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Adverse Oral Functions and Habits

Literature review

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CONTENTS

ABSTRACT

The stomatognathic system is a functional complex characterized by skeletal and dental components, temporomandibular joint, masticatory muscles and soft tissues. Its harmonious functioning depends on the balanced relationship between these structures. Different functional operations such as suction, swallowing, mastication, speaking and respiration are comprised in the stomatognathic system and can interfere with maxillofacial growth.

Oral habits, such as mouth breathing, atypical swallowing pattern, anterior resting posture of the tongue, thumb sucking and lip incompetence, are defined as repetitive patterns of behavior. They are considered harmful based on frequency, duration and intensity and they can influence the position of the teeth, the inter-arch relationship and the function of the orofacial musculature, especially in the primary dentition. Anterior open bite, increased overjet, posterior crossbite and altered molar relationship can be some of the consequences on normal occlusion, as mentioned in many studies.

The literature review pointed out that collaboration among health care professionals such as pediatric dentists, otolaryngologists, orthodontists, psychologists, speech therapists, myofunctional therapists, as well as the proper examination of the stomatognathic system and the accurate diagnosis are the success key to patient's therapy.

The purpose of this literature review is to provide thorough information about the adverse oral functions and habits. Furthermore, it aims to explore the connection between each of them and the stomatognathic system, the effect on the occlusion of teeth, the treatment options and the optimal treatment timing.

Keywords: adverse oral functions and habits; malocclusion; mouth breathing; thumb sucking; atypical swallowing and anterior resting posture of tongue; lip incompetence.

METHODOLOGY

For this literature review, three electronic databases were selected including PubMed, Clinical Key and Science Direct. Studies published in English were chosen. The year spectrum is from 2012 to 2023, however older studies have also been included due to their high importance. The studies that were presented in this review were based on infants and children and some on adults, with broad sample size. Keywords such as "adverse oral function and habits, malocclusion, mouth breathing, thumb sucking, atypical swallowing, anterior resting posture

of tongue and lip incompetence were used to conduct this research. In this paper, 239 references are included.

INTRODUCTION

The stomatognathic system is the combination of organs, tissues and structures both static and dynamic, and well-coordinated functioning of these different elements is based upon the balanced association between them (1). The functions of the complex structure of the stomatognathic area, such as sucking, respiration and swallowing, are considered to be the elements that most affect the model of the maxillofacial development as well as the position of the teeth in a child's arch, acknowledged also as malocclusion (1).

Malocclusion, a developmental condition, described as defective related dentofacial anomaly by the World Health Organization (WHO), ascribes to abnormal occlusion and/or disrupted craniofacial correlations, which may impact facial functions and harmony, appearance and social aspects (1, 2). Midline deviations, anterior crossbite, deep overbite, excessive overjet, malalignment, space and open bite are the most frequently types of malocclusions observed in dental clinics (1-3).

Hereditary and environmental factors, as well as the combination of these, lead to multifactorial etiology of malocclusion in the affected individuals, among which dental diseases afflict very much (2).

There are controversial issues considering the causes of malocclusion in primary dentition and whether or not these causes can also predict malocclusion in the permanent dentition. Identifying, analyzing and detecting the relating factors that lead to the causes of malocclusion, is a very important asset for planning health policies that help preventing, managing and intercepting the problem as well as planning an effective treatment. Considering the fact that there is an increased interest in the early diagnosis and treatment of malocclusion and an analogous emphasis on the preventive procedures, additional information is required (3).

Orofacial functions (e.g., breathing, chewing, swallowing) are complex, life-sustaining, sensorimotor actions, controlled by the central and peripheral nervous system and neuromuscular system (4). They are the basis for social interactions regarding speech, emotional communication, facial expression and appearance (4,5). Orofacial myofunctional disorders (OMD) are defined as abnormalities of the muscles and the functions of the face and the mouth. They interfere with normal growth and development, or functional problems of the orofacial structures affecting the orofacial muscular system and/or creating an aesthetic problem (5,6). OMD, including dysfunction of the lips jaw tongue and oropharynx may occur as a result to several genetic and congenital disease, the presence of parafunctional habits and

as consequence of trauma (6). Various issues contribute to the development and establishment of an OMD including compromised airway, enlarged tonsils or adenoid neurological impairments that limits the patient's ability to achieve correct muscle function (5,6). Moreover, oral habits such as, sucking habits, mouth breathing (MB), atypical swallowing, mouth and lip posture, are included in orofacial dysfunction and constitute the main functional factors that influence the development of malocclusion (4,6). The consequences of living with an OMD can impede the quality of life. Lack of intervention at specific and critical times can result in malocclusion and deficiency facial development (4,5,6).

Habit is a regular tendency acquired by the constant repeated act that happens intentionally at the beginning and later on automatically and unintentionally. For any habit to produce detrimental and long-lasting consequences, factors such as duration, degree and intensity of the particular habit, are mainly responsible. In childhood, pacifier sucking followed by finger sucking, are the most frequent damaging habits, mainly from ages 0 to 3 years old, as a consequence of developmental process and world exploration. Nevertheless, these habits are crucial risk factors for malocclusion and several epidemiological studies have reported their adverse consequences. Another indication often mentioned in studies as a risk factor for the beginning of malocclusion and facial issues is MB, a habit that takes place most frequently during sleeping (7). The treatment for these types of conditions must be conducted orderly to maximize the results, including professional guidance and counseling by a dental surgeon, regular reminders of therapies following by rewards and orthodontic appliance therapies (8). An oral habit must be managed when there is indication associated with adverse dentofacial development, negative outcomes on the entire well-being of the patient, or if there are rational signs that the particular habit will result damaging aftereffects in the developing permanent dentition (9). Habit treatment approaches comprise counseling with patients and parent's behavioral adjustment techniques, orthodontic device therapy or referral to other practitioners such as psychologists, orthodontics, myofunctional therapists or otolaryngologists (9).

In developing countries, patients have limited access to dental facilities and very often is noted the fact of seeking medical assistance only in an emergency situation. In these countries the expensive orthodontic services and the absence of public sponsored dental treatment programs, set several restraints, bringing up important issues such as to identify the need for orthodontic treatment in accordance to the dental severity and to associate modifiable factors which can be directed through interceptive and preventive orthodontics efforts (7). Analyzing the related factors associated with behavioral changes and habit treatment approaches is crucial for

planning public health policies aimed at preventing and interrupt the progression of malocclusion (7).

The purpose of this systematic review was to analyze the available scientific literature about the contribution of adverse oral functions and habits to normal occlusion development, as well as the correction, the timing and effectiveness.

ADVERSE ORAL FUNCTIONS AND HABITS

Oral adverse functions and habits are associated with abnormal repetitive movements of the oromandibular system. They have a very complex nature relating to emotional functions such as sleep and tooth eruption (10). Repetitious actions towards a particular situation or stimulus are habitual in infantile phase and most of them are began and ended without external cause. Since the mouth is the main and perpetual place for utterance of emotions and many times works as a source of anxiety relief in children and adults, stimulating this area with tongue and finger can be a soothing activity (11). Oral parafunctional habits in all societies in varying potency resulting in malocclusion, facial disfigurement and TMJ disorders as well as psychological implication, such as distress, reduced confidence and self-esteem among children and adolescents (10). Habit is characterized by the repetition of acts that being performed mechanically. Normal habits play a positive role in growth motif whereas abnormal habits can lead to interferences in normal growth pattern. Persistent oral habits are one of the most considerable etiologic factors leading to malformation in dentofacial structures (10).

Studies from different areas of the world, verify that habits influence the development of occlusion therefore have a critical part in child's facial appearance (12). Yassaei et al., reported that the prevalence of oral habits in high schools in females is 87,9% and in primary school students is 30% (13). Quashie Williams er al., reported that 34,1% of children have one oral habit (14), while in a study conducted by Bandung et al. on kids between the age of 6 to 12 years, the prevalence of one oral habit was higher, reaching 50% (15). Kristina Kasparaviciene et al., notices in their study that 71,4% of the children had one or more characteristics of malocclusion and 16,9% had oral habits (16). S. Anila et al., found that the general currency of oral habits in the study participants was 72,7%, while 19,1% had two habits and 5,5% had three or more habits (17).

Harmful persistent patterns of muscle behaviour are frequently related with irregular or obstructed osseous growth, tooth altered positioning, dysfunctional breathing habits and speech

difficulties. These patterns often cause asymmetry to facial musculature causing phycological problems (18).

Oral habits might cause disorders on teeth and supporting tissues depending on the duration or intensity of the performed action, frequency of the action (19). A strong association exist among oral habits and development of malocclusion in the primary dentition. 40% of causes of malocclusions are associated to oral habits, such as anterior open bite (AOB), increased overjet, decreased maxillary arch width, posterior cross bite and class II canine and molar relationship (20,21).

With the eruption of all permanent teeth malocclusion is set up to its full expression; consequently, young adolescents at the late mixed dentition and early permanent dentition period provide a greatly clear image of malocclusion's prevalence and its related oral habit (22,23).

Mouth Breathing

Description

Respiration is the natural sequence of events that results in the exchange of oxygen and carbon dioxide between the atmosphere and the body cells. Pulmonary ventilation, commonly referred to as breathing, is the process of air following into the lungs during exhalation. Nose breathing manage the capacity of inhaled, and more important the capacity of exhaled air. The addition of oxygen to human body systems occurs during exhalation, not during inhalation. Upon exhalation, the negative pressure produced in lungs in nose breathing motif versus MB provides additional time for the maximum amount of oxygen to bind haemoglobin in the blood. This process requires proper build-up of carbon dioxide in the blood. For brain and muscle cells oxygenation, the level of carbon dioxide has to be 5% in alveoli and arterial blood (24).

Oxygenation of the body and removal of the waste of carbon dioxide is the purpose of breathing. Carbon dioxide indicates several functions in the body; to facilitate the release of oxygen from haemoglobin, to regulate blood pH through buffering with bicarbonates and carbonic acid and to trigger the inhalation. In mouth breathers all these functions are limited or disrupted (25)

Individuals are naturally designed to breathe through the nose but several reasons can compel to MB causing a broad range of consequences (24,25). MB is often related with congestion,

obstruction or other abnormalities of the upper respiratory system in addition with other medical and oral conditions. Basically, oral breathing is a risk factor for dental health. During oral breathing malocclusion might occur, the intraoral space becomes dry and saliva production is lessened (24,26).

Sassouni defined MB as a constant habit respiration through the mouth instead of nose. Merle, little after, presented the term oronasal breathing of oral or MB considering this term more accurate and precise (27,28)

Currently the adopted point of view is that MB are those individuals who breath through the mouth even in case that they are resting (29).

Prevalence

In the existing literature the prevalence of children who breath by mouth has point out mixed results. In some studies, it is confirmed as a frequent condition that affects approximately 10-15% of the children's population (20, 30, 31).

Cucc et al., reported a prevalence of MB in children with maxillary and dental abnormalities; in the study were more affected women and children living in urban places (31). Other study's results showed that the prevalence of children's MB is 55% (31). A Brazilian study in 2010, examined 419 school children aged 6-11 years and found that the prevalence of MB in the sample, was 56,8% (32). Another study contacted in Cuba also found that the percentage of MB was 24,7% and the majority was children aged 6-11 years (33).

An additional related study recently conducted by Kukwa et al., found a prevalence of 18,7% and the findings were more common in boys (6,5%) versus girls (5,4%) (34). At the Padhadjaran University Dental Hospital, a study on the prevalence of MB was performed in 2011, and the results showed that 10,9% of the patients who came to the paediatric dental clinic, were mouth breathers and the condition was more common in girls (35).

Garde et al., in their study in 2014 showed that MB habit was noticed among 4,3% of study population, the findings were lower compared to the results of a preceding study conducted by Amrabout et al. (36).

In a study conducted by Felcar JM et al., over 496 children, the results of the prevalence of MB were 56,8% and the average age of children was 7 years old. There was no remarkable statistical difference between genders (37).

Based on the data we can conclude that the prevalence of MB is very high.

Etiopathogenesis

Etiopathogenesis of MB involves genetic as well as environmental factors. Poor oral habits, nasal obstruction including adenoid/tonsil hypertrophy, nasal polyps, nasal septum deviation, turbinate hypertrophy, or sinusitis can lead to MB (38,39). Furthermore, MB may be associated to respiratory allergies, climate conditions or poor sleeping positions (38).

Hypertrophy of the adenoids, which are the nasopharyngeal cushions of lymphoid tissue and allergic rhinitis are the main cause of airway obstruction. Several symptoms are related to these two conditions, such as lack of nasal airflow, sneezing, itching, runny nose and snoring, possible obstructive sleep apnoea and increased upper respiratory infections, such as ear infections, tonsilitis, and sinusitis. MB caused by airway obstruction results in postural alterations like lip incompetence, low position of the tongue in mouth floor, and increased vertical dimension of the face for clockwise rotation of the jaw (39).

A study conducted by Rubens Rafael Abreu et al., examined children ages 3 to 9 years old. The results showed that the principal causes of MB were allergic rhinitis, to an extent of 81,4%, enlarged adenoids in a rate of 72,2%, enlarged tonsils in a percentage of 12,6% and obstructive deviation of the nasal septum in a percentage of 1.0% (40).

Allergic rhinitis was determined as the most significant etiological factor for MB in other studies, up to 36% children with MB had atopic cause (41,42). This finding was in accordant with a study referred on the impact of allergic rhinitis on the breath disclosing that 100% of adults, 96,7% of adolescents and 83,3% of children had MB because of allergic rhinitis (43). Additionally, there were reports associated with cystic fibrosis and moderate persistent asthma present in 44% and 45% of patients sequentially (44,45).

Research in Chile showed, that among 100 oral breathing children between ages 3-5 years, 27% had no obstruction of the upper airway. The leading cause of the obstruction was adenoid hypertrophy (48%) succeeded by turbinate hypertrophy (29,0%). The inconsequential causes coincided to choanal and maxillary atresia with 12,0% and 7,0% respectively (46).

A study conducted in Brazil among 308 mouth breathers ages 3-12 years detected palatine tonsillar hypertrophy in 47%, adenoid hypertrophy in 46% and atopy in 36% of patients being evaluated (47).

Clinical manifestations and occlusion

The relation between inadequate nasal breathing and dentofacial morphology has been researched thoroughly and many authors are of the opinion that the pattern of craniofacial growth can be influenced by disequilibrium of muscle function which is typical in MB (29,39,48).

Children experience MB have representative physiognomic features such a long face, narrow nostrils, dark circles, transverse contraction of the upper jaw, high arched palate and gummy smile related to malocclusion of Class II or occasionally Class III with high occurrence of posterior crossbite and AOB (29,48). This children's category has a notably higher mean depth of the hard palate for the reason that the absence of negative pressure on the nasal cavity impedes the palate from descending and the movement of bones and other facial muscles helping compress the maxilla's outer arch, consequently the growth is more prominent vertically (49). MB children, rotating the mandible in a posterior and inferior direction develop Class II malocclusion and a profile of skeletal Class II with increased overjet. Actually, the muscles which press down the jaw to open the mouth exercise a backward pressure upon in which dislodge the mandible distant and delay its growth. The buccinator muscles are made stretched by opening the mouth and have the tendency to apply lingual pressure on the maxillary bicuspids and molars which do not gain adequate support from the tongue, hence the palate and the upper dental arch becomes quite narrow. Function of the lip is characterized by anomaly, the lower lip is being large and bulbar and the upper lip is being short and lacks function, with frequently lower lip forced up under the upper incisors, that are further sticked out with increased overjet (48).

Task et al., found that allergic children with MB condition had longer and more retrusive face comparing to children with nasal breathing (39).

During the time that craniofacial systems develop, they change to accommodate to different breathing motives. There is an agreement in literature in accordance with the problems and deleterious consequences MB creates, such as changes in the stomatognathic system that impact fascial muscles which affect dental arches and tooth position, related with structural disorder of the lips, tongue, palate and mandible, resulting in facial deformation. Furthermore, MB reduces masticatory activity, lessening the vertical effect on the posterior teeth, which can adversely affect their vertical position inducing malocclusion. These changes are defined by a long face with an increase in the height of the lower anterior face, an increase in palatal height

with a decrease in the area and the volume of the palatal surface, a narrowed nasal airway. The lower jaw keeps retracting in growth with increasing mandibular plane and gonial angles, ensuing in a small chin, dental malocclusion Class II, hypotonic upper lip, hypertonic lower lip, projection of the anterior teeth and aquiline nose, with a negative side view of the face. Moreover, it has been supposed that the diminution in mandibular growth in children with adenoid faces is caused by abnormal excretion of nightly growth hormone and its mediators. After adenotonsillectomy and reparation of MB, hormone secretion is normalized, the growth of mandible is accelerated and changes in its growth direction. This can be interpreted by more intensive formation of endochondral bone in the condylar cartilaginous tissue and by growth of appositional bone at the lower border of the mandible, after restitution of normal nasal breathing and hormonal status (26,38,50,51,52)

In a systemic study conducted by Bahija Basheer and his colleagues in 2014, 50 children ages 6-12 were examined and the results showed that bimaxillary proclination and facial convexity were significantly seen in MB children (50). The outcomes found in the literature concerning the inclination of the maxillary and mandibular incisors are controversial since McNamara (53), Faria et al. (54), and Mahony et al. (55), deduced in the mouth breathers, reasoned by interference of the hypertonic lower lip between maxillary and mandibular incisors causing displacement of maxillary incisors. Nevertheless, in their studies Solow et al. (56), Behlfelt (57), Ung et al. (58), and Zettergren-Wijk et al. (59), pointed out that maxillary incisors are found retroclined in these patients in regard with the S-N line and Tarvonen and Koski (60) announced that the mandibular incisors displayed retroclination in relation to the mandibular plane.

Rakosi and Schulli believe that MB contributes in the aetiopathogenesis of some types of Class III malocclusion. Children that breath through their mouth have continually open jaw and a low posture of the tongue with immoderate mandibular growth, with continuous disturbance of the mandibular condyle from the fossa which might be a growth stimulus. Furthermore, the absence of thrust of the tongue on the palate and on the upper jaw may provoke a sagittal and transverse maxillary skeletal deficiency, a class III malocclusion with decreased or reverse overjet (61).

Additionally, Harari er al., found a high prevalence of narrow dental arches and dental crowding, mainly considering the upper arch, in mouth breathers (48).

In a study conducted by Kasparaviciene et al., among 503 pre-school children, MB was the most prevalent condition (10,1%) with a potential negative result on occlusion with molar class III relationship (16). This is in accordance with many other studies such as Gois et al. (62), and Suki et al. (63), for the reason that MB and nasal obstruction have evidenced negative effects on development of the cranio-facial system.

Doron Harari and his associates assessed 116 paediatric patients who has gone orthodontic treatment (48). Among them 55 patients suffered from nasal obstruction's symptoms and 61 were normal nasal breathers. Compared to the nasal breathers' group, the mouth breathers group demonstrated considerable or significant backward and downward rotation of the mandible plane angle, a higher palatal plane and narrowing of both upper and lower arches at the level of canines and first molars. The predominance of a posterior cross bite was remarkably more frequent in the mouth breathers' group than nose breathers. Irregular lip to tongue anterior oral seal was notably more frequent in the mouth breathers' group (56%) than the nose breathers' group (30%) (48).

Correction and effectiveness

The management towards a paediatric patient with the habit of MB must take under consideration several aspects and treatments depending on the root cause.

1. Age of the child: MB in most cases is self-corrected after puberty. Children's craniofacial bones, dental occlusions and facial soft tissues are changing dynamically thus, there is a development of nasal passages as a child grows resulting in the reduction of the obstruction caused by adenoid enlargement.
2. Ear, nose and throat examination: An examination conducted by an otorhinolaryngologist might be suggested in order to specify if the condition that requires treatment is in the tonsils, adenoids or nasal septum. In case that the habit persists, upon removal of the cause this condition is habitual.
3. Prevention and interception: The usage of an oral screen can prevent MB (64).

The application of oral screens has been noticed as the typical administration protocol for MB. Comprehension of adjunct therapy results must be observed for better understanding of the pathogenesis, as well as confine the progression of the condition. According to Das et al., oral screens have become appropriate tools for lip training. The screen act to stretch the lip muscles, providing a force which push out the proclined incisors and lips are strengthened at the same

time. After surgical management did not become nasal breathers without any other intercession (65).

Rogers AP, was one of the first that suggest the utilization of muscles for correcting malocclusion. The aspect of myofunctional therapy in addition to most functional appliances, was to utilize muscle activity as the initial source of power for the analysis of malocclusion (66).

Ultrasound diagnostic assessments were made prior to and after the peristomal muscle exercises and were compared among the experimental and control groups; the results suggested a notable increase in the thickening of muscle and altogether improvement in managing good oral seal only in the experimental group (66). A similar study conducted by Kumar and Kuriakose showed a strong correlation with the above results (67).

In an experimental-randomized study by Campanha SM et al. in 2010, the combination of speech therapy and beclomethasonediproprionate inhalation has resulted in earlier and more effective clinical and functional control for asthma, allergic rhinitis and MB (68).

In a study conducted by Huang TW and Young, examined the mechanism of oral porous oral patches which showed positive results in obstructive sleep apnoea and obstructive MB (69). The porous oral patches are composed of 3 layers: silicone sheet, polyurethane foam, and polyurethane film. The properties of the silicone sheet, which is positioned over the mouth during sleep, include non-toxic and wound healing activity, resistance to water and allows easy removal and reposition of the patches. The polyurethane film, which is the outermost layer, provides protection, whereas the thicker polyurethane foam consists of the lotus root-like porous structures that provides complete stability. The polyurethane foam is a water absorbing layer and can help to decrease snoring noise. Consequently, the use of the patches during sleep decreases the snoring intensity while avoiding dry mouth and drooling (69).

Regarding the surgical approach, studies have demonstrated variation of results concerning the effectiveness of adenotonsillectomy and adenoidectomy. In a study conducted by Pereira, Bacor and Weckx, 38 patients were examined from which 18 of them had adenotonsillar hypertrophy leading to MB, underwent adenotonsillectomy. The evaluation after 14 months showed that the patients return to nasal breathing, improve dental measurements, prevent further malocclusions from becoming difficult to treat and provide support for sufficient facial morphofunctional development (70). Another study by Mattar et al. in 2012, compare 2 groups

of children; mouth breathers and nasal breathers. The results conclude that before the surgery both groups had similar occlusal morphologies, whereas 28 months after the surgery most of them remained the same except a larger overjet and higher tendency towards mesial step in MB children (71).

The scientific literature also reports the effect of rapid maxillary expansion (RME) technique concerning the correction of MB. Langer et al. observed differences in nasopharyngeal space only after 30 months of RME, which can be explained by facial growth and not due to orthodontic treatment (72). On the contrary, five other studies reported immediate improvement in nasopharyngeal space and respiratory function after RME (73-77). In a study performed by Monini et al. (74), 65 children submitted to RME. The results were compared to the control group of 50 children and revealed differences in nasal flow and resistance in the supine and orthostatic positions, directly and 12 months after RME respectively. Similarly, Compadretti et al. (78), noticed a correlated result in nasal resistance after the same follow-up period.

In the study by Itikawa et al. (76), inspiratory nasal resistances returned to baseline values 3 months after RME. Same data was observed by Matsumoto et al., in the follow-up period of 30 months after RME, when nasal resistance values returned to baseline values (79).

Moreover, physiotherapy has many therapeutic techniques to restore MB. In a study of Ferreira et al. (80), 10 MB children underwent 20 sessions programme of respiratory muscle re-education through diaphragmatic stimulation and manual stretching of the accessory muscles of inspiration. After the programme was completed an increase in maximal inspiratory pressure was noticed.

In regard to the area of speech therapy, one study with 24 children and adolescents with asthma and allergic rhinitis, isometric exercises were performed for strengthening the lips, tongue and cheeks, resulting in a better sealing of lips and togue position (81). In combination with breathing exercises nasal breathing was promoted. In another study with 40 children the same results were observed (82).

Furthermore, dentists can provide treatment for MB children with facial and dental abnormalities with functional appliance. In 3 studies various functional appliances including Frankel II and Herbst appliances have been used to open retrognathic mandibles which tend to

obstruct the pharyngeal airways. The study's patients after palatal expansion, had better nasal respiration (83-85).

Timing

The analogy of mouth breathing and malocclusion is a principal subject in view of prevention and early treatment of disorders of the craniofacial growth. Since oral breathing can cause an amplitude of systemic and development or worsening of malocclusion and if previously developed to treat it by early orthodontic therapy in order to help eugnathic skeletal growth (86).

Page D.C. Mahony D. pointed out that dentists are in a distinctive situation to monitor children for noticeable indication and symptoms of MB, malocclusion, craniofacial anomalies and related conditions such as obstructive sleep apnoea syndrome (87).

Primary diagnosis of respiratory obstruction, compel MB and malocclusion with recognition of the fundamental causes, is crucial to prevent worse orofacial growth abnormalities. It is now comprehended that early diagnosis can lead to earlier innervations and orthodontic treatments which can improve the occlusal relationship (87).

Early orthodontic treatments can be more effectual, simpler and less restrictive than later age and are necessary to modify skeletal malocclusions achieving more stable results and less extraction of permanent teeth and reducing the length of orthodontic treatment in permanent dentition with lower danger of enamel decalcifications and gum diseases following treatment (87).

Concerning the diagnosis of dental malocclusions and skeletal deformities related to MB, periodic, repeated and comprehensive orthodontic examination and diagnosis could be initiated at birth or immediately after. All infants should be tested for craniofacial deformities that can influence airway structure and function. Distinctive dental signs of nasal obstruction and MB can be noticed at the age of 2 and 3. Several distinguishable signs include open bite, posterior crossbite and excessive overjet. From ages 3 to 12, early respiratory obstruction and craniofacial deformities often increase themselves in such a degree providing easiness and options for correction (87). According to Linda D'Onofrio standard orthodontic treatment consultations are suggested commence by the age of seven. Nevertheless, the dysmorphic alterations leading to malocclusion are often apparent years earlier (86).

It is of significant importance for prognosis to early obliterate the associated problems to malocclusion in order to guarantee a functional and adequate surrounding (86).

Additionally, the success of an orthodontic treatment relies not only on the understanding of when the craniofacial growth starts, but also when this growth ends. The vertical element of growth is considered to be the last to end, so failure to control it may endanger the results and cause relapse after the treatment (87).

Thumb Sucking

Description

Thumb sucking (TS) is an action that can be categorized under a catalogue of habits known as non-nutritive sucking habits (88). Thumb sucking is an aspect of non-nutritive sucking that takes place as early as the 29th week of gestation, it is being noticed regularly in infants and reaches its peak at 18 to 21 months of age (89).

Non-nutritive sucking is regarded a common mark of the development of a foetus and neonate. Finger- sucking is normal in the first 2 years of life. It offers the child a sense of calmness and this is the reason that usually happens before sleeping time (90). Sucking habit, is a bad oral habit causing a dentofacial alteration that influences the process of swallowing, breathing, mastication, phonetic, densupportic structure and aesthetic, as well as the occlusion of teeth (91).

Kumar V. et al., reported that thumb-sucking has been identified as an adaptive function activity that offers stimulation or self-soothing (92).

Prevalence

Non-nutritive sucking habits such as TS and finger sucking are common among children all over the world in all social and economic classes. The frequency of TS can be changeable based on the geographic region. TS habit is considered to be one of the most prevalent oral habits (93)

Kanika Dull in a crossectional study among preschool children found that prevalence rate of TS was 12,8% (94). Similar prevalence of TS was stated by Santos et al., and Omer and Abuaffan among Brazilian and Sudanese preschool children respectively (95). In a study conducted in Mewar city in India, TS was observed as 12,4% in the total sample with the percentage in males as 13% and 11,12% in females. In the age of 15 years the prevalence had

reached 15,6% and at the age of 9 years is 3,9% (96). In a study in Karad district in India among 832 school children aged 6-12 years old the ratio of TS habit was 8,7% (97).

Shetty et al., on a study among 1891 school children aged 6-11 years old reported that the prevalence was 1,7% (98). Another study included 2707 children aged 7-15 years old from Tirana, Albania has shown that the prevalence of thumb sucking was 11,4% (99). In relation of harmful oral habits among 1385 Brazilian school children aged 5-6 years old finger sucking was reported by 17,2% (100). Another study by Johanbin et al., on 77 years old girls in Mashhad Islamic republic of Iran, reported the prevalence of finger sucking to be 10,6% (101).

Older literature has reported higher prevalence of TS such as 82% for the period of first 5 months of birth (102) and in a group of Saudi schoolchildren aged 3-5 years old in Riyadh, Saudi Arabia, the prevalence of sucking habits has been noticed to be 48,38% (103). Another study conducted in the US showed a 73% incidence of non-nutritive sucking habits in children between 2 and 5 years. The sucking habit persists in 1,9% of 12-year-old children (88).

Etiopathogenesis

The process of sucking by itself is a primitive reflex appearing early in infants with no obvious contributing factors (104). Sucking is a natural instinct and constitutes a baby's untimely coordinated muscular activity and helps oral motor development (105,106). Muscle tone is increased by the repetition of the action and correct development is promoted; as a result, correct oral function is ensured (107). Sucking behavioural patterns in children are related with self-comforting and security feeling (104). Caretakers usually give pacifiers to assist the infants and relax when they are nervous or restless (104,108). Ferrante et al., conducted a study in Italy and they reported that thumb sucking was the cause to stimulate the nasopalatal receptors and receive muscular balance to free psychological and physical tension. Consequently, it appears, that finger sucking is nearly connected to the psycho-emotional maturity of a child (105).

Kumar et al. reported that incidents of TS which take place in early childhood usually become less distinct gradually at the age of 4 following the process of other procedures that manage any phyco-emotional distress the child may confront (92). When breastfeeding is insufficiently, infants may evolve TS habits. Non-nutritive sucking habits are adopted by some infants in order to manage frustration, reduced sense of security or need for contact (109). Certain studies have examined the relationship between breastfeeding and non-nutritive sucking habits like TS and pacifier use (110-113).

Clinical manifestations and occlusion

Non-nutritive sucking habits namely TS can be a risk element for the development of malocclusion, AOB, Class II incisor and Class II canine relationship, an increase overjet and posterior crossbite (114,115). TS replaces the tongue to a low position. The alteration in the balance among the outward thrust of the tongue on the palate and the inward activity of the cheek's muscles can influence the upper arch, which often induce in protrusion of the upper incisors and the premaxilla, unusual swallowing, AOB and posterior crossbite. The posterior teeth might push out given that placement of the thumb between upper and lower arch decreases occlusal proximity. Downward and backward rotation of the mandible might happen. The associations between TS and their relationship with occlusion are similar when researching the literature (116). Finger sucking has been determined to cause an asymmetrical AOB, the side where digit sucking occurs is worse (114). The aetiology of malocclusion as a result of TS is caused by the insertion of the thumb in the mouth and the pressure induced by it, especially against the teeth causing interference with the eruption path (114). Additionally, all the complications of the finger sucking are dependent on the duration and frequency of the habit (114). Zoo in his article stated that thumb and finger sucking may change dento-skeletal development leading to malocclusion if it is constant and repeated for a long period of time. People with this oral habit frequently display bite marks and malformation of the fingers or thumb (116).

In a study conducted by Freire et al., children with a history of TS had malocclusion 4,25 times higher than children without a history of the habit (115). In Hong Kong 114 children ages 2 to 5 years old were recruited in a cross-sectional done by Bonnie Ling et al. . The results indicated that children who exposed daily in TS for more than a year had higher possibilities for developing Class II incisor and Class II canine relationship, an increase overjet and AOB (117). In another study conducted to explore the association between finger sucking habit and malocclusion in deciduous dentition 80 preschool children same age and gender were examined. 40 children with chronic TS had higher occurrence for anterior bite, increased overjet and posterior crossbite compared to 40 children from control group (118).

Luzzi et al., in a study examined 81 children with TS habit 40,4% of the children with TS behaviour were affected by an AOB, 29,2% by posterior crossbite and 42,4% by an increased overjet (119). In a study done by Hasan in 42 preschool children the results showed that sucking habit affects the deciduous teeth by increasing overjet, overbite and prevalence of open bite (120).

A cross-sectional study conducted by Bahammam pointed out the prevalence of open bite on children ages 2 to 10 years old with TS (121). Additionally, to other studies data, Rudy Joelijanto identified that TS can cause not only crowded, crooked teeth or problems concerning bite, but also can affect the speech (122). Contrary, Baker et al., conducted a cross-sectional study of 199 Australian pre-schoolers from whom 15% sucked their thumb or fingers and found no association between a history of TS and the presence or severity of phonological impairment (123). Another study completed by Barbosa et al, stated that of 128 participants with speech disorders, 18,3% had involved in finger sucking (124).

People with this oral habit frequently display bite marks and malformation of the fingers and thumb. In addition, the thumb can be damaged and show complications such as deformities that demand surgical approach on some occasions (88).

Treatment and effectiveness

An oral habit when is associated with negative dentofacial development or adverse effects on the well-being should be managed. If there is also an indication that the habit will cause complications in the developing permanent dentition should be regulated too. Any treatment must be relevant to child's development, understanding and ability to cooperate (9, 125, 126). Trident of factors such as duration, frequency and intensity of habit should be also assessed and the evaluation of potential harmful consequences should be made as early as possible, so that the habit does not produce detrimental and long-lasting effects (9,125).

Habit treatment methods involve several approaches such as counselling of patient and parent, behavioural changing techniques, appliance therapy, myofunctional therapy; additionally, referral to other specialists should include orthodontists, psychologists, myofunctional therapists or otoryngologists. Patients and their parents/caregivers should be informed about the consequences of an oral habit. Parents behaviour may have a negative role in the correction of an oral habit because nagging or punishment might result in an opposite way increasing the habit; changes in the home environment might be essential before a habit can be overcome (9). Unprofessional methods to break NNS habits such as punishment, use of restraints or topical application of disagreeable lotion can cause psychological distress to children (126). Afifi et al., were able to demonstrate the association between severe physical punishment and mental illness. Although this study was not able to mark the types of punishment used to children, who engaged in NNS habits, the chance that a number of children may have to face harsh punishment cannot be excluded. This is an additional reason to advise parents for active

professional education about NNS and how to reach professional support for breaking the habit (127). Criticism, nagging or threats towards the child might intensify the habits. For that reason, parents should handle the problem with patience and understanding. Both clinicians and parents must use discretion as the time and manner in which the treatment should be sought (128).

A cochrane review conducted in 2015 to evaluate the effects of different interventions for cessation of NNS in children showed that phycological interventions and orthodontic appliances or the combination of both, was more likely to lead to stopping of the habit than no treatment (88).

In cases of an AOB coming from TS, non-surgical and non-orthodontic interventions which have been studied for treatment, include stomahesive wafers and myofunctional therapy. This particular therapy requires a set of exercises that educate again the muscles involved in speech, swallowing and resting posture (114,129). Degan and Ruppin Rontani deduced that myofunctional therapy related to the discouragement of sucking habits displayed a better and faster improvement of the tongue rest position. Physical forces are eliminated by myofunctional therapy; additionally, the therapy contributes for the oral cavity forces to be re-arranged (130). Conversely, other researchers believed that myofunctional therapy can work well with voluntary activities such as swallowing whereas involuntary activities such as tongue posture habits are difficult to re-educate. More clinical studies are needed to be done in order to achieve a clear picture for the role of myofunctional therapy and tongue posture in correcting the AOB and in maintaining the results of the treatment. In the literature most studies available are based on a case report or a small sample with the absence of control group (131,132). In Australia, another study was to evaluate behavioural and occlusal results of non-orthodontic intervention in 91 children age 4-12 years with TS habit. Each patient had 2 examinations, separated by a period of 4 months, applying standard clinical procedures. Out of 77 children who had a 4-month non-orthodontic intervention (NOI), 69 had stopped their TS habit by the end of the NOI period. In 72 individuals who had front teeth, the number with an AOB decreased from 37 to 12 after NOI completion. Among the 32 children with a measurable overjet the mean overjet decreased measurements upon completion of NOI. Children who took NOI were more probable to stop the habit in the 4-month period and were more probable to come into view without AOB in a 4-month recall (133). The American Dental Association and the Canadian Dental Association (CDA) have contiguous guidelines on the proper use of pacifiers (134,135). More extensive use causes a stronger relationship. The CDA suggests to the parents and caregivers, the use of pacifiers since it is easier for them to control the sucking habit. The

associations recommend not to use sweetening such as honey, sugar or syrup on a soother by reason of the risk of caries induction and advice for caution that a sucking habit should ceased before the eruption of permanent teeth. Furthermore, the Associations state that even though chronic and continuous use of pacifiers can harm the teeth, it is easier to break of a child's sucking habit from a pacifier than from a thumb (134,136). Early dental appointments allow intentional to assist children quitting sucking habits by age of 36 months or younger (136).

There are several choices available with orthodontic appliances, including palatal cribs, palatal bars, spurs, hay rakes and cage-type appliances (137). Orthodontic surgery can be an option or need in severe cases. When treatment is completed the possibility of relapse and reappearance of malocclusion is always a contingency (138). A study was conducted by Madiraju GS, and Harika in order to compare the effectiveness of appliance therapy and reward therapy in decreasing overjet and open bite related with TS habit. 39 children with chronic TS habit were divided into 3 groups. Pre-treatment and post-treatment study subjects were evaluated for changes in overjet and open bite. The group which treated with appliance therapy showed statistically noteworthy reductions in mean overjet and open bite compared to other 2 groups (139). Another study aimed to evaluate the long-term stability of quad-helix/crib treatment in patients with dentoskeletal open bite. 28 children were treated continuously with quad-helix/crib appliances. At the end of the active treatment with the appliances the subjects were re-evaluated and no less than 5 years after the treatment completion. Results indicated that in the long term the quad-helix/crib group displayed an important reduction in the ANB angle, a downward rotation of the palatal plane, a substantial increase in overbite and a decrease in overjet compared to control group. Over a long time, the use of the quard-helix/crib appliance brought successful results in almost 93% of the patients. Dentoskeletal open bite correction was related with a clinically significant downward rotation of the palatal plane (140). Nogueira et al., declared that a palatal crib and spurs are effective techniques for AOB treatment in patients with AS as a result of lingual resting. However, consultation is needed for shaping and installing the device along with calculation of laboratory expenses. The spur, in contrast, is inexpensive and gives greater freedom to the tongue because its small (141).

No studies were found comparing the use of spurs to a control group or the use of spurs and palatal crib to corroborate the effectiveness of the 2 treatments.

The primary goal of a study conducted by McRae et al., was to evaluate the effects of the fixed palatal crib and bonded lingual spur, for early treatment of AOB in the mixed dentition phase.

This study also addressed the cephalometric effects of these appliances as a secondary outcome (142). In a systematic review Borrie et al., pointed out that orthodontic appliances were more helpful to stop sucking habit than no treatment and the use of palatal crib was more beneficial than no treatment (88).

When other methods of treatment have been unsuccessful, appliance therapy, such as palatal cribs or Bluegrass appliances might be essential to prevent the positioning of the thumb in its sucking place. These tools are very effective and are connected with few unfavourable effects, nevertheless the cooperation of the child is required and these tools cannot be used as punishment (143).

Managing the factors that causes AOB, stability of the AOB correction is achieved (144). Smithpeter and Covell asserted that patient's AOB accompanied by oral habits, tongue thrust, speech errors and low forward tongue rest posture have a major possibility for relapse after orthodontic treatment if these features are not being changed before removal of the orthodontic appliance. Moreover, Smithpeter and Covel examined the efficacy of myofunctional therapy for maintaining closing of open bites in combination with orthodontic treatment. They noted that myofunctional therapy increase the stability of AOB correction in patients who had forward tongue posture and tongue thrust. Palatal cribs discourage TS habit and prevent the tongue from resting on the maxillary incisors; through the stated method, they correct AOB. In some cases, palatal cribs might not be adequate to control and adapt tongue position. Consequently, they should be combined with myofunctional therapy aimed to assist the tongue to adapt its normal position (145). A retrospective study on 30 subjects for the use of the Bluegrass appliance in the elimination of TS habit stopped in 28 of them after treatment with this appliance (146). Furthermore, Mink and Haskel in their study with bluegrass appliance stated that all 24 patients (100%) had successful results after this treatment and there was not any reinsertion in any of the cases (147). Another study utilized the modified bluegrass appliance fabricated with an inexpensive acrylic roller in order to decrease the cost of treatment and make it more affordable for the patients in developing countries. 40 children ages 4-14 with TS habit were chosen. The modified bluegrass appliance was used accompanied by the positive reinforcement. Following the appliance, the patients were checked out after 2 weeks and then monthly for a period of 12 months. 33 patients were included in the final analysis and the treatment was successful in 32 of them. The treatment period for stopping the habit was less than 4 weeks in 13 patients and 5-20 weeks in 50% of the patients. In 2 of the subjects the habit ceased after 21-24 weeks and 1 of the subject after 25-28 weeks. Of the total 32 patients,

5 patients had to reinserted the appliance. The complete treatment time for the cessation of the TS habit was less than 24 weeks in 53,1% of the patients, 25-36 weeks in 34,4% and 37-48 weeks in 12,5%. The study concluded that the modified bluegrass appliance assessed to be very successful in eliminating the habit during a short period of time without any complications (148).

The management approach taken should depend on the personal and individual circumstances surrounding the habit, as well as consideration of any previous treatment approaches.

Timing

An oral examination is extremely important to assess for potential complications of TS. The initial oral evaluation for all children is recommended by the time the first tooth erupts, no later than 12 months. The examination of the oral soft tissues, alveolar ridges, palate and any erupted or erupting tooth is crucial. After dental care is set up, regular clinic visits are necessary in order to monitor the developing primary dentition (2,9,92). Health care professionals must be aware of the non-nutritive sucking habits and their negative effect on oral health, along with the complications that can occur. When the non-nutritive sucking habit continues, referral to an orthodontist to assess dental complications should be considered (92,93).

According to Tanaka et al., TS comes to an end without an apparent external cause or stimulus between 2 and 4 years of age in most cases. Generally, the prognosis is good if dental malocclusion occurs as a result of TS, it is self-corrected if the habit ends and the skeletal deformation is mild (149). If the habit continues after 4 years of age management can be taken under consideration. After sufficient treatment, there is always a possibility for the habit to relapse, as Tanaka et al. mentioned (149). Nasir also stated that non-nutritive sucking habit are usual for young children and as they grow older there is a tendency to stop them. At the ages between 2 and 4 years old the habit ceases spontaneously in the majority of the cases. When additional developed self-management skills emerge, most children break off the habit by the age of 4 (93).

Hatala indicated that TS constitutes a problem when a child continues the habit after the age of 4 years, while their secondary dentition is developing and getting ready to erupt (150). Warren and Bishara stated that dental changes caused by finger sucking do not require any treatment if the habit stops before the age of 5 years; dental changes will be corrected spontaneously once you giving up the habit. Proffit and Fields were also in accordance with Warren and Bishara (151,152)

Atypical Swallowing and Anterior Resting Tongue Posture

Description

The swallowing process model in childhood physiologically suggests the intervention of the tongue between the osseous bases (153). The physiological swallowing of the adult is made of positioning the tip of the tongue at the level of the incisive papilla with the dental arches in contact. A deviation from this swallowing pattern is called atypical swallowing (AS) (153-155).

AS is a myofunctional problem defined by altered tongue posture in the cause of swallowing (155). The first basic swallowing function starts from the 11^{th} week of gestational age and initial infantile deglutition develops about the 12^{th} week of intrauterine life and it's characterized by an onwards tongue posture (156) and systole of perioral muscles such as buccinator and orbicular causing a higher negative force in oral cavity (157). In normal situations around the age of 3 and the growth of alternate unilateral mastication the infantile swallowing model changes into a supposedly mature deglutition motif (158,159). The period at which infantile swallowing progresses to adult swallowing ranges between 6 and 7 years of age (154,155). During adult or mature swallowing dental arches are in contact and tongue is raised, resting in the posterior-superior palatine vault (160). Throughout this period the tongue applies forces and stimulate the anteroposterior part and transversal growth of the maxilla (161, 162). If transition from infantile swallowing to adult swallowing does not occur, the previous activated a pathological mechanism describes as AS (163).

Moreover, it is often mentioned the significant alteration of the resting tongue posture for people with AS. Tongue is resting in a more forward position than normal and that can cause many oral problems and malocclusions (155).

Prevalence

AS is a common oral habit in paediatrics, although only on rare occasions shown alone; there is a strong relationship with extended thumb sucking and oral breathing (16,99).

Kristina Kasparaviciene et al., examined 503 preschool children participated in a study. Finding showed that 27 of them had AS, 5,4% were boys and 2,7% girls (16). In an epidemiological study conducted by Lagana et al., in a population of 2617 Albanese schoolchildren ages 7-15 years old showed that 424 children had AS pattern (99). Omaya Amr-Rey examined 290 schoolchildren between the ages of 4 and 7 years, and found that 29,7% of them had AS (164). A cross-sectional study conducted by Olivos et al., among 155 children aged 6-12 years old.

51 children had AS with higher prevalence to the girls versus the boys (165). Rozela Xhemnica and Milton Rroco in a study, which aimed to analyse the demographic profiles of the children with AS, examined 194 children ages 6-15. They found that 15 subjects had AS (7,6% of total sample), 6 male (7,0%) and 9 females (8,1%) (166). A study conducted by Barata et al., examined 86 patients and showed that AS was more prevalent in women (56,1%) than in men (43,9%) (167). Furthermore, there was one study with lower prevalence of AS in patients such as 5% (159).

Etiopathogenesis

Hazaat et al., and Maspero et al., stated that there are 2 types of AS from an aetiological point of view. The primary AS has a psychological origination parental over nursing and in general is often related with a childish behaviour, sleep, digestion and mood disorders (153,155). The secondary AS is caused by physical factors, oral habits such as TS, nail biting, bruxism and prolonged artificial breastfeeding (153,155).

The aetiology of AS defined by Begnoni et al., is multifactorial. Actually, environmental and hereditary elements, bad habits, and allergic and oral diseases can be associated with its beginning (168). Main causes of AS defined by Schmid et al., and Caruso et al., are associated with improper eating habits, such as breastfeeding, delayed weaning and liquid diet, poor oral habits such as TS, MB, prolonged use of pacifiers, or pathological factors such as hypertrophy of the pharyngeal and palatine tonsils, hypertrophy of the turbinate and hereditary dysmorphia such as macroglossia (169,170). Furthermore, 2 more studies are also in accordance with the previous states regarding the hereditary factors (153,155). Anichini et al., also stated that macroglossia is one of the factors that causes AS (171). Di Vecchio et al., also stated that the same factors cause AS is involving such as bottle feeding, late weaning, food consistency and bad habits such as finger sucking, onychophagy and labial interposition could cause AS (172). Furthermore, respiratory problems, adenoid and tonsillar hypertrophy, rhinitis, bronchial asthma as well as congenital oral anomalies or dysmorphias (lingual frenulum or ankyloglossia) are factors related to AS (172). Meenakshi et al., and Saccomanno et al., stated that ankyloglossia causes AS because of the insufficient palatal support to create a mature adult swallow. The physiological procedure of transition from childhood swallowing to adult swallowing in the early years of life is interrupted due to the restricted driving force in the child with hypertrophic lingual frenulum (173,174). Marchesi and his colleagues conducted a study showing that the prevalence of AS in the group with TMD is higher than in the group without TMD (175).

Furthermore, several authors are in accordance with previous referring studies concerning the aetiology of AS. (176-178).

Clinical manifestations and occlusion

Many medical specialities such as dentists, orthodontists, radiologists, neurophysiologists, otorhinolaryngologists, oral surgeons and speech pathologists are interested and engaged in case of AS and tongue functions throughout it (179).

Tongue thrust is a condition during AS, where the tongue is placed between the front anterior teeth and against the upper lip (180). Tongue thrust was defined by Begnoni et al. as the forward position of the tongue between upper and lower incisors or cuspids during swallowing (168). Maspero et al., also mentioned the anterior resting posture of the tongue during AS (155). Generally during the act of swallowing not only the tongue movement would be considered oral habit but also a change of the resting position of the tongue itself (155). Accordingly, it would be more suitable to refer as "tongue thrust' rather than "swallowing disorders in the exact sense (155). Forward resting tongue posture and forward position of the tongue during swallowing are thought to be the most frequent signs of tongue thrusting, as well as contraction of the perioral muscles, excessive buccinator hyperactivity and swallowing without the brief tooth contact usually required (180). During swallowing the pressure of the tongue occurs lesser than a second and would not be considerable to elucidate the correlation which has with tissues of the development of the dental and skeletal problems (155) The association connecting this habit and malocclusion is apparently reciprocal signifying that the specific habit might cause malocclusion and malocclusion may contribute to creation or production of the habit (180).

At the present time one of the most controversial subjects is the existing relationship between atypical deglutition and open bite. The prevailing belief is that duration of the tongue pressure on the anterior teeth during swallowing is too short to have an impact on the eruption of the anterior teeth and consequently the formation of AOB (152). Maspero also in his review stated that the first cause of AOB would be the tongue thrust during resting posture of the tongue and not the act of atypical swallowing itself (155). Another mentioned recent opinion by Dixit et al. is that tongue thrust is related with AOB formation because the altered forward position of the tongue and the pressure that it creates, leads to skeletal and dental alterations (180). According to Proffit the infantile swallowing pattern is more likely to be caused by AOB rather that the other way around. On the other hand, the ultrasonography assessment of swallowing

provided information which is indicating that infantile swallowing is an important element for AOB formation (152). It has been indicated that protrusive tongue posture may result in labial inclination of incisors, AOB, and spacing problems in several instances. It is believed that there is a functional relationship between deviated swallowing and AOB, as well as overjet (152, 180, 181)

Dixit U., said that children with tongue thrust tend to have lip incompetency, parafunctional maxillary incisors, open bite and lisping, MB, hyperache mentalis muscle activity compared to children without tongue thrust. Tongue thrust might affect oral sensory perception which can cause a change in motor activity, intensifying the degree of malocclusion (180, 181). A number of studies stated that AS entails lingual interposition, contraction of the mental muscle, interposition of the lower lip between dental arches and mutual movements of the head and neck. It can have unpleasant outcomes for breathing, speech and posture and chewing (157, 168, 182). AS was also noticed in studies for stomatognathic disorders such as TMD (183-186). Counted with these complications an apparent alteration of the facial profile and mimicry accompanied by hypertonia of the chin and hypotonia of the orbicularis oris muscle is also supported (187, 188).

Specific the lip strength is analogous to altered jaw movements for instance, during mandibular protrusion and is implicated in labial incompetence, while is as well very important in maintaining balance in anterior teeth position (188, 189). In addition, it appears that lip strength deficits may possibly lead to important damage of daily function and facial growth, since all the splanchnocranium facial muscles act synchronized and during chewing all the perioral facial muscles are activated simultaneously as the lip (190). Tecco et al., expressed that AS is often corresponded with proclined maxillary AOB, increased overjet, flaring and spaced dentition and skeletal malocclusions such as sagittal and transversal discrepancies with a narrow and protruded maxillary arch and mandibular retroposition (186, 191,192).

Treatment and effectiveness

AS requires treatment so that is possible to eliminate damaging interference of tongue which impede the stomatognathic system to develop harmoniously and the optimum therapeutic approach appears to be a multidisciplinary one. Passive treatment (orthodontic therapy) is essential to correct malocclusion and active treatment (myofunctional therapy) is important to establish a myofunctional reformation process to correct the oral habit, consequently providing long-lasting or permanent results (155, 168, 193).

Myofunctional therapy (MFT) is founded on the knowledge of all the multi-functions involved in the stomatognathic system, breathing, swallowing, speech articulation, chewing, aesthetics, and sensory activities (168, 194). All these specific functions belong to the same apparatus system called oral functions. The speech therapist should take into consideration all these functions as they are characterized by reciprocal interactions (155, 168, 194). The purpose of the MFT is the treatment of OMD that involve changes and abnormal functioning of orofacial musculature which meddle with the growth development and functions of the stomatognathic system (155, 168, 194). During the MFT the speech therapist must set the proper function by eliminating the deviated motif, creating new motor images, adopting these images and making them automatic (194). Idris et al., stated that orofacial myofunctional therapy (OMT) includes personalized therapeutic scheme of resistive and passive orofacial muscle exercises. OMT trains again the orofacial neuromuscular system to normalize the facial muscle disparities, re-educate normal tongue posture, set up balance between the tongue and the cheek muscles, and achieve again corrected chewing and swallowing standards (195). 15 children and young adolescents who had diagnosed with AS by a phoniatrician were examined by Begnoni et al. The patients underwent on myofunctional therapy performed by speech therapist. The MFT constituted of 10 weekly sessions with duration of 45 minutes each and daily exercises performed at home. The same operator conducted the therapies. Patients were re-evaluated by the phoniatrician who had diagnosed the AS. The phoniatrician observed a total recovery of AS; myofunctional therapy had 100% effectiveness (168). Guika et al., conducting a study, examined 57 children aged 5 to 13 years old who had AS pattern and underwent MFT. The therapeutic protocol consisted of eight sessions, but this number changed according to the patient's condition. The exercises were repeated at least four or five times daily. The patients had monthly check-ups. Following every session, the patients received written instructions with fully detailed explanation of the exercises. The purpose of the exercises was to retrain lingual posture and functionality, increase sensibility and acquire a physiological swallowing. Patients with a severe Class II were treated with a functional device, using a bionator. The results display the benefits of myofunctional therapy in the therapy of children with abnormal swallowing. By the 5^{th} session the correct swallowing mechanism was understood by 32% of the children. Subsequently the treatment, 47% of the children got a physiological swallowing, the majority in the 7^{th} session. 62% of the patient who were treated with bionator and myofunctional therapy also gained correct swallowing pattern (196).

For the treatment of AS several orthodontic therapies have been proposed using functional devices such as Bionator, Frankel, lingual spurs, fixed guards and eruption guidance appliances (197).

Rebecca Jungbauer et al., evaluated long term changes of dental parameters after using Bionator. This device is special applicable in patients with orofacial dysfunctions and parafunctional habits that cause malocclusion. Orthodontic dental cast analysis of 18 patients with skeletal Class II treated with Bionator without any other fixed therapy was carried out with a digital calliper of 3 stages; before (T0) after (T1) and 20 years after (T2) treatment. 20 years after the treatment with Bionator without extra fixed devices, the improved sagittal relationship and the reduced overjet remained reasonable stable (197).

Nogueira et al., declared that palatal crib and spurs are both efficient techniques for treating AOB in patients with AS due to lingual pressing. Nevertheless, the crib demands consultations to shape and install the appliance incurring the laboratory expenses additionally, in contrast, the spur is inexpensive and gives substantial freedom to the tongue due to its small size. Leite et al., conducted a study to evaluate the effectiveness of fixed palatal crib and bonded lingual spur in the early treatment of AOB in mixed dentition as well as the influence on dental and skeletal cephalometric measurements. For the treatment of AOB, they resulted that both methods are simple and effective with the advantage given to fixed palatal crib (141).

Dr Patrick Fellus was the first to propose a new appliance, the Froggy Mouth (FM). It is a small removable orthodontic appliance made from flexible material, thermoplastic elastomer. The device is not placed inside the mouth as other devices do, but is placed between the lips preventing any form of sucking swallowing. It also stimulates the contraction of the lips to keep the device stable. Therefore, it is considered a myofunctional re-education device that when it is placed between the lips prevents bilabial contact, stimulates optimum development of buccolingual functions forcing the tongue in a correct position, aiming to re-establish a new swallowing pattern and functional balance. FM can be prescribed to very young children since impressions are not needed to be taken (198). Quinzi et al., conducted an observational study whose aim was to detect the effects of FM therapy on 40 children with AS and lip strength. The FM device was prescribed in the appropriate size-small, medium, large according to children's age. The patients were asked to wear the appliance daily for 15 minutes for a period of 6 moths, while watching television in an upright position and at a minimum distance of 2 metres, or during a recreational activity. Monthly, each patient had a clinical evaluation as well

as a recording of a video clip while was seated in an upright position. This study demonstrated that after 6 months, 82,5% of the subjects (33 out of 40) showed good ability to adjust and all of the patients succeed in the clinical result. Among the subjects, 2 children had an early correction after only 3 months, 5 children achieved correction after 4 months, 11 children after 5 months and 15 children after 6 months (154). The effectiveness of the FM device for correcting AS pattern also mentioned by Di Vecchio et al.. They stated that the device provides the medical practitioner a new therapeutic perspective for neuromuscular retraining of AS and dysfunctional deglutition in patients during their growth stage (172). Nevertheless, additional scientific observations are required to support the results of this study.

Essential elements for a successful outcome of the treatments of AS are a good cooperation between patients and doctor, correct process of treatment, eliminating all bad habits, motivation for the treatment and collaboration with other physicians such as surgeons, otolaryngologists and speech specialists when is necessary.

Timing

The optimal age to begin the MFT for AS is still debated. Several authors suggest MFT to start before the age of 10 years, while others recommend that the treatment begins when patients are at least 10 years of age (145, 199).

Literature mentions that the most used speech therapy methods got to 47% of corrected cases in a group of 57 children ages 5 to 13 (mean age 8,2) with AS diagnosis, after nearly 6 months of treatment (200). Moreover, in children who are too young, about 3-4 years of age, speech therapy treatment is not effectual (196).

Another opinion mentions that early intervention is necessary in order to eliminate the oral habit. Specific, according to Condo et al., a therapy conducted during the deciduous dentition or the early mixed dentition would have remarkably better results compared to therapies that begin later (201).

Lip Incompetence

Description

The lips are an important aesthetic characteristic of the face, which play main functional roles in phonation and in the process of forming an anterior oral seal in swallowing. Lip posture can be described as a typical way in which a person continues the normal lip position in repose, for

example, with normal muscular tone and without too much muscular contraction. The orolabial soft tissue posture is a trait of each individual and under normal conditions, he or she will attain a lip seal in the rest position. In case that postures are used with nearly continual contraction of the circumoral musculature in order to maintain a sufficient lip seal (202). Naini F., stated that the term "competent lips" signifies that the lips are capable to contact one another without tension when the mandible is in rest position (202). The term "incompetent lips" indicates that the lips cannot form an adequate seal under similar impetuous conditions, such as excessive separation of the lips at rest lip separation should not be more than 3-4mm as a common guideline; above this number the lips are characterized incompetent, as Niani F. mentioned (202). The terms "pseudo-incompetent" or potentially competent are used to characterized lip posture when the maxillary incisors are put in between the upper and lower lips and correcting the incisor relationship will allow normal lip posture (202). Lip incompetence (LI) is a usual complaint between patients and is often attributed to excessive protrusion of incisors as Proffit et al. also stated (203). Lips that are separated more than 3-4 mm and are considered a pathological problem, which can lead to serious oral complications because which can indirectly cause aesthetic, periodontal and orthodontic problems (203). Hockenbury stated that when lips are parted at rest, lip incompetency is observable. The "inability to close the lips without strains defined as lip incompetency". An interlabial gap is usually observed with incompetent lips (204). Saccomanno et al., and Robert M. Mason are also in agreement with the above statement (205, 206). Saitoh et al., defined incompetent lip seal as insufficiency in keeping the lips together which derives from a dysfunction in the orofacial area. They reported that retaining the mouth dosed at rest is difficult and the hypertonic muscular contraction related with forceful closing is visible (207).

Prevalence

A national large scale epidemiological study to reveal prevalence of incompetent lip seal in children was conducted by Nogami et al. in Japan. 3399 children ages 3-12 years old were surveyed by using a questionnaire concerning daily health routines, conditions and lifestyle habits. The study concluded that 7% of the participants showed an incompetent lip seal and its prevalence increased with age (208). Gross et al., assessed 133 children age 8,4 years old and a prevalence of a resting open mouth posture was at 34,3% with statistically significant racial differences (209). In a study conducted by Yata et al., among Japanese children ages 7 to 14 years old the incompetent lip seal rate was 45% for those with normal occlusion and 43% for those with malocclusion (210). De Menezes et al., stated an incompetent lip seal rate of 34%

in children form Brazil ages 8 to 10 years old, with a statistically significant higher prevalence between mouth breathers than nasal breathers (211). In another study of 348 first-grade children, 48% had open mouth posture (212).

Etiopathogenesis

Systemic and localized elements might lead to disturbance of craniofacial growth and development causing lack of equilibrium between the orofacial skeleton-bones, muscle and soft tissue during periods of growth (207). Lip closing power is the force of the orbicularis oris muscle. The orbicularis oris muscle just like the other muscles of the buccolabial group, functions to control the shape, movements of the lips; additionally, it closes, protrudes and compresses the lips, as well as, press the lips against the anterior teeth, keeping the balance between the inner and outer forces on the teeth in the rest position (207). Several oral habits, like MB can bring about various malocclusion by disordering this balance (16, 207). Saitoh et al., conducted a survey to 380 elementary school children. They concluded that incompetent lip seal is associated to MB (207). Dale V. after completed his study, he also concluded that it is often presumed that the person displaying with the lips apart posture in the relaxed condition maintains this posture because of high nasal resistance. There is a necessity to breathe through the mouth in order to take adequate air so the lips are kept open (213). Lessa et al., have reached the same conclusion (214). Hannuksela also reported that severe nasal allergy and swollen adenoids can cause incompetent lips and affect the orofacial structure (215). Furthermore 2 more studies stated that adenoid tonsils are also associated with incompetent lip seal (216, 217).

In the orthodontic literature the view that incompetent lips are only a consequence of bimaxillary dentoalveolar protrusion is popular. Several studies evaluated the cephalometric features of patients with bimaxillary dentoalveolar protrusion and concluded that lip incompetence is a consequence of this (218-220).

Clinical manifestations and occlusion

The existence of LI is believed to be a pathological situation, that it can proceed to serious oral problems, if it is not treated (221). According to Proffit et al., poor facial aesthetics, presence of AOB and gingivitis related to incisors, could be some of the consequences of LI (203). Lione et al., also in accordance with Proffit et al. about the complications that LI can create, adding also that maxillary incisor protrusion and articulation defects can be included as well on the consequences of untreated LI (222). Wagaiyu and Ashley also mentioned that LI is often linked to higher levels of plaque, which is leading to higher chances to get gingivitis (223). Tomiyama

et al., stated that people with LI are facing masticatory dysfunction, since they cannot chew properly when their lips are relaxed (224). Endo et al., examined and studied the connection between lip seal and labial inclination of anterior teeth, in 19 subjects with normal occlusion. From 19, the 8 subjects had open lips for the whole day and night, while the other 11 subjects were having strong lip seal. After analysing the skeletal and dental morphology of each patient using lateral cephalogram, they found that incisors of both jaws of the LI group were more forward inclined that the lip competent group. They came to the conclusion that, even though none of the subjects had any malocclusions, the labial position of incisors of LI group was one of the consequences of inadequate lip seal. They also mentioned that the LI group had more skeletal class II relationship, longer lower facial height and backward position of the Pogonium (225, 226). Lambrechts et al., explained that a weakened lip seal can cause an imbalance between the pressures of lip and tongue, and this can cause the labial inclination of the incisors as well as narrowing of maxillary dental arch. Their study showed that patients with LI had lower lip pressure in comparison to the patient with normal lip seal (227). Gross et al., as supported the opinion that inadequate lip seal is associated with narrow dental arch and longer facial height (228). Langbury et al., and Chae et al. stated that LI is commonly connected with protrusion of incisors, Angle Class II and Class I malocclusion (229, 230). Another study by Lida et al., is also in accordance with this opinion (231). Drevensek et al., studied how LI can affect facial proportions. Results from their cephalometric analysis showed that children with open mouth posture have higher anterior facial height and they concluded that it can affect the growth and development of craniofacial complex (232).

Treatment and effectiveness

Efforts have been made to ameliorate LI by using MFT. “Button Pull” which is recommended by Zickefoose is one of the characteristic exercises of MFT. With this exercise the orbicularis muscle is trained by inserting a large button into the oral vestibule and pulling with a string or having a weight on the string (233). Oya tested the proper conditions of this lip training method by measuring oxygen saturation in the orbicularis oris muscle and specified effective training conditions as aerobic exercise and hypoxic exercise. The effective conditions were noticed to be loading 80% of the maximum force for 5 seconds and testing for 5 seconds with 5 repetitions as hypoxic exercise and the effective conditions for the aerobic exercise were noticed to be loading 50% of the maximum force for 5 seconds and resting for 5 seconds with 20 repetitions. It is also depicted that training under the condition of aerobic exercise for period of 4 weeks resulted in considerable increase in endurance of the orbicularis oris muscle and that training

under the situation of hypoxic exercise for 4 weeks, increased maximum muscular strength as well as muscular endurance (234, 235). Following, Ohtsuka and Yoshizawa et al., examined if LI can be improved by aerobic and hypoxic practice training of orbicularis muscle and whichever exercise is more effectual. 38 subjects were selected. 18 patients carried out training of the orbicularis oris muscle by aerobic exercise for 4 weeks and the remain patients performed training of the same muscle by hypoxic exercise for the same period of time. The status of the lip closure was monitored in 2 situations at rest and during a work demanding concentration in a conscious stage. Findings showed that patients who had LI for most of the daytime reached an approximately 90% lip competent state by using whichever training method. Ohtsuka and Yoshizawa et al., also noticed that the obtained lip competent state was kept for a period of 2 months after the training termination. Therefore, it was concluded that both aerobic and hypoxic exercise for 4 weeks can improve a lip incompetent state to a lip competent state (236, 237).

Yoshizawa next concentrated on muscle activity of the orbicularis oris muscle and tested the muscle activity during lip closure using electromyography. The electromyogram of the orbicularis oris muscle did not display much activity of the muscle during lip closure in the lip competent group, pointing out that the orbicularis oris muscle was not activated and that lip closed condition was maintained naturally. Conversely, in the lip incompetent group strong muscle activity was observed during lip closure, indicating that the orbicularis oris muscle required to be firmly activated in order to close the lips (237). Then Yoshizawa carried out training by hypoxic exercise using the Button Pull method for 4 weeks in a group of patients with LI and researched muscle activity of the orbicularis oris muscle achieved as the result of the training when lip is in closed state. It was ascertained that lip closure could be performed without big activity of the orbicularis oris muscle, as was pointed out in the lip competent group, until 8 weeks after the end of training. This outcome is surprising because it indicted that elements other than reinforced strength or reinforced endurance of the orbicularis oris muscle might have created an environment in which the lips can succeed naturally closed state with orbicularis oris muscle activity (237).

Dana K. Hockenbury conducted a study to assess the effectiveness of lip stretching and strengthening exercises in subjects with LI. In this study 56 children, teens and adults participated and data was collected. In the patients were prescribed daily exercises (3 times per day) for a 4-month period of time. A digital calliper and lip strength gauge were used to calculate the length and strength of the upper lip in the therapy sessions. Completing the 4-

month treatment period. All patients evidenced improvements in length and strengthened lip. Mean upper lip length achieved was 0,96mm, maximum upper lip length was 5,71mm. increased lip length was noticed in 92,9% of subjects. Regarding lip strength, children and adolescents (8-20 years old) demonstrated the biggest improvements. Mean improvement of lip strength among this age group was 2,96, while the maximum amount of lip strength was 6,25 lb. among adults, the mean improvement in lip strength was 1,55 lb while maximum improvement in lip strength was 4,25lb. all patients showed a considerable reduction in interlabial gap. The average decrease in interlabial gap was 3,16 mm and the maximum decrease was in 7,23 mm. Hockenbury deduced that the results demonstrated that therapy exercises to stretch lengthen and strengthen the upper lip soft tissues are effective. When the therapy programme was completed 36 of 56 subjects reported that achieved lip competence both daily and nocturnally (204).

Timing

LI has a great impact on maxillofacial anatomy, as well as on the form of the dental arch. Emi Inada et al., stated that if the balance between the lips and the tongue gets disrupted, malocclusions and oral problems can arise. They concluded that in order to prevent those problems, it is essential to check for signs of LI, during early years, and to restore the gap between the lips, preferably before the age of 3 (238). Fellus also mentioned that the correction of LI can be successful at the age of 3 years old (239). After a study Dana Hockenbury conducted, she concluded that the greatest improvements regarding lip strength gaining, had young children. She also mentioned that all age groups that participated in the study had good results, but it is more demanding to strengthen the lip muscles when the patient is older (204).

CONCLUSION

Oral adverse functions and habits such as, mouth breathing, thumb sucking, atypical swallowing pattern and lip incompetence can have a direct impact on the quality of life and can also affect the stomatognathic system. The relationship between the presence of adverse oral functions and habits and the commencement of disorders of the stomatognathic complex can be described as biunique. The persistence of adverse oral functions and habits is associated with detrimental effects causing not only aesthetic but also functional problems in the mouth. Among different studies conducted in the scientific community, association of oral habits and their role in aetiopathogenesis of malocclusions was confirmed. It was also found that this association is varying due to the fact that biological damages caused by adverse oral functions

and habits depends on many factors, like age of initiation, intensity, duration, the type of oral habit and how it changes the physiological balance of growth. For example, while mouth breathing is always notably related with occlusal problems other oral habits have a considerable role only in some, maybe because of their lower connection than other factors involved in the aetiopathogenesis of malocclusions. Thus, the association between deleterious oral habits and different types of malocclusions would be expressed in individuals more affected to genetic causes and adverse growth pattern. Since numerous studies have pointed out that adverse oral functions habits can cause functionals problems in the oral cavity, an early diagnosis and therapy additionally with immediate intervention can have a significantly positive influence on therapy results and better outcomes in terms of quality and durability. The best therapeutic approach seems to be multidisciplinary one and optimal management of oral habits relies on close collaboration and intervention of various health specialists such as paediatricians, dentists, orthodontists, ear nose and throat diseases and myofunctional specialists and speech therapists. In children's population there is an increase susceptibility to develop anomalies associated with occlusion due to adverse oral functions and habits; so preventive measures such as periodic clinical examinations, timely diagnosis and early treatment should be taken in order to prevent the progression of more severe problems. Orthodontic prevention should focus on eliminating risk factors in order to assist a correct dento-skeletal growth. In the literature there was also proof of essential difference between the results obtained from early – deciduous or primary mixed dentition- and late treatment. Dental procedures and corrective behavioural techniques can help in breaking an adverse habit; however, if these habits are not totally discontinued, treatment will only work as a temporary measure. According to literature examined the prevalence of oral habits varies among different societies depending on a broad range of variables including ethnic groups, gender, geographical areas, the actual habit involved, its duration, its intensity and genetic dental and skeletal factors. On these variables also depends on the severity of malocclusion related with adverse oral functions and habits. With the spread of health education and improvement of living standards oral health issues raise more attention and highlight the need to implement programmes for early recognition and elimination of oral habits and for planning preventing strategies to deal with deleterious oral habits at an early stage.

ABBREVIATIONS

MB-mouth breathing

AOB-anterior open bite

TMD- temporomandibular disorders

OMD- orofacial myofunctional disorders

TS-thumb sucking

AS-atypical swallowing

FM-Froggy mouth

MFT-myofunctional therapy

OMT-orofacial myofunctional therapy

LI- lip incompetence

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