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The Role of the Orthodontist in the Treatment of Obstructive Sleep Apnea Syndrome (OSAS): An update

Rajae Elhaddaoui [1*], Leila Elhajoubi [2], Asmae Bahoum [3], Fatima Zaoui [4]

[1] Assistant Professor in Dentofacial Orthopedics, Department of Orthodontics and Dentofacial, Orthopedics, Faculty of Dental Medicine, Mohammed V University in Rabat, Morocco

[2] Specialist in Dentofacial Orthopedics, Faculty of Dental Medicine, Mohammed V University in Rabat, Morocco

[3] Professor of Higher Education in Dentofacial Orthopedics, Faculty of Dental Medicine, Mohammed V University in Rabat, Morocco

[4] Head of Dentofacial Orthopedics Service, Professor of Higher Education in Dentofacial Orthopedics, Faculty of Dental Medicine, Mohammed V University in Rabat, Morocco

* Corresponding Author: **Rajae Elhaddaoui**

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Abstract

Orthodontics, in collaboration with other medical specialties, plays a key role in the diagnosis and treatment of obstructive sleep apnea (OSA). Thanks to their expertise in dentofacial structures, orthodontists are able to identify anatomical abnormalities that can obstruct the upper airway and thus cause sleep apnea.

Technological advances, particularly artificial intelligence (AI), have revolutionized this approach. AI enables more accurate analysis of medical imaging data (such as 3D scans) to detect risk factors for OSA. In addition, it assists orthodontists in treatment planning by proposing personalized solutions based on each patient's individual characteristics. AI algorithms can simulate different treatment scenarios and optimize the design of orthodontic appliances to achieve the best functional and aesthetic results.

The multidisciplinary approach, coupled with the integration of AI, has led to more effective and precise orthodontic treatment for OSA. This results in personalized care that significantly enhances patients' quality of life.

Keywords: OSAS, Orthodontist's role, Oral Appliance Therapy, Mandibular Advancement Devices, Orthopedic Appliances, Artificial Intelligence

Introduction

Obstructive sleep apnea (OSA) is a common condition characterized by repeated pauses in breathing during sleep. These airflow interruptions disrupt sleep and lead to serious long-term health consequences, including high blood pressure, increased risk of stroke and impaired quality of life [1].

While continuous positive airway pressure (CPAP) remains the gold standard for the treatment of moderate to severe OSA, orthodontics is increasingly emerging as an attractive treatment option for this condition. Indeed, dento-facial malocclusions can play a significant role in upper airway obstruction and promote the onset of OSA [2, 3].

This article highlights the crucial role of the orthodontist in the early diagnosis and multidisciplinary management of OSA. We will examine in detail the effectiveness of orthodontic treatments, in particular mandibular advancement orthoses and maxillary disjunction, in improving breathing and quality of life in patients with mild to moderate OSA. We will emphasize the importance of a personalized approach to orthodontic treatment, considering the individual patient's needs and the severity of their OSA. Finally, we will explore future advancements and innovative therapies that will enhance the role of orthodontics in OSA management.

1. Etiology and Pathophysiology of OSA

The etiology of OSA is plurifactorial. Patients will have, among other factors, an anatomical obliquity in the upper airway that predisposes the patient to present with this disorder regularly. Obesity and enlarged adenoids/tonsils can contribute to upper airway obstruction by increasing soft tissue volume and narrowing the airway. Additionally, abnormal neuromuscular control, such as impaired activity of the hypoglossal nerve (which controls tongue movement), has been implicated in the pathogenesis of OSA [1].

The influence of genetic induction and environmental trigger factors is probable. It is inferred that habitual snoring can start with the large number of females in their forties. Smokers have an increase in the chances of diagnosing OSA as an adult. Similarly, OSA risks are shown in patients with relatives diagnosed with OSA. Environmental risks, often related to harmful substances, industrial chemicals, or toxic gases, and those associated with unfavorable conditions, will have a greater impact on the manifestation of OSA [3, 4, 5].

OSA has always been considered a respiratory disorder characterized by temporary airway obstruction and a variable degree of hypoxemia. OSA is more related to a combination of additional factors in a complex pathophysiological picture than to just one cause. Advances in the understanding of sleep and the development of polysomnographic assessment have shown that there is an interaction between predisposing factors (genetic, anthropometric, and anatomical) and some aggravating factors related to aging and hormonal changes, along with certain coexisting pathological conditions such as capillary resistance, obesity, and changes in the components of the respiratory muscles, all of which contribute to the collapse of breathing [3, 4, 5].

2. The association between OSAS and malocclusions

Obstructive sleep apnea is characterized by repeated episodes of complete or partial obstruction of the upper airway during sleep, leading to oxygen desaturation and micro-arousals. This obstruction may be due to a variety of factors, among which dentofacial malocclusions play a prominent role [1, 4].

The link between malocclusions and OSA is complex and multifactorial. Several studies have demonstrated a significant association between certain malocclusions and the risk of developing OSA. For example, Ferati and al. (2024) [1] showed in their systematic review that children with Class II and III malocclusions were more likely to suffer from OSA. Other factors, such as the presence of a narrow palate or supernumerary or impacted teeth, could also contribute to reduced volume and obstruction of the upper airway.

The pathophysiological mechanisms involved are multiple and interact with each other:

- **Reduction in the volume of the upper airways:** Malocclusions can reduce the available space for airflow, as highlighted by Kazmierski (2024) [6] and Faber and al. (2024) [7].
- **Collapse of the pharyngeal walls:** A decrease in muscle tone during sleep can promote the collapse of the pharyngeal walls, worsening obstruction [1, 6, 7].
- **Abnormal tongue position:** A low and retroposed tongue can obstruct the oropharynx, as explained by Mirhashemi and al. (2020) [8].

3. Diagnosis of OSA: the role of the orthodontist

The orthodontist's in-depth knowledge of dentofacial anatomy and its relationship to respiratory function plays a crucial role in the early detection of OSA. Indeed, they are often the first healthcare professionals to examine a patient's mouth and upper airways [3, 9].

Clinical signs of OSA, identifiable by the orthodontist

- **Typical malocclusions:** class II, III, narrow palate, anterior hollowness. These malocclusions are frequently associated with OSA, as numerous studies have show [1, 6].
- **Habitual mouth breathing:** a sign of chronic nasal obstruction that can promote OSA [9].
- **Relative macroglossia:** large tongue in relation to the oral cavity, which can obstruct the upper airway [10].
- **Enlarged tonsils or adenoids:** visible on clinical examination, these hypertrophies can reduce airway volume and contribute to obstruction [10].
- **Signs of bruxism:** tooth wear, tooth sensitivity, muscle pain, which may be associated with sleep-disordered breathing, as some studies have suggested [11].
- **Nail clubbing:** an indirect sign of chronic hypoxia, which can be observed in children [11].
- **Adenoid facies:** characterized by an open mouth, pinched nose, and a fixed facial expression, this feature is often observed in children [3, 9].

These clinical signs, associated with a personal or family history of OSA, should alert the orthodontist and prompt them to refer the patient to a sleep specialist to confirm the diagnosis and initiate appropriate treatment [1, 3, 6, 9].

Additional tests

In addition to the clinical examination, other tests may be performed to confirm the diagnosis of OSA and assess the severity of the disease:

- **Cephalometry:** assesses upper airway dimensions and highlights skeletal abnormalities [6].
- **Computed tomography:** provides a detailed image of the bony structures and soft tissues of the upper airway, enabling stenoses and obstructions to be identified [10].
- **MRI:** can be used to assess upper airway soft tissues and brain structures [10].
- **Polysomnography:** this test is considered the gold standard for diagnosing OSA. It involves nocturnal recording of respiratory, cardiac and cerebral parameters. Polysomnography quantifies the number of apneas and hypopneas per hour of sleep, as well as the duration of oxygen desaturation. This examination enables the diagnosis of OSA to be made with certainty, and its severity to be assessed [11].

Polysomnography can be used to differentiate between different types of respiratory events:

- **Obstructive apneas:** complete cessation of airflow for at least 10 seconds, associated with respiratory effort.
- **Obstructive hypopneas:** significant decrease in airflow for at least 10 seconds, associated with oxygen desaturation or micro-arousal.
- **Central apneas:** cessation of airflow without respiratory effort, generally due to dysfunction of the respiratory center.
- **Mixed apneas:** association of an obstructive and a central component.

The apnea-hypopnea index (AHI) is a key parameter for

assessing the severity of OSA:

- AHI < 5: normal
- 5 ≤ AHI < 15: mild OSA
- 15 ≤ AHI < 30: moderate OSA
- AHI ≥ 30: severe OSA

Once the diagnosis of OSA has been confirmed, the orthodontist can propose different treatment options, depending on the severity of the disease and the patient's anatomical characteristics [1, 3, 11].

4. Treatment Options for Obstructive Sleep Apnea Syndrome

Treatment for OSA depends on the severity of the condition, the patient's age, and the underlying cause of the upper airway obstruction. The main treatment options are:

- **Continuous Positive Airway Pressure (CPAP):** This is the gold standard treatment for OSA. A device delivers a continuous flow of air through a nasal mask during sleep, preventing the airway from collapsing.
  - Indications: All stages of OSA, especially severe forms.
  - Contraindications: Mask intolerance, severe psychiatric disorders [1, 3, 4, 5].
- **Mandibular Advancement Devices (MADs):** These devices reposition the lower jaw forward, increasing the volume of the upper airway.
  - Indications: Mild to moderate OSA, patients intolerant to CPAP.
  - Contraindications: Temporomandibular joint (TMJ) disorders, severe malocclusions [12].
- **Surgery:** It is considered in cases of failure of conservative treatments or in the presence of significant anatomical abnormalities. The most common surgical procedures are uvulopalatopharyngoplasty (UPPP), reduction of soft tissues in the pharynx, and maxillofacial surgery.
  - Indications: Severe OSA, severe obesity, significant anatomical abnormalities.
  - Contraindications: Significant comorbidities, high anesthetic risk [7, 12].
- **Medical treatments:** These are used as an adjunct to other treatments and aim to treat risk factors associated with OSA, such as obesity, hypertension, and allergies [1, 4, 7].

5. Orthodontic treatment of OSA

Orthodontic treatment is particularly indicated for children and adolescents, as it can correct the dentofacial anomalies that cause OSA and promote harmonious jaw growth [1, 7].

- **Mandibular advancement orthoses (M.A.O.):** As previously mentioned, M.A.O. are an attractive treatment option for mild to moderate OSA. They are often used as a first-line treatment for young patients. Rengasamy Venugopalan S and al (2024) [12] emphasize the importance of the orthodontist in the follow-up of patients treated with OAM.
- **Maxillary disjunction:** This technique widens the palate and increases the volume of the upper airway. It is particularly indicated for patients with a narrow palate and mouth breathing. Kazmierski RH (2024) [6] emphasizes the role of the orthodontist in the diagnosis and management of OSA, particularly with regard to maxillary disjunction.
- **Other orthodontic treatments:** Orthodontic treatments may also include tooth extractions, functional appliances and orthopedic treatments to correct dentofacial anomalies and improve respiratory function [1, 6].

Indications and contraindications for orthodontic treatment depend on patient age, severity of OSA, type of malocclusion and bone growth. Alansari RA (2022) [13] emphasizes the importance of a thorough patient assessment before orthodontic treatment is initiated.

Treatment of OSA is multidisciplinary and requires close collaboration between the orthodontist, stomatologist, ENT specialist and pulmonologist. The orthodontist plays a key role in the diagnosis and management of OSA, particularly in children and adolescents. Orthodontic treatment, combined with other therapies if necessary, can significantly improve the quality of life of patients with OSAS [6, 13, 14, 15].

5.1. Oral Appliance Therapy

The orthodontist's role in the treatment of OSA is to manage patients with craniofacial abnormalities predisposing or perpetuating the syndrome by means of performed oral appliances or customized, in a multidisciplinary collaboration with a sleep medicine specialist [11, 12].

Oral appliance therapy is a commonly recognized, orthodontic treatment for OSA, a highly prevalent sleep-disordered breathing condition characterized by repetitive cessation or decrease in airflow during sleep due to upper airway obstruction [11]. This therapy option has been a staple in managing mild to moderate OSA cases who are unwilling or intolerant to continuous positive airway pressure (CPAP) therapy, a conventional non-surgical OSA therapy modality. It comprises prefabricated or custom-made oral devices, which function to reposition the mandible (or both mandible, and possibly maxilla) and the tongue forward, enhancing the posterior airway area [13, 16, 17, 18, 19].

Oral appliances function by repositioning the mandible and maintaining it in a forward position during sleep, which can trigger a series of muscle contractions, notably of the genioglossus muscle (tongue). This muscle pulls the pharyngeal tissues in a forward 'wrapping' direction, thus enlarging the pharyngeal airway. Examples of oral appliances for the treatment of OSA include mandibular repositioning devices (MRDs), tongue retaining devices (TRDs), or combinations of both. The effectiveness of oral appliance therapy for OSA has been extensively documented in scientific research and publications, ranging from in vitro studies to systematic reviews. Clinical research has demonstrated successful management of OSA cases treated with oral appliances, leading to improvements in subjective and objective measures of sleep, respiratory function, and overall health outcomes [20, 21, 22, 23, 24].

Patient-centered care focuses on aligning the clinical needs and preferences of patients; due to relatively high compliance rates with oral appliances, patients generally express satisfaction with this therapy. Common side effects and complications may include occlusal (bite) changes, dental or skeletal relapse, temporomandibular joint (TMJ) dysfunction, mucosal or muscle pain, and excessive salivation [20, 23, 24].

Adherence to therapy, regular follow-ups, and maintaining a healthy lifestyle are essential for reducing the incidence of these complications. Patient education plays a vital role in the

success of the therapy. All dental professionals involved in prescribing therapeutic oral appliances must stay informed about the fitting process and the mechanisms of action to ensure the devices operate effectively [24].

5.2. Functional Orthopedic Appliances

OSA is a common disorder characterized by recurrent episodes of partial or complete upper airway obstruction during sleep due to pharyngeal collapse, ultimately leading to oxygen desaturation and disrupted sleep. There are multiple treatment modalities for this condition to varying degrees of success, including functional orthopedic appliances (FAs), which comprise a mechanical design capable of improving respiratory function by modifying jaw relationships and increases airway dimensions either through advancing the mandible or modifying breathing patterns [1].

FAs have been successfully used in the case of adolescents or children with nasal obstruction, mandibular growth discrepancy, or poor intraoral behaviors. OSA children often show mandibular retrognathia that results in a narrow pharyngeal space for breathing during sleep [1, 19, 22]. FAs can be applied to advance the mandible or enhance the growth of the mandible, which promotes enlargement of the pharyngeal space. In the current context of pharyngology, the most widely used FAs for OSA children are mandibular advancing devices (MADs), also known as oral appliance therapy. However, variations in the designs and materials of MADs also exist. Twin-blocks (TBs) are a type of MADs that have been applied to children with mandibular retrognathia having an adjustable design compared with other fixed designs [1, 19, 22].

Using FAs to manage OSA is based on the belief that the appliance may change the anatomical configuration of the oropharynx and nasopharynx or modulate neuromuscular activities related to the patency of the airway. The former belief envisions that FAs therapy may dilate the oropharynx by increasing the transverse dimensions and advancing the mandible, thus enlarging the dimensions of the upper airway. The latter belief suggests that FAs therapy might be effective on the inspiratory opening of the upper airway by altering the coordination of upper airway dilator muscles [1, 5, 25, 26, 27].

Besides, children and adolescents have shown favorable compliance rates of FAs, and early improvement in upper airway breathing conditions may subsequently contribute to positive patient growth development [25, 26, 27]. From the orthodontic perspective, various orthopedic appliances, such as rapid maxillary expansion (RME), were then implemented as monotherapy for mild OSA children. Orthodontists are encouraged to be involved in the early evaluation and treatment of children with snoring or sleep-disordered breathing (SDB) symptoms to prevent the risk of future severe OSA. Eventually, the trial demonstrated that RME therapy exhibited various degrees of improvement for the respiratory function of childhood OSA. As the novelty of this topic, orthodontists and other professionals need to consider further clinical examination and involvement of these RME devices [1, 5, 18, 26, 27].

Orthodontic treatment is an attractive option for OSA, particularly in younger patients. Technological advances and a multidisciplinary approach help optimize results and improve patients' quality of life [1].

The selection of orthodontic therapy is customized based on multiple variables, including patient age, OSA severity, malocclusion type, and the presence of concomitant anomalies. Benefits of these therapies encompass a non-invasive nature, reversibility, and the potential to improve esthetics. Nonetheless, treatment duration is variable, and patient compliance is imperative [1, 2, 4, 23, 24, 26].

6. Orthodontic technological advancements for OSA treatment

Auto-Titrating Mandibular Advancement Device represent a significant development in the treatment of OSA. Unlike conventional orthoses, which require regular manual adjustment by a healthcare professional, these devices are equipped with mechanisms capable of automatically modifying the position of the mandible in response to variations in respiratory parameters during sleep. This real-time adaptation optimizes treatment efficiency and enhances patient comfort [28].

The manufacturing of these oral appliances relies on cutting-edge technologies, such as 3D printing and the integration of miniaturized sensors. The materials used are generally flexible and comfortable, while offering sufficient resistance to maintain the mandible in a forward position. The operating principle is based on the detection of respiratory events (apnea, hypopnea) by sensors integrated into the appliance. This data is then transmitted to a microprocessor which automatically adjusts the position of the mandible to maintain an open upper airway [28].

Advantages over conventional orthoses

- **Optimal personalization:** real-time adaptation enables the orthosis to be adjusted to the specific needs of each patient, maximizing treatment efficiency.
- **Improved comfort:** by avoiding frequent manual adjustments and minimizing irritation due to incorrect positioning, these orthoses offer greater comfort.
- **Improved adherence:** customization and increased comfort promote better adherence to treatment [28].
- **Potentially superior efficacy:** studies such as that by Son and al (2024) [28] suggest that self-titrating orthoses may have a positive impact on the autonomic nervous system, which could improve long-term results.

Comparison with conventional oral appliances

While conventional oral appliances remain a viable option for many patients, self-titrating oral appliances offer several advantages: increased personalization, enhanced comfort, and potentially superior efficacy. However, their higher cost and technical complexity may limit their accessibility. Furthermore, long-term studies are needed to confirm their superiority over conventional oral appliances [28].

In conclusion, self-titrating mandibular advancement devices represent a significant advancement in the treatment of OSA. Their ability to adapt in real-time to each patient's needs makes them a very promising option to improve the efficacy and comfort of treatments [28].

Maxillary expansion has been revolutionized by computer-assisted surgical techniques, ensuring greater precision and predictability of outcomes. Patient-activated expansion devices offer enhanced patient autonomy and improved treatment compliance [6, 12, 22].

A multidisciplinary approach integrating speech therapy and physical therapy has advanced functional and dentofacial orthopedic treatments. The use of biofeedback enables patients to better understand and control their respiration and deglutition, thereby promoting long-term treatment success

[1, 19, 25, 26].

7. Artificial Intelligence: Advancing Orthodontics

The incorporation of artificial intelligence (AI) into orthodontics is driving significant advancements. Machine learning algorithms, leveraging extensive clinical data, facilitate precise and rapid analysis of complex information, thereby enabling novel applications [1, 4].

AI for OSA diagnosis

- **Early, personalized detection:** AI can analyze data from a variety of sources (polysomnography, wearable sensors, medical imaging) to identify patterns and biomarkers specific to OSA. This makes it possible to detect the disease at an early stage and offer treatments tailored to each patient.
- **Classification of phenotypes:** AI can help classify different types of OSA (obstructive, central, mixed) based on complex characteristics, which is crucial for choosing the best therapeutic strategy.
- **Risk assessment:** By analyzing clinical and genetic data, AI can assess the risk of developing OSA and its associated complications, enabling more effective prevention [1, 4, 6].

AI to optimize treatment

- **Personalizing treatments:** By analyzing large quantities of data, AI can propose customized treatment plans, taking into account each patient's individual characteristics (age, gender, severity of OSA, comorbidities).
- **Optimization of device parameters:** For patients using continuous positive airway pressure (CPAP) devices, AI can help adjust pressure parameters according to individual needs, improving treatment efficacy and patient comfort.
- **Predicting treatment adherence:** By analyzing behavioral data and socio-economic factors, AI can predict treatment adherence and implement strategies to improve compliance [6, 7, 10, 12, 28].

AI to improve patient monitoring

- **Adverse event detection:** AI can analyze data collected by sensors integrated into treatment devices to detect adverse events (leaks, residual apneas) and alert healthcare professionals.
- **Assessment of treatment efficacy:** By comparing pre- and post-treatment data, AI can assess treatment efficacy and identify patients who are not responding satisfactorily.
- **Recurrence prediction:** AI can identify risk factors for recurrence and propose long-term prevention strategies [6, 7, 10, 12].

Challenges and future directions

- **Data Quality:** Data quality is a cornerstone of AI model training. Reliable, comprehensive, and representative datasets are indispensable.
- **Interpretability:** The interpretability of AI-generated results necessitates medical expertise. Physicians must comprehend the limitations of these tools to make informed clinical decisions.
- **Ethical Implications:** The deployment of AI raises profound ethical concerns, particularly regarding data privacy and algorithmic bias [28, 29, 30].

In conclusion, artificial intelligence is revolutionizing the management of OSA. By automating tasks and personalizing treatments, AI significantly improves patients' quality of life. However, it is crucial to develop these tools responsibly and integrate them into a patient-centered approach.

Conclusion

A multidisciplinary approach, centered on orthodontics, is essential for managing OSA. Technological advancements, especially artificial intelligence, enhance our understanding of OSA mechanisms and allow for personalized treatment plans. Orthodontists, with their knowledge of dentofacial structures, can provide customized treatment options, improving both functional and aesthetic outcomes.

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