Management of anterior open-bite in the deciduous, mixed and permanent dentition stage: a descriptive review

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Anterior open bite is one of the most complex malocclusions to manage. The interaction of skeletal, dental, and soft tissue effects can contribute to develop an anterior open bite. The skeletal open bite requires a more complex approach of treatment to reach function, aesthetics, and stability. The approaches vary depending on the causative factors and the age of patients. Treatment approaches for open bite patients differ when dealing with adults and growing patients. The aim of this descriptive review was to summarize the main existing treatment strategies for anterior open bite, from the non-invasive behavioural shaping to the orthodontic intrusion with skeletal anchorage.

Anterior open bite is a malocclusion characterized by the vertical alteration of the physiological dental occlusion, with the lack of contact between antagonist incisors when the posterior teeth are brought into full occlusion (1). It may occur with an underlying class 1, class 2, or class 3 orthodontic patterns.

Anterior open bite can be defined as simple, characterized by the vertical separation of incisors extending up to premolars, or complex, where the separation extends right up to the molars (Fig. 1). Severity assessment score has been proposed by measuring the distance between the maxillary and mandibular incisor borders perpendicularly to the functional occlusal plane (Fig. 2). Based on severity, vertical separation of 0-2mm is considered as moderate, 3-4mm severe and more than 4mm extreme (2). The etiology is multifactorial, involving into genetic and environmental factors (3). Environmental factors include dento-alveolar eruption disturbances, aberrant neuromuscolar function related to prolonged sucking habits, mouth breathing, tongue or lip thrusting, tongue dimension (4, 5). Anterior open bite can be broadly classified into two categories: dento-alveolar open bite and skeletal open bite (6).

Dentoalveolar open bite

Dento-alveolar open bite is the result of a mechanical blockage of the vertical development of the incisors and the alveolar component while craniofacial

Key words: anterior open bite, skeletal open bite, dentoalveolar open bite, treatment of open bite

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0393-974X (2020)

configurations are normal. When incisors are proclined, anterior teeth are under-erupted accompanied by normal molar height; dental open bite can be related to thumb-sucking or other oral habits. Prolonged non-nutritive sucking habits cause frequently asymmetrical anterior open bite, being greater on the side where the digital dummy is inserted (7). The finger acts as a barrier to the erupting incisor, whilst allowing increased eruption of the posterior teeth (8).

Skeletal open bite

Skeletal open bite is at least partly genetically determined by a vertical skeletal discrepancy due to excessive vertical growth. Skeletal open bite must be evaluated as a deviation in the vertical relationship of the maxillary and mandibular dental arches. It is usually more severe than dental open bite. Genetic and environmental influences encourage vertical growth in the molar region, which are not compensated by growth at the condyle or posterior ramus (9). Adverse functional activities such as mouth breathing may affect the facial feature and enhance the development of open bite. Pisani found a correlation between oro-facial musculature and facial structure suggesting a relationship between tongue position and anterior open bite pattern (10). The craniofacial features constantly linked with the skeletal open bite may include a short mandibular ramus and body, increased gonial angle, a retrognathic mandible, divergent cephalometric planes, excessive lower anterior facial height and weak oro-facial musculature (11). A skeletal open bite is usually characterized by excessive eruption of posterior teeth, normal or excessive eruption of anterior teeth and downward rotations of the mandible (12).

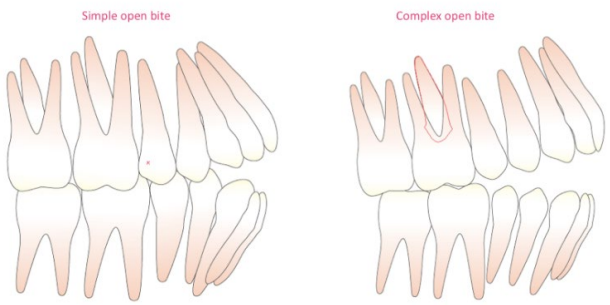

Fig. 1. *Classification of anterior open bite in simple or complex.*

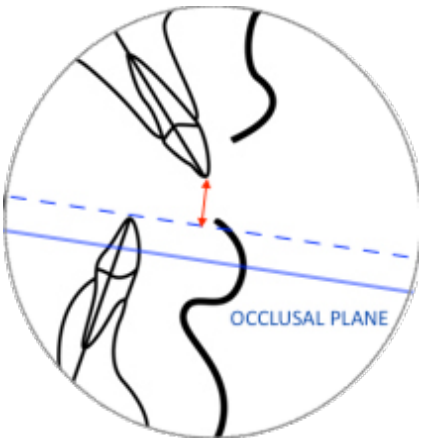

Fig. 2. *Severity measurement method.*

A proper research of the etiologic factors causing the malocclusion and the clinical diagnosis are necessary to develop an effective treatment plan. Treatment approaches for open bite patients differ when dealing with adults and growing patients.

DISCUSSION

Management in the deciduous dentition

In the deciduous dentition, anterior open bite has been linked to a dento-alveolar involvement in about 95% of cases (13). When dental open bite is due to thumb-sucking, mouth-breathing and atypical swallowing habits, the treatment is mainly "etiological". The clinician should encourage the patient to the cessation of oro-para-functional habits with positive motivation and reward strategy. Interceptive appliances, when needed, aim to correct the altered tongue posture (14).

Orofacial myofunctional therapy

Orofacial Myofunctional therapy is composed of a set of exercises that re-educate orofacial muscles in swallowing, speech and resting posture (15).The aim is to modify function and to stop the non-nutritive sucking habits before the age of 6 years in order to create a favourable environment for the eruption of permanent teeth (16).

Lingual crib and spurs

Wire orthodontic appliances placed in a position

lingual to the maxillary incisors can prevent the tongue to rest on the anterior teeth and help a child overcome the habits of thumb sucking or tongue thirsting (17, 18). Passive devices such as lingual crib and lingual spurs are usually attached to the palatal surface of the upper arch and allow the sucking to stop as they act as a digit-inhibiting tool.

A digit sucking habit should ideally stop before the eruption of the permanent incisors, otherwise it can result in long-term skeletal changes. Tongue posture plays an important role in the disorder of anterior open bite, hence the tongue then returns to its original position resulting in relapse of anterior open bite (19). This is the reason why the cooperation with other specialists, as well as and otolaryngologist and speech therapist, is crucial to resolve at this stage mouth breathing related to chronic respiratory obstruction and to re-educate the bucco-facial musculature during swallowing and speech (20).

Management in the mixed dentition

In the pre-pubertal growth, patients with prolonged sucking habits associated with excessive vertical dimension of the face have been considered as candidates for developing an anterior open bite (8). It has been demonstrated that if anterior open bite persists during the cranio-facial pubertal growth spurt, it hardly ever self-corrects o even worsens (21). On the other hand, in cases with significant vertical skeletal imbalance, an underlying craniofacial pattern seems to be present early before the growth spurt and it tends to either persist or accentuate.

The orthodontic treatment for open bite during the pre-pubertal growth is controversial in literature. Feres reported that spontaneous correction is more difficult and takes longer time. The early treatment is indicated when there is not improving with time and overbite is severe (22). It seems also indicated to intercept the dysfunctional habits that, if removed early enough, become likely to promote optimal development of the masticatory system (23). Rosa et al. highlighted that the most cases of anterior open bite could self-correct during the pre-pubertal phase, this is the reason why they suggested not performing any active correction during this stage for the risk of overcorrection and of patient compliance loss (24).

When active correction is suggested, orthodontic appliances work to give vertical growth modification and to control tongue position and the molar vertical eruption in growing patients (25). Early treatment modalities during the mixed dentition include mainly functional appliances, multi-brackets techniques, headgears and bite blocks (26, 27).

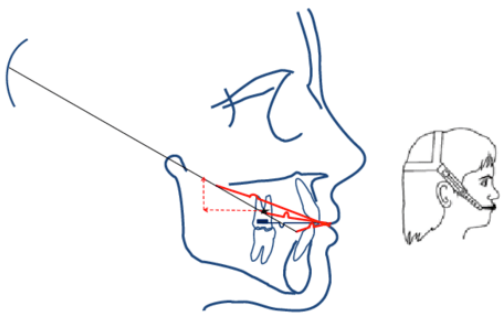

Fig. 3. *High-pull headgear. Intrusive force is directed to the maxilla through the center of resistance.*

High-pull headgear

Headgear for the treatment of anterior open bite can be used to control molar eruption by generating orthopaedic intrusive forces (Fig. 3). Intrusive forces are directed to the maxilla through the center of resistance of the upper first molar (28). In literature has been referred that high-pull headgear produce dental changes of intrusion (0.96+/- 0.54mm) in addition to the distal movement (2.6+/-0.6mm) (29). The use of a trans-palatal arch, in combination with high-pull headgear, can be necessary to prevent the undesirable extrusion by molar crown tipping (29).

The high-pull headgear can be used with a functional appliance, with a covering occlusal splint or on its own. The connection to an occlusal splint covering the indenting teeth has been considered efficient to intrude a group of teeth, not only molars (29).

Posterior bite-block

Posterior bite-blocks are passive acrylic splints bonded on the occlusal plane of posterior teeth. The aim of this appliance is to hinge the mandible open by approximately 3-4mm beyond its resting position, thereby maintaining pressure on the neuromuscular system supporting the mandible (30). Bite-blocks have been effective in controlling vertical dimension instead of a real molar intrusion (31).

Magnetic bite-block

Kiliaridis et al reported that magnetic bite-blocks can be efficient for non-surgical molar intrusion (32). This appliance consists of two posterior occlusal splints, one for the upper and one for the lower jaw. Samarium cobalt magnets are incorporated into the acrylic splint and generate intrusive forces between 600 and 650gr per module (33).

Vertical pull chin cap

Non-surgical intrusion of mandibular molars can be possible by the high pull chin cap. A force of 400gr is applied per side and the force vector passes through the anterior and inferior region of the mandibular corpus (34). The vertical forces applied against molars serve to reduce or redirect vertical skeletal growth and to allow normal vertical developmental and eruption of the anterior teeth (35).

Generally, a dental open bite has a better prognosis than a skeletal open bite. On the other hand, it has been likely that treatment of skeletal open bite during the mixed dentition reduce the need of treatment in the permanent dentition: the younger the patient and the milder the open bite, the faster is the correction (36). Early treatment also offers the advantage to have more stable results (37).

Management in the permanent dentition

In severe adult cases, the gold standard treatment is the combined approach of orthodontics and orthognathic surgery (38). Although satisfactory results can be achieved by orthognathic surgery, the complexity, risks and costs have initiated a search for alternative treatments (39). When a patient rejects orthognathic surgery, treatment approaches include orthodontic treatment with extractions; extrusion of the anterior teeth with inter-maxillary elastics; intrusion of the molars and a combination of these (40, 41).

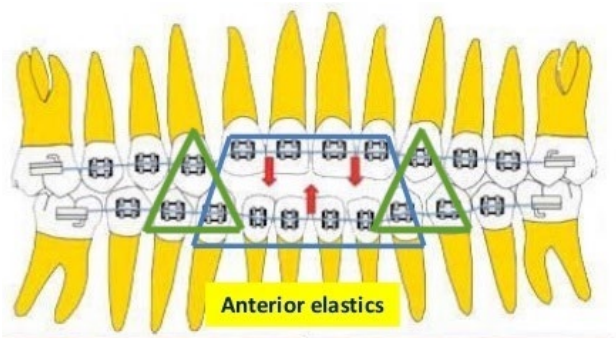

Fig. 4. *Extrusion of anterior teeth through anterior elastics.*

Camouflage with extractions

Extractions of permanent molars or premolars have been considered a viable option for the treatment of mild to moderate discrepancies of maxillary structures in patients with open bite (42). In adolescent or adult patients where 3rd molars are not good in shape or impacted, extraction of 3rd molars provides spaces for necessary to intrude 2nd molars and bite closing is facilitates.

Extractions of upper and lower bicuspids also help bite closing because wedging molars are moved forward. In this way, mesial movement of wedging molars is good to correct open bite. It has been indicated to extract upper 1st and lower 2nd premolars when canine and molar relationship is in class II and in cases of severe upper anterior protrusion or crowding (43). Extractions of upper and lower 2nd premolars have been suggested canine and molar relationship is in class I with mild upper anterior protrusion or crowding.

Extrusion of the anterior teeth

The use of curved nickel-titanium arches and anterior elastics can be close the open bite while maintaining the vertical positions of molars (Fig. 4) (44). This technique has been not recommended when patients with an anterior open bite exhibit external root resorption of incisors and less facial bony support for these teeth (45). Simple extrusion of the anterior teeth has been criticized as being unstable, especially considering that the vertical height of the anterior maxilla is already excessive in an open bite case (46, 47). Extrusion of maxillary anterior teeth might also compromise facial aesthetics, especially in a patient with a gummy smile, also influence the occlusion and determine temporo-mandibular disorders (48, 49).

Intrusion of the posterior teeth

In non-growing patients with the absence of

vertical compensation of ramus growth, the intrusion of the posterior teeth can close the open bite without the need for surgical intervention. According to jaw geometry, every 1mm of intrusive vertical movement of the molars would result in about 2 mm of bite closure (50). Excluding the orthognathic surgery, molar intrusion techniques have been classified into compliance and non-compliance approaches. High-pull headgear, bite blocks, vertical chin cup have been considered to achieve relative intrusion of molars but require remarkable patient's cooperation. Posterior intrusion by TADs (temporary anchorage devices) ensure a real vertical intrusion without the patient's compliance (51–53).

True molar intrusion

The maximum anchorage in molars intrusion can be gained only using TADs, which allow orthodontic movements that were previously thought to be difficult if not impossible (54). Currently, mini-screws are increasingly used in comparison to other TADs due their low cost and less invasion. Molars intrusion by mini-screws can provide satisfactory occlusal results when facial aesthetics is not compromised and a great comparable stability to other open-bite treatment modalities, as tooth extractions, inter-arch elastics and orthognathic surgery (55).

Mini-screws as temporary anchorage devices

Small titanium screws can provide temporary skeletal anchorage. Mini-screws have a slightly tapered profile, which come in different heights, lengths ranging from 6 to 12mm and diameters from 1.2 to 2mm (56). Mini screws mostly consist of three components: threaded shaft, cervical area and a head for loading orthodontic forces. The head design differs in a spherical heads and in a slot, indicated for all the most types of skeletal anchorage with the limitation of using rectangular wires (57). They are biocompatible, do not suffer expansion and are small in order to be placed in any area of the mouth (58). Self-tapping or self-drilling, mini-screws can be inserted directly through the gingival tissue into bone with a hand driver under local anaesthesia and must with stand orthodontic loads in all planes of the space (59). Mini-screws system is advantageous with great stability for the optimal force and forces can be applied immediately after insertion (60, 61).

Clinical application of mini-screws

The clinical success of orthodontic anchorage by mini-screws depends on the anatomic site for placement (62). For good stability, the application site must provide bone of good quantity and quality (63, 64). Stationary anchorage is achieved by gripping mechanically to cortical bone, rather than by osteointegration (65). A proper location for TADs insertion is a region with high bone density and thin

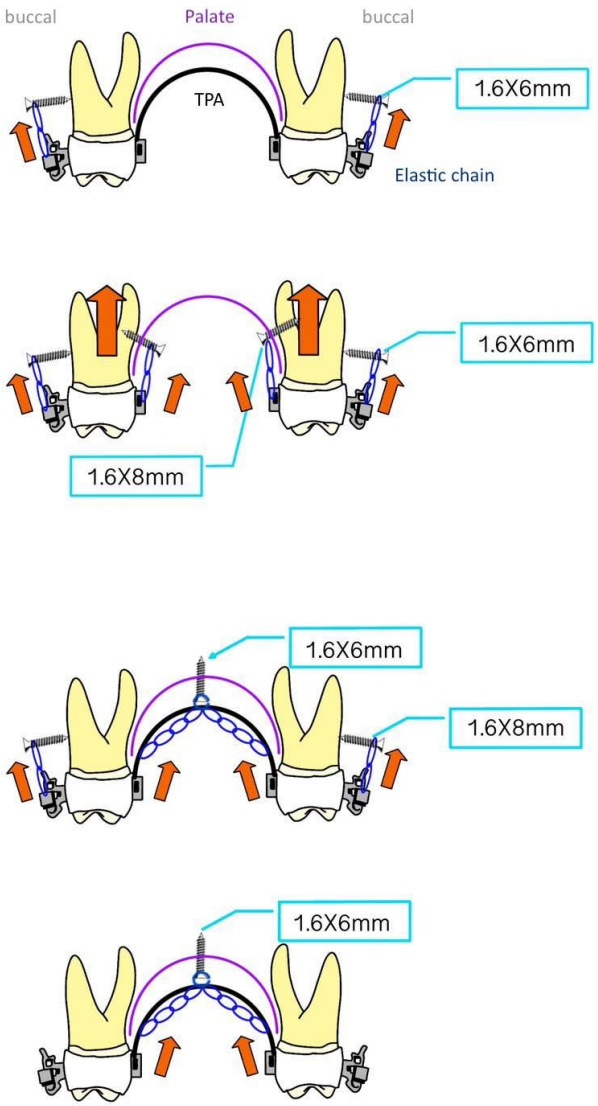

Fig. 5. *Methods of molar intrusion with TADs in the maxilla.*

keratinized tissue, as regions of D1to D3 bone based on Mish classification of bone density (66).

Skeletal anchorage for molars intrusion in the maxilla can be inserted buccally or palatally (67). Into the buccal alveolar bone mini screw can be positioned near the mucogingival junction, between roots of the second premolar and the first molar, 5 to 8mm from the alveolar crest (68). Into the palate mini screw can be inserted in the posterior mid palatal area, where bone density is favourable (69). In the mandible, the greatest amount of bone is on either side of the first molar, about 11mm from the alveolar crest (70).

Proper angle of insertion is important for cortical anchorage. In the maxillary and mandibular posterior regions, the angle should be 30 to 45 degrees to the occlusal plane (71). For an efficient intrusion, several authors have recommended loading forces between 100 and 300 grams (72, 73). Intrusive force, performed by the elastic chains or NiTi coil, should be light and continuous to minimize the risk of root resorption (74).

Several mechanics for molars intrusion have been proposed (Fig. 5). First method suggests inserting two mini-screws in the maxilla from the buccal area between the second premolar and the first molar, and the palatal slope on every molar (75). Intrusion could be performed by one elastomeric chain or nickel-titanium coil to pass diagonally across the occlusal table o by two small elastomeric chain connected between slot of molar and mini-screw. Intrusive force will exert without tipping of molar crowns. When a single mini-screw is placed in the buccal maxilla each side, a trans-palatal arch must control the over-rotation of molar crowns during intrusion (76). A rotational moment is created when intrusion force passes buccally to the centre of resistance of the maxillary molars. Trans-palatal arch with crown lingual torque can be bonded on upper molars to control this side effect. Trans-palatal arch should be raised 3 to 5mm away from the palatal mucosa to allow resting tongue pressure to aid with intrusion (77).

In the absence of adequate inter-radicular space, TADs can be placed in the midline palate (75). With TADs located in the palate, it could be difficult to obtain a vector sum that passes through the centre of resistance. Therefore, monitoring is important to verify the torque and bucco-palatal position of the molars being intruded by a trans-palatal arch (78). To enhance anchorage, two mid palatal mini-implants can be connected to each other through a bar. Otherwise, a system composed by one mid palatal and two buccal mini-screws with trans-palatal arch could perform intrusive force (75). In the mandible, one buccal mini-screw per each side of molars combined to lingual arch with lingual crown torque can intrude lower molars, without tipping side effects (79). Molars intrusion rate is 2.39mm on average using skeletal anchorage, with better results in the maxilla than mandible (80). It has been stated that lower molar intrusion, combined with upper intrusion, should be considered in severe open bite cases where maximal closure of the mandibular plane angle is needed, such as lack of incisor showing and lack of overjet in open bite patients (81). Molars intrusion with skeletal anchorage induces counter-clockwise rotation of the mandible and as a consequence corrects the inter-maxillary relationship with a dramatic improvement in the facial soft tissue convexity in anterior open bite patients (82).

Behaviour shaping strategies aim to eliminate sucking habit and to improve, or at least control, the increased vertical dimension in the deciduous and mixed dentition. In non-growing patients who rejects orthognathic surgery, molar intrusion by TADs has simplified the treatment of skeletal open bite by making it more efficient and aesthetic, without the patient's compliance.

Mini-implants have influenced orthodontic treatment plans by providing possible management of complicated discrepancies than those treatable by convectional biomechanics. Intrusion of posterior teeth with TADs was suggested to lead to decreased lower facial height by a counter-clockwise rotation of the mandible.

Current evidence suggests the use of aligners as aesthetic alternative to fixed appliances. The aligner system rapidly evolved and incorporated features able to treat more complex malocclusions. The appliance is purported to have a bite block effect to maintain vertical control (83–86).

This paper highlighted the open bite treatment

options in the literature. Successful treatment of anterior open bite greatly relies on both diagnoses, including cephalometric evaluation, and management. In the light of our findings, it appears advisable to firstly consider the age of the patient to develop a treatment plan. Further investigations lending insight into the efficiency of aligners system in control of the vertical discrepancy need to be carried out in order to appreciate their role as an adjunctive option of treatment for open bite patients.

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