Criteria for diagnosing and treating anterior open bite with stability

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Abstract

Introduction: Anterior open bite is considered a malocclusion that still defies correction, especially in terms of stability. The literature reports numerous studies on the subject but with controversial and conflicting information. Disagreement revolves around the definition of open bite, its etiological factors and available treatments. It is probably due to a lack of consensus over the etiology of anterior open bite that a wide range of treatments has emerged, which may explain the high rate of instability following the treatment of this malocclusion. **Objective:** Review the concepts of etiology, treatment and stability of anterior open bite and present criteria for diagnosing and treating this malocclusion based on its etiology, and provide examples of treated cases that have remained stable in the long term.

Keywords: Open bite. Etiology. Treatment. Stability.

INTRODUCTION

The term "open bite" was coined by Caravelli in 1842 as a distinct classification of malocclusion[1] and can be defined in different manners.[2] Some authors have determined that open bite, or a tendency toward open bite, occurs when overbite is smaller than what is considered normal. Others argue that open bite is characterized by end-on incisal relationships. Finally, others require that no incisal contact be present before diagnosing open bite. For semantic reasons, and because it is in agreement with most definitions in the literature,[2,3,4,5] anterior open bite (AOB) is herein defined as the lack of incisal contact between anterior teeth in centric relation.

Given these different definitions for AOB, its prevalence varies considerably among studies depending on how authors define it. Prevalence in the population ranges from 1.5% to 11%.[6] The age factor, however, affects prevalence, since sucking habits decrease and oral function matures with age. At six years old 4.2% present with AOB whereas at age 14 the prevalence decreases to 2%.[5] In the US population, differences in prev-

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alence were detected between the different ethnicities, with 3.5% occurring in Caucasian children and 16.5% in Afro-descendant children.[5] Despite its low prevalence, the demand for treatment of this malocclusion is very common as approximately 17% of orthodontic patients have AOB,[6] which means that professionals should treat it in an effective and stable manner.

AOB ETIOLOGICAL FACTORS: FUNCTIONAL OR SKELETAL?

Teeth and alveolar bones are exposed to antagonistic forces and pressures stemming mostly from muscle function, which may partly determine the position of the teeth. On the other hand, the intrinsic forces of the lips and tongue at rest generate the balance required to position the teeth (Fig 1). By definition, balance occurs when a body at rest is subjected to forces in various directions but does not undergo acceleration or — in the case of teeth — is not displaced.[7] Every time this balance is altered, changes occur, such as for example contraction of the dental arches in animals subjected to glossectomy when compared to control animals.[8] Thus, when a tooth is extracted its antagonist continues the process of passive eruption, indicating that the mechanism of eruption remains basically unchanged throughout life and that the tooth seeks occlusal or incisal contact until balance is reached.[7]

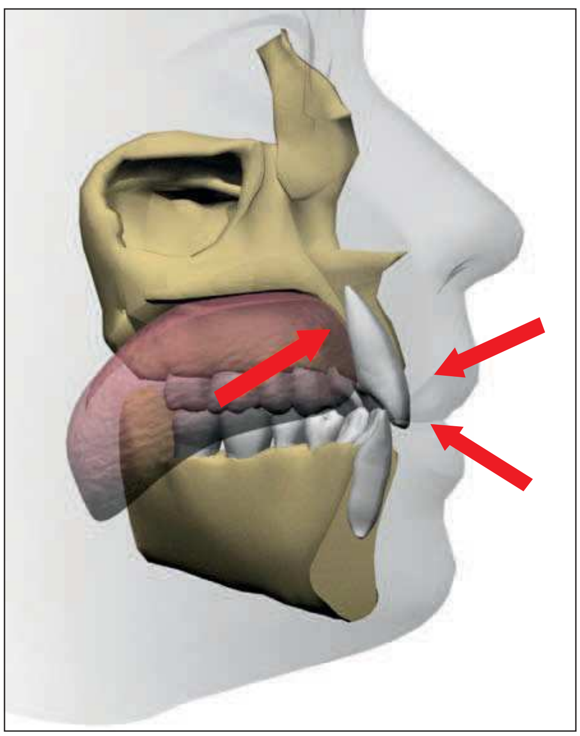


FIGURE 1 - Schematic illustrating balance between forces of lips and tongue (arrows), allowing contact of maxillary incisor and therefore achieving normal overbite.

Based on this idea of balance several etiological factors related to oral function have been associated with AOB. For example, sucking habits, presence of hypertrophic lymphoid tissues, mouth breathing, atypical phonation and swallowing, and anterior posture of the tongue at rest.[2,3,9,10,11] It should be noted, however, that not all of these etiological factors exhibit a perfectly clear cause and effect relationship.

The causal relationship between AOB and nonnutritive sucking habits, such as the sucking of fingers and pacifiers, has been very well established.[12] In such cases, AOB self-corrects consistently after removal of the sucking habit, provided that no other secondary dysfunctions have set in[2] (Fig 2). These secondary dysfunctions may develop from maxillary incisor protrusion generated by the sucking habit, thereby hindering the lip seal required for swallowing, and causing the tongue to be abnormally positioned, especially at rest.[11]

During childhood the tongue is proportionally larger than the oral cavity and it therefore protrudes beyond the alveolar ridges. The jaw bones grow faster than the tongue during childhood and eventually the size of the oral cavity adapts to tongue size.[10] In fact, longitudinal studies in children showed that the prevalence of tongue protrusion in speech and swallowing is significantly reduced starting at 8 years of

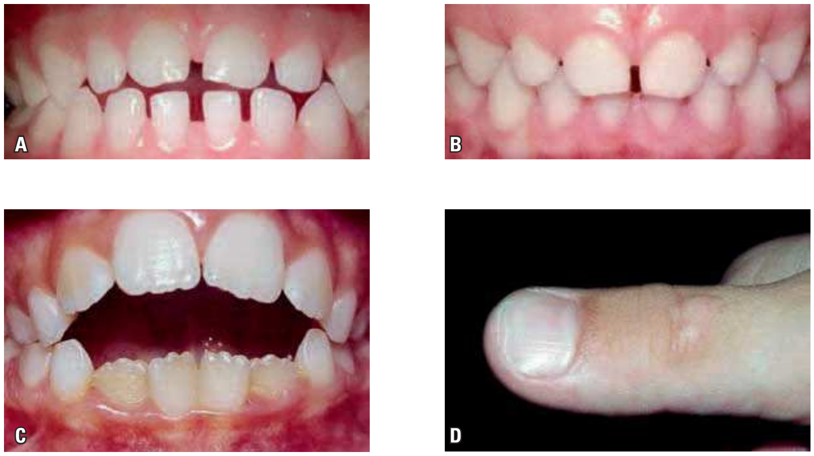


FIGURE 2 - **A**) AOB in primary teeth caused by pacifier sucking and **B**) spontaneous correction after removal of habit. **C**) AOB in mixed dentition caused by thumb sucking. It is noteworthy how AOB morphology differs according to causative agent. Pacifier is soft and deformable, creating more elongated and narrow open bite, whereas finger is stiffer and larger, creating wider, rounded open bite with protruded maxillary incisors and deficient eruption in mandibular incisors. **D**) When thumb sucking habit is so intense the back of the finger may become callous.

age. It is approximately 51.7% at 4 years of age and 38.9% at age 12.[14]

Some authors believe that the forces generated during swallowing and phonation can cause changes in the shape of the dental arches.[4] Although these disorders are associated in the literature with AOB etiology, other studies show that these functions are short lived and not sufficient to cause dental changes.[7,11] Frequency of atypical speech and swallowing is much higher than AOB prevalence, which may explain the tenuous causal link between the presence of atypical speech and swallowing, and the presence of this malocclusion.[11]

Hypertrophic adenoids and tonsils are the most common cause of nasal obstruction and, consequently, mouth breathing in children.[4] The effect of airway obstruction on the occlusion was demonstrated by Harvold et al[16] who, after placing acrylic blocks in the posterior region of the palate of rhesus monkeys, found that AOB had developed. Induced nasal obstruction was also performed using nasal splints in rhesus monkeys, which, in an attempt to secure an oral air passage, developed open mouth posture and protruded tongue.[17]

Therefore, hypertrophic lymphoid tissues and nasal obstruction may force the tongue to remain in a position designed to allow breathing to occur through the oropharyngeal rather than nasopharyngeal space.[12,18] In general, lymphoid tissues undergo involution during puberty, allowing the tongue to adopt a position more posterior than what is deemed normal.[2] However, Linder-Aronson et al[19] found that dentoalveolar response to adenoidectomy is highly variable and therefore should not be considered as a prophylactic procedure for the development of AOB. Indeed, not all patients with mouth breathing due to partial nasal blockage develop AOB.[4]

Most investigations of AOB etiology agree on the existence of secondary dysfunctions, which remain after the correction of an abnormal function, such as, especially, poor tongue posture at rest.[4,7,12] It is believed that a gentle but continuous

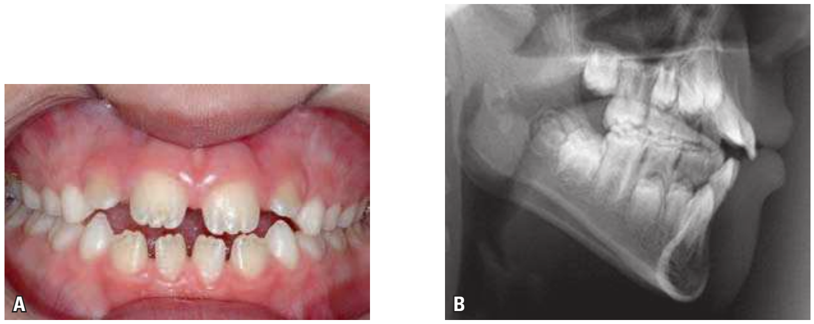


FIGURE 3 - AOB caused by poor posture of the tongue at rest and lip interposition (**A**). Cephalometric radiograph contrast allows the tongue to be viewed in its resting position, supported by the mandibular incisors, preventing their proper eruption, and the interposition of the lower lip between the incisors, preventing the proper eruption of the maxillary incisors is also visible (**B**).

pressure exerted by the tongue against the teeth can move such teeth, yielding significant effects. If a patient has a previous posture in which they have positioned their tongue, the duration of this pressure — even if very light — can affect the eruption process, or move anterior teeth, resulting in an open bite.[10,11]

Tongue posture at rest is long lasting (several hours a day), which makes it clinically important as it can prevent the eruption of incisors, thereby causing and maintaining AOB (Fig 3). In addition, a low tongue posture may encourage the eruption of posterior teeth and constrict the upper arch since the tongue does not touch the palate.[7] This etiological factor has not been studied enough and is generally overlooked during AOB treatment. Failure to eliminate this factor may be the primary reason of AOB relapse.[10]

In 1964, Subtelny and Sakuda[2] published an article on the diagnosis and treatment of AOB. Based on the premise that abnormal functional habits either decrease or are absent in adolescents, these authors sought out an explanation for the existence of what they called "persistent open bites," i.e., those that persist after childhood. They conducted a cephalometric study in 25 patients with "persistent open bite" and compared them with 30 patients with normal occlusion. All subjects were over 12 years of age. Basically, in cases of open bite the following significant differences were found: Greater eruption of maxillary molars, extrusion of maxillary incisors and overly increased mandibular planes and gonial angles. This facial pattern was named "skeletal open bite." Its primary etiological factor is an unfavorable growth pattern with divergent basal bones and therefore no contact between the incisors. These etiological factors are associated with growth and not function, and can thus be defined as skeletal factors.

Over the years, vertical facial pattern was ultimately considered as the main risk factor for AOB and its treatment instability. However, other studies[10,20] have reported that most hyperdivergent patients exhibit a normal or excessive overbite (Fig 4) while patients with normal facial patterns display a "persistent open bite"[4] (Fig 5).

One can therefore infer that skeletal pattern per se cannot be the cause of AOB.[7] In revisiting the aforementioned idea of balance of forces between teeth, the presence of a physical barrier prevents the incisors from coming into occlusal contact. Since an abnormal posture of the tongue at rest may occur in different situations,[4,10] this may be the key etiological factor in AOB.

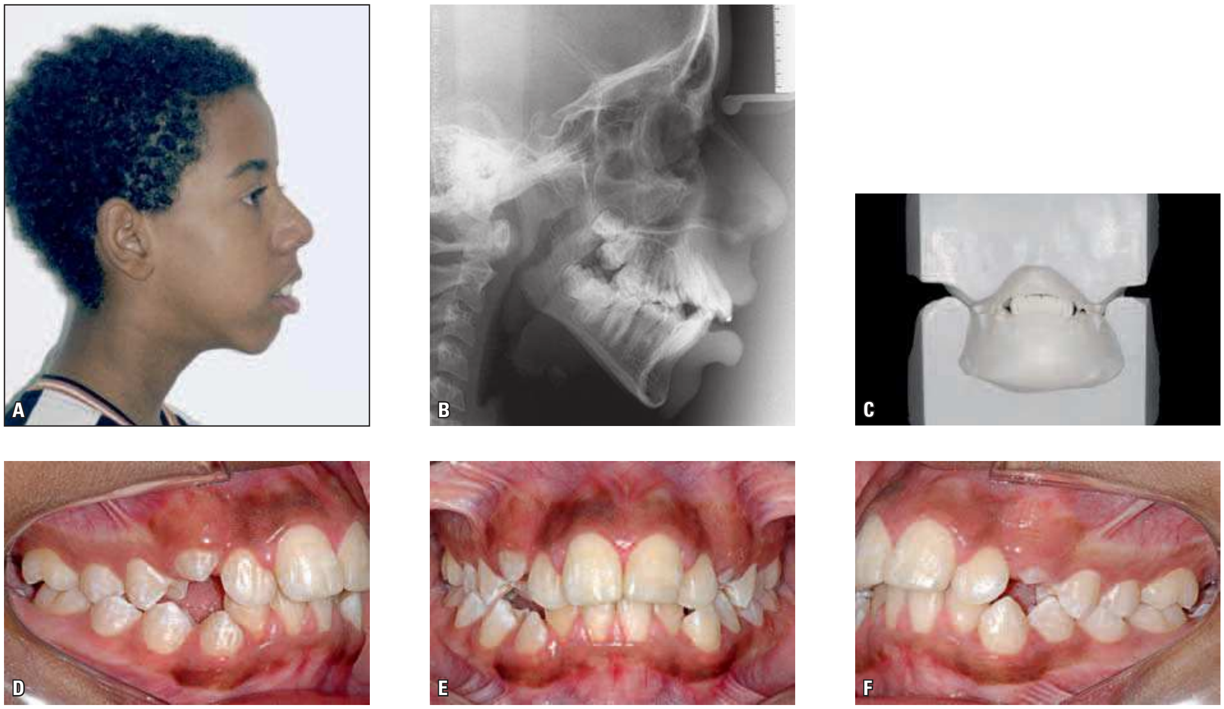


FIGURE 4 - Profile photograph (**A**), cephalometric radiograph (**B**), casts (**C**) and intraoral photographs (**D**, **E** and **F**) of a patient with hyperdivergent facial pattern (SNGoGn=49º), showing excessive overbite, which can be seen more clearly in a posterior view of the plaster casts in occlusion. The lower incisors touch the palate seeking occlusal contact since there is no structure preventing its eruption.

AOB TREATMENT AND STABILITY

Due to numerous etiological factors described in the literature various types of treatment have been postulated for correcting AOB. No consensus has been reached, however, as to what would be the best treatment for this malocclusion:[6] (a) Changes in behavior to eliminate habits or abnormal functions, (b) Orthodontic movement by extruding the anterior teeth or intruding the molars, or (c) Surgical treatment of the basal bones.[21] The only consensus that seems to exist is that AOB treatment is challenging[3,6] and has poor stability.[6,9,22]

Functional treatments

Myofunctional therapy is used to alter function and consists of a set of exercises to reeducate orofacial muscles in swallowing, speech and resting posture.[11,12,15] It is believed that voluntary activities such as swallowing and speech are easier to correct using myofunctional exercises while involuntary activities such as tongue posture habits are hard to automate.[11,14]

Another way to correct functional habits is through mechanisms that prevent the tongue from resting on the teeth.[23] The best known are palatal or lingual cribs[24] and spurs[10,25] There is a consensus that these devices should be fixed with the purpose of re-educating the function until automatic movements are attained.[25,26]

Palatal or lingual cribs are aimed at correcting AOB by preventing the tongue from resting on the teeth. They must be long to prevent the tongue from positioning itself below them.[24] However, such structures are smooth and deliberately allow the tongue to rest on them so

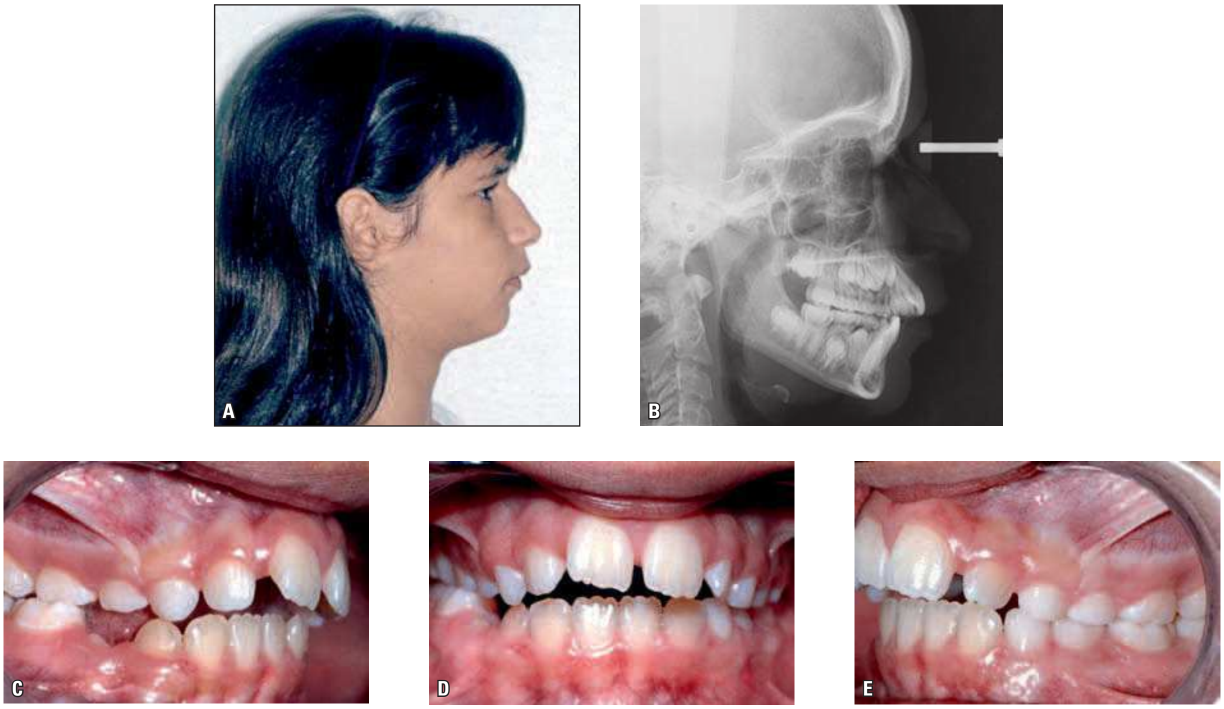


FIGURE 5 - Profile photograph (**A**), cephalometric radiograph (**B**) and intraoral photographs (**C**, **D** and **E**) of a patient with normal facial pattern (SNGoGn=34º), with AOB. The incisors are not in contact due to mechanical obstruction, possibly due to tongue posture since the patient reported no sucking habits.

that in some cases this may prevent the functional re-education of the tongue. In these cases, the tongue returns to its original position as shown by the cinefluoroscopic method,[28] thus leading to AOB relapse.

The use of spurs was described by Rogers[28] in 1927 in the treatment of three AOB cases. The spurs were welded to a palatal arch and placed from canine to canine. All cases were corrected by normalizing the tongue posture. Several types of similar devices were later described in which spurs can be soldered to the lingual surfaces of maxillary incisor bands or attached to palatal[10] or lingual[29] arches or, alternately, bonded to the lingual or palatal surfaces of the incisors.[26]

Despite their efficacy, treatments using spurs are sometimes regarded as punitive,[1,2] although there are no reports of pain or injury to the tongue.[10] Furthermore, Haryett et al[23] concluded that any type of device used to break the finger sucking habit, including spurs, can cause psychological disorders.

Spurs induce a change in the resting position of the tongue, thus allowing tooth eruption and open bite closure. This change in tongue position alters sensory perception by the brain, thereby producing a new motor response. This response can be imprinted permanently in the brain, which explains the permanent change in tongue posture produced by spurs. This is one of the factors responsible for AOB treatment stability.[10,25]

Huang et al[3] evaluated AOB treatment stability using cribs or spurs in 33 patients divided into two groups, one with and one without growth. These authors found that AOB correction occurred in both groups but 17.4% of cases showed relapse. Since no comparison between different treatment types was performed, one could argue that patients whose overbite is corrected with the use of cribs or spurs stand a good chance of maintaining long-term treatment outcome. However, comparative studies between these two types of treatment would be invaluable for the prognosis of AOB treatment.

Orthodontic treatments

There are several types of treatment involving orthodontic movement for correction of open bite, with different therapeutic goals. Extraoral appliances, vertical chincups, bite-blocks and functional appliances are designed to reduce the extrusion of molars, allowing a counterclockwise rotation of the mandible.[6,9,22] More recently, the same mechanism was implemented with the aid of anchorage to intrude molars.[6,21] Mechanics with intraoral elastics are used both for incisor extrusion[2] and molar intrusion, as well as for rotation of the occlusal plane combined with multiloop archwires.[30] Although there are many successful reports of these therapies few studies have been conducted to investigate their long-term stability, which precludes any reliable prognoses for these treatments.[4,6,22]

Stability in the correction of AOB in patients treated orthodontically with fixed appliances associated with high-pull and combined headgear was evaluated 10 years after treatment.[9] AOB relapse was greater than 3 mm in 35% of the cases. The sample was then stratified into stable and relapse groups for comparison of cephalometric variables. All variables were similar between the groups at the beginning of treatment, except for anterior dental height in the mandibular arch, which was lower in the relapse group at all treatment times.

Zuroff et al[6] assessed AOB stability 10 years after treatment. Sixty-four patients were divided into three groups: One with incisal contact, one with open bite and overlap, and one with open bite. All patients were only treated orthodontically. After treatment, 4% of the group with incisal contact had overjet relapse; 20% of the group with open bite and overlap had overjet relapse but preserved incisal contact; and 40% of the open bite group had overjet, with 60% displaying no incisal contact. These results indicate that a lack of vertical overlap prior to treatment exerts a greater adverse effect on AOB stability compared to open bite with overlap.

Surgical Treatments

Surgical treatments for AOB began in the 70s and were indicated for extremely severe cases with mandibular plane above 50 degrees. Thereafter, these treatments have become more common and usually include LeFort I osteotomy for superior repositioning of the maxilla. This allows a counterclockwise rotation of the mandible, thus correcting AOB.[22]

Denison et al[22] assessed the stability of AOB surgical treatment in 66 adult patients followed up for at least 1 year after surgery. These patients were stratified according to preoperative vertical overlap, namely: Open bite, open bite with overlap, and normal overlap. Open bite recurred in 42.9% of cases in the open bite group while the groups with open bite and overlap, and normal overlap showed no changes in postoperative overbite. It was found that the instability found in patients in the open bite group was due to dentoalveolar changes and not to skeletal changes.

Once it has been eliminated in surgical patients, one cannot claim that hyperdivergence is an etiological factor since these patients are adults and exhibit little or no growth. Therefore, it is believed that the relapses found in the study described above are of dentoalveolar origin, generated by oral disorders overlooked in the pretreatment phase.[10]

Greenlee et al[21] published a meta-analysis which evaluated AOB treatment stability in surgical and nonsurgical studies. A 75% stability rate was found in both types of treatment. However, these results should be viewed with caution since these various treatments were examined in different studies and applied to different populations. Moreover, these studies lacked control groups.

Nowadays there are not enough evidence-based findings to support the effectiveness of AOB[21] treatment or stability of AOB correction. Randomized trials evaluating different therapies are thus necessary.[5] However, the outcomes of the stability studies described above indicate that AOB relapse is linked to two factors: Dentoalveolar changes and open bites with no vertical overlap prior to treatment.[3,6,9,22] These data suggest that AOB relapse is generally caused by the anterior position of the tongue at rest, an etiological factor that has not merited due attention in both orthodontic and surgical treatment.[3,10]

DIFFERENT POSTURES OF THE TONGUE AT REST

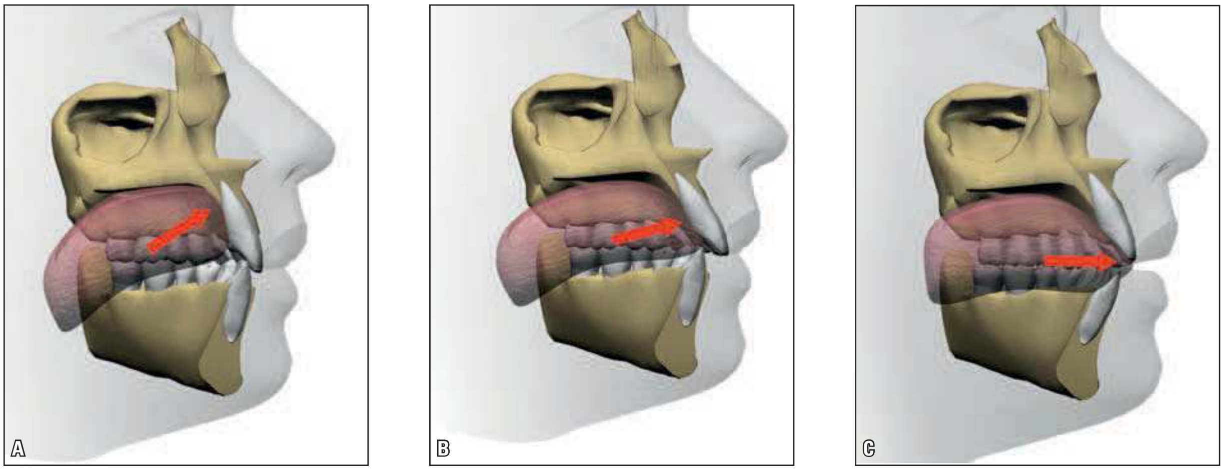
AOB morphology is directly associated with etiological factors,[7] which differ for each type of habit (Fig 2). In AOB cases that do not result from sucking habits one can use this logic to differentiate between the resting positions of the tongue, as there may be more than one type of resting position.

The position considered normal for the tongue at rest is one in which the tip of the tongue rests on the incisal papilla and its back lies along the palate (Figs 1 and 6A), keeping the anterior teeth in balance while preserving the transverse dimension of the upper arch.[7] However, some AOBs show changes in the positions assumed by maxillary incisors and others display changes in the positions of mandibular incisors. Based on these morphological characteristics some different resting positions of the tongue are suggested: High, horizontal, low and very low (Fig 6).

A high posture of the tongue at rest is associated with slightly protruded maxillary incisors and AOB may exhibit vertical overlap and positive horizontal overlap. Since the tongue rests on the palatal surface of the incisors, beneath the incisal papilla, upper incisors are positioned above the occlusal plane. Leveling of the mandibular arch is unaffected and displays a single occlusal plane (Fig 7). Posterior crossbites are not present as the back of the tongue rests on the palate while maintaining the transverse dimension of the upper arch.

In the horizontal posture of the tongue at rest, the tongue appears lower than in the high position, although with greater protrusion, resting on the palatal surface of the upper incisors and on the incisal edges of the lower incisors. The major effect in this case can only be seen in the upper arch, where protrusion of maxillary incisors was more prominent, which prevented their extrusion, thereby causing AOB. Also due to the greater protrusion of the incisors, a positive and increased horizontal overlap was noted. As the tongue positions itself lower, its back turns away from the palate allowing transverse changes to occur in the maxillary arch, which may cause posterior crossbites (Fig 8).

As the tongue assumes a lower position, pressure begins to be exerted on mandibular teeth. In the low posture of the tongue, it rests on the lingual surface of the crowns of mandibular incisors, thereby protruding these teeth and preventing their eruption, which establishes a moderate open bite. Due to protrusion in the lower incisors, horizontal overlap may be zero or negative. A gap can be seen between the occlusal surfaces of posterior teeth and the incisal surfaces of anterior teeth in the lower arch only, with lower incisors positioned below the occlusal level. Posterior crossbites may be present for the same reason mentioned above (Fig 9).



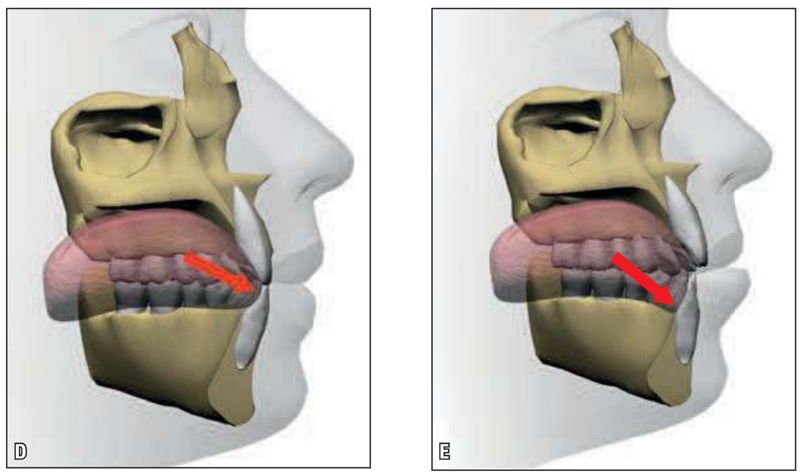


FIGURE 6 - Classification for posture of the tongue at rest: (**A**) Normal, (**B**) high, (**C**) horizontal, (**D**) low and (**E**) very low.

FIGURE 7 - Schematic (**A**) and photographs (**B** and **C**) of high posture of the tongue at rest, associated with a mild AOB; may exhibit vertical overlap. The maxillary incisors are protruded and lower arch leveling is unchanged. No posterior crossbite was observed. The arrows represent the direction of the force exerted by the tongue.

A very low tongue posture occurs when the tongue rests below the crowns of the mandibular incisors in the lingual region of the lower alveolar ridge. The direction of tongue pressure produces retroclination of mandibular incisors and prevents their eruption, positioning them below the occlusal level. The open bite is more severe and associated with posterior crossbite due to the fact that the tongue moves away from the palate. The tongue sprawls across the mouth floor, expanding the lower arch in the transverse direction (Fig 10).

TREATMENT CHOICE BASED ON TONGUE POSITION AT REST: RESTRAINING AND ORIENTING TREATMENTS

Understanding AOB etiology in each patient may help in their treatment and long-term stability.[4] These various postures of the tongue at rest will guide orthodontists in choosing the treatment capable of bringing the tongue back to a correct resting posture, thus removing the causative agent of the malocclusion.

Once the AOB causative agent has been identified and ascribed to an abnormal posture of the tongue, orthodontists should classify tongue posture through an analysis of the morphological features of the malocclusion.

High and horizontal tongue postures are positioned very close to normal posture and require control in the horizontal direction only. It is suggested that blocking mechanisms such as cribs are sufficient to produce this tongue retraction and adapt it to its correct posture at rest. This type of treatment will be referred to as restraining treatment.

However, in the low and very low tongue postures, the tongue is not only protruded but it is positioned below its correct position and needs to be retracted and elevated. This process is difficult to learn and automate,[25] requiring educating devices which force the direction of the tongue, such as spurs. This type of treatment will be referred to as orienting treatment.

To illustrate these types of treatment, and in particular their stability, AOB cases caused by each type of tongue posture at rest, which were monitored in the long-term, will be presented.

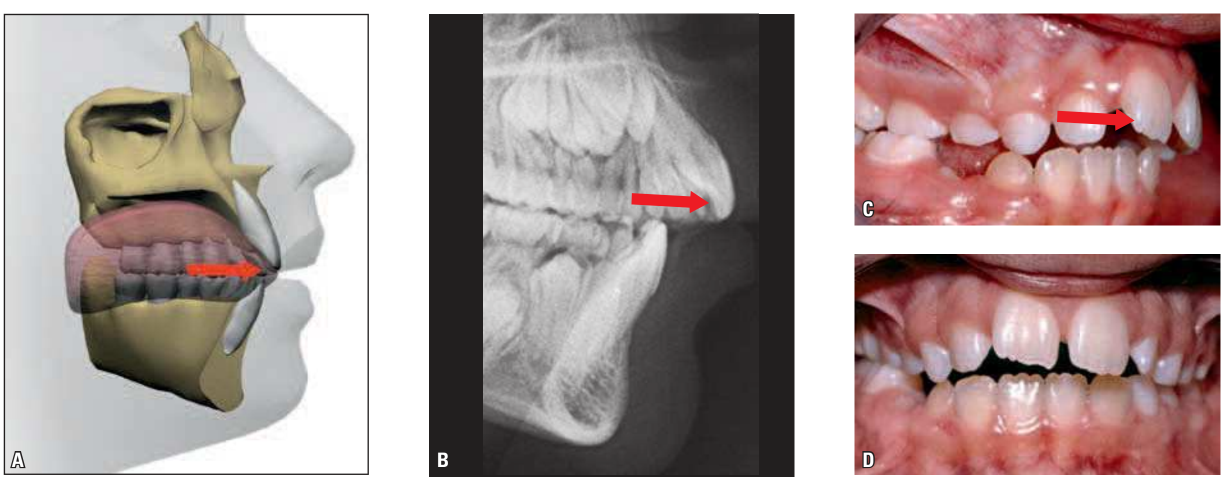


FIGURE 8 - Schematic (**A**), radiograph (**B**) and photographs (**C** and **D**) of horizontal posture of the tongue at rest, associated with a moderate AOB; may exhibit vertical overlap. The maxillary incisors are markedly protruded and above the occlusal plane. Lower arch leveling is unchanged. Due to the distance between the back of the tongue and the palate, posterior crossbites may emerge. The arrows represent the direction of the force exerted by the tongue.

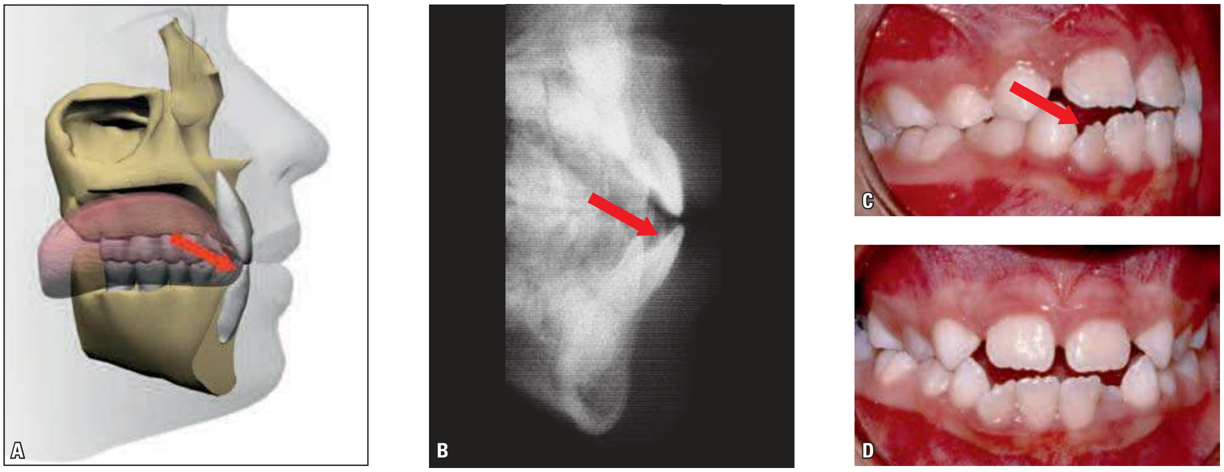


FIGURE 9 - Schematic (**A**), radiograph (**B**) and photographs (**C** and **D**) of low posture of the tongue at rest, associated with a moderate AOB. The mandibular incisors display a pronounced protrusion. Lower arch leveling is changed, with mandibular incisors positioned below the occlusal level. Due to the distance between the back of the tongue and the palate, posterior crossbites may emerge. The arrows represent the direction of the force exerted by the tongue.

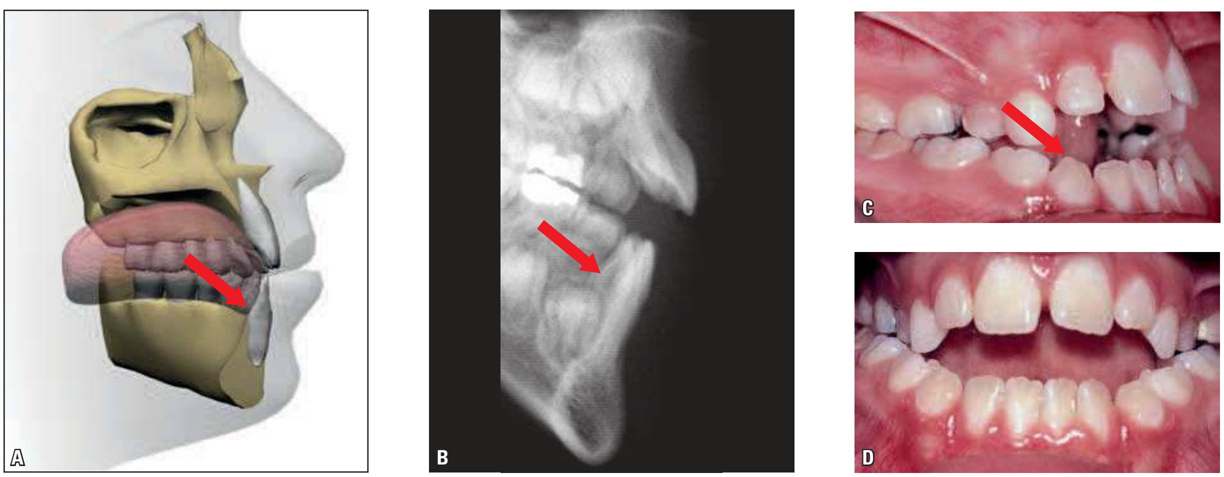


FIGURE 10 - Schematic (**A**), radiograph (**B**) and photographs (**C** and **D**) of very low posture of the tongue at rest, associated with a severe AOB. The mandibular incisors appear uprighted or retroclined. Lower arch leveling is changed, with mandibular incisors well below the occlusal level. Due to the distance between the back of the tongue and the palate, posterior crossbites are bound to emerge. The arrows represent the direction of the force exerted by the tongue.

APPLYING CRITERIA FOR AOB DIAGNOSIS AND TREATMENT: CASE REPORTS

Case 1: High Posture of Tongue at Rest

This is an 8-year-old female patient in the mixed dentition stage. She presented with an Angle Class I malocclusion with AOB, slightly increased overjet, protruded maxillary incisors and interincisal diastemas in the upper arch. The lower arch was normal. The face was symmetrical with a slightly convex facial profile (Fig 11).

Patient history did not reveal sucking habits, indicating that AOB was caused by an abnormal posture of the tongue at rest. AOB morphological characteristics indicated that the patient had a high tongue posture as it did not change the occlusal plane in the lower arch. However, the maxillary incisors were protruded and positioned above the occlusal plane (Figs 11C, D and E). Since the treatment goal was to restrain the tongue in the horizontal direction, placing it further back, restraining treatment was preferred and a Hawley retainer was therefore used, combined with a crib (Fig 12A).

The retainer was used for a period of two years until the patient was in the final stage of mixed dentition (Fig 12B). She was monitored until the permanent dentition phase. The open bite was closed, overjet and interincisal diastemas reduced (Figs 13C, D and E). No other treatment was performed on this patient, who achieved a stable result as can be seen from the records obtained 32 years after treatment (Fig 14).

It was only thanks to the removal of a poor tongue posture that establishing a normal horizontal overlap became possible and, more importantly, the AOB etiological factor was eliminated, thus ensuring a stable result for many years (Fig 15).

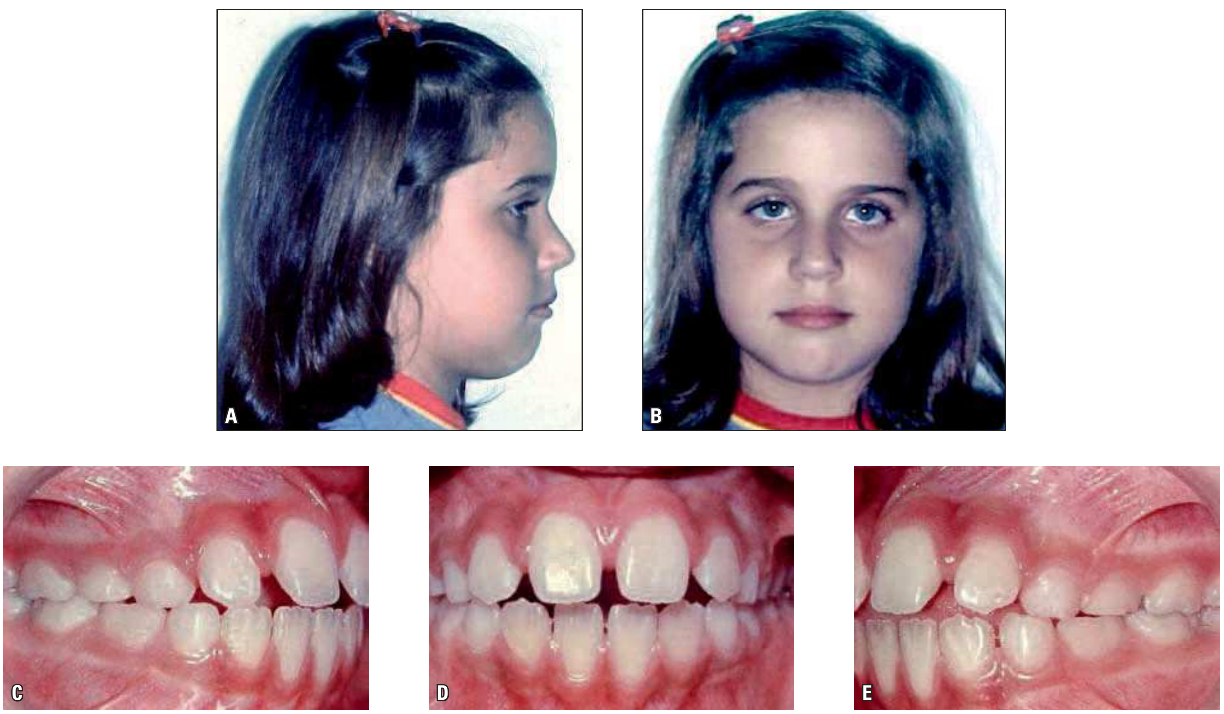


FIGURE 11 - Initial facial (**A** and **B**) and intraoral photographs (**C**, **D** and **E**).

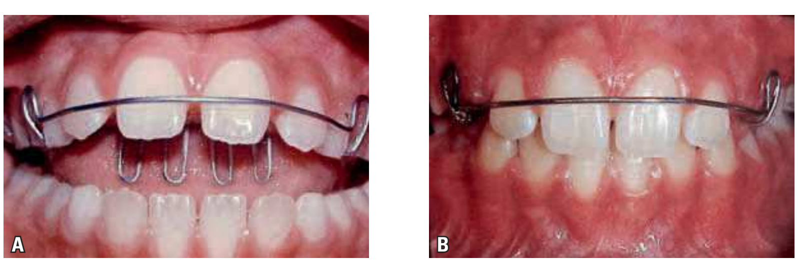


FIGURE 12 - Hawley retainer with crib (**A**) used to treat patients for a two-year period until a normal overbite was attained (**B**).

FIGURE 13 - Extraoral (**A** and **B**) and intraoral photographs (**C**, **D** and **E**) at the end of treatment. The patient was not subjected to any other type of orthodontic treatment.

FIGURE 14 - Extraoral and intraoral photographs 32 years after treatment.

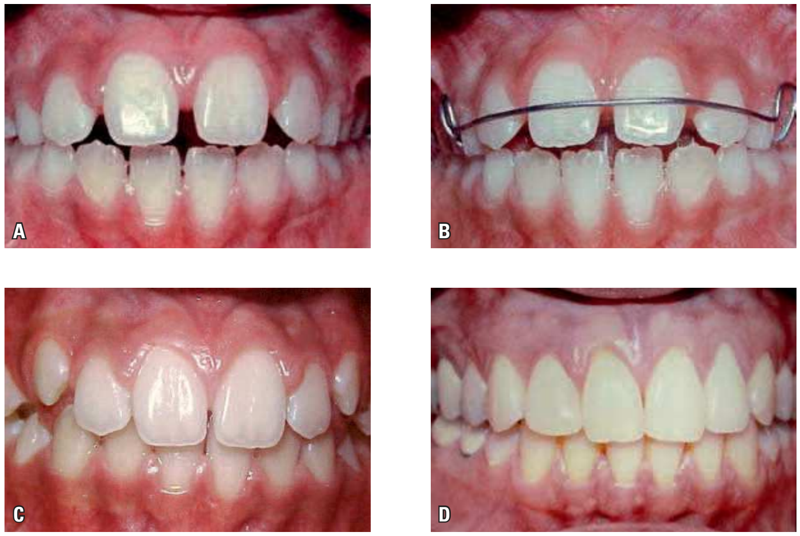


FIGURE 15 - **A**) Initial AOB condition, **B**) during treatment with Hawley retainer with crib, **C**) end of treatment and **D**) 32 years after treatment, demonstrating stability of AOB correction.

Case 2:
Horizontal Posture of Tongue at Rest

A female patient aged 9 years, in the mixed dentition period presenting with an Angle Class II, Division 1 malocclusion, 8 mm overjet, cross bite of teeth 16 and 46, AOB and less than 2 mm midline shift to the right (Figs 16E, F and G). She had a Class II skeletal pattern with 10° ANB (SNA=88° and SNB=78°) and normal mandibular plane (SNGoGn=34°) (Fig 16D). Facial evaluation showed a symmetrical face and convex profile (Figs 16A, B and C).

Patient history revealed that she had no sucking habits, suggesting that AOB etiology was related to abnormal tongue posture. To determine what sort of tongue posture the patient had it was observed that lower arch leveling was normal while the upper incisors were protruded and positioned above the occlusal level. These features suggest a horizontal posture of the tongue associated with marked overjet. Therefore, restraining treatment would be indicated in this case.

It was decided the use of a modified Thurow appliance with expansion screw and palatal crib (Fig 17), which was worn for six consecutive months. After this period, an Angle Class I molar relationship was attained with 3 mm overjet, the crossbite was corrected as well as the AOB (Figs 18E, F and G) and there was improvement in the skeletal relationship (SNA=83°, SNB=78° and ANB=5°) (Fig 18D). The face remained symmetrical and the profile slightly convex (Figs 18A, B and C). The appliance was then worn only at night for another six months for retention purposes.

At age 12 the second phase of treatment was initiated with the placement of a fixed metallic orthodontic appliance. Due to the correction of tongue posture the upper incisors extruded (Fig 19), reaching a situation of excessive overbite, as shown in Figures 18E, F and G. It was therefore necessary to employ utility archwires to intrude the incisors and attain a normal overbite. The second phase of treatment was completed by correcting the horizontal and vertical overlaps, and the Class I molar relationship was maintained (Figs 20D, E and F). The face remained symmetrical with a balanced facial profile (Figs 20A, B and C).

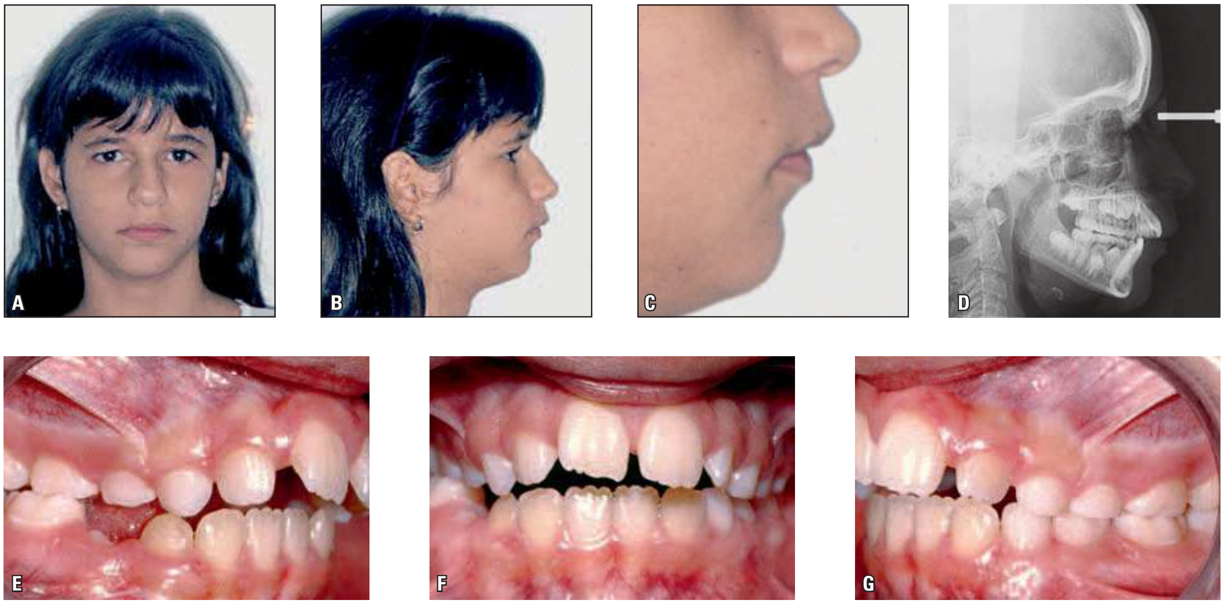


FIGURE 16 - Initial extraoral photographs (**A**, **B**, **C**), cephalometric radiograph (**D**) and intraoral photographs (**E**, **F** and **G**).

FIGURE 17 - Modified Thurow headgear used in the first treatment phase containing a posterior maxillary splint with an expansion screw, lingual crib and Hawley clasp.

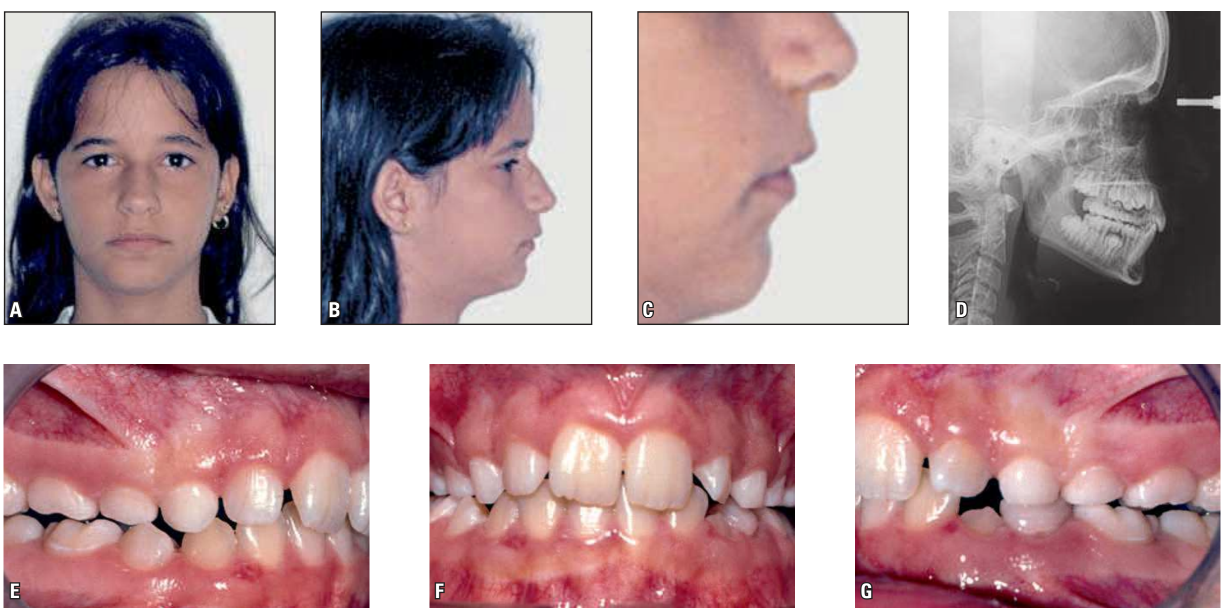


FIGURE 18 - Extraoral photographs (**A**, **B**, and **C**), cephalometric radiograph (**D**) and intraoral photographs (**E**, **F** and **G**) at the end of the first treatment phase.

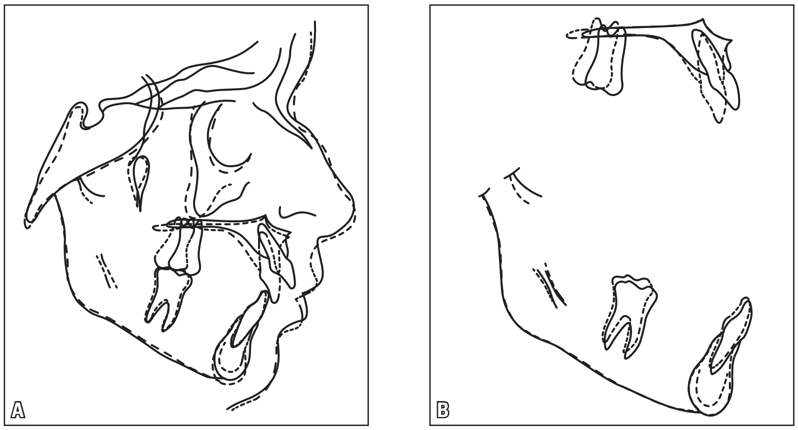


FIGURE 19 - Total (**A**) and partial (**B**) cephalometric superimpositions comparing the beginning and end of the first treatment phase. It is noteworthy that AOB correction occurred by extrusion of the maxillary incisors.

FIGURE 20 - Extraoral (**A**, **B** and **C**) and intraoral photographs (**D**, **E** and **F**) at the end of the second treatment phase.

In this case, AOB correction occurred thanks to a spontaneous extrusion of the incisors (Fig 19) after using a palatal crib and correcting the tongue posture. The results were stable as can be seen in the follow-up photographs 10 years after treatment (Fig 21). Stability of AOB correction was accomplished because the etiological factor was eliminated and, in this case, it was curious to note that the AOB evolved into an excessive overbite (Fig 22). This suggests that after removing the AOB etiological factor one can develop any degree of overbite (normal or excessive) and, therefore, it is advisable to use plates with stops as a retention mechanism like the ones used in this patient.

FIGURE 21 - Extraoral (**A**, **B** and **C**) and intraoral photographs (**D**, **E** and **F**) 10 years after treatment.

FIGURE 22 - Degrees of vertical overlap at the beginning of treatment showing AOB (**A**), after the first treatment phase with excessive overbite (**B**), at the end of treatment (**C**) and 10 years after treatment, with adequate vertical overlap (**D**).

Case 3: High Posture of Tongue at Rest

A 7-year-old female patient with mixed dentition presented with a Class I molar relationship, without horizontal overlap, with AOB and tendency toward posterior crossbite (Figs 23E, F and G). No sucking habit was reported. She had a typical skeletal Class I (SNA=78°, SNB=77° and ANB=1°) with increased mandibular plane (SNGoGn=37) (Fig 23D). The face was balanced with no apparent asymmetries, with lip incompetence and a convex profile (Figs 23A, B and C).

The morphological features of this AOB included slightly protruded maxillary incisors with deficiently erupted and protruded mandibular incisors (IMPA=100°) (Figs 23D and F). These effects in the lower arch suggest a low posture of the tongue at rest. Since this tongue had to be retracted and elevated, it was decided to conduct orienting treatment with spurs on the lingual arch (Fig 24).

The spurs were worn for a period of two years and the patient monitored for another two years until the permanent dentition stage. By then the patient had developed a Class I molar relationship, severe lack of space in both arches, posterior crossbite on the right side, and normal overbite (Fig 25). The mandibular incisors were uprighted and extruded through the use of spurs (IMPA=92°) (Fig 26). The skeletal Class I relationship was maintained (ANB=1°). Corrective treatment was then initiated with extraction of first premolars.

Corrective treatment was performed with canine distalization followed by retraction of the incisors. No anchorage mechanism was used, nor any vertical elastics, which attests to the stability of the AOB correction. Dental alignment was attained as well as vertical and horizontal overlaps, and adequate intercuspation. The profile remained balanced (Fig 27).

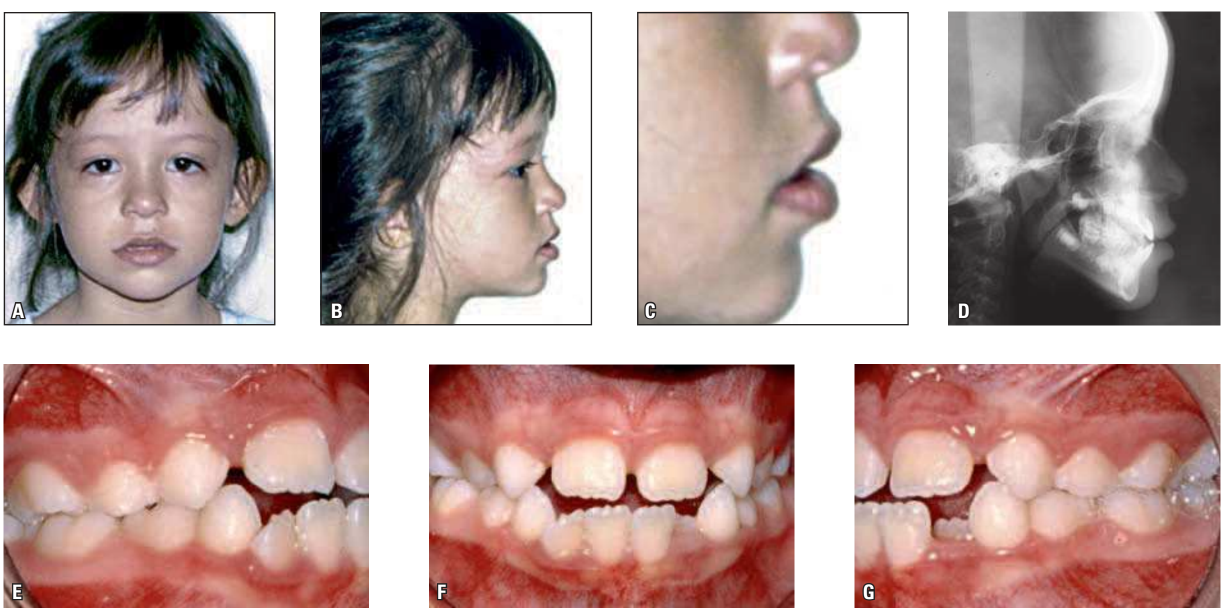


FIGURE 23 - Initial extraoral photographs (**A**, **B**, **C**), cephalometric radiograph (**D**) and intraoral photographs (**E**, **F** and **G**).

FIGURE 24 - Panoramic radiograph of patient with spurs in place, reorienting the tongue backwards and upwards.

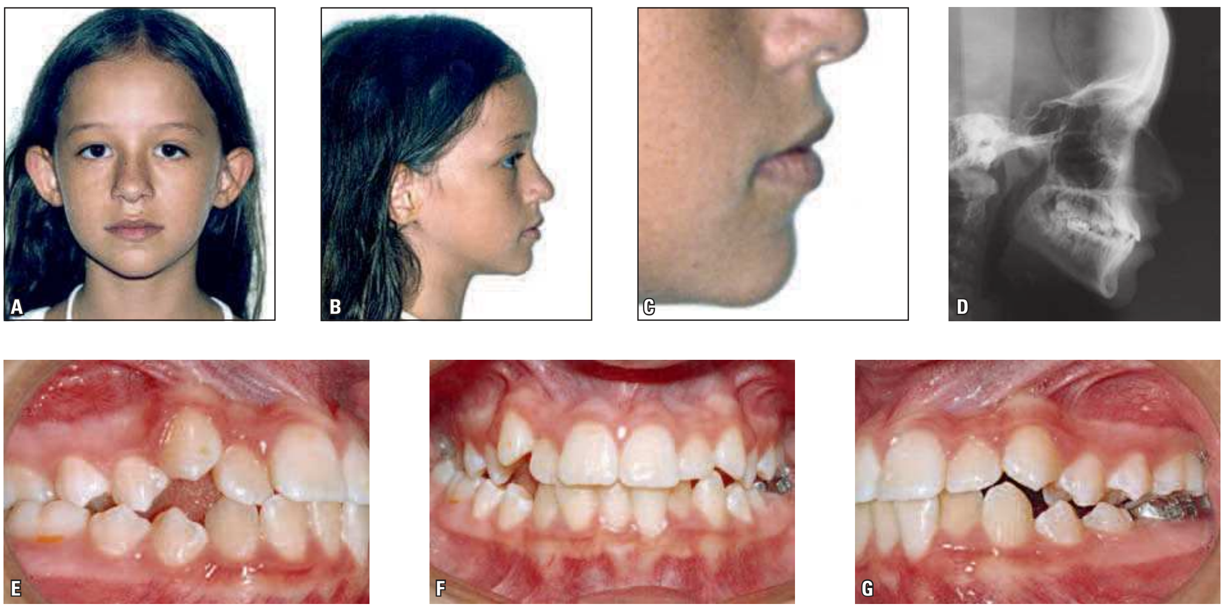


FIGURE 25 - Extraoral photographs (**A**, **B** and **C**), cephalometric radiograph (**D**) and intraoral photographs (**E**, **F** and **G**) after use of spurs in permanent dentition.

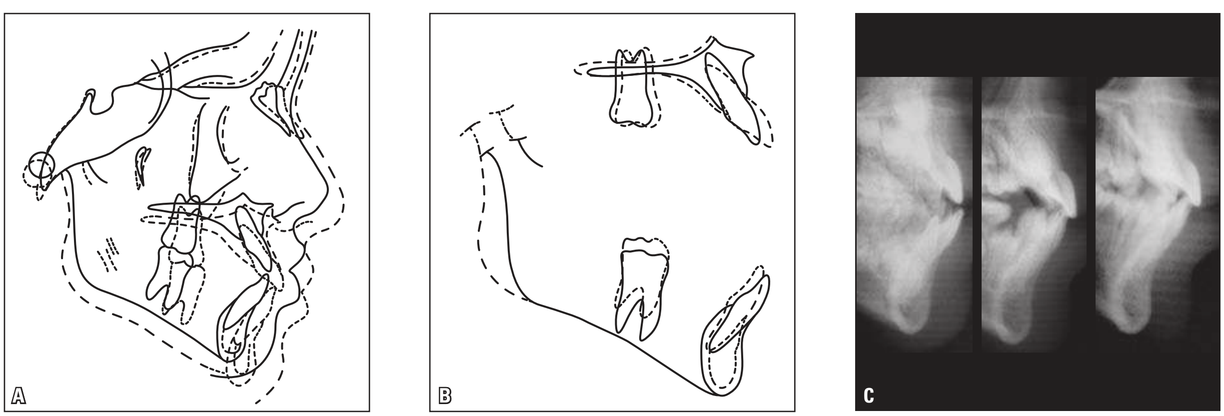


FIGURE 26 - Total (**A**) and partial (**B**) cephalometric superimpositions comparing the initial phase with the phase prior to corrective treatment. It is noteworthy that in the radiographs (**C**) uprighting and extrusion were attained in the lower incisors with the use of spurs alone, and the stable outcome was monitored over 5 years.

FIGURE 27 - Extraoral (**A**, **B** and **C**) and intraoral photographs (**D**, **E** and **F**) at the end of corrective treatment after 7 years of spur use, showing stability of AOB correction.

Case 4: Very Low Posture of Tongue at Rest

A female patient aged 9 years, showing severe anterior open bite and severe lack of space in the lower arch (Figs 28E, F and G). The patient was a mouth breather and undergoing speech therapy. She had a Class III skeletal pattern (ANB=-1°), a tendency toward vertical growth, and an increased mandibular plane (SNGoGn=49°) (Fig 28D). The face showed no clear asymmetry and had an adequate profile (Figs 28A, B and C).

According to the morphological characteristics of the open bite, the patient had a very low position of the tongue at rest, clearly characterized by retroclination of mandibular incisors (IMPA=70°) and posterior crossbite. To perform the correction it would be necessary to move the tongue upward and backward with orienting treatment. The appliance of choice was a lower lingual arch with spurs. Firstly, a single spur was placed in the midline region, then other spurs were gradually inserted in the canine-to-canine region (Fig 29).

Use of lingual arch with spurs was suspended four years later. At this time a significant improvement in vertical overlap was observed as well as the presence of diastemas in the mandibular incisor region (Figs 30D, E and F) due to the protrusion of these teeth. The profile remained balanced and the face symmetrical (Figs 30A, B and C). At this stage, it was decided to place a fixed orthodontic appliance in the mandibular arch in order to close spaces.

The upper arch received no appliances and was monitored for a period of one year to assess stability of AOB correction. Should the AOB have relapsed it would have meant that the tongue posture had not been corrected. An adequate vertical overlap was achieved and the posterior crossbite corrected (Figs 31C, D and E).

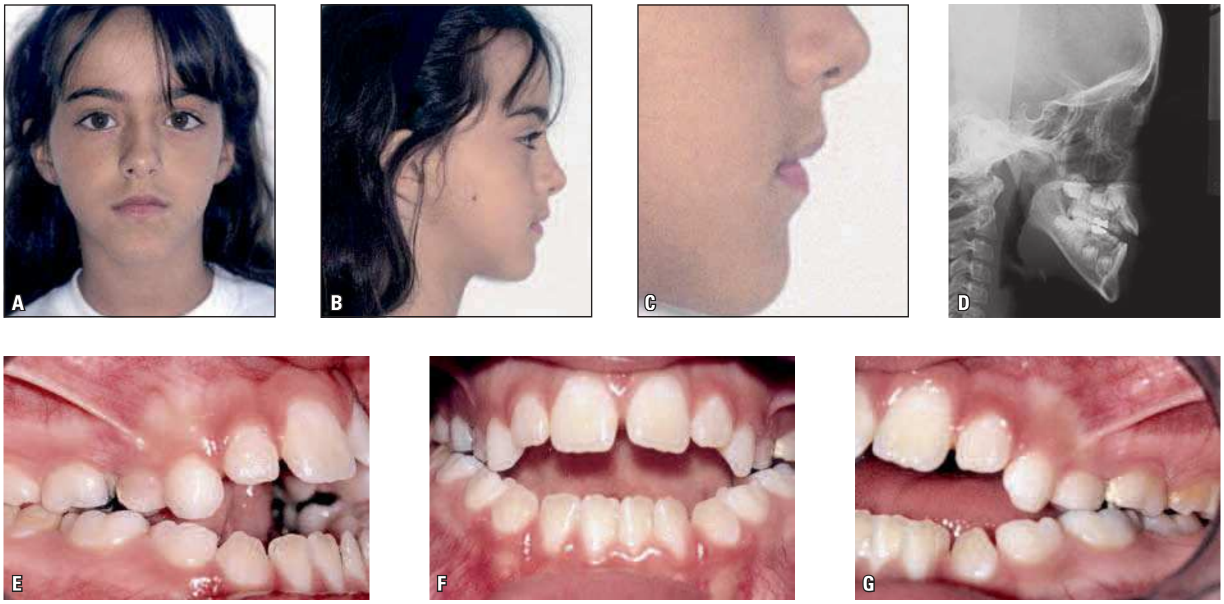


FIGURE 28 - Initial extraoral photographs (**A**, **B**, **C**), lateral cephalometric radiograph (**D**) and intraoral photographs (**E**, **F** and **G**).

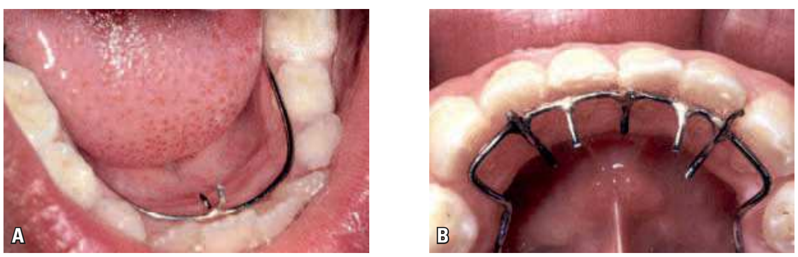


FIGURE 29 - Spurs used on lingual arch, starting with one spur at arch center (**A**) and increasing number and size of spurs (**B**) in order to reorient tongue posture backwards and upwards.

No expansion was performed in the upper arch and crossbite was corrected by positioning the tongue higher, thus changing the transverse dimension of the arch. The face remained symmetrical with a balanced facial profile (Figs 31A, B and C). At this stage, fixed appliances were installed in the upper jaw to finish the case.

At the end of treatment an excellent occlusal outcome was accomplished, with the establishment of a Class I relationship and correct horizontal and vertical overlap (Figs 32E, F and G). A skeletal Class I relationship was attained (ANB=1°) (Fig 31D). Despite the high mandibular plane (SNGoGn=50) the face was balanced with a good profile and adequate lip seal (Figs 32A, B and C).

Correction of this AOB was achieved mostly by a significant extrusion of the mandibular incisors (Figs 33A and B). The backward and upward change in tongue posture allowed eruption of the incisors, thereby lengthening the alveolar process (Figs 33C, D, E and F), as reported by Meyer-Marcotty et al.[25] The skeletal features of this face would have one believe that the cause of the AOB might be an unfavorable growth pattern.[2] However, this case suggests that AOB occurs — even in hyperdivergent faces — when the eruptive process is hampered by a mechanical obstruction (in this case the tongue), and thus,

FIGURE 30 - Extraoral (**A**, **B** and **C**) and intraoral (**D**, **E** and **F**) photographs after 4 years of spur use.

FIGURE 31 - Extraoral (**A**, **B** and **C**) and intraoral (**D**, **E** and **F**) photographs after placement of appliance in the lower arch.

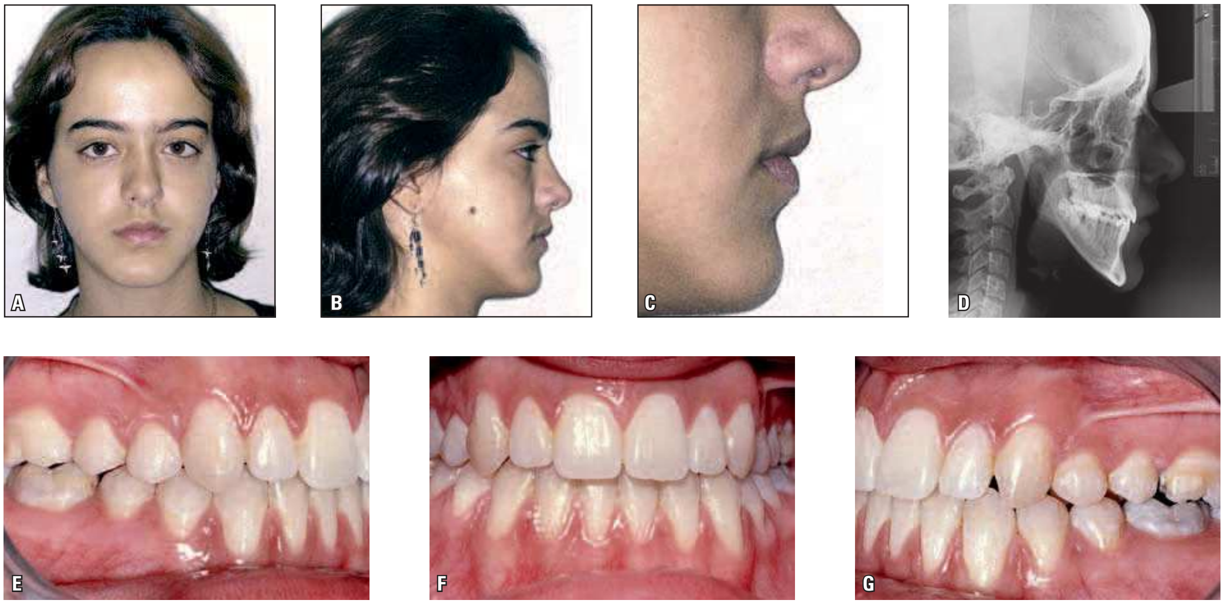


FIGURE 32 - Extraoral photographs (**A**, **B** and **C**), lateral cephalometric radiograph (**D**) and intraoral photographs (**E**, **F** and **G**) at the end of treatment.

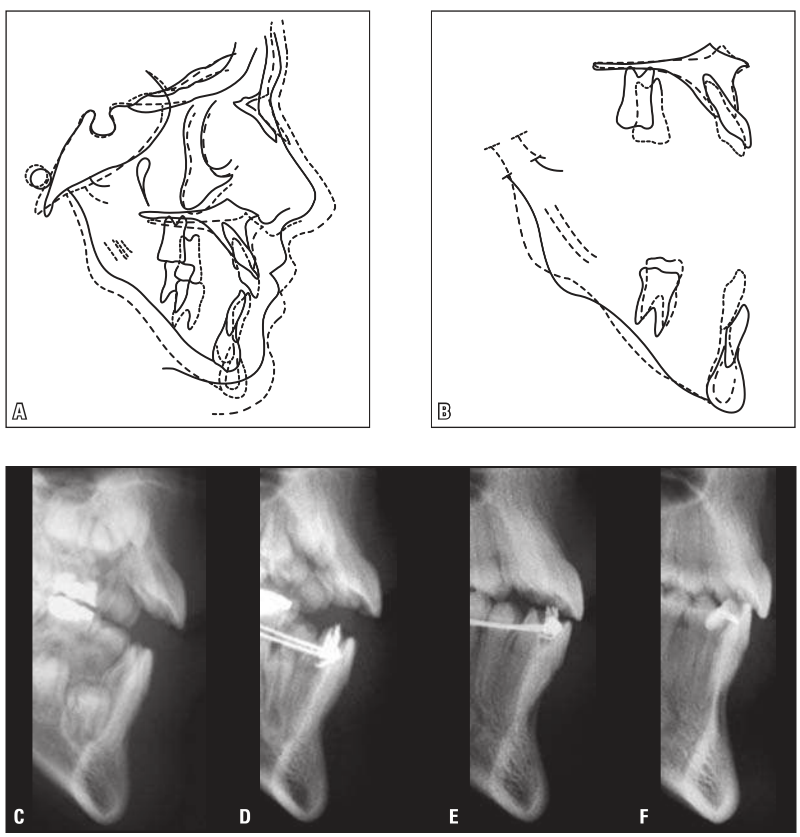


FIGURE 33 - Total (**A**) and partial (**B**) cephalometric superimpositions comparing initial and final treatment phases. Radiographs (**C**, **D**, **E** and **F**) show protrusion and marked extrusion of incisors obtained with the use of spurs only.

skeletal pattern would not play an etiological role in AOB.

Removal of the causative agent of this AOB ensured outcome stability 10 years after treatment, as shown in Figure 34. Treatment of these cases requires patience and the long-term use of spurs, which in this case lasted for 4 years. Due to AOB severity, the amount of extrusion required for incisors to attain vertical overlap is considerable (Fig 35). Moreover, the process of automating tongue posture is slow, demanding time for neuromuscular restructuring.[10,25]

FIGURE 34 - Extraoral (**A**, **B** and **C**) and intraoral (**D**, **E** and **F**) photographs 10 years after treatment.

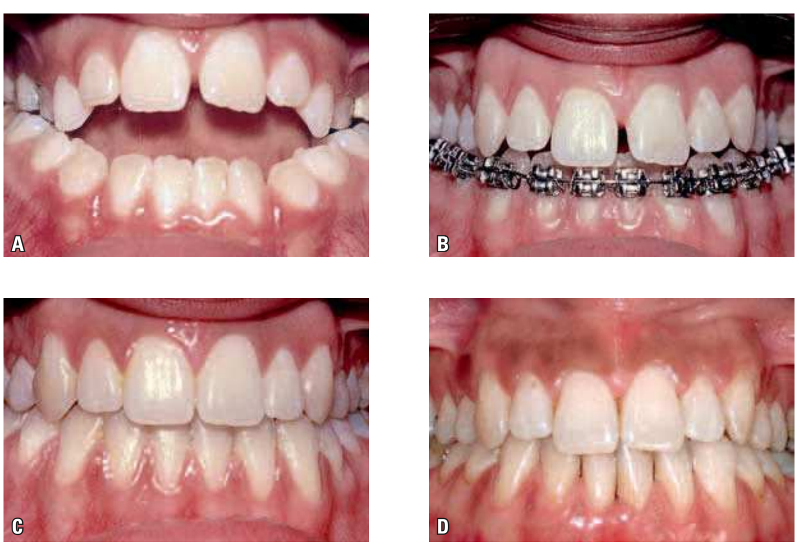


FIGURE 35 - **A**) Initial open bite position, **B**) Intermediate treatment stage after adjusting overbite with spurs and placement of appliance in the lower arch, **C**) Overbite achieved after corrective treatment and **D**) Overbite stability 10 years after treatment.

FINAL CONSIDERATIONS

The difficulties encountered in obtaining stable results for AOB correction can be justified by the fact that their true etiology still defies understanding. The posture of the tongue at rest is not highly regarded in AOB treatments. Some evidence suggests that the posture of the tongue may be one of the most important etiological factors in AOB. Therefore, it must be analyzed and addressed when it is abnormal.

There is more than one possible resting position for the tongue. It can position itself on a higher or lower level, producing open bite with different morphological characteristics and severity. Appropriate treatment should be selected based on these characteristics, and can be conducted by either restraining or orienting the tongue. Once the posture of the tongue has been corrected, the etiological factor is extinguished and treatment stability is ensured.

Clinical studies of AOB are generally case-control experimental models with small samples and lack of control groups. This fact makes the information available about this malocclusion incomplete and therefore inconclusive. Further research is warranted, particularly to reassess whether or not tongue posture and a hyperdivergent facial growth can be considered as an etiological factor of AOB.

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