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Review article

Strategic treatment planning for anterior open bite: A comprehensive approach

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Stability

Abstract Anterior open bite (AOB), characterized by the lack of vertical overlap between upper and lower anterior teeth, poses a considerable challenge in orthodontics. The condition depends on many factors that combine to render it difficult to achieve post treatment stability. AOB is commonly classified as dental, skeletal, or functional on the basis of the clinical presentation and causative factors. Traditionally, skeletal AOB necessitates surgical intervention, whereas nonsurgical approaches such as extrusion arches and the Multiloop Edgewise Archwire Technique (MEAW) can be employed in more straightforward cases. Functional appliances are reserved for situations in which a patient's growth potential offers the possibility of effectively addressing AOB. This review presents a strategic treatment approach for addressing AOB, taking into account the classification and severity of the condition. The proposed SHE framework describes the use of mini-screws (S) for anchorage and vertical control, encouragement to correct habits (H), and the utilization of extractions and elastics (E). By incorporating extra-radicular mini-screws, AOB closure is achieved through anterior retraction in extraction cases or whole arch distalization of dentition with elastics in non-extraction cases. This framework emphasizes habit correction through a regimen of oral myofunctional therapy (OMT) and habit-correcting appliances to enhance posttreatment stability. This review suggests that nonsurgical correction is viable in the majority of cases,

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whereas surgical intervention should be reserved for severe cases of skeletal vertical overgrowth or horizontal discrepancies.

Introduction

Anterior open bite (AOB) is identified by the lack of vertical overlap or contact between the upper and lower anterior teeth. AOB is commonly classified into three distinct types: dental AOB, skeletal AOB, and functional AOB.[1] However, in clinical practice, categorizing a case exclusively into one of these types can be challenging or even impossible because of the intricate nature of the condition.[2,3]

Dental AOB is characterized by a normal craniofacial pattern with proclined and under-erupted anterior teeth.[1] Individuals may have this condition due to experiencing ankylosis of the anterior teeth following traumatic tooth replantation,[4–6] having systemic or localized factors that cause delayed teeth eruption,[7] or having a persistent thumb-sucking habit that hinders complete eruption of the incisors.[8,9]

Skeletal AOB is marked by specific anatomical characteristics, including an overlarge mandibular plane angle, gonial angle, anterior facial height, and total facial height as well as an anteriorly upward-tilting palatal plane and a retrognathic mandible.[10,11] Skeletal AOB can be caused by several factors that disrupt the growth patterns of the maxillae, mandible, and dentoalveolar complex, such as a hereditary predisposition, developmental disorder, and history of trauma.[12,13] These disruptions contribute to the hyperdivergence of inter-base angles, resulting in an augmented posterior vertical dimension.[1,14] Such vertical posterior excess impedes the establishment of a normal overbite even when the anterior teeth are overerupted.

Functional AOB is closely associated with the behavior of the head and neck muscles during speaking, breathing, chewing, and swallowing. The equilibrium of the dentition can be affected by imbalances in the orofacial muscular system, particularly by abnormalities in the tongue, lips, and cheeks.[15–18] The resting position of the mandible is influenced by the temporomandibular joint.[19] Maintaining occlusal stability is challenging in individuals with a temporomandibular disorder (TMD). AOB is a predisposing factor for TMDs, and TMDs can also lead to AOB.[20–22] The AOB—TMD connection arises from internal disc derangements with compression of retro-discal tissues,[23] hemifacial dystrophy in the lower face due to joint diseases,[24] or neuromuscular deficiency of the masticatory muscles.[25] Additionally, macroglossia resulting from amyloidosis, acromegaly, or Beckwith—Wiedemann syndrome can induce a tongue-thrusting habit. This habit pushes the incisors outward, causing a V-shaped maxillary arch and disrupting the balance of the orofacial musculature, leading to AOB.[26–28] Finally, retrognathia, adenoid/tonsil hypertrophy, and nasal obstruction may contribute to a mouth-breathing habit,[29,30] which exacerbates AOB.

Etiology

AOB is a multifactorial condition involving a combination of genetic, developmental, and environmental factors.[1,2] In the past, developmental factors including thumb-sucking, tongue-thrusting, and mouth-breathing habits were the primary concerns in the development of AOB. Correction of these habits during early childhood helps in decreasing the difficulty in treating AOB thereafter. Recently, genetic and epigenetic contributions to the etiology of AOB have been gaining attention. Further exploration of their role in AOB development and their interaction with environmental factors holds promise for extending the treatment strategy of AOB to the molecular level in the near future.

(1) Genetic factors

Genes involved in the development of craniofacial disorders play a role in the etiology of AOB. Specifically, the *FGFR2* gene is linked to Crouzon syndrome and Apert syndrome, which cause midface hypoplasia, a high-arched palate, and malocclusions, including AOB.[31,32] Another gene that may cause AOB is the *TCOF1* gene associated with Treacher—Collins syndrome, a genetic disorder characterized by micrognathia, cleft palate, and other craniofacial anomalies.[33] Additionally, in certain rare hereditary diseases, such as trichorhinophalangeal syndrome linked to the *TRPS1* gene, AOB malocclusion is a common clinical manifestation.[34]

Numerous studies have revealed the potential involvement of genetic and epigenetic pathways in AOB. Exploring these mechanisms may offer valuable insights into prospective therapeutic targets for preventing or correcting AOB. An illustrative example is the matrix metalloproteinase family member MMP-9, which modulates extracellular matrix metabolism within periodontal ligaments. This specific protein plays a critical role in tooth eruption, craniofacial development, and the establishment of a proper occlusal relationship. In the study conducted by Küchler et al.,[35] the authors hypothesized that the GG genotype of the MMP-9 rs17576 variant, involving a glutamine-to-arginine substitution, may serve as a protective factor against AOB.

Gene polymorphisms—including *TNF-α*, *FAM83H*, *ENAM*, *AMGX*, *PAX5*, *PTPN11*, *SOS1*, and *IGF-1*—are currently being investigated as potential causes of AOB because of their roles in inflammation and dentoalveolar embryology.[36–42] Until now, the existing knowledge in genetics and epigenetics has not been sufficient to bridge the gap between genetics and orthodontic practice. However, numerous efforts have been made to leverage these findings to facilitate accurate diagnosis and provide more precise prognoses. In a farsighted view, individualized gene therapy may be applicable by eliminating phenotypical expressions of dentofacial dysmorphologies, including AOB. By addressing genetic factors early, interventions during mixed dentition stage may help prevent the development of AOB, or reduce the difficulty of orthodontic and orthognathic treatments in adulthood for individuals predisposed to malocclusion.

(2) Developmental and environmental factors

Developmental factors such as prolonged thumb-sucking, pacifier use, and tongue-thrusting during early childhood can exert mechanical forces on the teeth, disrupting their alignment and contributing to the development of AOB. Additionally, chronic mouth breathing, often associated with nasal congestion or airway issues, can affect the facial growth pattern and increase the risk of developing AOB. Environmental factors—including diet, stress, infections,[43] and medications[44] —may also predispose individuals to AOB. Finally, the tongue's resting position plays a crucial role in the development of AOB and is influenced by both developmental and environmental factors, affecting the teeth from childhood to adulthood.

Diagnostic index

(1) Index for assessing skeletal pattern and determining potential surgical requirements

Various indicators from cephalometric analyses—such as the Downs mandibular plane angle, the Steiner mandibular plane angle, and lower anterior face height—are commonly employed to assess the dentoalveolar and skeletal relationships associated with AOB. However, these assessments can be influenced by reference lines such as the S—N and Frankfort planes, potentially leading to overestimation or underestimation of hyperdivergency between the jaw bones. Recognizing this limitation, Kim and Vietas proposed two novel indices for AOB evaluation: the overbite depth indicator (ODI) and anteroposterior dysplasia indicator (APDI).[45] Additionally, the KIX index, defined as APDI/ODI, has been employed to assess the potential need for orthognathic surgery.[46] The parameters used in lateral cephalometric analysis are illustrated in Fig. 1.

The ODI is determined by the sum of the AB—MP and PP—FH angle measurements. According to Kim, the mean ODI value is 74.5° for a normal mouth and 74.0° for a maloccluded mouth, with standard deviations of 6.07° and 7.31°, respectively.[47] An ODI value below the norm suggests a greater tendency for vertical growth. The ODI offers an accurate assessment of AOB, overcoming the challenges associated with traditional cephalometric parameters. By contrast, the APDI serves as an index for evaluating sagittal skeletal relationships. This index is computed by summing three angles: FH—NPg, PP—FH, and AB—NPg. Finally, a KIX index exceeding 1.5 signifies a high APDI value and a low ODI value, suggesting a higher-than-average risk of skeletal class III malocclusion and skeletal AOB and thus indicating that surgical intervention may be required.[48]

(2) Index for evaluating severity

Some case reports propose the use of nonsurgical approaches for effectively managing AOB cases under the dental or dental—skeletal combined category. By contrast, severe skeletal AOB may necessitate orthognathic surgery to correct large deviations. Despite the clarity in classification and definition, standardized criteria for clinically evaluating the severity of AOB are lacking. The lack of a universally accepted standard makes it challenging to consistently and objectively assess the degree of AOB severity in a clinical setting. However, the Photographic Open Bite Severity Index (POSI), a novel measurement tool proposed by Huang et al., can score the severity of AOB on the basis of intraoral photographs and may serve as a standard for evaluating AOB.[49]

The six classifications of the POSI are based on the type and quantity of teeth with insufficient vertical overlap, as depicted in Fig. 2. As the POSI increases, the extent of teeth without vertical overlap increases; these teeth range from specific incisors (POSI I, II, and III) to all incisors (POSI IV), to all anterior teeth (POSI V), to anterior teeth extending into the premolar region (POSI VI).

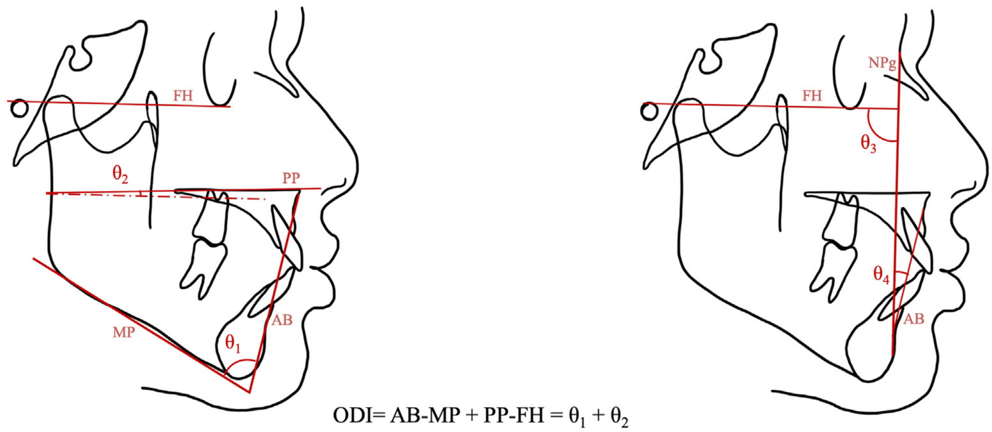
Huang's student, Sherry X. Wan, conducted additional experiments to validate the effectiveness and reliability of the POSI as an indicator for anticipating the severity and treatment difficulty of AOB.[50] A lower POSI value suggests a simple condition with contributing factors such as a tongue-thrusting habit, local interference with tooth eruption, and transitional developmental disharmony. By contrast, increased involvement of posterior teeth is associated with risks of long-face syndrome, mesially inclined mandibular molars, and temporomandibular joint disorders. The POSI thus provides valuable insights into the complexity and severity of AOB and its possible contributing factors, making it simple for dentists to determine appropriate treatment options for the condition.

Strategic treatment planning

(1) Conventional treatment approach for anterior open bite

Conventional nonsurgical approaches offer potent means of correcting AOB. The extrusion arch and the Multiloop Edgewise Archwire (MEAW) techniques are instrumental in treating AOB.

One of the first treatments developed for correcting AOB was extrusion arches, which extrude incisors to close the open bite. Extrusion arches are bent from a 0.016×0.022-inch stainless steel wire and are designed with the posterior end seamlessly inserted into the molar tubes; the anterior segment of the arch is meticulously secured incisal to the anterior teeth that require extrusion, facilitating controlled and targeted movement of the teeth along the main wire.[51] Extrusion arches can treat POSI VI cases and achieve a reported 5-year stability of 75%.[52] Nevertheless, extrusion arches are only suitable for patients exhibiting inadequate incisor exposure during rest and smiling. If an individual has compensatory supererupted incisors,



$$\text{ODI}= \text{AB-MP} + \text{PP-FH} = \theta_1 + \theta_2$$

$$\text{APDI}= \text{PP-FH} + \text{FH-NPg} + \text{AB-NPg} = \theta_2 + \theta_3 + \theta_4$$

$$\text{KIX}= \frac{APDI}{ODI}$$

Figure 1 Illustration of ODI, APDI, and KIX in lateral cephalometric analysis. The Overbite depth indicator (ODI) is determined by adding the angle between AB and MP (denoted as θ_1) and the angle between PP and FH (denoted as θ_2). The anteroposterior dysplasia indicator (APDI) is determined by summing the angle between PP and FH (denoted as θ_2), the angle between FH and NPg (denoted as θ_3), and the angle between AB and NPg (denoted as θ_4). KIX is an acronym for an index without a full name, calculated by dividing APDI by ODI (Note: AB represents the line connecting point A and point B, MP signifies the mandibular plane, PP denotes the palatal plane, FH refers to the Frankfort horizontal plane, and NPg refers to the line connecting nasion and pogonion.) Modified from Fatima et al.[45]

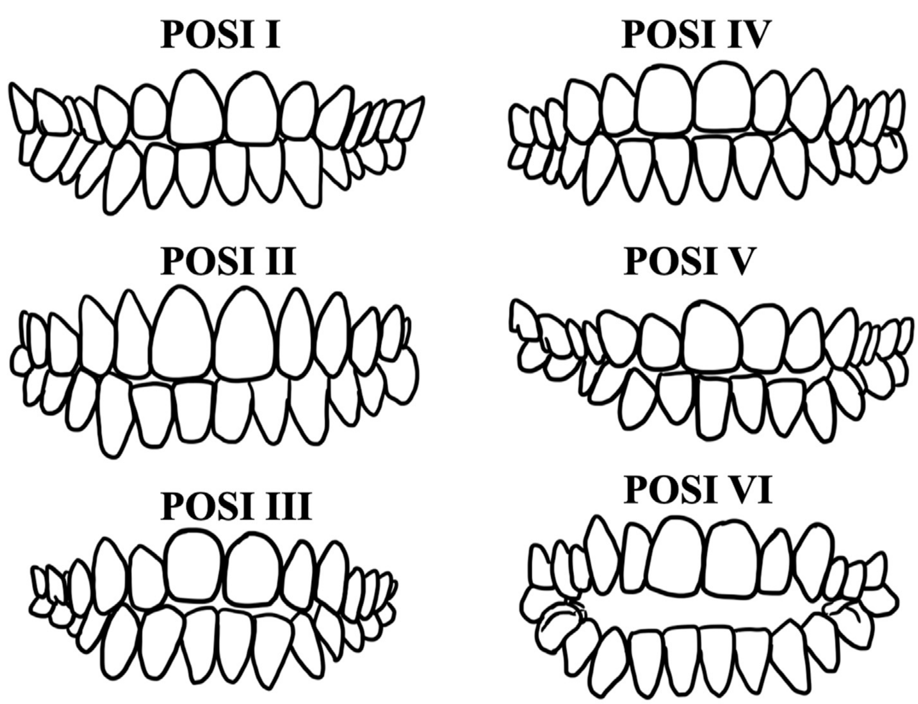


Figure 2 Illustration of the six types of photographic open bite severity index (POSI). Modified from Huang et al.[49] Six types of anterior open bite (POSI I to XI) are depicted through drawings derived from photographs displaying the coronal view of patients' dentition, with posterior teeth in maximum intercuspation. POSI I is defined as the absence of vertical overlapping involving 1 or 2 lateral incisors. POSI II is defined as the absence of vertical overlapping involving only 1 central incisor. POSI III is defined as the absence of vertical overlapping involving both central incisors. POSI IV is defined as the absence of vertical overlapping involving all incisors. POSI V is defined as the absence of vertical overlapping involving all anterior teeth, and POSI VI is defined as the absence of vertical overlapping extending to at least 1 premolar.

extrusion arches are not recommended because they may adversely affect esthetic outcomes.

The MEAW technique utilizes 0.016 × 0.022-inch stainless steel wires and double edgewise brackets with 0.018-inch slots for delicate extrusion of incisors. The configuration of the archwires is five pairs of L-shaped loops on each side; the 2–3 mm vertical segment of the loop serves as a break between the teeth, and the horizontal loop length varies from 5 to 6 mm mesial to the canine to 7–8 mm between the premolars and 8–9 mm between the molars. Two symmetric 3/16 heavy anterior vertical elastics are placed between the first loop, and a force of approximately 150 g is exerted to close the AOB.[53] The MEAW technique utilizes loops to preserve wire elasticity and maintain molars in a distally upright position.[54,55] This approach results in higher overall efficiency of the incisor extrusion compared with that achieved with extrusion arches. Moreover, maintaining the molars in a distally upright position is advantageous to the whole arch distalization of dentition in non-extraction cases. However, evidence supporting the efficacy of the MEAW technique in modifying skeletal patterns[56] is lacking. Additionally, no consensus exists on whether the MEAW technique can be used in cases with molar intrusion.

Addressing AOB by predominantly relying on the extrusion of anterior teeth raises concerns about posttreatment relapse. Extruded anterior teeth are prone to relapse because periodontal fibers have elastic recoil, unlike the fibers in intruded posterior teeth, which maintain their position due to occlusal forces. Posttreatment AOB relapse following the use of extrusion arches may be associated with the pullback of extruded anterior teeth and an imbalanced tongue-thrusting habit.[52,57,58]

(2) Contemporary perspective on non-surgical anterior open bite treatment: The "SHE" framework

Orthodontists must be cognizant of skeletal deviations and dentition crowding during AOB correction. Additionally, they must precisely control the torque of anterior teeth and judiciously apply posterior anchorages. Achieving posttreatment dentition stability often involves additional considerations, such as implementing counterclockwise rotation of the mandible through molar intrusion, using fixed or removable retainers for dentition maintenance, and rehabilitating a stable tongue posture through myofunctional therapy or tongue cribs.[59] Moreover, AOB cases combined with bimaxillary protrusion or class II or class III malocclusion require tailored strategies to address the specific complexities of these scenarios.

Contemporary nonsurgical treatment approaches for AOB can be conveniently referred to by the acronym SHE, where the "S" refers to the utilization of mini-screws, the "H" refers to habit correction, and the "E" refers to extraction or the application of elastics. Fig. 3 illustrates and summarizes this conceptual framework.

S — mini-screws

Traditional methods for addressing vertical problems in orthodontics include vertical pull chin caps, passive posterior bite blocks, and active vertical correctors. These approaches intrude molars by curbing the natural vertical growth tendency of the posterior dentoalveolar complex,[60] influencing masticatory muscle function,[61] or using magnets incorporated into removable appliances.[62] However, the advent of temporary anchorage devices (TADs) has revolutionized the field because these devices offer more effective vertical control during the correction of AOB. TADs provide a reliable means of achieving satisfactory anchorage, whether for retraction in extraction cases or for whole arch distalization of dentition in non-extraction cases.[63,64]

TADs encompass mini-screws and mini-plates strategically placed in the dentoalveolar region to provide anchorage, facilitating predictable tooth movement. Mini-screws differ from mini-plates in their cost-effectiveness, lack of requirement for open-flap surgery, and versatile application.[65] Titanium, titanium alloys, and stainless steel are the primary materials used to manufacture mini-screws. Intra-alveolar mini-screws are inserted in the inter-radicular areas of both jaws, whereas extra-alveolar mini-screws are inserted in the infra-zygomatic crest region of the maxilla and the buccal shelf of the mandible.[66] The use of extra-alveolar mini-screws minimizes the risk of root damage. Because they can be inserted into the dense cortical bone, these screws can be long and have large diameters, rendering them less likely to fail.[67]

The biomechanical process employed to close AOB by using extra-alveolar mini-screws is as follows: Elastics such as power chains or coiled springs are employed to introduce a clockwise rotation in the maxillary dentition and a counterclockwise rotation in the mandible and its dentition. The anchorage is secured by two infra-zygomatic screws alone or reinforced with an additional two buccal shelf screws. The closure of AOB is a direct consequence of the resultant force being occlusal to the center of resistance of the dentition, leading to a modification of the occlusal plane. The use of infra-zygomatic screws induces simultaneous incisor extrusion and molar intrusion. For more precise torque control, an additional mini-screw can be strategically placed in the anterior region.[67]

In a study by Xun et al., the ability of screws to correct skeletal AOB through intrusion of the posterior dentoalveolar region was evaluated. The results indicated that the average duration of molar intrusion during AOB correction was 6.8 ± 1.1 months. Overbite increased by an average of 4.2 mm, with maxillary molars intruding by a mean distance of 1.8 mm and mandibular molars intruding by a mean distance of 1.2 mm. Additionally, the mandibular plane angle (SN–MP) was reduced by 2.3°, leading to a favorable counterclockwise rotation of the mandible and closure of the AOB.[68]

H — habit correction

Thumb sucking, tongue thrusting, and mouth breathing are habits that are associated with the development of AOB and play a pivotal role in posttreatment relapse of AOB. Whether these habits contribute to the development of AOB or the growth pattern of AOB influences the formation of these habits[43] remains controversial. Hong et al. conducted a study on the electromyographic characteristics of muscles associated with mastication (the masseter,

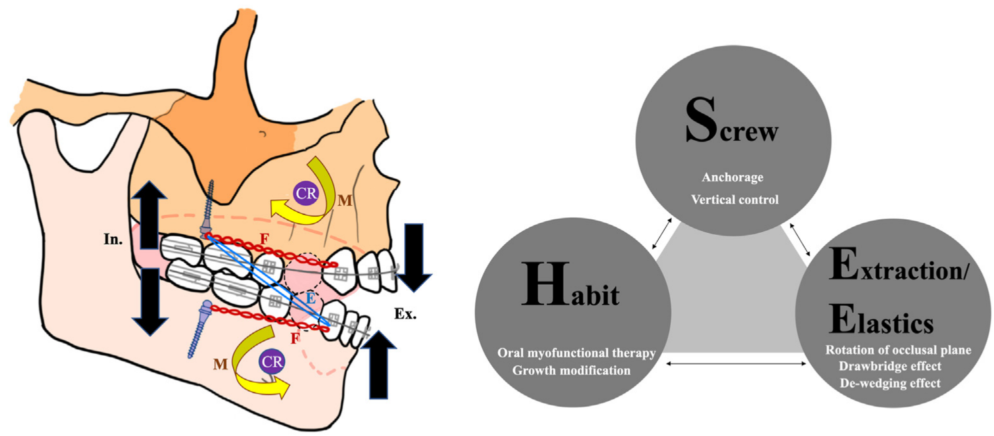


Figure 3 The SHE framework in nonsurgical treatments of AOB. This diagram illustrates the biomechanical process involved in nonsurgical AOB treatment. Four extra-radicular mini-screws (S) are inserted to act as anchorages for anterior retraction in extraction cases (E) or whole arch distalization of dentition in non-extraction cases. This corrective process involves clockwise rotation of the maxillary dentition, counterclockwise rotation of the mandible and its dentition, extrusion of anterior teeth, and intrusion of molars. These actions contribute to the closure of the open bite (CR = center of resistance. M = moment. F = force. S = mini-screw. H = habit correction. E = extraction or elastics. Ex. = extrusion. In. = intrusion.) When addressing habit correction in AOB treatment, the tongue and lips are pivotal components influencing the etiology and risk of relapse of AOB. In particular, training must focus on placing the tip of the tongue at a specified spot just posterior to the incisive papilla, with the entire body of the tongue attaching to the palatal vault. The proper resting position of the tongue is illustrated in pink in the diagram.

temporalis, and anterior digastric) and muscles associated with mouth closure (the orbicularis oris and mentalis). Their findings demonstrated considerably higher activity of the anterior temporalis and mentalis muscles during the rest position in individuals with skeletal AOB than in those without. Additionally, higher activity in both the orbicularis oris and mentalis muscles was observed during the lip-sealed swallowing process in these individuals. However, in the interdental centric position, the electromyographic signals of the masseter and temporalis revealed weakness, indicating a smaller muscle contraction force during functional activities.[69]

The hyperdivergent jaw relationship in patients with AOB is believed to result in greater muscular tension in masticatory muscles when at rest, coupled with diminished biochemical advantages during chewing function.[70] The concomitant lip weakness may lead to forceful mouth closure and mentalis strain,[71] as depicted in Fig. 4.

The characteristics of a hyperdivergent jaw relationship include a large gonial angle and severe vertical maxillary excess, potentially causing a posterior shift in load application position and an increase in the moment arm,[72] leading to masticatory muscle weakness during occlusal function. Such muscle weakness suggests that the balance of the orofacial musculature is substantially disturbed in patients with AOB. Rehabilitation combined with orthodontic treatment may be necessary to stabilize the treatment outcome or to expedite the treatment progress in

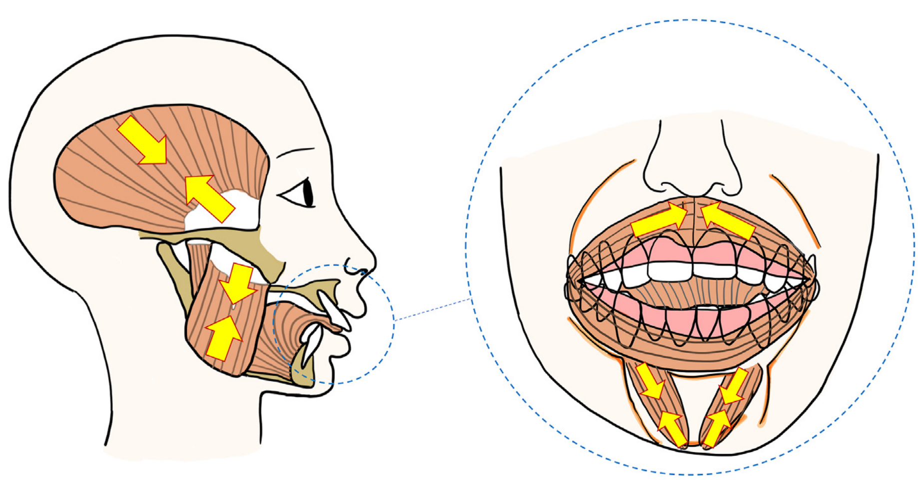


Figure 4 A hyperdivergent jaw relationship results in excessive tension of the muscles involved in mouth closure when in the resting position.

individuals with skeletal AOB. Finally, tongue cribs effectively enhance posttreatment stability in patients with AOB.[73] Tongue cribs serve as a tactile habit corrector, discouraging tongue thrusting due to the discomfort associated with touching them.

Oral myofunctional therapy (OMT) consists of individual muscle training, chewing, swallowing, and pronunciation exercises and training to position the lips and tongue in a relaxed posture.[74] The goal of OMT is to encourage relaxation of muscles around the oral cavity, ease the burden imposed on the dental arch by overly tense jaw muscles, and establish a routine for long-term maintenance. The rationale behind OMT is that an imbalance in the orofacial muscular system could cause both the onset and recurrence of AOB.[69] We propose that OMT can prevent deformities in children with AOB. Additionally, orthodontic treatments in conjunction with OMT are effective in adults, resulting in relatively short treatment times and establishing long-term orofacial muscular stability.[75]

An increasing number of case reports and review articles endorse the utilization of OMT to treat AOB. However, only a few papers provide comprehensive details on its constructive implementation. The concept of OMT can be traced back to Dr. Rogers' notion (1929) of the "living orthodontic appliance," which posits that oral musculature alone has the potential to correct malocclusion without retention or appliances being needed.[76] The foundations of OMT are rooted in the five stages of ingestion reported by Leopold and Kagel in 1983. In order, these stages are the cognitive, preparatory, oral, pharyngeal, and esophageal phases.[77] The muscles targeted for training are the tongue, lips, facial expression muscles, masticatory muscle groups, and soft palate. The objective is to establish a harmonious oral environment that facilitates efficient chewing,[78] corrects atypical swallowing, and maintains a proper tongue resting posture.[74] A harmonious oral environment is achieved by training overly tense muscles to relax and strengthening underactive muscles, enhancing masticatory function and improving the stability of the dental arch.

The clinical methodology of OMT, as described by O. and M. Takahashi,[79] outlines specific steps to train distinct muscle functions. OMT training typically involves pointing the tongue at a specific spot, correctly producing sounds, and trapping substances on the dorsum of the tongue, often facilitated by assistive devices such as sticks, straws, cotton rolls, or water sprayers, and incorporating foods such as yogurt, a raisin, an apple, or a biscuit. In OMT, the "spot" is the region slightly behind the incisive papilla. Several methodologies in OMT involve training the tip of the tongue to rest and swallow while pointing at the spot to exert negative pressure around the oropharyngeal tract,[80] which aids in correcting atypical swallowing in adults. An additional technique is the "lip exerciser" created by Zickefoose, designed to enhance the closing strength of the orbicularis oris through bucket-bearing and resistance against a pulling hand. Increased lip-closure strength also plays a role in stabilizing the dentition and countering the outward force exerted by the tongue.

In addition to water, foods of various consistencies play a role in OMT.[79] Soft foods such as pudding, yogurt, and jelly reinforce the sensation of correctly swallowing and are used to gradually increase the training difficulty. Small foods like raisins and peanuts are suitable for molar-chewing practice. Moist foods, including apples, pears, and cucumbers, are recommended for "quiet sucking" practice. Quiet sucking trains patients to collect the juice squeezed out during mastication and quietly swallow it without tongue thrusting or engaging other facial muscles. Finally, body posture is closely linked to the development of orofacial myofunctional disorders. Keeping the back upright and extending the muscles to align the head, neck, and shoulders are crucial steps in establishing proper posture for subsequent orofacial balance.[81]

E — extractions and elastics

Malocclusions—including bimaxillary protrusion, class II malocclusion with excessive horizontal open bite, and class III malocclusion with a compensatory dentition pattern—can be effectively addressed using an extraction strategy to create space for sagittal relationship modifications. When managing AOB combined with malocclusion, applying the "drawbridge effect" or the "de-wedging effect" during anterior retraction increases overbite. The "drawbridge effect" refers to anterior retraction following extractions as the space-closing force pulls the anterior teeth downward like a drawbridge being lowered. The "de-wedging effect" refers to the idea that following the extraction of posterior teeth, particularly the second premolars, the mesial movement of the remaining posterior teeth promotes a mesial shift in the masticatory fulcrum.[82] This shift is believed to be advantageous for the closure of AOB by reducing the vertical skeletal height or the mandibular plane angle.[83] Extraction can also assist in alleviating mentalis strain in individuals with lip incompetence, helping to establish a balanced oral environment that promotes the closure of AOB.

Elastics are widely employed for correcting AOB. When securely anchored by TADs, these elastics can be employed to rotate the occlusal plane and achieve anterior retraction in extraction cases or to the whole arch distalization of dentition in non-extraction cases. According to Al-Thomali et al., no significant differences in AOB posttreatment stability were observed between extraction and non-extraction cases.[84] However, the study by Janson et al. revealed that individuals undergoing extraction exhibited a significantly greater level of stability (74.2%) than that observed in individuals not undergoing extraction (61.9%).[85]

(3) Surgical approaches for severe anterior open bite

In cases where adult patients display excessive vertical skeletal growth, surgical intervention may be necessary to correct AOB. Surgical treatments for skeletal AOB typically include maxillary impaction and bilateral sagittal split osteotomy (BSSO) of the mandible followed by its counterclockwise rotation.

The impaction of the maxillae can be categorized as either differential posterior impaction or segmental impaction. In differential posterior impaction, a Le Fort I down-fracture of the maxillae is executed, and the entire block of the dentoalveolar complex is rotated and impacted, with the posterior maxilla being raised more than the anterior maxilla. Consequently, presurgical orthodontic treatment often involves proclination of incisor teeth to compensate for the differential impaction of the maxilla. In the case of segmental impaction of the maxilla, a vertical cutting line is established either distal to the lateral incisors or distal to the canines. Subsequently, the two segments created by this line are separately impacted. Typically, the two segments are separately aligned preoperatively,[86] as in the approach reported by Naini et al., which involves assessing the facial profile, evaluating the skeletal pattern, and preoperatively establishing the objectives of orthodontic treatment.[86] These preoperative factors depend on incisor inclination, appropriate incisal display, and the design of the smile line in relation to the lips.

One study discovered a nonsignificant difference in post-AOB-treatment stability between surgical and nonsurgical cases.[87] Moreover, according to a systemic review conducted in 2013, vertical relapse is a characteristic of combined treatment involving both surgical and nonsurgical approaches. An increase in anterior facial height of 1.2–1.4 mm was observed after Le Fort I surgery.[88] Furthermore, BSSO of the mandible is susceptible to post-surgical relapse due to muscular tension, a condition referred to as the "pterygomasseteric sling".[89] Finally, segmental impaction of the maxilla without preoperative orthodontic extrusion of maxillary incisors, namely align and level anterior and posterior segment of maxillary dentition independently, may result in greater stability because there is less relapse of maxillary incisors in an apical direction that tend to reopen the bite.[86]

Conclusion

In summary, managing AOB poses a complex challenge in orthodontics, meticulous diagnosis through extraoral and intraoral photographs and radiographic records is required. Tools for assessing clinical severity—such as the ODI, APDI, KIX, and POSI classification—are crucial to providing a comprehensive view for treatment planning. Additionally, treatment options for AOB encompass both nonsurgical and surgical approaches. Our proposed SHE framework encapsulates current nonsurgical methods of managing AOB. The SHE framework leverages mini-screws for reliable anchorage of retraction and vertical control, integrates OMT, and utilizes appliances like tongue cribs to help patients correct improper habits and reconstruct a balanced orofacial environment. Closing forces for AOB correction are applied through the drawbridge effect during anterior retraction following extractions and the de-wedging effect when the posterior teeth move mesially during space closure. In cases of pronounced vertical overgrowth, surgical intervention may be necessary. Procedures such as maxillary impaction and BSSO of the mandible achieve similar objectives to the nonsurgical approaches.

In treating AOB, the primary focus is achieving lasting dental and skeletal stability and minimizing the risk of open bite relapse. A range of strategies can be employed to enhance posttreatment retention of AOB corrections. Such strategies involve the use of retainers, tongue cribs, and OMT. Because genetic factors may be significant contributors to the etiology of AOB, they may also be worthy subjects of future therapeutic research. However, a thorough understanding of the genetic factors behind AOB remains elusive, and these factors have yet to be incorporated into therapies for treating AOB. Exploring the intricate genetic and epigenetic pathways governing the development of the teeth, craniofacial bones, and head and neck muscles holds great promise for the early correction and prevention of AOB. Future studies are warranted to explore genetic therapies as adjuncts to individualized treatments for AOB.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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