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Sleep Apnea in Orthodontics – A review

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Abstract:
Aim:
To review the effect of sleep apnea and its management in orthodontics.

Background:
Sleep apnea is a serious sleep disorder that occurs when a person's breathing is interrupted during sleep. There are two types of sleep apnea, obstructive sleep apnea and central sleep apnea. Obstructive sleep apnea syndrome is a common, chronic disorder of sleep and breathing that causes disability from pathologic sleepiness and respiratory and cardiovascular complications. OSA is re- lated to upper airway obstruction that develops during sleep with manifestations that include snoring, apneas and hypopneas. Several oral devices have been designed to treat sleep apnea. One of the most common devices used are the orthodontic appliances.

Reason:
The review elaborates on the different types of orthodontic appliances used in the treatment of sleep apnea and also their effectiveness.

Keywords:*Sleep apnea, airway obstruction, upper airway, orthodontic appliances, Mandibular advancement.*

I. Introduction:

Sleep apnea is a potentially serious sleep disorder in which there are momentary pauses in breathing after which breathing resumes again and is often accompanied by loud snoring or choking sound. There are primarily two types of sleep apnea, namely Obstructive sleep apnea (OSA) and Central sleep apnea. As the name conveys, Obstructive sleep apnea is more commonly due to airway obstruction caused by structures in the posterior region of the throat – the tonsils, adenoids, the uvula, etc,.(1-7). Whereas, central sleep apnea is due to the loss of control of the respiratory centre of the brain over the muscles of respiration. While central sleep apnea is less common, obstructive sleep apnea is one of the most common problem encountered and has remained an exciting arena of research and review in the field of Orthodontics.

Obstructive sleep apnea (OSA) along with upper airway resistance syndrome is grouped under the category of Sleep disorder breathing (SDB) I.e. a group of disorders characterised by abnormalities of respiratory pattern during sleep (5). Patients with OSA experience frequent episodes of apnea or hypopnea, with each episode lasting for about to 10 – 30 seconds (7). This causes the patient to wake up frequently and gasp for air. This results in daytime sleepiness, poor quality of life, cognitive impairment, stroke and increased risk of cardiovascular diseases. This is also accompanied by blood oxygen desaturation and carbon dioxide accumulation (6). When Obstructive sleep apnea is accompanied by excessive daytime sleepiness, it is referred to as Obstructive sleep apnea syndrome.

Enlarged adenoids remains one of the most common causes for Obstructive sleep apnea. The other more commonly identified etiological factors include craniofacial abnormalities such as mandibular deficiency, an inferiorly placed hyoid bone relative to the mandibular plane, a narrowed posterior air space, a greater flexion of the cranial base, and elongation of the soft palate (8-11). Obstructive sleep apnea also increases the risk of several systemic complications such as hypertension, coronary artery disease, cerebrovascular diseases, cardiac arrhythmia, heart failure, chronic kidney disease, etc, (5).

The management of OSA varies according to the etiology. Several case reports and study articles have described the plethora of options available for the management of OSA. However, orthodontic strategies remain the commonest of all, as orthodontists work closely with the craniofacial development and related abnormalities in an individual. There are literature reviews briefing the clinical and diagnostic features of obstructive sleep apnea. On the other hand there are clinical studies reporting the efficacy of various orthodontic appliances employed in

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the management of OSA (12). This literature review aims at bringing an overview of the clinical and diagnostic features and the management of Obstructive sleep apnea, particularly focusing on the orthodontic part of treatment as this forms the conservative part of treatment of Obstructive sleep apnea, while the surgical procedures form the invasive part of the treatment.

II. Literature Review

Etiopathogenesis

The etiopathogenesis behind obstructive sleep apnea needs to be paid keen attention to, as it has a deterministic effect on the type of management and treatment involved. Among all the factors involved in the etiopathogenesis, most factors revolve around the fact of airway obstruction. The other factors include Male predilection, smoking, Down's syndrome, Marfan's syndrome, obesity, etc, (13, 14). The role of obesity in sleep apnea can be explained as follows: obesity can contribute to obstructive sleep apnea in two ways, either by the increased amount of fat in the soft tissues of pharynx or by increased superficial fat masses in neck which compress the pharynx (15, 16, 17). The obstructive causes can be broadly studied under the classes of changes in upper airway anatomy, changes in upper airway resistance, and in upper airway muscle function. When discussing about muscle function, according to Scmidt Nowara et al., the patency of upper airway when a person is awake is maintained by the inspiratory excitation of the upper airway muscles. But during sleep, in some people, there is excessive relaxation of upper airway muscles or there is loss in the compensatory excitation of the upper airway muscles. This leads to collapse of upper airway muscles during sleep, thus propagating towards sleep apnea.

Pertaining to upper airway anatomy, obstruction can be caused by narrowing of upper airway at the level of base of tongue, soft palate, and lateral pharyngeal wall. According to et al., this obstruction can also be due to elongated soft palate and inferiority positioned hyoid bone. This narrowing is a sequel of macroglossia, retrognathic maxilla and mandible, tonsillar or adenoid hypertrophy, etc,. There also occurs hypopharyngeal obstruction in sleep apnea. This is commonly attributed to the position of base of the tongue which causes hypopharyngeal obstruction (3).
Discussing about the changes in upper airway resistance, it has been stated that the airway pressure is dependant on the end-expiratory lung volume. When this volume falls below normal there is increased chances of upper airway collapse. A continuous positive pressure needs to be maintained in order to have a patent airway. But in case of obstructive sleep apnea, there is a negative airway pressure. This is because the patency depends on the action of oropharyngeal muscles and these abductor and dilator muscles usually function in a rhythmic and coordinated manner. But when the negative pressure exceeds the activity of the dilator and abductor muscles, the pharynx will collapse, obstructing the airway.

Fluid shifts have also been identified to be one of the causes of Obstructive sleep apnea in certain patients. This is due to the rostrum fluid shift or displacement from legs to the neck during night time leading to change in neck circumference. This causes an increase in the amount of fat in pharynx, thus indirectly leading to airway obstruction.

The posture of patients during sleep also causes obstructive sleep apnea. There is a strong potential for airway collapse due to gravitational force. This leads to retropulsion of tongue and soft palate in supine position. This increases the positive pressure and narrows the airway (5).

Epidemiology

There are no particular studies, explaining the age based epidemiological values separately. But there are several studies, briefly outlining the striking epidemiological characteristics of Obstructive sleep. According to the Wisconsin sleep cohort carried over by Mehta et al., about 9-24% males and 4-9% females in the middle age I.e. 30-60 years have OSA (5). The study results of Vishwanath et al. also agree with the same (15). There is also a 3 fold increase in risk in post menopause. Also, the presence of snoring habit has also been found to be associated with an increased risk (6) of Obstructive sleep apnea, with 8-12% risk in patients less than 18 years old(14). The patients with hypertension are also 2.5 times more likely to develop OSA, which is 83% in case of drug resistant hypertension. In particular, in women there is a 3 fold increase in risk in post menopause than in pre menopause (5).

Clinical features and Symptoms:

There are many characteristic clinical features and symptoms suggestive of Obstructive sleep apnea. One of the cardinal symptoms of obstructive sleep apnea is excessive daytime sleepiness (3, 5, 6, 14, 17). During sleep there is snoring, gasping, choking, saliva drooling, sleep restlessness, bizarre sleeping positions and occasionally bed wetting (3, 5, 6, 14, 17).

Questions	Responses given	Percentage
Are you aware of the term HIV	Yes	96.2%
	No	3.8%
Is HIV a viral infection	Yes	88.5%
	No	11.5%
Are you aware of the term pediatric HIV	Yes	61.5%
	No	38.5%
Do you know any child with pediatric HIV	Yes	30.8%
	No	69.2%
Do you treat HIV positive child as a normal child	Yes	67.3%
	No	32.7%
HIV infected child should be blamed for their illness	Yes	24%
	No	76%
Will you allow your child to play with a HIV infected child	Yes	62.5%
	No	37.5%
Would you like to help a HIV positive child	Yes	79.8%
	No	20.2%
If you get to know that your close friend child is infected with HIV will you keep same relationship with him/her	Yes	71.2%
	No	28.8%
Should HIV infected persons feel ashamed	Yes	21.2%
	No	78.8%
Should HIV infected child get treated by doctors	Yes	85.6%
	No	14.4%
Should HIV infected child should be treated good way in society	Yes	78.8%
	No	21.2%
Will you allow a HIV positive child to study in your child school	Yes	72.1%
	No	27.9%
Would you like to talk or play with HIV positive child	Yes	76.9%
	No	23.1%

There can also be psychological changes such as irritability, depression, change in personality, poor work performance, etc., (3, 5, 6, 14).

The systemic changes include xerostomia, high blood pressure, overweight, asthma, nocturia, heart burn, stunted growth and also decreased libido (1, 3, 5, 6, 14, 17).

The clinical features involving the oral cavity include jaw deficiency, macroglossia, long soft palate, large tonsils, large tongue base and redundant mucosa with fatty infiltration (18)

Thus, such prominent clinical features play a pivotal role in the easy identification of patients with obstructive sleep apnea, particularly in a dental office.

Diagnosis:

An array of diagnostic options are responsible for the detection of obstructive sleep apnea. One of the most common and easiest way of diagnosis is the careful observation of the clinical features presented by an apneaic patient. The most common methods of diagnosis, as stated in literature are as follows:

- Epworth's Sleepiness Scale
- Apnea Hypopnea Index
- Oximetry
- Multiple sleep latency test
- Respiratory distress index
- Polysomnography

The above mentioned three indices and three tests are the commonly used diagnostic aids for OAS.

Epworth's Sleepiness Scale

Epworth's Sleepiness Scale is an important self assessment scale, to measure the daytime sleepiness of a person. The daytime sleepiness is assessed in 8 different situations (3,5) as follows:

- Sitting and reading
- Watching television
- Sitting inactive in a public place such as theater or meeting
- As a passenger in a car for an hour without a break
- Lying down to rest in the afternoon when circumstances permit
- Sitting and talking to someone
- Sitting quietly after a lunch with alcohol
- In a car stopped for a few minutes in traffic

The sleepiness experienced by the patient during these eight situations is graded as (3):

0- No chance of sleepiness
1- Slight chances of sleepiness
2- Moderate chances of sleepiness
3- High chances of sleepiness

The total scores were calculated and the patients were graded as follows (4):
0-10 Normal range in healthy individuals
11-14 Mild sleepiness
15-17 Moderate sleepiness
18 and above Severe sleepiness
However, according to Ankit Mehta et al., this scale can be considered inaccurate as it is a self assessment and the data obtained as a result is ordinal in nature.

Apnea Hypopnea Index

Apnea is a complete cessation or obstruction of airflow for a period of at least ten seconds accompanied by a 2-4% drop in the arterial O_2 saturation.
Hypopnea is a reduction in airflow with a 30-50% drop in O_2 saturation.
AHI >5 Normal
AHI 5-15 Mild sleep apnea
AHI 15-30 Moderate sleep apnea
AHI >30 Severe sleep apnea

Oximetry

Polysomnography is considered as the most accurate diagnostic aid for OAS at present. There's one test that can at least match the accuracy of polysomnography – the Oximetry test.
This test measures the patient's O_2 saturation throughout the night or sleep time and is also preferred as it is inexpensive.

Multiple sleep latency test

Multiple sleep latency test is used to assess the time taken by a person to fall asleep. A normal person takes about 10 minutes time. But this is reduced in case of OSA.
This test is taken for around 4-5 naps, each for a duration of 20 minutes, every 2 hours, during the day. The average of all the latency durations is taken as the final score. A score of less than ten minutes indicates OSA.

Respiratory distress index

The respiratory activities during sleep are monitored by the Respiratory distress index (6,13).
This index measures the number of apnea and Hypopnea during one hour sleep. The scoring is as follows: 0-5 Normal, 5-20 Mild, 20-40 Moderate, and >40 Severe apnea.

Polysomnography

Polysomnography is an inevitable aid in the diagnosis of Sleep apnea. This sleep study consists of Electrocardiography, Electroencephalography, Electrooculography, Electromyography, Oximetry and body position. A person can be categorised as sleep apneic if his/her test results satisfy the following conditions:

- Cessation of airflow for 10 seconds.
- 5 or more episodes of apnea per hour
- Decrease in the O_2 saturation by at least 4% for each episode.

Management

The management of Sleep apnea as recognised by the American Association of Sleep Medicine (AASM) includes, Continuous Positive Airway Pressure (CPAP) as the gold standard, followed by eight surgical and five conservative procedures (4).
The surgical procedures include bariatric surgery for weight reduction, tracheostomy, uvulopalatopharyngoplasty (UPPP), maxillary and mandibular advancement, inferior Sagittal osteotomy of mandible with hyoid myotomy and suspension (13), laser assisted palatoplasty, radio frequency ablation,and pillar palatal implants (5).

Continuous positive airway pressure

The most standard treatment for sleep apnea, involves the use of a mask fitted over the nose or mouth and connected to an oxygen device on the other end via a tube. This provides a continuous flow of air I.e. a positive pressure and prevents the muscles from collapsing during the deeper stages of sleep (5,6).

Surgical procedures

Tonsillectomy is one of the most common surgical procedures for OSA. It involves the removal of tonsils along with total adenoidectomy (5). Uvulopalatopharyngoplasty is a surgical procedure that enlarges the retropalatal airway by the excision of tonsils if present, uvula and the posterior portion of the palate(6).

According to Riley et al,. (13), maxillary and mandibular advancement by surgical means is the best alternative to tonsillectomy. It is a combination of Leofort 1 osteotomy and sagittal split osteotomy.
Temporary tracheostomy is used before other surgical procedures like bariatric surgery to maintain the latency of airway. Permanent tracheostomy is performed only in highly inevitable circumstances wherein the patient doesn't responds to methods like CPAP (5).

Oral appliances

A number of oral appliances are commonly employed for the correction of malocclusion disorders. However these appliances are nowadays employed for the treatment of sleep apnea and snoring. This can be attributed to the potential posed by these appliances to modify the existing oral anatomy, I.e., the unusual anatomy of certain structures in oral cavity which contribute to airway obstruction. The commonly used appliances includes Mandibular advancement device (MAD), Maxillomandibular advancement (MMA), Tongue retraction device (TRD), Rapid maxillary expansion (RME).

Mandibular advancement device (MAD)

These devices are used to enlarge the airway size to reduce the collapsibility. According to Schmidt-Nowara et al,. MAD modifies the upper airway dimensions, as follows:

- Advancement and downward rotation of mandible
- Increase in superior airway space I.e., the space between the nasopharynx and soft palate
- Increase in posterior airway space I.e., the space between base of tongue and posterior oropharynx

Helen et al,. (10) observed that the mean sleep latency on the multiple sleep latency test and ESS scores were progressing towards normal after the use of a Mandibular advancement device.
Like any other appliance, side effects do occur in Mandibular advancement device. These include subjective symptoms like dryness of mucosa, discomfort to teeth, hypersalivation (8), jaw pain, masseteric muscle pain, TMJ pain etc,.(17). There are also certain dentoskeletal changes leading to labial inclination of Mandibular incisors and lingual inclination of maxillary anteriors leading to a reduction in the overjet (18,19,20). However, these side effects are of no significance when compared with the benefits obtained out of the use of a Mandibular advancement device.
There are many designs for a Mandibular advancement device which includes:

1. Klearway oral appliance – This appliance is used for mild to moderate OSA. This basically has a maxillary expander which guides the advancement of mandible, but in a gradual manner. Such gradual expansion prevents, discomfort and dislocations caused by rapid expansion.
2. Modified Herbst appliance – This appliance works based on a telescopic mechanism and piston post. There are maxillary and mandibular splints which are linked to each other. But studies have reported that it doesn't cause significant Mandibular advancement, though the degree of mouth opening is fairly high when compared to other devices.
3. Thornton adjustable positioner – This positioned has separate splints for maxillary and mandibular arches. The labial aspect of upper splint has screws which can be adjusted to facilitate Mandibular advancement.
4. Parker mandibular positioner – This is similar to modified Herbst appliance. One difference is that, the upper and lower splints are linked by bilateral orthodontic expanders and also the appliance is made of a thermoplastic material which must be heated in hot tap water every night before wearing.
5. Elastic Mandibular advancement – The design of this appliance is similar to that of clear acrylic orthodontic retainers. It leads to Mandibular advancement in a sequential manner which is quite difficult to tolerate. However, this is one of the most thinnest and least bulkiest of all devices used for Mandibular advancement.
6. Silencer system – All other Mandibular advancement devices allow movement only in an anterior and posterior direction. However, this facilitates movement in " open and closed" positions as well. The Silencer system has titanium screws incorporated within it. These screws facilitate sequential 2mm advancement of mandible upto 8mm and lateral movement of upto 6mm, 3mm on each side.
7. Oral positive airway pressure – Here, a Mandibular advancement device is combined with a Continuous Positive Airway Pressure. But an advantage is that, instead of the mask that fits over the nose in a conventional CPAP, there is a small conduit attached to the palate that maintains a continuous positive airway pressure.

Tongue retraction device

These devices prevent the tongue from obstructing the upper airway space, thus reducing collapsability. TRDs are used in dental arches which do not permit the construction of a Mandibular advancement device(4,17). One of the most common TRD is the tongue retaining device, which is a custom made one. It consists of grooves for dental arches in which the teeth rest. There is a bubble that extends out between the grooves, where the tongue is to. E placed and held with suction. This prevents the base of tongue from obstructing the airway (20).

RAPID MAXILLARY EXPANSION

A narrow maxillary arch can lead to an increased airway resistance, and alterations in tongue position leading to a reduced retroglossal airway, thus propagating to sleep apnea (11). Rapid maxillary expansion is used in such situations, particularly in children and adolescents with a narrow maxillary arch and also in children with Down syndrome(21). The device consists of a screw attached to the palate, with its arms attached to the anchor teeth, which are mostly the premolars and molars. The force is directed through the anchor teeth to the mid palatine suture, leading to movement of teeth and opening up of the suture. However at the end of treatment, normal mineralised bone and palatal processes are formed leading to normal closure of suture (9).

Karwetzky activator

This activator was designed by Karwetzky and has a loose fit. This appliance basically has both tooth and tissue borne activator and is bimaxillary in its design and divided along the occlusal plane. This appliance permits both lateral and vertical jaw movements. It consists of two U – loops fixed in the lingual acrylic in the region of first molars. This design permits adjustment of Mandibular advancement in the sagittal plane. The protrusion can be individually adjusted for each patient in the sagittal plane and vertical plane, to ensure retention of the appliance as follows:

Sagittal plane – Protrusion is half to three fourths the width of premolars. The degree of adjustments was based on the position of first molars.

Vertical plane – Protrusion is around 8 to 10 mm. The degree of adjustment was based on the position of central incisors. (16)

The selection of an appropriate appliance is based on three criteria: patient eligibility, the requirements of the provider and the features of the appliance or the device.

Patient eligibility includes the age of the patient, severity of OSA, potential risks and complications. Discussing about the features of the appliance, the appliance must be customised, adjustable, and the changes occurring as a result of the use of the appliance must be gradual and cause only minimal or no discomfort to the patient. The provider requirements include a thorough knowledge about the fabrication, activation and use of an appliance for the provider.

III. Conclusion:

Sleep apnea can pose to be simple in its context, but is also one of the most life threatening conditions. Sleep apnea if ignored can cause drastic changes in a person's lifestyle due to a wide range of disturbances caused by sleep apnea, in particular Obstructive sleep apnea, in regular metabolism and also systemic abnormalities. The management of sleep apnea includes both surgical and conservative means. An orthodontist plays a pivotal role in the conservative management of Sleep apnea, which is more effective and advantageous over surgical management. This doesn't stop just with the fabrication of oral appliances, but also necessitates the requirement of a thorough knowledge about the etiopathogenesis and risk factors for sleep apnea. Hence, this review outlined the etiopathogenesis in detail, apart from elaborating the orthodontic treatment modalities for sleep apnea. Further, more clinical trials need to be initiated in the field of orthodontics, for overcoming the minor side effects associated with the current devices.

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