mm, 29 patients (11,1 %) une BA de 3 mm,
21 (8%) presented AOBs of 4 mm, and 6 (2.3%) individuals with AOBs of 5 mm were reported. Within the speech alterations, distortion occurred most frequently within the AOB group (39.8%), mainly during the pronunciation of the words /t/ (45.7%), /s/ (14.7%), and /d/ (10.9%). There were associations between AOB and the presence of lingual interposition, lingual thrust, distortion, protrusion of the tongue, contact with the palatine rugae, and type of dentition (Table I). No association was found between AOB and contact of the tongue with the gingival margin, with the lower teeth, and with the palatine surface of the incisors, as reflected by P-values greater than 0.05 in the Chi² test of independence. When evaluating the relationship between the magnitude of the AOB and tongue contact points during swallowing, significant relationships were found for tongue contact with the palatine rugae, tongue contact with the lower teeth, and the tongue in protrusion (Table II).

We found associations between the presence or absence of AOB and lingual interposition, distortion, and the presence of tongue contact with the gingival margin, the palatine rugae, and the lower teeth (Table III). The logistic regression model was significant (omnibus test P<0.0001), with a Nagelkerke coefficient of 50.9%, a P-value for Hosmer-Lemeshow of 0.631, and a global classification percentage of 81%. The significant variables for the model were distortion, lingual thrust, and tongue contact with the palatine rugae (P < 0.05). The variables that behaved as protective factors associated with AOB were the presence of lingual thrust and the contact of the tongue with the palatine rugae; the presence of distortion during speech was a risk factor (Table IV).

The probability of having AOB in those children with speech distortion was 10.8 times greater than those who did not have distortion. Lingual thrust decreased the probability of having AOB by 99%, and contact of the tongue with the palatine rugae decreased it by 58%.

During the regression analysis, different types of interactions were evaluated, including both significant and non-significant

<table>
<thead>
<tr>
<th>Table II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tableau II</strong></td>
</tr>
<tr>
<td>Relationship between the amount of anterior open bite (AOB) and the position of the tongue during swallowing.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Magnitude of AOB / Amplitude de la BA</th>
<th>Contact of the tongue with the palatine rugae / Contact de la langue avec les crêtes palatines</th>
<th>Contact of the tongue with the lower teeth / Contact de la langue avec les dents mandibulaires</th>
<th>Tongue in protrusion / Langue en protrusion</th>
<th>Contact of the tongue with the gingival margin / Contact de la langue avec la gencive marginale</th>
<th>Contact of the tongue with the palatine surface / Contact de la langue avec la surface palatine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P-value</strong> / <strong>Valeur p</strong></td>
<td>0.001</td>
<td>0.025</td>
<td>0.001</td>
<td>0.923</td>
<td>0.114</td>
</tr>
</tbody>
</table>

*Mann-Whitey U test,* Test-U de Mann-Whitey. BA : béance antérieure ; OVN : occlusion verticale normale.
variables. There were interactions between the following variables: lingual thrust with distortion and lingual thrust with lingual interposition. The children who presented only lingual thrust were not necessarily associated with AOB, whereas AOB was associated with those presenting lingual thrust with distortion during speech. In the latter case, lingual thrust became a risk factor when accompanied by distortion. The influence of the interaction between lingual thrust and lingual interposition was different since the odds ratio [OR] of the thrust increased to 0.097; therefore, it continued to be a protective factor with a slightly greater effect on the AOB (Table IV).

Table III
Associations of alterations in the position of the tongue and phonation according to the type of dentition.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mixed dentition 8–12 years, n (%) / Dentition mixte 8–12 ans, n (%)</th>
<th>Permanent dentition 13–16 years, n (%) / Denture permanente 13–16 ans, n (%)</th>
<th>P-value / Valeur de p</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOB / BA</td>
<td>97 (73.4)</td>
<td>35 (26.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>NVO / OVN</td>
<td>65 (49.2)</td>
<td>58 (43.9)</td>
<td></td>
</tr>
<tr>
<td>Lingual interposition / Interposition linguale</td>
<td>59 (22.3)</td>
<td>49 (18.5)</td>
<td>0.016</td>
</tr>
<tr>
<td>Distortion</td>
<td>68 (25.7)</td>
<td>57 (18.9)</td>
<td>0.005</td>
</tr>
<tr>
<td>Lingual thrust / Propulsion linguale</td>
<td>22 (8.3)</td>
<td>18 (6.8)</td>
<td>0.283</td>
</tr>
<tr>
<td>Substitution</td>
<td>3 (1.1)</td>
<td>2 (0.3)</td>
<td>0.448</td>
</tr>
<tr>
<td>Gingival margin / Gencive marginale</td>
<td>40 (15.1)</td>
<td>35 (13.2)</td>
<td>0.039</td>
</tr>
<tr>
<td>Protrusion of the tongue / Protrusion de la langue</td>
<td>16 (6.1)</td>
<td>10 (3.9)</td>
<td>0.991</td>
</tr>
<tr>
<td>Palatine surface / Surface palatine</td>
<td>36 (13.6)</td>
<td>23 (8.7)</td>
<td>0.899</td>
</tr>
<tr>
<td>Palatine rugae / Crêtes palatines</td>
<td>79 (30)</td>
<td>25 (9.3)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Lower teeth / Dents mandibulaires</td>
<td>4 (1.5)</td>
<td>12 (4.5)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Table IV
Results of logistic regression. OR: odd ratio; CI: confidence interval.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Constant / Constante</th>
<th>Coefficient</th>
<th>OR</th>
<th>CI / IC</th>
<th>P-value / Valeur de p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distortion</td>
<td>-1.341</td>
<td>2.375</td>
<td>10.751</td>
<td>5.658–20.427</td>
<td>0.001</td>
</tr>
<tr>
<td>Lingual thrust / Propulsion linguale</td>
<td>-2.710</td>
<td>0.067</td>
<td>0.009–0.518</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td>Contact of the tongue with the palatine rugae / Contact de la langue avec les crêtes palatines</td>
<td>0.868</td>
<td>0.420</td>
<td>0.216–0.818</td>
<td>0.011</td>
<td></td>
</tr>
</tbody>
</table>

non significatives. Nous avons trouvé des interactions d’une part entre propulsion et distorsion linguales, et d’autre part entre propulsion et interposition linguales. Les enfants qui présentaient uniquement une propulsion linguale n’avaient pas forcément une BA, alors que la BA était présente quand propulsion et distorsion linguale durant l’élocution étaient associées. Dans ce dernier cas, la propulsion linguale devait un facteur de risque lorsqu’elle était accompagnée d’une distorsion linguale. L’influence de l’interaction entre la propulsion et l’interposition linguale était différente étant donné que l’odds ratio [OR] de la propulsion a augmenté jusqu’à 0.097 ; par conséquent, elle a continué d’être un facteur protecteur avec un effet légèrement plus important sur la béance antérieure (Tableau IV).

Tableau III
Associations des troubles positionnels de la langue et la phonation selon le type de dentition. BA : béance antérieure ; OVN : occlusion verticale normale.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mixed dentition 8–12 years, n (%) / Dentition mixte 8–12 ans, n (%)</th>
<th>Permanent dentition 13–16 years, n (%) / Denture permanente 13–16 ans, n (%)</th>
<th>P-value / Valeur de p</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOB / BA</td>
<td>97 (73.4)</td>
<td>35 (26.5)</td>
<td>0.001</td>
</tr>
<tr>
<td>NVO / OVN</td>
<td>65 (49.2)</td>
<td>58 (43.9)</td>
<td></td>
</tr>
<tr>
<td>Lingual interposition / Interposition linguale</td>
<td>59 (22.3)</td>
<td>49 (18.5)</td>
<td>0.016</td>
</tr>
<tr>
<td>Distortion</td>
<td>68 (25.7)</td>
<td>57 (18.9)</td>
<td>0.005</td>
</tr>
<tr>
<td>Lingual thrust / Propulsion linguale</td>
<td>22 (8.3)</td>
<td>18 (6.8)</td>
<td>0.283</td>
</tr>
<tr>
<td>Substitution</td>
<td>3 (1.1)</td>
<td>2 (0.3)</td>
<td>0.448</td>
</tr>
<tr>
<td>Gingival margin / Gencive marginale</td>
<td>40 (15.1)</td>
<td>35 (13.2)</td>
<td>0.039</td>
</tr>
<tr>
<td>Protrusion of the tongue / Protrusion de la langue</td>
<td>16 (6.1)</td>
<td>10 (3.9)</td>
<td>0.991</td>
</tr>
<tr>
<td>Palatine surface / Surface palatine</td>
<td>36 (13.6)</td>
<td>23 (8.7)</td>
<td>0.899</td>
</tr>
<tr>
<td>Palatine rugae / Crêtes palatines</td>
<td>79 (30)</td>
<td>25 (9.3)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Lower teeth / Dents mandibulaires</td>
<td>4 (1.5)</td>
<td>12 (4.5)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Tableau IV
Résultats de l’analyse de régression logistique. OD : odd ratio ; IC : intervalle de confiance.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Constant / Constante</th>
<th>Coefficient</th>
<th>OR</th>
<th>CI / IC</th>
<th>P-value / Valeur de p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distortion</td>
<td>-1.341</td>
<td>2.375</td>
<td>10.751</td>
<td>5.658–20.427</td>
<td>0.001</td>
</tr>
<tr>
<td>Lingual thrust / Propulsion linguale</td>
<td>-2.710</td>
<td>0.067</td>
<td>0.009–0.518</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td>Contact of the tongue with the palatine rugae / Contact de la langue avec les crêtes palatines</td>
<td>0.868</td>
<td>0.420</td>
<td>0.216–0.818</td>
<td>0.011</td>
<td></td>
</tr>
</tbody>
</table>
The association between lingual function and the presence of AOB is difficult to demonstrate because of the difficulty of performing a study that can control all variables that influence the growth and development of individuals since malocclusions are the result of the interaction of genetics with environmental factors. Specifically, the aetiology of AOB is complex, multifactorial, and mostly unknown [1,2,13]. Non-nutritive habits have been identified as associated etiological factors, among which the habits of lingual thrust and atypical swallowing have been related [1,2,13–18]. In the present study, the position of the tongue was significantly altered with lingual thrust, accompanied by distortion during speech in most patients with AOB (Table I). Additionally, in most of the patients, the position of the tongue was located against the gingival margin and the palatine rugae. Although the position of the tongue at rest may have more influence than the position of the tongue in function because the duration of the force applied during function is less than the duration of the force at rest, the magnitudes of the forces at the 2 different times are very different. At rest, forces between 0 and 0.005 N are reported, while in function, they increase from 0.008 to 0.025 N. Therefore, attributing changes in dental positions to the lingual function depends on several factors, such as the position of the tongue at rest, the forces exerted at rest and in function, and the point of contact of the tongue during swallowing [1,5,12,13].

According to Rijpstra, only 1 child out of 10 reported with lingual thrust presents AOB [1]. In the present study, 36.4% of the children with AOB had lingual thrust (3.6 out of 10 children). AOB is associated with dysfunctional habits [1,2,10]. However, the literature is contradictory in this respect, and it is said that 5% of the aetiology is unknown. AOB can develop as a result of inherited skeletal patterns, and the degree to which it is expressed appears to be influenced by unfavourable environmental factors [1]. According to Heimer in 2010, children with non-nutritional sucking habits are 4.7 times more likely to develop AOB [18], while according to Silvestrini et al. in 2016, these habits increase the probability of AOB by only 4-fold [19]. The individuals evaluated in the present study did not present dysfunctional habits at the time of testing but could have presented them in previous stages, which could have influenced the current presence of AOB. However, studies show that eliminating habits during mixed dentition corrects 70.1% of AOB, so the existence of AOB in the individuals evaluated in the present study is not necessarily related to previous habits [7]. The low frequency of substitutions during speech and the high prevalence of distortions are due to normal processes within language development and due to the fact that reading and writing processes begin from the age of 7.

L’association entre la fonction linguale et la présence d’une BA est difficile à démontrer en raison de la difficulté à réaliser une étude capable de contrôler toutes les variables qui influencent chez l’homme la croissance et le développement des malocclusions, compte tenu des interactions de la génétique et des facteurs environnementaux. En particulier, l’étiologie de la BA est complexe, multifactorielle et encore inconnue [1,2,13]. Des habitudes non nutritives ont été identifiées comme étant des facteurs étiologiques associés, parmi lesquels les habitudes de propulsion linguale et de déglutition atypique ont été incriminées [1,2,13–18]. Dans notre étude, la position de la langue était significativement altérée avec une propulsion linguale, accompagnée d’une distorsion durant l’élocution chez la plupart des patients avec BA (Tableau I). De plus, chez la plupart des patients, la position de la langue se situait contre la gencive marginale et les crêtes palatines. Bien que la position de la langue au repos paraîse plus marquante quant à sa durée d’application que la position de la langue en fonction, les amplitudes des forces développées dans ces deux activités sont très différentes. Au repos, les forces se situent entre 0 et 0,005 N, alors que durant la fonction, elles augmentent de 0,008 à 0,025 N. Par conséquent, l’attribution des malpositions dentaires à la fonction linguale dépend de plusieurs facteurs, tels que la position de la langue au repos, les forces exercées au repos et en fonction, et le point de contact de la langue durant la déglutition [1,5,12,13].

D’après Rijpstra, seulement 1 enfant sur 10 identifié avec une propulsion linguale présentait une BA [1]. Dans notre étude, 36,4 % des enfants avec une BA présentaient une propulsion linguale (3,6 sur 10 enfants). La BA est associée à des habitudes dysfonctionnelles [1,2,10]. Cependant, la littérature est contradictoire sur ce point, et il est dit que 5 % de l’étiologie en est inconnue. Le développement d’une BA peut résulter de schémas squelettiques héréditaires et son degré d’expression semble être influencé par des facteurs environnementaux défavorables [1]. D’après Heimer en 2010, les enfants avec des habitudes de succion non nutritionnelles sont 4,7 fois plus susceptibles de développer une BA [18], alors que d’après Silvestrini et al. en 2016, ces habitudes augmentent la probabilité d’avoir une BA de seulement 4 fois [19]. Les individus évalués dans notre étude ne présentaient pas d’habitudes parafonctionnelles au moment de la réalisation du test, mais ont pu en présenter à des stades antérieurs, ce qui justifierait la permanence d’une BA. Cependant, des études montrent que la suppression des habitudes durant la dentition mixte permet de corriger 70,1 % des BA ; par conséquent, l’existence d’une BA chez les sujets évalués dans la présente étude n’est pas nécessairement liée à de précédentes mauvaises habitudes [7]. La faible fréquence des substitutions et la haute prévalence des distorsions lors de l’élocution sont dues à des processus normaux propres au développement du langage, et dues également au fait que l’apprentissage de la lecture et de l’écriture commencent à partir de l’âge de 7 ans.
Several studies have shown that cultural and economic factors can influence the presence of habits [5,7,14,15,19] and the degree of dental development [5]. The prevalence of AOB changes with age. Some authors have reported a decrease (16.9% to 11.4%) [19] and others an increase with the passage from deciduous to mixed dentition (43.5% to 54.2%, respectively) [5,16]. Although the present study did not include patients in deciduous dentition, similar behaviours were identified in the prevalence of AOB as reported by Urzal et al. in 2013 and Vieira et al. in 2014, with a decrease in the same with the passage from mixed dentition to permanent dentition, which may be because in permanent dentition, the incisors have already completed their eruption process [17,20], and the prevalence of habits is lower [20].

The risk factor associated with the presence of AOB reported in the present study was the presence of distortion during speech (OR = 10.751; 5.658–20.427). When considered as a habit, its association has been previously reported [21], taking into account that the change in the position of the tongue during the distortion causes the lingual thrust to perpetuate the AOB [6], which indicates the importance of performing speech evaluation in children with AOB to apply timely and specific treatments. Although phonemes involved with distortion (/t/d/s/ with dental joint position, /l/s/ with alveolar joint position) do not force the tongue to protrude between the teeth, they do alter the position of the tongue, causing a lingual thrust that can perpetuate the AOB or cause its recurrence.

In the case of tongue contact with the palatine rugae (OR = 0.420; 0.216–0.818), the tongue acts as a protective factor for presenting AOB since this position of the tongue when swallowing is related to a normal language function, with a higher percentage in individuals with NVO (37.9%) [6]. Other studies have reported other risk factors in individuals between 3 and 7 years, such as maternal nutrition (OR = 0.87; 95% CI: 0.48–1.62) and bottle feeding (OR = 0.61; 95% CI: 0.38–1.00) [21]. However, these factors were not considered in the present study. In other studies, performed during the deciduous dentition stage, individuals with a habit of sucking for more than 36 months presented a more open bite (RP: 1.41; 95% CI: 1.30 to 1.53) [15].

The presence of lingual thrust in the children of the present study acted as a protective factor against the development of an AOB, which indicates that 49.6% of children with lingual thrust will present NVO, supporting the theories of dentoalveolar compensations that compensate the presence of AOB in individuals with oral habits [5].

However, the age differences compared with the other studies do not permit comparing the results. Having older individuals can cause the detected factors to be acquired as compensations for growth patterns, but it can also help because the processes of growth and development and their adaptation
The authors declare that they have no competing interest.

None of the variables studied acted as confounding factors in the present study; however, 2 interactions were found that influenced the presence of AOB in the individuals in which they occurred. Children who were reported with the presence of lingual thrust and lingual interposition at the same time presented a lower tendency to present AOB due to a decreased odds ratio.

**Conclusion**

The association of factors such as lingual thrust, interposition, and protrusion with the presence of AOB reflects how function influences the development of a malocclusion; however, they cannot be referred to as etiological factors. Some behave as protective factors and others as risk factors. For example, the presence of lingual distortion during speech as a risk factor associated with the presence of AOB shows the importance of assessing the position of the tongue during all of its functions, with the purpose of establishing an appropriate diagnosis that permits designing a treatment to achieve replicable results. It is recommended to complement the present study with others that take into account the other factors that can produce AOB, extending it to other ages and including studies of cohorts with follow-up evaluations of the children.

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**Disclosure of interest**

The authors declare that they have no competing interest.

**Conclusion**

L'association de facteurs tels que la propulsion, l'interposition et la protrusion linguales en présence d'une béance antérieure reflète la façon dont la fonction influence le développement d'une malocclusion ; cependant, ils ne peuvent pas être considérés comme des facteurs étiologiques. Certains se comportent comme des facteurs protecteurs et d'autres comme des facteurs de risque. Par exemple, la présence d'une distorsion linguale durant l'élocution est un facteur de risque associé à la BA ; cela montre l'importance d'évaluer la position de la langue durant toutes ses fonctions, dans le but d'établir un diagnostic approprié permettant de prendre en compte dans un traitement adapté pour obtenir des résultats reproductibles. Il est recommandé de compléter la présente étude avec d'autres qui prennent en compte les autres facteurs pouvant entrainer une BA, en l'élargissant à d'autres tranches d'âge, et en incluant des études de cohortes avec des évaluations du suivi des enfants.

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**Déclaration de liens d'intérêts**

Les auteurs déclarent ne pas avoir de liens d'intérêts.
References