THE INCIDENCE OF SLEEP DISORDERED BREATHING SYMPTOMS IN CHILDREN FROM 2 TO 19 YEARS OF AGE

By Brooke Stevens, BS, University of Michigan and Earl O. Bergersen, DDS, MSD

Sleep Disordered Breathing (SDB) has been found to be a root cause for many childhood health and behavioral conditions. This study consisting of 501 children ages from 2 to 19 years of age assess SDB in children through a parent questionnaire containing 27 items, which reflect various health and behavioral issues in children. This study found that 9 out of 10 children display at least one symptom of SDB. Prevalent symptoms include snoring, mouth breathing, talking in sleep, difficulty listening, teeth grinding, and bed-wetting. It is important to address these health issues early on in order to allow children to thrive and enjoy a long healthy life with a normal airway.

REVIEW OF LITERATURE

Sleep Disordered Breathing (SDB) is a condition that results from a compromised airway causing irregularities in the gas exchange, homeostasis, and restorative processes occurring during sleep.[1] SDB is associated with an expansive range of clinical symptoms, environmental and genetic factors, and dentofacial physical examination findings.[2] Some of these common clinical symptoms include mouth breathing, snoring, teeth grinding, bed-wetting, ADD/ADHD, and many more. Implications of improper breathing can be detrimental if not addressed as reduced oxygenation can negatively impact a child's ability to succeed in school and day-to-day life.[3]

Two of the most frequent symptoms involving sleep disordered breathing include daytime and nighttime open-mouth breathing[4] and habitual snoring.[5]

It is important that SDB breathing symptoms are recognized and addressed early on. The symptom of mouth breathing is considered a very critical symptom when evaluating a child for Sleep Disordered Breathing which was seen in an experiment conducted on Rhesus monkeys by obstructing the nasal cavity, thereby producing mouth breathing which resulted in a narrowing of dental arches, decreased maxillary arch length, tongue function, increased anterior facial height, anterior crossbite, and maxillary overjet.[6-8] Other conditions resulting from mouth breathing in children can be directly related to enlarged tonsils resulting in a tongue thrust. These enlarged tonsils displace the tongue in the mouth promoting a tongue thrust and mouth breathing.[9-10] Mouth breathing can involve a combination of frequent throat infections, abnormal development of a malocclusion, improper phonation, and changes in sleep.[11] Further complications can occur and should be addressed in the evaluation of the tonsils. A Tonsillectomy and adenoidectomy are often recommended at an early age if SDB is present, however, it is only 40-50% successful over time. Therefore, nasal training and palatal expansion are necessary for success.[12]

Snoring is a symptom of Sleep Disordered Breathing and it is an easily observed condition. The frequency of snoring has been reported to be 10%[13-16] when evaluating children who exhibit the snoring symptom whether periodic or habitual. Other significant symptoms can be found including hyperactivity, daytime mouth breathing, sleep talking, profuse sweating, and allergic symptoms.[17-18] Other research has seen children who are affected with allergies and asthma are at a greater risk of SDB with snoring and developing a compromised airway.[19] When observing the dental condition of snorers with sleep disorder breathing the following symptoms are seen such as a higher incidence of class II molar relations, lateral cross-bites, anterior open bite, mandibular and maxillary crowding, and more severe overjets.[4-5]

Addressing SDB in a holistic and natural way is far more beneficial than any alternative treatment needed to address the same issues after they manifest. It is empirical to evaluate children within the first several years following birth in order to maximize the expansion of the airway.[20] Other dental conditions, such as high palates and narrow arches are also strong indicators of SDB in children.[21] Therefore, in order to maximize the health of all children, it is important to acknowledge the prevalence of SDB early on and identify which symptoms are more prevalent and require immediate treatment.

PARTICIPANTS

This study includes 501 parent answered questionnaires that ask a parent to evaluate 27 different SDB symptoms that their child may display by answering yes or no. (Table 1) The questionnaires were distributed to six different states, which included Texas, California, Utah, Colorado, Illinois, and New York. The participants consisted of both males and females and no exclusion was made to ethnicity, or any pre-existing medical conditions. This study includes children from

THE TOTAL NUMBER OF SYMPTOMS PRESENT FOR EACH CHILD

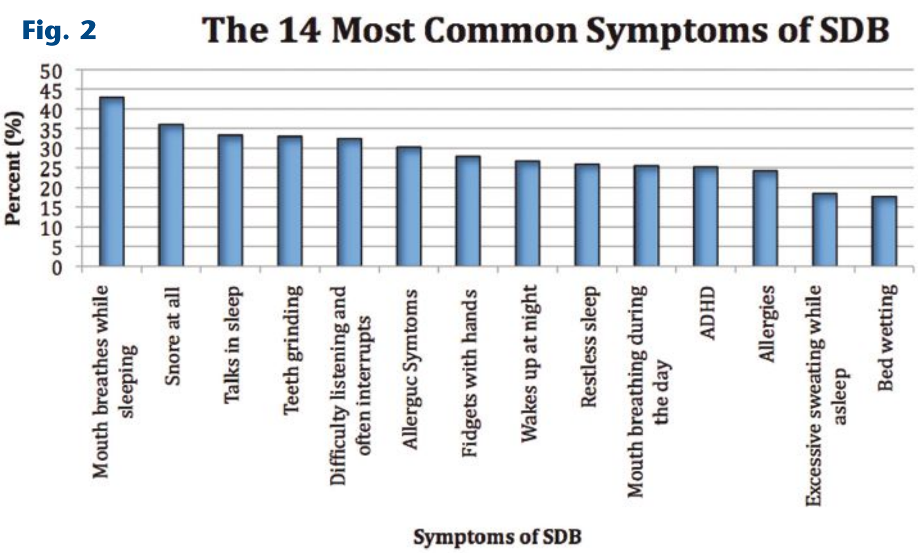
Table 1		**Age Categorized**						**Total**
		4 & younger	5-6	7-8	9-10	11-12	13 & older	
Total Number of Symptoms on Questionnaire	**0**	1	3	16	14	10	8	**52**
	1	1	8	13	13	10	6	**51**
	2	2	10	10	18	3	3	**46**
	3	2	4	18	11	7	5	**47**
	4	3	8	19	12	4	4	**50**
	5	0	8	11	15	10	2	**46**
	6	4	6	9	11	8	2	**40**
	7	4	4	6	9	5	3	**31**
	8	3	7	8	5	7	0	**30**
	9	2	4	7	2	4	3	**22**
	10	1	9	2	5	2	0	**19**
	11	2	1	6	4	4	0	**17**
	12	1	2	4	0	6	0	**13**
	13	3	0	3	1	2	1	**10**
	14	0	2	8	1	0	0	**11**
	15	0	1	2	0	2	0	**5**
	16	0	2	1	3	1	0	**7**
	17	0	1	1	0	0	0	**2**
	18	0	1	0	0	0	0	**1**
	20	0	0	0	1	0	0	**1**
Total		**29**	**81**	**144**	**125**	**85**	**37**	**501**

Sleep Disordered Breathing Questionnaire **Fig. 1**

Does your child:

	INITIAL	FOLLOW UP			INITIAL	FOLLOW UP	
1.			Snore at all?	14.			Talks in sleep
2.			Snore only infrequently (1 night/week)	15.			Poor ability in school
3.			Snore fairly often (2-4 nights/week)	16.			Falls asleep watching TV
4.			Snore habitually (5-7 nights/week)	17.			Wakes up at night
5.			Have labored, difficult, loud breathing at night	18.			Attention deficit
6.			Have interrupted snoring where breathing stops for 4 or more seconds	19.			Restless sleep
				20.			Grinds teeth
7.			Have stoppage of breathing more than 2 times in an hour	21.			Frequent throat infections
8.			Hyperactive	22.			Feels sleepy and/or irritable during the day
9.			Mouth breathes during day	23.			Have a hard time listening and often interrupts
10.			Mouth breathes while sleeping	24.			Fidgets with hands or does not sit quietly
11.			Frequent headaches in morning	25.			Ever wets the bed
12.			Allergic symptoms	26.			Bluish color at night or during the day
13.			Excessive sweating while asleep	27.			Speech Problems *

Fig. 2



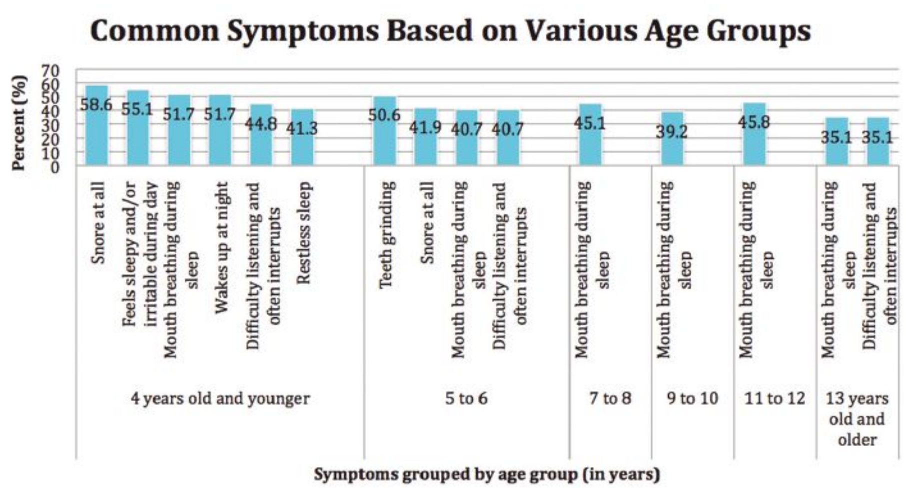


Fig. 3

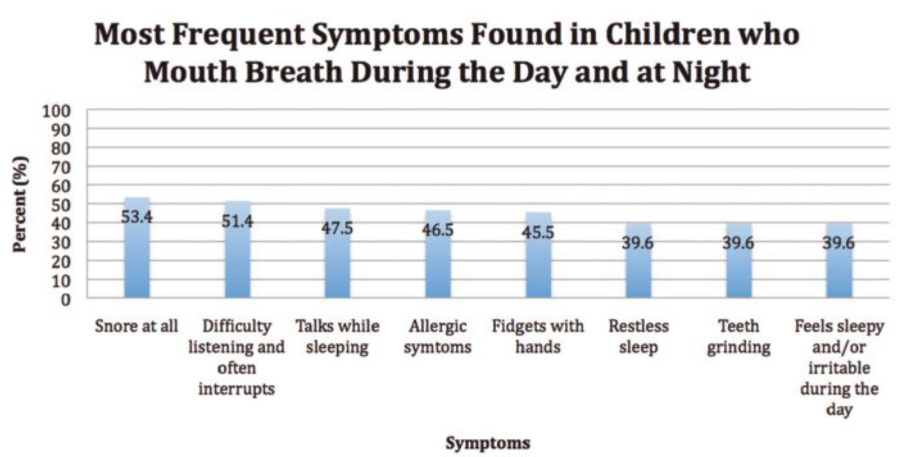


Fig. 4

ages 2 to 19 years of age. Among the 501 children in this study, 53.1% were male and 46.9% were female. These children were separated into 6 groups based on age, which consisted of 4 years old and younger (5.8%), 5 to 6 years old (16.2%), 7 to 8 years old (24.9%), 9 to 10 years old (24.9%), 11 to 12 years old (16.9%) and 13 years old and older (7.3%).

DESIGN

The questionnaire[22] (Fig. 1) was distributed to every potential patient using the oral appliance[23] during a nine-month period. This questionnaire was generally patterned after the Pediatric Sleep Questionnaire.[24] Fifteen of the symptoms used in the redesigned questionnaire for the dental profession were based on these characteristics that exhibited the most significant ($p< 0.001$) differences when comparing them to snoring categories[17] as well as from others.[25-26]

RESULTS

This study found that 90% of these children showed at least one symptom of SDB. Some common symptoms seen in these children include mouth breathing while sleeping (43.0%), snore at all (36.0%), talks in sleep (33.3%), teeth grinding (32.9%), and difficulty listening and often interrupts (32.5%). Among the 10 most common symptoms (Fig. 1), 40% are directly related to dentistry (mouth breathing at night, mouth breathing during the day, snoring, and teeth grinding). Out of the 27 symptoms, 26 of the symptoms, with exception to frequent throat infections, were more prominent in males than females.

Fig. 2 shows snoring was present in 58.6% of children in the 4 years old and younger age group, but then decreased to 18.9% in the 13 years and older age group. However, mouth breathing was present in 51.7% of children in the 4 years old and younger age group, but only decreased to 35.1% in the 13 years old and older age group. The symptom listed as having difficulty listening and often interrupts were present in 44.8% of children in the 4 years old and younger age

"AMONG THE 10 MOST COMMON SYMPTOMS, 40 ARE DIRECTLY RELATED TO DENTISTRY (MOUTH BREATHING AT NIGHT, MOUTH BREATHING DURING THE DAY, SNORING, AND TEETH GRINDING). OUT OF THE 27 SYMPTOMS, 26 OF THE SYMPTOMS, WITH EXCEPTION TO FREQUENT THROAT INFECTIONS, WERE MORE PROMINENT IN MALES THAN FEMALES."

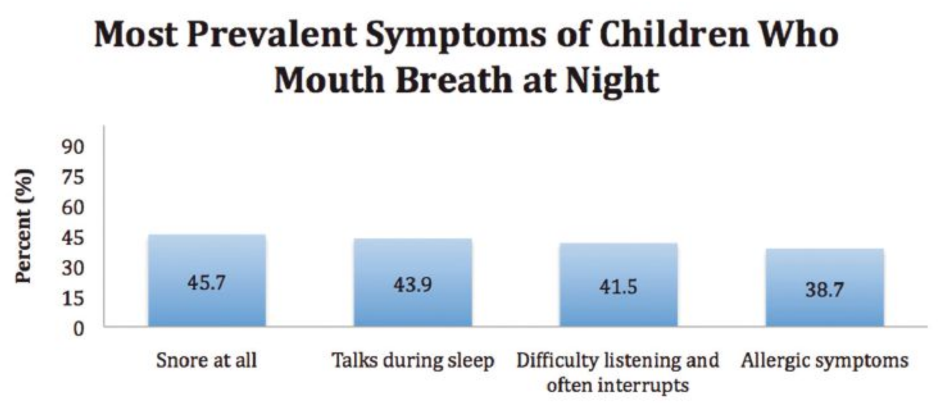


Fig. 5

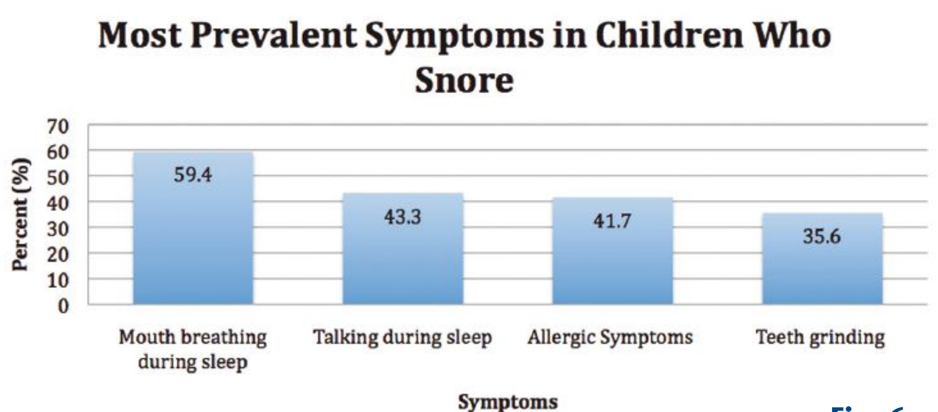


Fig. 6

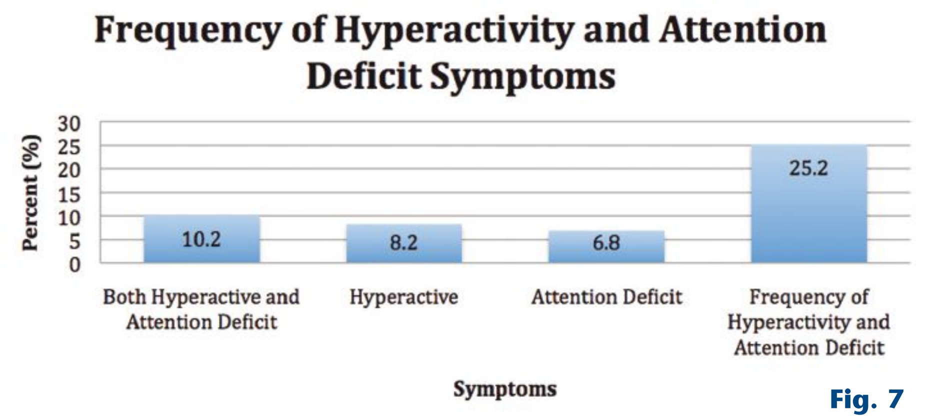


Fig. 7

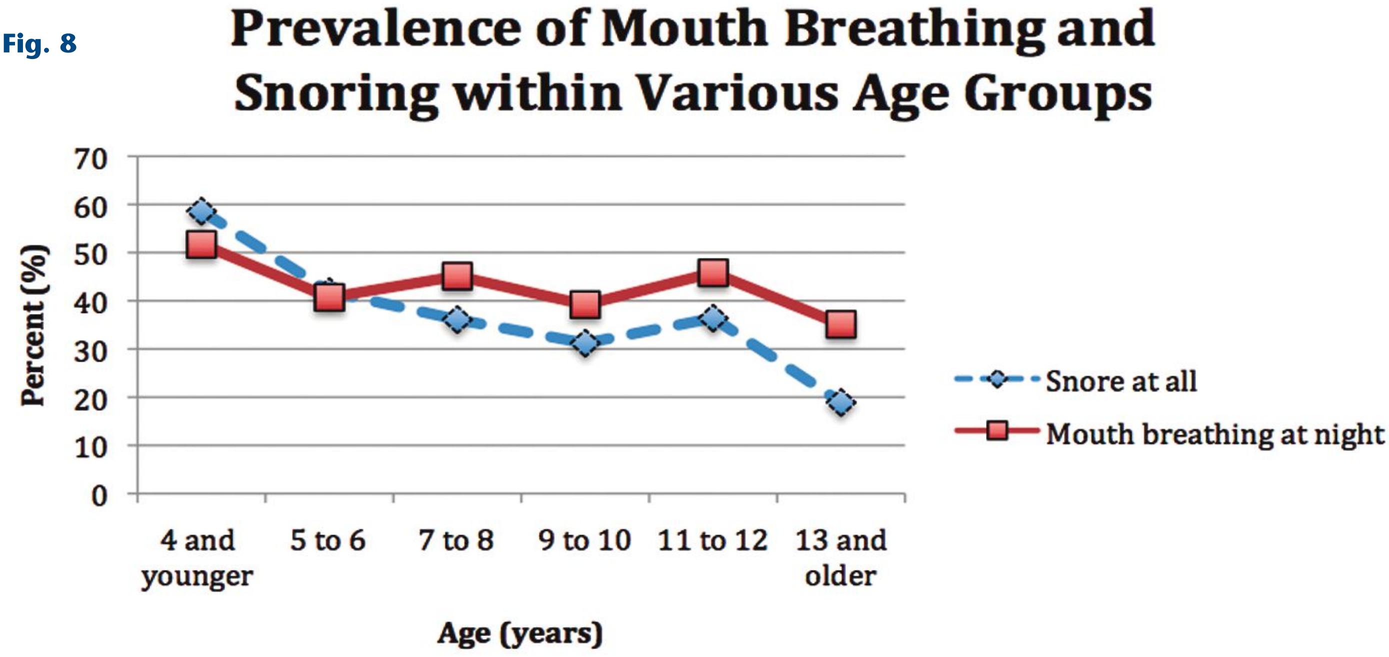
group and decreased to 35.1% in the 13 years old and older age group. Attention Deficit Disorder increased from 3.4% in children 4 years old and younger to 16.2% in children 13 years old and older.

Out of all of the children that mouth breathed at night, 47% of those children also mouth breathed during the day. An average number of symptoms found in children that both mouth breathed during the day and at night were 8 symptoms. These symptoms include snore at all (53.4%), difficulty listening and often interrupts (51.4%), talking in sleep (47.5%), allergic symptoms (46.5%), fidgets with hands or does not sit quietly (45.5%), restless sleep (39.6%), teeth grinding (39.6%), and feels sleepy and/or irritable during the day (39.6%).

However, the average number of symptoms found in children who only mouth breath at night were 7 symptoms. The most common symptoms found in children who only mouth breath at night (Fig. 4) were snoring (45.7%), talks in sleep (43.9%), difficulty listening and often interrupts (41.5%), and allergic symptoms (37.8%). In Fig. 5, the average number of symptoms of children who snore were 6 symptoms. The most common of these symptoms include mouth breathing during sleep (59.4%), talking during sleep (43.3%), allergic symptoms (41.7%), and teeth grinding (35.6%). The frequency of children who displayed hyperactivity and attention deficit was 25.2% as seen in Fig.6.

In that the dental profession begins to regularly examine patients at about 2 years of age, it is extremely important for the dentist to be aware of these various symptoms. Whether the symptoms are directly related to dentistry or not, they are essential to be able to assess the severity of sleep problems. In that 60% of children have 4 or more sleep deprivation symptoms (Table 1), and if these symptoms have the possibilities of being reduced or eliminated by removable appliances it would seem logical for the dental professional to be a primary source for treatment.

Fig. 8



To correct or modify these sleep symptoms, particularly before a child enters school can be a life saving procedure and one that can greatly improve the child's well-being in school and their normal social interaction with other children. To alter even a single symptom, such as prolonged bed-wetting can dramatically change a child's life.

The study has shown that 92.6% of the 27 symptoms do not self correct with increase in age. In fact, 30% actually increases in severity from 4 to 12 years of age. By eliminating nighttime (and daytime) mouth breathing and snoring in a child could probably improve a child's life significantly. For example, if a child does not mouth breathe (day or night) nor snore, the mean number of symptoms present in such children consists of 2 symptoms. In those that both snore and mouth breathe the mean number of symptoms present is 9 symptoms. It would seem, therefore, to successfully correct these two symptoms would probably have a great improvement in a child's sleep problem. Such appliances commonly called the Habit Corrector and Healthy Start Kids are designed specifically to correct snoring and mouth breathing.

CONCLUSION

The results of this study suggest that 9 out of 10 children have at least one symptom of Sleep Disordered Breathing. Previous research found that SDB occurs in 1% to 3% of children from the ages of 5 to 13 years of age, however, the findings of this study provides evidence that SDB is much more common and effects children even as young as 2 years of age.[18]

The implications of this study are essential in finding a way to improve the health of children today. Children begin to show symptoms of sleep disordered breathing as early as two years of age. It is essential that treatment to alleviate SDB in children begin as early as possible to ensure permanent dental changes in a growing child and the correction and promotion of proper oral habits in order to provide a long healthy life for these young children. This study supports the American Academy of Pediatric Dentistry's (AAPD) push to have all children find a dental home by the age of one.[27] The findings of this study suggest that males are more susceptible to SDB and generally display more symptoms due to greater body mass.[28] This study provides evidence that mouth breathing maybe a more prominent indicator of SDB than that of snoring because it continues to be prominent throughout childhood unlike snoring where a large decrease is seen as children get older as seen in Fig. 8.

As a result of this investigation the following conclusions can be made:

1. Mouth breathing and snoring are commonly associated with more SDB symptoms than the other symptoms studied.
2. The four most commonly occurring symptoms are: Mouth breathing at night, snoring, talks in sleep, and teeth grinding.
3. 90% of the sample had one or more symptoms commonly associated with SDB.
4. 60% of the sample had four or more symptoms.
5. Between 4 and 12 years of age, 92.6 % of symptoms did not self correct while 30% worsened with age.
6. The dentist is well positioned to be able to utilize appliances that can modify the most common symptoms.

Editor's Note:
Click here for references.

Table #1

A table of questions in order to determine what severity of sleep deprivation and speech problems present in a child.

Filled Out By: ____________________

Relationship to Patient: ______________

Sleep Disordered Breathing Questionnaire for Children

Earl O. Bergersen, DDS, MSD

Child's name ____________________ Date ____________________ Age __________

Does your child:

1. ____ Snore at all?
2. ____ Snore only infrequently (1 night/week)
3. ____ Snore fairly often (2-4 nights/week)
4. ____ Snore habitually (5-7 nights/week)
5. ____ Have labored, difficult, loud breathing at night
6. ____ Have interrupted snoring where breathing stops for 4 or more seconds
7. ____ Have stoppage of breathing more than 2 times in an hour
8. ____ Hyperactive
9. ____ Mouth breathes during day
10. ____ Mouth breathes while sleeping
11. ____ Frequent headaches in morning
12. ____ Allergic symptoms
13. ____ Excessive sweating while asleep
14. ____ Talks in sleep
15. ____ Poor ability in school
16. ____ Falls asleep watching TV
17. ____ Wakes up at night
18. ____ Attention deficit
19. ____ Restless sleep
20. ____ Grinds teeth
21. ____ Frequent throat infections
22. ____ Feels sleepy and/or irritable during the day
23. ____ Have a hard time listening and often interrupts
24. ____ Fidgets with hands or does not sit quietly
25. ____ Ever wets the bed
26. ____ Bluish color at night or during the day
27. ____ Speech Problems *

**If yes, provide parent speech questionnaire*

Based on Sahin et al, 2009; and Urschitz et al, 2004

Speech Questionnaire

To be filled out only if #27 was indicated above

Please check all that apply to your child:

1. ____ Is it difficult to understand your child's speech
2. ____ Difficult to understand over the phone?
3. ____ Nasal speech?
4. ____ Speech sounds abnormal?
5. ____ Others have difficulty understanding speech?
6. ____ Gets frustrated when people can't understand speech?
7. ____ Sometimes omits consonants
8. ____ Uses M, N, NG instead of P, F, V, S, Z sounds
9. ____ Hoarseness
10. ____ Swallowing problems with liquids and solids getting into nose
11. ____ Lisp

Based on Barr et al, 2007

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Table #2

A table of questions in order to determine if a patient has ADHD present. If 8 or more questions are answered yes, ADHD is present.

Filled Out By: ____________________

Relationship to Patient: ______________

Child's name ____________________ Age __________ Date ____________________

Standard Questions to Determine the Presence of ADHD in Children

A disturbance of six months or more, during which at least *eight* of the following behaviors are present:

1. ____ Often fidgets with hands or feet or squirms in seat (in adolescents may be limited to subjective feelings of restlessness)
2. ____ Has difficulty remaining seated when required to
3. ____ Is easily distracted by extraneous stimuli
4. ____ Has difficulty awaiting turn in games or group situations
5. ____ Often blurts out answers to questions before they have been completed
6. ____ Has difficulty following through on instructions from others (not due to oppositional behavior or failure of comprehension); for example, fails to finish chores
7. ____ Has difficulty sustaining attention in tasks or play activities
8. ____ Often shifts from one uncompleted activity to another
9. ____ Has difficulty playing quietly
10. ____ Often talks excessively
11. ____ Often interrupts or intrudes on others; for example, butts into other children's games
12. ____ Often doesn't seem to listen to what is being said to him or her
13. ____ Often loses things necessary for tasks or activities at school or at home (for example, toys, pencils, books, assignments)
14. ____ Often engages in physically dangerous activities without considering possible consequences (not for the purpose of thrill seeking); for example (runs into the street without looking)

From: Diagnostic and Statistical Manual

American Psychiatric Association, 1987

3rd Edition, Revised

SLEEP DISORDERED BREATHING QUESTIONNAIRES for Young Children

By Earl O. Bergersen, DDS, MSD

Sleep Disordered Breathing (SDB) has been researched for many years for the adult, however, interest in sleep problems for children is a more recent occurrence. Various questionnaires have been used for adults to determine the likelihood of sleep issues. These adult questionnaires such as the Epworth Sleepiness Scale[1], the STOP-Bang Score[2], the Multiple Sleep Latency Test[3], the Stanford Sleepiness Scale[4], and the Snoring Severity Scale[5] were specifically designed to analyze the symptoms typical for adults suspected of having SDB. Symptoms that are observed in children however, are different from those of the adult and as a result, the adult scales are not appropriate for the analysis of a child.[6]

The dental professional usually begins seeing young patients at around 2 to 4 years of age and traditionally they recall them back into the office every six months on a regular basis. This is in direct contrast to the medical professional, where a patient is usually only seen when a problem arises but not as a routine. The dental professional, as a result, is well positioned to recognize patients with SDB at a very young pre-school age. An easy to use questionnaire(s) for the parents of every child would be extremely beneficial to patients that are suspected to be suffering from sleep issues. Treating young patients before they start school would provide them with a great advantage. Treatment however, at any given age up to 12 years could be of great advantage to any patient.

A few questionnaires are available for children such as the Pediatric Sleep Questionnaire[7], the Pediatric Quality of Life Inventory[8], and the Cleveland Adolescent Sleepiness Questionnaire[9], however, a questionnaire that could be more specific for dental use would be an advantage in diagnosing children suspected of having sleep deprivation. The dental profession has appliances that are capable of preventing the mandible and tongue from being posteriorly displaced while sleeping, and these same appliances can also advance the lower jaw and tongue and as well as to increase mandibular growth in cases with a retrognathic lower jaw. Thus it follows that these appliances can be used for a greater advantage in treating sleep problems.[10] These various appliances can also, correct open-bites, swallowing abnormalities, maxillary palatal narrowing, mouth breathing, advance the maxillary dentition and pre-maxilla, increase nasal breathing with, improved palatal tongue position, snoring, thumb and finger sucking.

Table #3

A table of observations by the dental professional regarding possible sleep deprivation, the table also includes lateral cephalometric measures.

Filled Out By: ____________________

Relationship to Patient: ______________

Child's name ____________________ Date ____________________ Age __________

Dental Professional Questionnaire for Child

____ Are posterior cross-bites present?

____ Is maxillary posterior arch width narrow?

____ Is anterior tongue thrust present?

____Sucks thumb or finger during day and night?

____ Sucks thumb or finger only at night?

____ Tongue tied (ankyloglossia)?

____ Is overjet present (mandibular retrusion)?

____ Are tonsils swollen?

____ Is swelling minor ____, moderate ____, severe (touch each other) ____?

____ Does patient easily and normally breathe through nose?

____ Is nasal breathing noisy and difficult?

____ Any evidence of nasal blockage?

Cephalometric Analysis

____Is the adenoid tissue swollen? ____ minor, ____ major from lateral cephalometric radiograph

____ Is oropharynx narrow (less than smallest finger)?

____ Is nasopharnyx narrow (less than smallest finger)?

____ Any cephalometric measures abnormal?

____ ANB	____ Uvula center to posterior pharyngeal wall
____ Ba-B male	____ Uvula tip to posterior pharyngeal wall
____ Ba-B Female	____ Tongue base to posterior pharyngeal wall

Table #4

A table of typical symptoms of ADHD from birth to two years of age

Common Symptoms of Possible ADHD from Birth to 2 Years of Age

1. Excess crying, kicking, screaming
2. Resistant to routines such as sleeping, eating, and elimination
3. Frequent health problems, particularly allergies, but also asthma, colds, and middle ear infections.
4. Resistant to everything that is different.
5. Sleeping is particularly irregular, amount of sleeping is less than other children often wake up frequently at night crying or screaming.
6. Infrequent smiling or gurgling – is usually moody and sad, and does not respond to others trying to make them laugh.
7. Does not lie down quietly in bed and is always getting out of the bed or crib.
8. Has to be watched carefully all the time or will do dangerous things impulsively.
9. Difficult to hold child – resists cuddling, and squirms during breast feeding.
10. Touch and handle everything they see.
11. Are often hyperactive even before birth
12. 60-70% of hyperactive children show many of these signs

From: Ingersoll B, Your Hyperactive Child, 1988, Doubleday, NY

Table #5

A table of typical symptoms of ADHD from two to five years of age

Common Symptoms of Possible ADHD from 2-5 Years of Age

1. Often have fits of temper
2. Always active – running, jumping
3. Fearless and impulsive- often do dangerous things
4. Destructive
5. Poor attention span
6. Do not respond to discipline
7. Stubborn and strong willed
8. Touch and handle everything
9. Frequent bedwetting and lack of bowel control
10. About half are clumsy and uncoordinated
11. Aggressive and belligerent – often bite others, push and shove and are bossy
12. Forgetful and messy, are not responsible
13. Demand attention
14. Many develop lying, bragging, and frequent fighting and stealing
15. Constant touching and physical contact with others
16. Frequent temper tantrums
17. Resist authority

Table #6

A table of typical symptoms of ADHD from six to twelve years of age

Common Symptoms of Possible ADHD from 6-12 Years of Age

1. Poor school performance
2. Attention difficulties
3. Impulsive
4. Underachieve in school despite high intelligence
5. Lacks responsibility
6. 50% have failed at least one grade
7. Rebellious in nature
8. Argumentative
9. Often moody and antisocial
10. Forgetful
11. Do not respect authority
12. Half develop drug and alcohol problems
13. Constantly teasing, hitting or pestering others
14. Have few friends – often are called weird of crybabies
15. Often has fits of temper
16. Poor school performance and often in trouble
17. Often brags, lies, and steals
18. 50% have failed at least one grade and 1/3 have had to repeat 2 or more grades

All of these problems above that can be corrected by the dental professional are typically associated with SDB as well as being interconnected with many other symptoms. These problems, when treated at early ages are easily corrected and are usually more stable than those attempted to be treated at other ages such as at 12 years or older. As a result, these corrections by the dental professional[11,12] may be able to permanently improve a young child's well-being.

The SDB Questionnaire for Children is patterned after the various child questionnaires that are commonly used at present. It is specifically designed to be more applicable for the dental professional. This Parent Questionnaire for children consists of 15 symptoms obtained from Sahin et al's research[13] from a sample size of 1164 children. These 15 items had statistical confidence levels of P=0.001. Four items were obtained from research by Urschitz et al[14] while one item was used from Attanasio and Bailey[15] (dark circles under the eyes, that is reported to be linked to a reduction in nasal breathing). Symptoms #6 and #7 in the questionnaire are based on data from the American Thoracic Society Standards.[16] The section of abnormal speech symptoms that are associated with SDB are based on research by Barr et al.[17] A questionnaire to determine the presence of

Table #7

A table of typical symptoms of ADHD from thirteen to nineteen years of age

Common Symptoms of Possible ADHD in teenagers 13-19 Years of Age

1. 80% of hyperactive children retain symptoms into the teen years while only 20% improve
2. Often considered most difficult period due to past personality and social behavior influence.
3. Poor school performance and poor achievement
4. Battles over homework on school assignment
5. Rebellious
6. Argumentative
7. Moody
8. Poor responsibility in even dressing and eating schedules
9. Antisocial behavior and have few or no friends
10. High risk for those with 2 symptoms by end of teens
11. 50% have drug and alcohol problems
12. Often load when speaking
13. Explosive temper
14. Restlessness
15. Often is a loner

Table #8

A table of typical symptoms of ADHD from twenty years of age through adulthood.

Common Symptoms of Possible ADHD from 20 Years of Age Through Adulthood

1. Attention and concentration difficult
2. Poor at organization and forgetful
3. Relentless and fidgety – often more legs constantly
4. If subject interests the person, other often work very hard and intense with excess energy
5. Moody and depression
6. Irritability and hot temper
7. Some are child abusers
8. Assault charges associated with sever temper problems
9. Antisocial behavior
10. Frequent alcohol and drug abuse
11. Immaturity and dependency
12. Impulsive behavior
13. Low self-esteem
14. Work tardiness and absenteeism frequent
15. Frequent changes in employment.

ADHD in a child is drawn from standards of diagnosis of those children suspected of having ADHD from the American Psychiatric Association[18] and is a separate addition to the basic questionnaire.

A third questionnaire (Questionnaire #3) is for the dental professional. This questionnaire consists of 12 items filled out during the general patient exam and 9 items that are present from a cephalometric evaluation involving measures of the antero-posterior position of the mandible in relation to the pharynx and the width of the pharynx as well as the size of the adenoid tissue.

These three questionnaires cover a diagnosis applicable for the dental professional in order to consider treatment of these symptoms. The Pediatric Sleep Questionnaire1 was analyzed by Chervin et al (2007)[9] in order to see if this questionnaire could predict the presence of obstructive sleep apnea (OSA). It was found to accurately predict OSA about 74% of the time in children as verified by polysomnography. OSA has an incidence of only 1.6% in children[20] however, there are many other symptoms that have a significant impact on a child's future life without the presence of apnea.

If one examines common symptoms of children at various ages having suspected ADHD, one is impressed by the increase in serious consequences as the affected child matures. One is also impressed by the great similarity between the symptoms of ADHD and sleep problems in children. Tables 4-8 show the advancing and increasing detrimental effects as the child matures.[21] Of significance is the general behavioral problems (Tables #4 and #5), however, when the affected child begins school, the difficulties become considerably more serious (Table #6). Such symptoms as poor school performance, 50% failing at least one grade, being antisocial, 50% developing drug and alcohol problems, having fewer friends, and often being in trouble are all quite common. Once the child starts high school (Table #7) the problems become even more serious since 80% of hyperactive children retain these symptoms even into the teen years. Those with 2 symptoms or more are considered to be at high risk. Fifty percent have drug and alcohol addiction and are often in trouble with the law.[19]

These tables

Table #9

Filled Out By: ____

Relationship to Patient: *Mother*

Sleep Disordered Breathing Questionnaire for Children

Earl O. Bergersen, DDS, MSD

Child's name *Male* Date *April 20, 2007* Age *5*

Does your child:

1. ✓ Snore at all?
2. ___ Snore only infrequently (1 night/week)
3. ___ Snore fairly often (2-4 nights/week)
4. ✓ Snore habitually (5-7 nights/week)
5. ✓ Have labored, difficult, loud breathing at night
6. ___ Have interrupted snoring where breathing stops for 4 or more seconds
7. ___ Have stoppage of breathing more than 2 times in an hour
8. ✓ Hyperactive
9. ✓ Mouth breathes during day
10. ✓ Mouth breathes while sleeping
11. ✓ Frequent headaches in morning
12. ___ Allergic symptoms
13. ✓ Excessive sweating while asleep
14. ✓ Talks in sleep
15. ✓ Poor ability in school
16. ___ Falls asleep watching TV
17. ✓ Wakes up at night
18. ✓ Attention deficit
19. ✓ Restless sleep
20. ✓ Grinds teeth
21. ✓ Frequent throat infections
22. ___ Feels sleepy and/or irritable during the day
23. ✓ Have a hard time listening and often interrupts
24. ✓ Fidgets with hands or does not sit quietly
25. ✓ Ever wets the bed
26. ___ Bluish color at night or during the day
27. ✓ Speech Problems *

**If yes, provide parent speech questionnaire*

Based on Sahin et al, 2009; and Urschitz et al, 2004

Speech Questionnaire

To be filled out only if #27 was indicated above

Please check all that apply to your child:

1. ___ Is it difficult to understand your child's speech
2. ___ Difficult to understand over the phone?
3. ___ Nasal speech?
4. ___ Speech sounds abnormal?
5. ___ Others have difficulty understanding speech?
6. ___ Gets frustrated when people can't understand speech?
7. ___ Sometimes omits consonants
8. ___ Uses M, N, NG instead of P, F, V, S, Z sounds
9. ✓ Hoarseness
10. ___ Swallowing problems with liquids and solids getting into nose
11. ___ Lisp

Based on Barr et al, 2007

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Table #10

Filled Out By: ____

Relationship to Patient: *Mother*

Sleep Disordered Breathing Questionnaire for Children

Earl O. Bergersen, DDS, MSD

Child's name *Male* Date *August 11, 2015* Age *13*

Does your child:

1. ___ Snore at all?
2. ___ Snore only infrequently (1 night/week)
3. ___ Snore fairly often (2-4 nights/week)
4. ___ Snore habitually (5-7 nights/week)
5. ___ Have labored, difficult, loud breathing at night
6. ___ Have interrupted snoring where breathing stops for 4 or more seconds
7. ___ Have stoppage of breathing more than 2 times in an hour
8. ___ Hyperactive
9. ___ Mouth breathes during day
10. ___ Mouth breathes while sleeping
11. ___ Frequent headaches in morning
12. ___ Allergic symptoms
13. ___ Excessive sweating while asleep
14. ___ Talks in sleep
15. ___ Poor ability in school
16. ___ Falls asleep watching TV
17. ___ Wakes up at night
18. ___ Attention deficit
19. ___ Restless sleep
20. ___ Grinds teeth
21. ___ Frequent throat infections
22. ___ Feels sleepy and/or irritable during the day
23. ✓ Have a hard time listening and often interrupts
24. ___ Fidgets with hands or does not sit quietly
25. ___ Ever wets the bed
26. ___ Bluish color at night or during the day
27. ___ Speech Problems *

**If yes, provide parent speech questionnaire*

Based on Sahin et al, 2009; and Urschitz et al, 2004

Speech Questionnaire

To be filled out only if #27 was indicated above

Please check all that apply to your child:

1. ___ Is it difficult to understand your child's speech
2. ___ Difficult to understand over the phone?
3. ___ Nasal speech?
4. ___ Speech sounds abnormal?
5. ___ Others have difficulty understanding speech?
6. ___ Gets frustrated when people can't understand speech?
7. ___ Sometimes omits consonants
8. ___ Uses M, N, NG instead of P, F, V, S, Z sounds
9. ___ Hoarseness
10. ___ Swallowing problems with liquids and solids getting into nose
11. ___ Lisp

Based on Barr et al, 2007

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Table #11

Filled Out By: ____________

Relationship to Patient: Mother

Child's name Male Age 5 Date April 20, 2007

Standard Questions to Determine the Presence of ADHD in Children

A disturbance of <u>six months</u> or more, during which at least *<u>eight</u>* of the following behaviors are present:

1. ✓ Often fidgets with hands or feet or squirms in seat (in adolescents may be limited to subjective feelings of restlessness)
2. ✓ Has difficulty remaining seated when required to
3. ✓ Is easily distracted by extraneous stimuli
4. ✓ Has difficulty awaiting turn in games or group situations
5. ✓ Often blurts out answers to questions before they have been completed
6. ✓ Has difficulty following through on instructions from others (not due to oppositional behavior or failure of comprehension); for example, fails to finish chores
7. ✓ Has difficulty sustaining attention in tasks or play activities
8. ___ Often shifts from one uncompleted activity to another
9. ___ Has difficulty playing quietly
10. ___ Often talks excessively
11. ✓ Often interrupts or intrudes on others; for example, butts into other children's games
12. ✓ Often doesn't seem to listen to what is being said to him or her
13. ✓ Often loses things necessary for tasks or activities at school or at home (for example, toys, pencils, books, assignments)
14. ✓ Often engages in physically dangerous activities without considering possible consequences (not for the purpose of thrill seeking); for example (runs into the street without looking)

From: Diagnostic and Statistical Manual

American Psychiatric Association, 1987

3rd Edition, Revised

Table #12

Filled Out By: ____________

Relationship to Patient: Mother

Child's name Male Age 13 Date August 11, 2015

Standard Questions to Determine the Presence of ADHD in Children

A disturbance of <u>six months</u> or more, during which at least *<u>eight</u>* of the following behaviors are present:

1. ___ Often fidgets with hands or feet or squirms in seat (in adolescents may be limited to subjective feelings of restlessness)
2. ___ Has difficulty remaining seated when required to
3. ___ Is easily distracted by extraneous stimuli
4. ___ Has difficulty awaiting turn in games or group situations
5. ___ Often blurts out answers to questions before they have been completed
6. ___ Has difficulty following through on instructions from others (not due to oppositional behavior or failure of comprehension); for example, fails to finish chores
7. ___ Has difficulty sustaining attention in tasks or play activities
8. ___ Often shifts from one uncompleted activity to another
9. ___ Has difficulty playing quietly
10. ___ Often talks excessively
11. ___ Often interrupts or intrudes on others; for example, butts into other children's games
12. ___ Often doesn't seem to listen to what is being said to him or her
13. ✓ Often loses things necessary for tasks or activities at school or at home (for example, toys, pencils, books, assignments)
14. ___ Often engages in physically dangerous activities without considering possible consequences (not for the purpose of thrill seeking); for example (runs into the street without looking)

From: Diagnostic and Statistical Manual

American Psychiatric Association, 1987

3rd Edition, Revised

strongly indicate the need for early recognition of these symptoms in the pre-school child, or at least before the child enters high school. In that these various symptoms are so similar to those of sleep-disordered breathing, it makes it imperative for the dental practitioner to recognize and treat these problems as early as possible.

A perfect example is of an 8 year old boy that had a sleep and speech questionnaire which indicated 17 problems (Table #9). The same child's questionnaire at 13 years of age is shown in Table #10 after wearing an appliance this patient was voted as the most popular and the most athletic student in his 6th grade. When the mother filled out the questionnaire for ADHD, the result was predictable (Table #11). He would not sit still even for 30 seconds and had severe attention deficit. He breathed through his mouth while sleeping and snored every night. When an appliance (Nite-Guide®) was given to him that prevents the distalization of the mandible and tongue while sleeping, several of his telltale symptoms immediately stopped (constant movement in bed, sitting up and talking, sleep walking). In addition the patient had more energy upon waking. School performance also began to improve. Taking the same ADHD test at 13 years (Table #12) shows the improvement. This case illustrates the changes that the dental professional is able to make in order to redirect a young person's life. Eighty percent of early ADHD patients maintain the problem into their teen years, as stated above.[21]

This patient makes a point of wearing his preformed mandibular advancement appliance to prevent the mandible from posteriorly displacing while sleeping before a scheduled sports competition. He experienced increased energy and performance as a result. This is probably due to the increased oxygen restoration while sleeping. Often ADHD patients are found to be clumsy and uncoordinated, so this is a dramatic change for this patient. He was captain of his hockey team and had the highest number of goals as a 13 year old. He also ran the half mile and was ranked #3 over approximately 38000 6th grade students.

This case illustrates the importance of intercepting such a case at a young age to change a child's coarse of development without medication to calm the hyperactivity which can dull a child's personality without curing the cause of such a problem.

The introduction of the dental professional into the diagnosis and treatment of sleep problems in children is a great advantage for a couple of reasons. The first of these is that with the early monitoring of patients on a regular basis, starting at 2 to 4 years of age, allows the dental office the ability to intercept sleep issues at a very early age. The second is that the child can be corrected prior to their entering school where more complicated issues exist.

Editor's Note: CLICK HERE to view references.

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SLEEP-DISORDERED BREATHING IN CHILDREN:

A Review of the Research Applicable for the Dental Professional

By Earl O. Bergersen, DDS, MSD and Ben Miraglia, DDS

This article is a review of research findings regarding the many behavior problems associated with disordered breathing in addition to their significance when compared to symptom free controls. Also discussed are those cephalometric and dental measures that can be helpful in assessing whether a child has a serious problem. Since severe breathing problems can reduce the oxygenation of the blood that can severely affect the child's performance in school, and, if not recognized, can be a lifelong struggle for the patient. The various cephalometric and dental measures that are most meaningful in a diagnosis are discussed. One case is presented to illustrate possible changes in behavior and another case that converted from a mouth-breather to a nasal breather both wearing a preformed early treatment appliance (Nite-Guide® and Occlus-o-Guide®).

Sleep-disordered breathing (SDB) can be present in 1% to 3% of children[1] 5 to 13.9 years of age and occurs in three different severities.[2]

1. Primary snoring (PS) – no reduction in oxygen blood levels, no CO_2 increase and no frequent wakening.
2. Upper airway resistance syndrome (ARS) - snoring with difficult breathing with no reduction in oxygenation and no CO_2 increase.
3. Obstructive sleep apnea, (a pause in breathing) – hypopnea (abnormally low breathing) syndrome (SAHS) – and apnea with oxygen desaturation, CO_2 increase, and frequent wakening.

These apneic events (which for children is a cessation of breathing for 2 breaths or about 5 seconds at least once per hour) are habitual in 1.6% and occasionally in 3.4% for a total of 5% in children 2.8 years of age.[3] Eighteen percent of children (mean age 9.7 ± 4.4) had some apnea and the apnea index (# of incidences/hour) was 0.1 ± 0.5.[4] Habitual snorers represent 3.5%.[5] Although these percentages are low, those that suffer can have serious future consequences. The orthodontist could easily contribute in a significant way provided he or she is familiar with the various meaningful symptoms commonly associated with breathing problems outlined in Table 1.[5,6]

Table 1 Incidence of Sleep Symptoms in Non-Snorers and Snorers in Children 7-13 years of age.

Symptom	Non-Snorers N = 711	Periodic Snorers N = 412	Habitual Snorers N = 41	P-Value
Category Percentage	61.1%	35.4%	3.5%	
Hyperactivity	21.1%	30.1%	58.5%	< 0.001
Daytime Mouth Breathing	18.4%	34.0%	65.9%	< 0.001
Excessive Daytime Sleepiness	0.7%	2.2%	9.8%	< 0.001
Sleep Talking	28.8%	42.0%	56.1%	< 0.001
Difficult Night Breathing	1.3%	8.0%	22.0%	< 0.001
Profuse Sweating	35.6%	45.9%	58.5%	< 0.001
Attention Deficit**	11.1%	18.0%	31.9%	------
Poor Ability in School**	36.1%	38.8%	46.8%	------
Falling Asleep Watching TV**	24.8%	36.2%	46.8%	------
Peer Problems**	24.9%	25%	27.0%	------
Waking up at Night	22.2%	32.0%	34.0%	< 0.001
Allergic Symptoms	28.1%	41.7%	68.3%	< 0.001
Tooth Grinding	17.3%	28.7%	34.1%	< 0.001
Restless Sleep & Irritability	9.4%	16.7%	34.1%	< 0.001
Headaches upon Waking	21.1%	33.5%	48.8%	< 0.001
Throat Infections	12.2%	24.5%	34.1%	< 0.001
Difficult Breathing During Sleep	1.3%	8.0%	22.0%	< 0.001
Adenoidectomy	9.4%	13.4%	29.3%	< 0.001
Bed Wetting	3.5%	5.8%	17.1%	< 0.001

*Sahin et al, 2009 - 5 N = 711 (non-snorers), N = 412 (periodic snorers), N = 41 (habitual snorers), except ** below age range 7-13 years (66% 7-10 years).
** From Urshitz et al, 2004 - 6 N = 410 (non-snorers), N = 605 (periodic snorers), N = 114 (habitual snorers), mean age 9.6 years.

Table 2 The Most Influential Symptoms for Sleep-Disordered Breathing and Apnea

Symptom	Normal	Abnormal	% Change	P-Value	N	Age
Adenoid Size *	6.4 cm³ ± 2.3	9.9 cm³ ± 3.9	+ 53.8%	< 0.005	18,18	4.8, 4.9 yrs.
Tonsil Size *	5.8 cm³ ± 2.2	9.1 cm³ ± 2.9	+ 56.9%	< 0.0005	18,18	4.8, 4.9 yrs.
Mouth Breathing (days) **	18.0%	27.1% (snoring regular)	----	< 0.001	567,48	4.4 yrs.
Habitual Snoring ***	50.9% (never)	7.3% (habitual)	----	--	1615	9.7, 9.1 yrs.

*Arens et al, 2001 (8), ** Lofstrand-Tedestrom et al, 1999 (11) *** Corbo et al, 1989 (12)

Table 2 presents the four most frequent symptoms involving sleep-disordered breathing (SBD). The most frequent is swollen adenoids with enlarged tonsils[7] close behind. An accurate estimate of their size can be made with an MRI,[8] however a simple oral examination can indicate if the tonsils are swollen and adenoid size can be seen on a lateral cephalometric radiograph. If enlargement is suspected, the patient can be referred to a specialist. Swollen tonsils can slightly displace towards the pharynx when the patient lies down and can cause pharyngeal obstruction in a supine position when they seem more normal when the patient is vertical.[9] Adenoids and tonsils are at their peak size between 3 and 6 years of age[10] and an adenotonsilectomy is often all that is needed to solve a serious breathing problem in a young child.

Two other important diagnostic symptoms in Table 2 are daytime and nighttime open-mouth breathing,[11] and habitual snoring.[12] The presence of these two characteristics should be a strong indication for a parent questionaire[13] and if apnea is suspected, a home night study and a lateral cephalometric radiograph would be recommended. A home night study is a reliable diagnostic aid to determine the presence of sleep apnea, hypopnea, and oxygen desaturation.[14] Any indication for sleep apnea should be referred for an overnight study called a polysomnograph.

Many of the behavior problems in Table 1 do not improve with an increase in age,[15] however, there are three behavioral problems that seem to be very important, namely inattention or attention deficit, hyperactivity and daytime sleepiness.[13] When these symptoms are present, a correct diagnosis becomes more assured. Two studies were used to prepare Table 1.[5,6] While other studies confirm such symptoms.[15-23] Helpful guidelines have been established as to a recommended protocol in children that can be helpful in a diagnosis.[24]

A rather typical example of a patient who had several of the


Fig. 1

symptoms listed in Table 1, was an habitual-snoring male patient, 6½ years old, in the second grade, with symptoms such as hyperactivity, attention deficit, mild aggressiveness to peers, limited school success, periodic bed wetting, sleep walking, and excessive movement during sleep, often sitting up in bed without waking. The patient was immediately given an Eruption Guidance Appliance® called Nite-Guide®*. This appliance serves as a template to properly guide the permanent upper and lower incisors into the mouth. As these teeth erupt without rotations, and without displacement, they force the arch (upper and lower) to enlarge to properly accommodate the larger permanent incisors. Once the lower central incisors were completely erupted, an Occlus-o-Guide® was inserted, which allowed further arch enlargement to occur. The patient's upper arch increased a total of 6 mm. while the lower increased 4 mm. At the same time, the posterior maxillary segment enlarges by 3.5 mm. at the level of the first permanent molars. The maxillary left central erupted lingually and was about 1 mm. crowded (Fig. 1). This enlargement occurs gradually as the maxillary and mandibular incisors erupt, and usually takes 2 years to obtain the full arch expansion.[25-27]

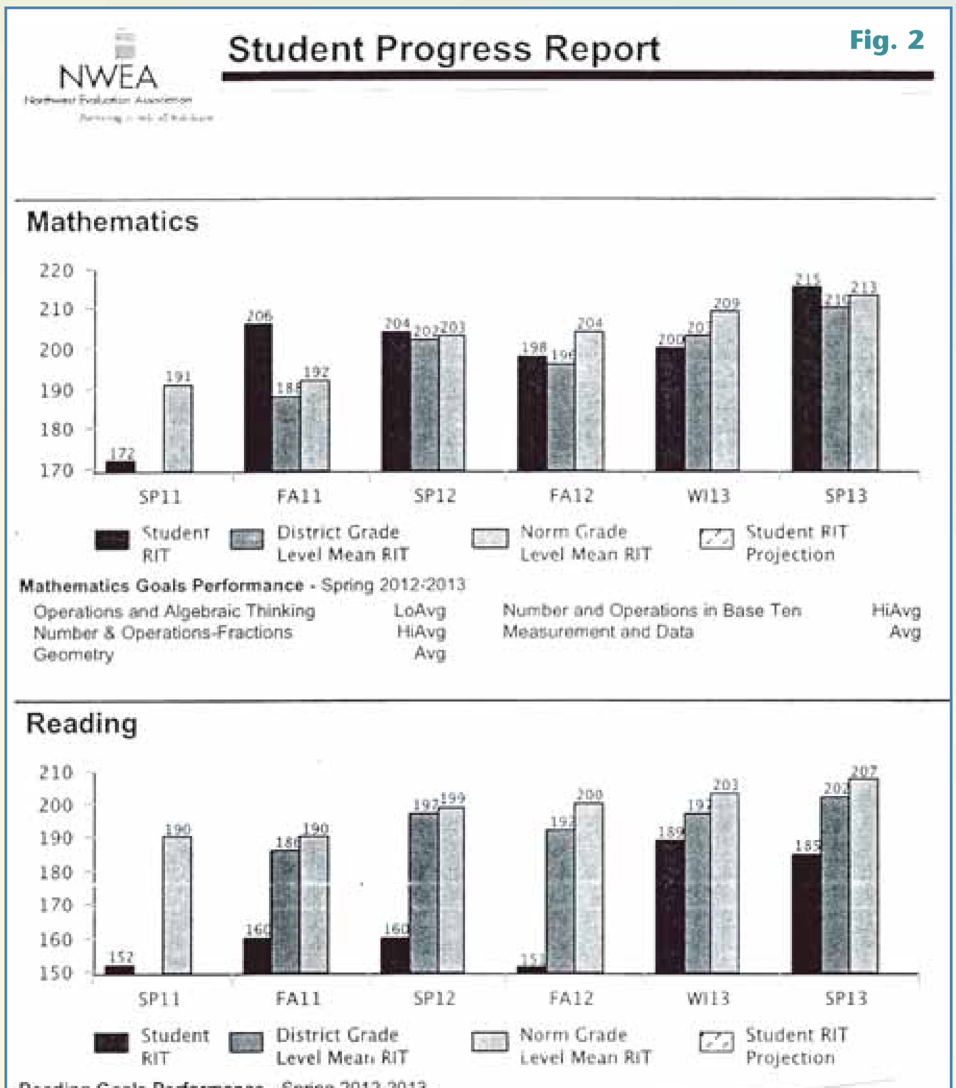

Fig. 2


Fig. 3a


Fig. 3b


Fig. 4a


Fig. 4b


Fig. 4c

It might be a logical assumption that the nasal cavity would also enlarge in response to the upper arch increase of 6 mm. and increase air intake volume at the same time.

The patient stopped snoring and only breathed through the nose while the appliance was in his mouth. Initially the patient did not have any appreciable overjet or overbite, had a normal total and lower face height as well as a normal mandibular plane angle. He was not a daytime mouth breather and did not have enlarged tonsils or adenoids.

Fig. 2 shows the patient's progress report in his school achievement after wearing these appliances for 6 months prior to the beginning of this report. This report compares the patient's status with other children in his grade level as well as to the national average. At the start of the second grade, he was issued his Nite-Guide® appliance and wore it every night while sleeping. The first student's RIT score for mathematics (Fig 2) indicated that his achievement level was at the 6th percentile which indicated that 94% of the other children were better achievers than he was. By the time he was at the end of the 4th grade (2 years later) his achievement was at the 57th percentile for a gain of 950%. The lower scale (Fig. 2) of the chart is for reading and also shows improvement but not as dramatic as the mathematics score.

One might reason that this improvement might be due to his increase in maturity. The patient's skeletal maturity has been followed with the use of hand-film radiographs for this same 2 year period. His skeletal age was estimated using the Greulich and Pyle atlas (1959),[28] and indicated that he has been maturing along a constant path, being 3 months ahead of the mean for the past 2 years. Regarding his changes in behavior and other symptoms, he immediately stopped snoring when the initial appliance *as manufactured by Ortho-Tain, Inc. was inserted and breathed through the nose when the appliance was in place. Gradually he stopped his excessive movement while sleeping, bed wetting, and sleep walking. His hyperactivity, attention deficit and aggressiveness to peers also gradually subsided and is not present at the end of the 4th grade. According to research,[15,20] these symptoms do not usually improve with age, but usually increase in severity.

This patient's report cards for the 4th grade reported 85% of 40 individual grades were "A's", while 15% were "B's" for a grade point average of 3.84 and had no grade lower than a "B". Also of importance is the increase in upper arch size and its possible effect on the volume of air intake through the nose.

The upper right permanent canine was 1 mm crowded when it was erupting (Fig. 3a) and was guided into place successfully (Fig 3b). Figure 4 shows the final occlusion and Fig. 5 shows the second and last appliance used (Occlus-o-Guide®) which is also being used as a retainer to maintain the correction as well as to prevent snoring and open-mouth nighttime breathing. Initially, the patient had closed deciduous incisal spaces (upper and lower) and now has an ideal occlusion with sufficient space for all of

Measures of the Antero-Posterior Pharyngeal Space

Measure	Norm Control mm	Airway Resistance	P-Value	Z-Score	Age	Sample Size
Lower 1/3 of uvula to posterior pharyngeal wall *	7.4 ± 2.89	4.6 ± 2.09 Upper airway measure	< 0.01	-1.18	7.3	70.17
Lowest point on uvula to posterior pharyngeal wall *	9.6 ± 3.39	5.4 ± 3.20 Upper airway measure	< 0.01	-1.18	7.3	70.17
Base of tongue to posterior pharyngeal wall **	14.2 ± 0.9	9.8 ± 0.7 Adenoid facies mouth breathing day & night	< 0.001	-4.89	8.6	13.11

Table 3

* Pirila-Parkkinen et al, 2010 (29)
** Finkelstein et al, 2000 (30)

Abnormal Limits of Common Cephalometric and Dental Measures for Sleep-Disordered Breathing in 7 Year-Old Child

Measure	Male	Female	Abnormal Limits ± 2 S.D. Males	Abnormal Limits ± 2 S.D. Females	N Male, Female
SN – Go Me *	32.5° ± 3.57	31.4° ± 4.9	3.96°	41.2°	25, 20
ANS – Me *	56.8 mm ± 3.4	52.9 mm ± 3.11	63.6 mm	59.1 mm	25, 20
Ar – GoGn **	130.5° ± 4.7	130.0° ± 4.3	139.9°	138.6°	44, 31
Ba – A **	94.3 mm ± 4.20	92.0 mm ± 4.50	85.9 mm	83.0 mm	44, 31
Ba – B **	96.9 mm ± 3.60	94.5 mm ± 5.00	89.7 mm	84.5 mm	44, 31
Maxillary Bi-Canine Arch Width ***	28.7 mm ± 2.05	27.99 mm ± 2.04	24.6 mm	23.9 mm	49, 52
Maxillary Bi-Molar (1st adult) Arch Width ***	42.37 mm ± 2.25	41.54 mm ± 2.60	37.9 mm	36.3 mm	49, 52
Overjet **	2.49 mm ± 1.73	2.30 mm ± 1.21	6.0 mm	4.7 mm	16, 20
Palatal Height at Most Posterior of Medium Raphe ***	12.18 mm ± 2.28	11.62 mm ± 2.39	16.7 mm	16.4 mm	95, 88
Go-Po **	68.9 ± 3.00	67.9 mm ± 3.90	62.9 mm	60.1 mm	44, 31
A-N-B **	5.0° ± 2.3	5.7° ± 2.7	9.6°	11.1°	44, 31

* From Bergersen, Denver Growth Sample, Unpublished Data (31)
** From Riolo et al, 1974, An Atlas of Craniofacial Growth (32)
***From Moyers et al, 1976, Standards of Human Occlusal Development (33)

Table 4

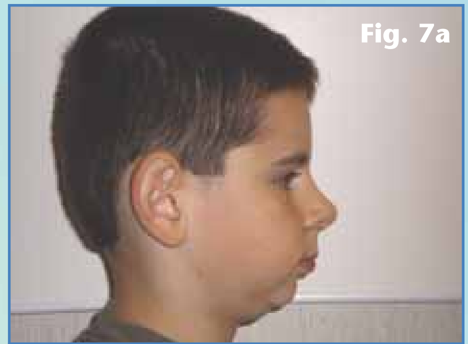

Fig. 7a

Fig. 7b

Fig. 5

the teeth.

Morphologic and Dental Symptoms in Analyzing for Sleep-Disordered Breathing

Cephalometric measures of the pharyngeal spaces (Fig. 6) consist of 4 easily-traced dimensions[29] and their mean amounts are found in Table 3.[29,30] Other meaningful cephalometric[31,32] and dental[32,33] measures are found in Table 4. A review of the cephalometric data between normal and those with breathing problems[9,30,34,35] is found in Table 5, while the dental measure of similar comparisons[36,11] are found in Table 6. The dental measures, however, have fairly low confidence levels with the exception of Class II molars (P = < 0.004).[36]

An example of a rather typical patient that is suspected of having a breathing problem (Fig. 7a) because of an excessive overjet and small mandible. The author (Miraglia) uses the lack of definition of the posterior portion of the mandibular plane, as a diagnostic symptom and can be seen in the initial profile. This patient is 10.7 years of age and is a habitual day and night mouth breather and snorer which may

Fig. 8a

Fig. 8b

have contributed to the lack of forward growth of the mandible. An Occlus-o-Guide® preformed appliance was issued to the patient and within a few months he converted to daytime and nighttime nose breathing. He wore the appliance for 1 to 3 hours daily for 20 months and then wore the same appliance as a retainer at night until he was 14.5 years of age. The final profile is seen in Fig. 7b.

In a study by Keski-Nisula et al[37] on 115 patients with a control sample of 104 cohorts found that the mandible grew 11.1 mm in the

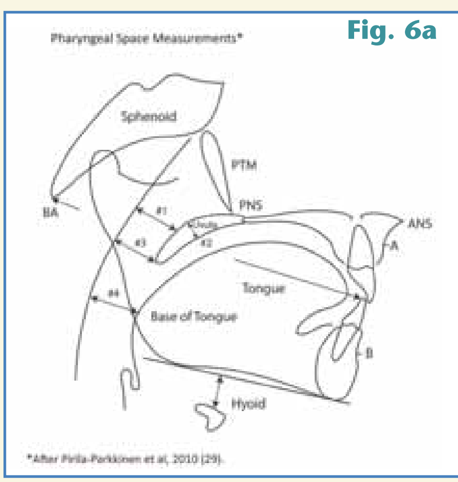

Fig. 6a

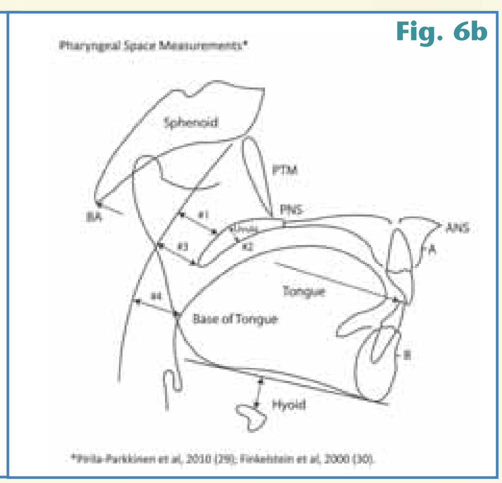

Fig. 6b

Important Cephalometric Measures for Various Breathing Problems

Measure	Control	Breathing Problems	P-Value	Age – Yrs.	Sample Size
Mand. plane angle * SN – mand. line	32.9°	38.5° enlarged tonsils	< 0.001	10/10.1 yrs.	73/71
Total face height * N – GN	106.0 mm.	111.5 mm. enlarged tonsils	< 0.001	10/10.1 yrs.	73/71
Mandibular length ** G0 – GN	58.9 mm ± 1.5	67.3 mm. ± 2.2 habitual snorers	< 0.007	8.6 yrs.	13/11
Gonial angle ** AR – GOGN	127.1 mm. ± 1.4	135.8 mm. ± 1.9	< 0.001	8.6 yrs.	13/11
Base of tongue to Post. pharynx wall **	8.9 mm. ± 1.1	14.2 mm ± 0.9 habitual snorers	< 0.001	8.6 yrs.	13/11
Mand. Plane to ** hyoid bone	16.4 mm. ± 1.7	12.2 mm. ± 1.5 habitual snorers	< 0.02	8.6 yrs.	13/11
Low incisal edge to *** post phargy wall along occl. plane	80.4 mm. ± 6.2	74.7 mm. ± 5.8 OSA	< 0.001	5.8 yrs.	17
Lower face height **** ANS – Me	58.8 mm. ± 3.97	63.0 mm. ± 4.9 large adenoids	< 0.001	9.3 yrs.	15/17

* Behlfelt et al, 1990 (9)
** Finkelstein et al, 2000 (30)
*** Zettergren et al, 2006 (34)
**** Adamales et al, 1983 (35)

Table 5

Incidence of Dental Symptoms in Those without and with Snoring and Sleep-Disordered Breathing (SDB) in Children 7.2 Years of Age*

Dimensions	Control Sample N= 41	Snorers & with Sleep Disordered Breathing N= 41	P-Value
Class II molars	4.9%	36.6%	0.004
Lateral cross-bite**	10.4%	31.8%	0.04
Overjet	2.6 mm.	3.7 mm.	0.05
Dec. canine-canine maxilla	31.2 mm.	30.4 mm.	0.05
De. 2nd molar – 2nd molar maxilla	35.5 mm.	34.2 mm.	0.05
Mandibular dec. arch length	26.8 mm.	26.1 mm.	0.05
Open-bite anterior	6.0%	12.2%	0.06
Mandibular crowding	26.8%	36.6%	0.38
Scissors bite	6.0%	8.9%	0.50
Maxillary crowding	4.8%	17.1%	0.55
Class I molars**	79.2%	86.4%	0.58
Overbite, excessive	2.6 mm.	2.1 mm.	0.05

*From Pirila-Parkkinen et al, 2009. All data except those marked ** (36)

** From Lofstrand-Tidestrom et al, 1999. Control Sample N=48, Symptomatic Sample N = 22 (obstructed) (11)

Table 6

treatment sample and 7.2 mm in the control sample for a 54.2% of increase due to increased mandibular growth over a 3½ year period, as a result of mandibular advancement by the Occlus-o-Guide® appliance. The initial cephalometric radiograph (Fig. 8a) indicated that the base of the tongue to the posterior wall of the pharynx was 3 mm, while the later film (Fig. 8b) indicated the opening to be 10 mm for an increase of 7 mm. Considering the possible increase of the pharyngeal space with growth, which is 3.3 mm. for the naso-pharynx[38] over the same age period, one might assume the same increase to be occurring in the distance from the base of the tongue to the posterior pharyngeal wall, the patient would still have had an increase of 3.7 mm. for a total space of 6.7 mm.

Since the genio-glossus muscle of the tongue arises from the genial tubercle of the mandible, any advancement of the mandible pulls the tongue forward away from the throat which opens the airway of the oropharyax. Also, the elimination of the patient's habitual daytime mouth breathing and replacement with normal nasal breathing might be helpful in increasing the nasal airway as well.

Review

Habitual snoring is probably the most reliable observable symptom and is ideally followed by a night home study. If apneic events and lowered blood oxygen are detected, then a polysomnograph would be indicated. Individual U.S. states and other countries offer varying restrictions on the treatment of sleep-disordered breathing and apnea problems and it is recommended that these possible restrictions, if applicable, should be researched before treating those cases suspected of having these severe problems. The general and pediatric dentist, however, are often the first in line to diagnose the breathing problems, and as a result, can also be the one to initiate interceptive procedures that can greatly benefit the young patient.

The incidence of habitual snoring is less in a child than in an adult. The frequency in a child has been reported to be 10%,[6,12,39] while in the adult it is 23%.[40] Even a child with an incidence of 10% should warrant serious attention considering its future implications with various behavioral problems. The four of these behavioral symptoms that are probably the most important are hyperactivity, daytime mouth breathing, daytime sleepiness, and attention deficit. Also of primary importance is to check the tonsils and adenoids for unusual swelling. The most important cephalometric and dental measures are found in Table 4, while their relation to various breathing problems are listed in Table 5 and 6.

Once a decision is made that a breathing problem might exist, a home night study would be indicated. Such a simple device can monitor a child while they sleep and will record the type and severity of apneic events, oxygen desaturation, snoring, number of breaths, pulse rate and volume of air intake. If serious problems exist (particularly with lowered oxygen levels and apneic events) it is recommended that the child have an overnight sleep study with a medical specialist. If the problem is less severe, an appliance or orthodontic procedure can be recommended that would advance the mandible (if the overjet allows it), and enlarges the upper arch to improve air intake and proper nasal breathing. These procedures should greatly improve a child's health and well-being. Such a case should be seen for a few years to monitor its future stability.

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Orthodontic Intervention in the Early Mixed Dentition: A Prospective, Controlled Study on the Effects of the Eruption Guidance Appliance

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Orthodontic intervention in the early mixed dentition: A prospective, controlled study on the effects of the eruption guidance appliance

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Introduction: A prospective, controlled cohort study was started in 1998 to investigate the effects of orthodontic treatment in the early mixed dentition with the eruption guidance appliance. **Methods:** Occlusal changes were recorded in 167 treated children and 104 controls after they had reached the middle mixed-dentition stage. Treatment began when the first deciduous incisor was exfoliated (T1) and ended when all permanent incisors and first molars were fully erupted (T2). The children's mean ages were 5.1 years (SD 0.5) at T1 and 8.4 years (SD 0.5) at T2. **Results:** From T1 to T2, overjet in the treatment group decreased from 3.1 to 1.9 mm and overbite from 3.2 to 2.1 mm. In the control group, overjet increased from 2.9 to 4.1 mm and overbite from 3.3 to 4.1 mm. At T2, the differences between the groups were highly significant ($P < .001$). At T1, 18% of the children in the treatment group and 22% of the controls had tooth-to-tooth contact between the maxillary and mandibular incisors. All others had an open bite, or the mandibular incisors were in contact with the palatal gingiva. At T2, tooth-to-tooth contact was observed in 99% of the treated children and 24% of the controls ($P < .001$). Almost half of children in both groups showed incisor crowding at T1. Good alignment of the incisors was observed in 98% of the treated children at T2, whereas maxillary crowding was found in 32% and mandibular crowding in 47% of the controls ($P < .001$). At T1, 41% of the children in the treatment group and 53% of the controls had a Class I relationship; the rest had either a unilateral or a bilateral Class II relationship. At T2, a Class I relationship was found in 90% of the treated children and 48% of the controls ($P < .001$). At least 1 occlusal deviation, including overjet ≥ 5 mm, overbite ≥ 5 mm, open bite, gingival contact of the mandibular incisors, crowding, or Class II relationship, was observed in 13% of the treated children, but the deviations were mild, and no child was considered to need treatment. In the control group, 88% of the children showed at least 1 occlusal deviation ($P < .001$). **Conclusions:** Treatment in the early mixed dentition with the eruption guidance appliance is an effective method to restore normal occlusion and eliminate the need for further orthodontic treatment. Only a few spontaneous corrective changes can be expected without active intervention. (Am J Orthod Dentofacial Orthop 2008;133:254-60)

Timing of treatment is a controversial area in orthodontics. Opinions among clinicians show great diversity; some recommend intervention in the early stages of occlusal development, and others argue in favor of treatment in the late mixed or early permanent dentition. It has been suggested that, although almost all types of malocclusion could benefit from early treatment, the effectiveness of intervention depends on malocclusion.[1] For example, treatment of posterior crossbite in the deciduous or early mixed dentition is generally considered more beneficial than early correction of a Class II relationship. The main reason for the controversy seems to be that our present knowledge about the timing of treatment is largely based on clinical experience and reflects various approaches and clinical traditions of orthodontic practice. Scientific evidence is limited, and few studies have specifically targeted questions about the effects of early treatment.

Clinical trials in the United States[2-4] and the United Kingdom[5] focused on the effectiveness of 2 alternative treatment modalities in Class II treatment. In these

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trials, 2-phase treatment that included an early growth modification phase and a second phase was compared with single-phase treatment in the early permanent dentition. The results showed that, apart from improved self-esteem, only minor benefits were obtained by the early treatment phase.[6] These studies provided valuable scientific evidence for clinical decision making, particularly when considering 2-phase treatment protocols. However, only a few treatment modalities and appliances were studied, and any generalizations drawn from the results should be limited to these. For example, rather low forces were used in the activation of the headgear. A similar growth-modification phase with higher orthopedic forces could have resulted in better and more consistent effects, as indicated by the findings of Kirjavainen et al[7-9] and Mäntysaari et al.[10] Furthermore, only a few of the children in the trials started the growth modification phase in the early mixed dentition.[2-5] Many questions therefore remain about the effectiveness of orthodontic intervention in the mixed dentition.

In Finland, where orthodontics is included in the public dental care, treatment modalities that emphasize early intervention are becoming increasingly popular.[11-13] After screening of malocclusions in the deciduous dentition, treatment is frequently started in the early mixed or, in some cases, even in the late deciduous dentition; appliances typically include expansive arches, orthopedic headgear, activators, and activator-type appliances.[12] Clinical experience suggests that systematic early intervention offers advantages in a publicly funded health care system. For example, treatment can be offered to more children without extra manpower or cost increases.[12,13] Recently, the eruption guidance appliance has been used more often in the orthodontic clinics focusing on early treatment.[12] This appliance has many indications and has been found to be effective in the treatment of many malocclusions including crowding, deepbite, excessive overjet, and distal bite. In addition, the eruption guidance appliance normally requires only minimal adjustments, allowing less chair-side time and longer intervals between check-ups. Furthermore, retention can be carried out with the same appliance as the treatment. Clinical experience indicates good and stable results.

A clinical investigation was started in 1998 in 2 municipalities in western Finland, Jalasjärvi and Kurikka. Orthodontic care in the dental clinics of these cities is based on comprehensive early treatment; most patients are treated in the early mixed dentition with the eruption guidance appliance as the main therapeutic device. Children with a skeletal Class III relationship and those with a posterior crossbite are usually treated in the deciduous dentition, the former with a combination of expansive appliance and facemask, and the latter with a quad-helix appliance. Other appliances—eg, Van Beek activator—are used occasionally.

Our goal in this prospective, controlled cohort study was to investigate the treatment effects of the eruption guidance appliance. Early treatment was studied in a real-world situation where the established treatment protocols were followed with only minor adjustments, mainly to ensure timely and controlled data collection. Ethical, practical, and financial restrictions prevented random assignment of the participants into treatment and follow-up groups in each municipality. The neighboring town of Seinäjoki, where orthodontic treatment is not given until the late mixed dentition, agreed to provide untreated control subjects for the study. Matching of the treatment and control groups was achieved by using large unselected and representative samples.

We describe the occlusal findings in 167 children treated in the early mixed dentition using the eruption guidance appliance as the only therapeutic device. The treatment effects were compared with the spontaneous changes in the occlusion of 104 control children during the same period—ie, the period that started when the first deciduous incisor was exfoliated (T1) and ended when all permanent incisors and first molars were fully erupted (T2).

MATERIAL AND METHODS

The treatment group was derived from the entire 1992 and 1993 age cohorts in Jalasjärvi (population, 9000) and the 1992 age cohort in Kurikka (population, 11,000). All children were screened in the late deciduous dentition, and a full clinical examination was made at the onset of the mixed dentition period of those who were considered to potentially need treatment. Children with at least 1 of the following occlusal characteristics were included: (1) distal step of $\geq$1 mm, (2) Class II canine relationship of $\geq$1 mm, (3) crowding, (4) overjet of $\geq$3 mm and lack of tooth-to-tooth contact between the incisors, (5) overbite of $\geq$3 mm and lack of tooth-to-tooth contact between the incisors, (6) anterior crossbite, and (7) buccal crossbite (scissorsbite).

The number of children fulfilling these criteria was 315. Of them, 33 were treated with other appliances, mainly the quad-helix, and they were excluded from the study sample. In 27 cases, the child or the family refused orthodontic treatment. Treatment with an eruption guidance appliance was started in 255 children. During the treatment, 12 children moved to another municipality and could not complete the treatment; their records were excluded from the analysis. Of the remaining 243 children, 167 completed the treatment successfully.

Seventy-six children (31%) were excluded from the study because they did not wear the appliance. The reasons for difficulties in cooperation were mostly psychosocial. In these patients, treatment was terminated when it became clear that the children did not cooperate, usually within a few months after starting treatment. In 3 patients, a serious illness prevented the completion of the orthodontic treatment. No further records of these children were collected or included in the analyses.

A random sample of 104 children from the same 1992 and 1993 age cohorts in Seinäjoki (population, 30,000) who fulfilled the inclusion criteria formed the control group. The ethnic background of all children in the treatment and control samples was Finnish. All were healthy, and none had had earlier orthodontic treatment. All treatment and control children and their parents were free to decline their participation in the study at any time.

The timing of all examinations and interventions throughout the study was based on each child's stage of dental development rather than on chronologic age. The treatment began immediately after the clinical examination at T1, the beginning of the mixed dentition period, defined as the time immediately after the exfoliation of the first deciduous tooth. The evaluations of the occlusal changes in the treatment and control groups were made at T2, after full eruption of all permanent incisors and first molars. At this point, the early treatment group entered the retention period, and treatment was started in the control group.

We analyzed the occlusal changes from T1 to T2 of 167 children in the treatment group (85 boys, 82 girls) and 104 children in the control group (52 boys, 52 girls). The mean ages in both groups were 5.1 years (SD 0.5) at T1 and 8.4 years (SD 0.5) at T2.

Two or 3 prefabricated eruption guidance appliances (Nite-Guide or Occlus-o-Guide; Ortho-Tain, Winnetka, Ill) were used in each patient (Fig). A Nite-Guide was the first appliance in only a few patients whose first permanent molars had not yet started to erupt. The appropriate size of the appliance was determined as recommended by the manufacturer. The appliances were worn during the night only. If difficulties were encountered, daytime wear of 1 hour was recommended until the problems with night wear disappeared. Active treatment was defined as the time between T1 and T2. The average duration of active treatment was 3.3 years. At T2, all treated children entered the retention period, when the last of the 2 or 3 appliances was used as a retainer, 2 nights a week. The retention was to be continued until all permanent canines, premolars, and second molars were fully erupted. Appointments were every 12 weeks during the active period and once every 6 months during the retention period.

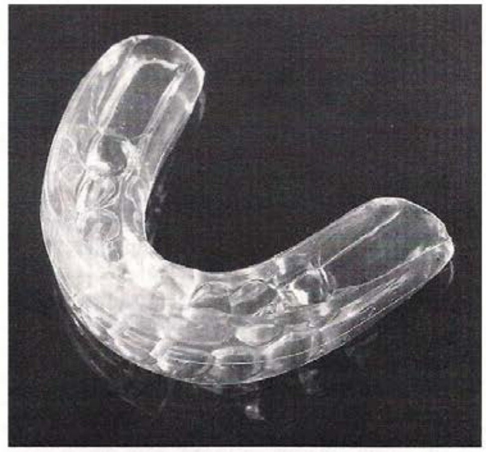

Fig. Eruption guidance appliance (Occlus-o-Guide).

Full clinical examinations, including collecting of dental casts, of all children were carried out at T1 and T2. Overbite and overjet were measured directly in the mouth with the mandible manipulated in centric relation as described earlier.[14] The measurement was taken between the mandibular and maxillary right central incisors, as suggested by Moorrees,[15] by using a metal ruler with accuracy of 0.1 mm. The values for overbite in the deciduous dentition were not corrected for incisal wear. The type of contact of the mandibular incisors to the maxilla was also registered directly in the mouth with the mandible in centric relation; it was classified as *tooth-to-tooth contact* when contact with the maxillary incisors was established, *gingival contact* when the mandibular incisors contacted the palatal gingiva or mucosa, and *open contact* when an open bite was present. Crowding in the anterior segment was assessed from the dental casts by registering overlapping teeth. The terminal plane relationship was measured from the dental casts, trimmed to centric relation, between perpendicular projections, on the occlusal plane, from the distal surfaces of the maxillary and mandibular second deciduous molars as suggested by Bishara et al.[16] A child was considered to have a Class II relationship with a distal step of $\geq$1 mm. The terminal plane relationship of the second deciduous molars was used

Table I. Overjet and overbite at T1 and T2

	Treatment group (n = 167)		Control group (n = 104)			
	Mean	*SD*	*Mean*	*SD*	P	*95% CI*
Overjet						
T1	3.1	1.4	2.9	1.8	>.05	–0.19 to 0.63
T2	1.9	0.7	4.1	1.9	<.001	–2.51 to –1.76
Overbite						
T1	3.2	1.7	3.3	1.9	>.05	–0.55 to 0.35
T2	2.1	0.9	4.1	1.3	<.001	–2.41 to –1.62

to classify the occlusion as Class I or Class II at T1 and T2. Analogously, the distance from the tip of the maxillary canine to the contact point between the mandibular canine and first molar on the occlusal plane was measured.

All dental assessments and measurements were performed by the first author (K.K.N.). The measurements were made with a digital caliper to the nearest 0.01 mm. Method error for the measurements, assessed by means of the standard error of a single determination on repeated measurements of 30 randomly selected subjects, was 0.14 mm.[17] In the statistical assessment, the chi-square test and the *t* test were used. *P* values less than .05 were considered statistically significant.

RESULTS

At T1, overjet varied from −2 to 10 mm and overbite from −3 to 7 mm; no statistically significant difference was found between the groups (Table I). Changes in overjet from T1 to T2 were −1.2 mm (SD 1.6) in the treatment group and 1.2 mm (SD 1.5) in the control group. The difference in overjet between the groups from T1 to T2 was highly significant ($P < .001$). Changes in overbite from T1 to T2 were −1.1 mm (SD 1.9) in the treatment group and 0.9 mm (SD 1.3) in the control group; this difference was highly significant ($P < .001$).

The contact point of the mandibular incisors was registered at centric relation at T1 and T2. At T1, tooth-to-tooth contact was found in 30 children (18%) in the treatment group and 23 children (22%) in the control group; all others had an open bite, or the mandibular incisors were in contact with the maxillary gingival or palatal mucosa. At T2, 165 of the treated children (99%) and 25 control children (24%) showed tooth-to-tooth contact between incisors ($P < .001$). In the treatment group, 50 children (30%) had gingival contact, and 86 (51%) had an open bite at T1. At T2, a mild open bite persisted in 2 treated children. In the control group, the situation did not change significantly from T1 to T2. Gingival contact was observed in 50 control children (48%) at T1 and in 42 (40%) at T2. The respective figures for open bite were 31 (30%) and 37 (36%).

Table II. Incisor crowding at T1 and T2

	Treatment group (n = 167)	Control group (n = 104)	P
Maxilla			
T1	19 (11%)	9 (9%)	>.05
T2	3 (2%)	33 (32%)	<.001
Mandible			
T1	80 (48%)	46 (44%)	>.05
T2	2 (1%)	49 (47%)	<.001

The treatment and control groups showed similar figures for crowding at T1 (Table II). At T2, all but 4 children in the treatment group showed well-aligned incisors; mild crowding was still present in the mandible of 1 child, in the maxilla of 2 children, and in both jaws of 1 child. The control children had significantly more crowding at T2 ($P < .001$).

The mean sagittal relationship of the canines at T1 indicated a Class II tendency in both groups: 1.6 mm (SD 1.5) in the treatment group and 1.4 mm (SD 1.7) in the control group. The difference was statistically nonsignificant ($P = .25$; 95% CI −0.12 to 0.44). At T2, the canine relationship had decreased to 0.2 mm (SD 0.7) in the treatment group but remained at 1.4 mm (SD 1.6) in the control group. The difference at T2 was highly significant ($P < .001$; 95% CI −1.49 to −1.04).

The mean terminal plane relationship at T1 showed a slight distal tendency in both groups: 0.7 mm (SD 1.7) in the treatment group and 0.5 mm (SD 1.7) in the control group. The difference was not statistically significant ($P = .20$; 95% CI 0.2 to 0.48). At T2, the terminal plane relationships had changed to −1.3 mm (SD 1.2) in the treatment group and 0.4 mm (SD 1.9) in the control group. The difference at T2 was highly significant ($P < .001$; 95% CI −1.91 to −1.34). The numbers of children with Class I, Class I/Class II, and Class II relationships are shown in Table III. The

Table III. Sagittal relationship of the posterior segments at T1 and T2

	Treatment group (n = 167)	*Control group (n = 104)*	P
Class I			
T1	68 (41%)	55 (53%)	>.05
T2	151 (90%)	50 (48%)	<.001
Class I/II			
T1	33 (20%)	18 (17%)	>.05
T2	11 (7%)	18 (17%)	<.001
Class II			
T1	66 (40%)	31 (30%)	>.05
T2	5 (3%)	36 (35%)	<.001

Table IV. Frequencies of deviating occlusal characteristics at T2

	Treatment group (n = 167)	*Control group (n = 104)*
Overjet ≥5 mm	0 (0%)	31 (30%)
Overbite ≥5 mm	1 (1%)	40 (38%)
Open bite	2 (1%)	37 (36%)
Gingival contact of mandibular incisors	0 (0%)	42 (40%)
Maxillary crowding	3 (2%)	33 (32%)
Mandibular crowding	2 (1%)	49 (47%)
Unilateral Class II	11 (7%)	18 (17%)
Bilateral Class II	5 (3%)	36 (35%)

The difference in the distribution of the characteristics between the groups is highly significant ($P < .001$).

distribution in the treatment and control groups was not significantly different at T1 ($P = .14$). A highly significant difference was found at T2 ($P <.001$).

Table IV shows the frequencies of deviating occlusal characteristics, including overjet ≥5 mm, overbite ≥5 mm, open bite, gingival contact of the mandibular incisors, crowding, and Class II relationship at T2. The numbers of children in the treatment and control groups with at least 1 deviation in the middle mixed dentition were 22 (13%) and 91 (88%), respectively.

DISCUSSION

The guidelines for orthodontic treatment at the dental clinics of Jalasjärvi and Kurikka are designed to outline a comprehensive early treatment protocol. Potential malocclusion cases are screened and diagnosed in the deciduous dentition. Depending on the type of the malocclusion, treatment is started either in the deciduous dentition or at the beginning of the mixed dentition. A similar approach to early treatment was described by Dugoni,[18] although the suggested time to start the treatment was later in the mixed dentition, between 7 and 9 years of age. Early diagnosis of malocclusions is largely based on the deciduous occlusion, and, in most cases, it is straightforward.[14] Early treatment at Jalasjärvi and Kurikka is intended to be 1 phase—ie, the treatment plan does not normally include a second phase of treatment. Conditions that cannot be detected early, such as congenitally missing premolars, ectopically erupting molars, and impacted canines are diagnosed and treated later.

Our findings indicate that significant improvement in the occlusion was achieved with early intervention. After reaching the middle mixed-dentition stage, most treated children showed favorable intermaxillary relationships in the incisor, canine, and molar segments. Overbite and overjet were both close to 2 mm, the incisors had tooth-to-tooth contact and good alignment, a mesial step was established in the molar region, and the canines showed almost full Class I relationships. As shown by Table IV, the need for further treatment had markedly decreased through the intervention. Only 22 (13%) of the 167 children in the treatment group had persisting mild deviations. None of these children was considered to need further treatment at this point. In the control group, on the other hand, 92 (88%) of the 104 children had at least 1 deviating occlusal characteristic. Early orthodontic intervention is frequently opposed on the basis of findings that occlusal development can show spontaneous correction in a growing child.[15] However, the results in the control group indicate that this is the exception rather than the rule. During the observation period from early to middle mixed dentition, the frequencies of the occlusal deviations remained relatively unchanged in the control group.

In our sample, the time from T1 to T2 was 3.3 years. Because the eruption guidance appliance was used to guide the erupting permanent teeth to their correct positions in the dental arches, the length of the active treatment period was the same. On the other hand, the total chair-side time that was required for the completion of the treatment was relatively short because routine checkups, every 12 weeks, normally took no more than 5 to 10 minutes each. An advantage of the eruption guidance appliance is that it not only guides the eruption of the teeth but also simultaneously acts on the transversal, sagittal, and vertical relationships of both dental arches.

Several attempts were previously made to reduce or eliminate malocclusion by early interceptive measures with and without appliance therapy.[13,19-23] Although all investigations reported beneficial effects, the results were variable, probably reflecting the diversity of the interceptive protocols and the wide age ranges of the children. Two studies were carried out in countries where orthodontic treatment is publicly subsidized.[13,23]

Those findings indicated that early interceptive measures, when applied in the community, can result in significant reductions in treatment needs.[13,23] A similar but even more extensive improvement of the occlusion was observed in our study.

The prefabricated eruption guidance appliance we studied has wide treatment indications, but it is usually recommended for mild to moderate malocclusions only.[24] However, clinical experience has shown that, if treatment is started in the early mixed dentition, the severity of the malocclusion seldom appears to be a contraindication. At this stage of occlusal development, almost all cases can be considered as mild or moderate and are therefore suitable for treatment with the appliance. The eruption guidance appliance is designed to guide the erupting teeth into the correct positions before the fibers of the periodontal ligament mature.[25] By starting active treatment at the onset of the mixed dentition period, as in this investigation, the action of the appliance can be exerted on all permanent incisors and first molars.

Although the effectiveness of the eruption guidance appliance is not limited to the period of active eruption, clinical experience indicates that treatment tends to become more complicated if it is started later.[26] After maturation of the periodontal ligament, daytime wear is regularly needed to achieve the desired effect because tooth movement requires higher forces and longer treatment times. Often, combined treatment with other appliances such as headgear, rapid palatal expansion, or fixed appliances might be necessary.[27] On the other hand, if treatment is carried out during the active eruption of the teeth, the appliance seems to be effective in most patients.

Parental guidance and support are always essential when treating young children with removable appliances, particularly at the beginning of the treatment. Of the children in this study who completed the treatment successfully, 4 had problems with the appliance at the beginning, but they overcame the difficulties quickly. On the other hand, treatment of 76 children (31%) had to be discontinued because of persistent problems with compliance, because either the child was not willing to wear the appliance or the parents were not motivated enough to support the child. Various psychosocial disturbances in the families of these children were the main reasons for poor cooperation. Our rate of noncompliance was somewhat higher than reported for the Twin-block appliance[5] and about the same as the Fränkel appliance.[2] It has been suggested that young age of the patients would be a major limiting factor for early treatment in the community.[28] Our findings indicate that family background seems to be the single most important factor affecting compliance, not the age of the patients per se. In spite of problems with cooperation, 43% of the children of the entire 1992 and 1993 age cohorts in Jalasjärvi and Kurikka were successfully treated with the eruption guidance appliance.

Intervention in the early mixed dentition with the eruption guidance appliance appears to be an effective method to reduce the need for orthodontic treatment. Clinical experience indicates that, with proper retention, treatment results remain good with little or no relapse. However, the long-term effectiveness of this treatment modality can be assessed only after the retention period and the out-of-retention follow-up.

CONCLUSIONS

The results indicate that orthodontic intervention with the eruption guidance appliance in the early mixed dentition is an effective treatment modality for malocclusions with Class II or Class II tendency, excess overjet, deepbite, open bite, crowding, anterior crossbite, or buccal crossbite. During the treatment, the erupting permanent incisors and first molars were guided into their correct positions in the dental arches. At the same time, intermaxillary relationships in the incisor, canine, and molar segments were largely corrected. During the observation period, only a few spontaneous corrective changes occurred in the control children. By the time the children reached the middle mixed dentition, little treatment need was left in the treatment group compared with the control group, where deviating occlusal characteristics were commonly observed.

We thank the staff, the patients, and their parents at the health centers of Jalasjärvi, Kurikka, and Seinäjoki for their cooperation and assistance.

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A Summary of "Orthodontic Intervention in the Early Mixed Dentition: A Prospective, Controlled Study on the Effects of the Eruption Guidance Appliance".

Keski-Nisula, K., Hernesnieml, R, Heiskanen, M., Keski-Nusula, L., & Varrela, J. Am. J. Orthod. & Dentof. Orthop., 133; 254-260, 2008.

(A study of the Nite-Guide® technique from 5 to 8½ years of age)

Sample size: Treatment Sample = 167 (85 males, 82 females).
Control sample = 104 (52 males, 52 females)

No statistical differences between groups at 5.1 years of age. No fees to patients

Appliances worn only passively while sleeping. 69% Wore appliances to completion

Appointments: every 3 months at 5 to 10 min. each; every 6 months during retention.

Results: (all results at 8.4 yrs. significant $P < .001$).

		5.1 yrs	8.4 yrs
Maxillary crowding incidence	treatment	11%	2%
	control	9%	32%
Mandibular Crowding incidence	treatment	48%	1%
	control	44%	47%
Open-Bite incidence	treatment	51%	1%
	control	30%	36%
Overbite	treatment	3.2mm	2.1mm
	control	3.3mm	4.1mm
Overjet	treatment	3.1mm	1.9mm
	control	2.9mm	4.1mm
Class II Canine Relation	treatment	1.6mm	0.2mm
	control	1.4mm	1.4mm
Class II Terminal Plane Relation	treatment	0.7mm	-1.3mm
	control	0.5mm	0.4mm
Need for Treatment based on overbite & openbite	treatment		2%
	control		74%
Need for Treatment mandibular crowding	treatment		1%
	control		47%
Need for Treatment maxillary crowding	treatment		2%
	control		32%
Need for Treatment overjet ≥ 5mm	treatment		0%
	control		30%
Need for Treatment Overbite ≥ 5mm	treatment		1%
	control		38%
Need for Treatment of Class II	treatment		10%
	control		52%

Of Interest: Crowding, open bite, overbite, and overjet increased 5.1 to 8.4 yrs in control sample and decreased in the treatment group. ($P<.001$ at 8.4 yrs.)

Conclusions: The Nite-Guide® technique is an effective treatment modality for CL II tendency, overjet, overbite, open bite, crowding, anterior and posterior crossbite. Little treatment need was required at middle mixed dentition stage when compared to the control group. 13% had mild deviations at end of procedure – none needed further treatment.

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Original Article

Dentofacial Changes after Orthodontic Intervention with Eruption Guidance Appliance in the Early Mixed Dentition

Katri Keski-Nisula[a]; Leo Keski-Nisula[b]; Hannu Salo[c]; Kati Voipio[d]; Juha Varrela[e]

ABSTRACT

Objective: To evaluate skeletal and dentoalveolar changes induced by the eruption guidance appliance in the early mixed dentition.

Materials and Methods: Pre- and posttreatment cephalometric radiographs of 115 consecutively treated children, 62 boys and 53 girls, were compared with those obtained from a control group of 104 children, 52 boys and 52 girls. Pretreatment radiographs were taken at the deciduous-mixed dentition interphase (T1) and after full eruption of all permanent incisors and first molars (T2). The mean age of the children in both groups was 5.1 years at T1 and 8.4 years at T2.

Results: A significant difference between the groups at T2 was found in the mandibular length, midfacial length, and maxillomandibular differential. The increase in mandibular length was 11.1 mm in the treatment group and 7.2 mm in the control group. No differences were found in measurements of maxillary position or size. There was a significant shift toward a Class I relationship in the treatment group. Labial tipping and linear protrusion of the mandibular incisors was evident in the treatment group at T2. There was no effect on the inclination or position of the maxillary incisors.

Conclusions: Occlusal correction was achieved mainly through changes in the dentoalveolar region of the mandible. In addition, the appliance enhanced condylar growth resulting in a clinically significant increase in mandibular length. No effect was observed on maxillary position, maxillary size, inclination or protrusion of the maxillary incisors, or facial height.

KEY WORDS: Early treatment; Eruption guidance appliance; Cephalometry

INTRODUCTION

Large individual variation in children's growth patterns and growth potential is usually considered to favor an individualized approach in orthodontic therapy. However, attempts have been made to apply more generalized interceptive measures in the community to reduce or eliminate malocclusion.[1,2]

Väkiparta et al[2] studied the effects of an early treatment oriented orthodontic program for which a systematic screening at the age of 8 years was followed by early interceptive treatment. Examination of the children at the age of 12 years showed that the treatment need was significantly reduced. Al Nimri and Richardson[1] investigated the effectiveness of an interceptive program that targeted selected unfavorable features of the developing occlusion and showed that the change in the dental health component of the Index of Orthodontic Treatment Need (IOTN) was significantly greater in the treated children compared to the controls.[1]

Neither of the studies cited above[1,2] included Class II occlusion or Class II tendency to select children in the interceptive program. This seems to be in line with the recent findings suggesting that only minor benefits can be obtained by early treatment in Class II patients.[3–6] However, other studies have reported considerably better results after an early intervention.[7–9] A recent clinical trial investigated the occlusal effects of

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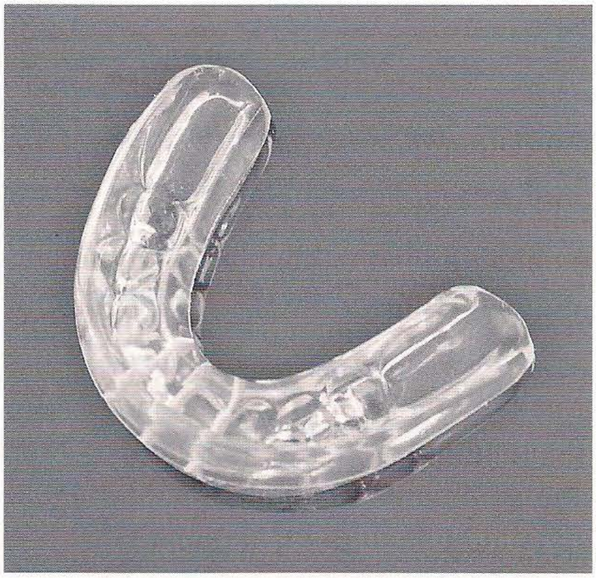

Figure 1. Prefabricated eruption guidance appliance (Occlus-o-Guide, Ortho-Tain Inc).

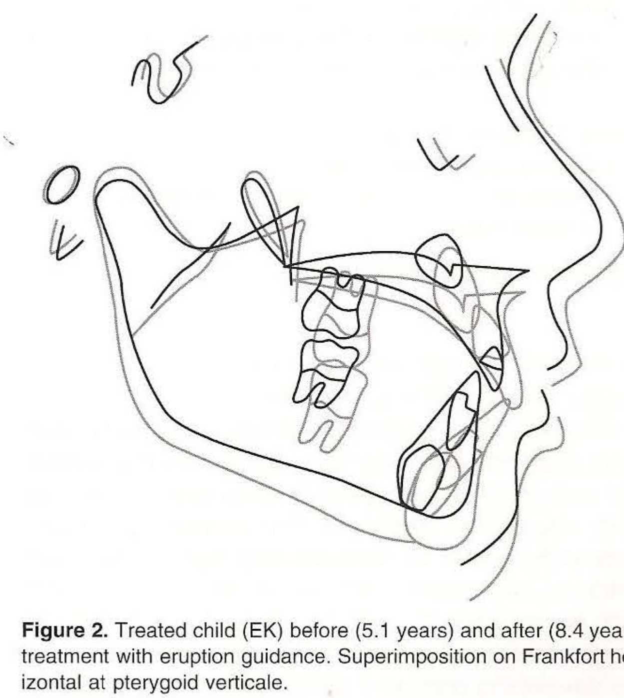

Figure 2. Treated child (EK) before (5.1 years) and after (8.4 years) treatment with eruption guidance. Superimposition on Frankfort horizontal at pterygoid verticale.

the eruption guidance appliance.[9] Complete age cohorts of children were screened in the deciduous dentition, and orthodontic intervention with the eruption guidance appliance was carried out in the mixed dentition in children showing a tendency to Class II occlusion, crowding, increased overjet or overbite with lack of tooth-to-tooth contact between the incisors, anterior crossbite, and/or buccal crossbite (scissors bite). A comparison with an untreated control group with similar malocclusions revealed that an efficient Class II

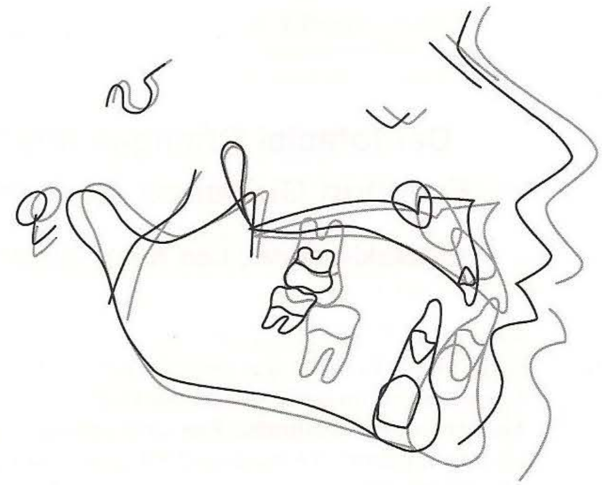

Figure 3. Treated child (JT) before (6.1 years) and after (8.9 years) treatment with eruption guidance. Superimposition on Frankfort horizontal at pterygoid verticale.

correction, along with a general normalization of the occlusal development, was achieved in the majority of the patients.[9]

The purpose was to cephalometrically analyze craniofacial and dentoalveolar morphology in children who had undergone orthodontic intervention with the eruption guidance appliance in the early mixed dentition.

MATERIALS AND METHODS

The study population was collected from three rural municipalities in western Finland: Jalasjärvi, Kurikka, and Seinäjoki. The treatment sample of 115 children was derived from the 1992 and 1993 age cohorts in Jalasjärvi and from the 1992 age cohort in Kurikka. All children in these age cohorts were screened during the late deciduous dentition period, and those diagnosed as needing treatment received a full clinical examination at the onset of the mixed dentition period.[10] Children were included in the treatment group if they showed one or more of the following occlusal characteristics: (1) distal step (≥1 mm), (2) Class II canine relationship (≥1 mm), (3) excess overbite (>3 mm and lack of tooth-to-tooth contact between the incisors), (4) deep bite (>3 mm with gingival contact of the incisors), (5) crowding, (6) anterior crossbite, and (7) scissors bite (buccal crossbite). The treatment group was treated using the eruption guidance appliance only (Figure 1). Children who had a moderately or severely constricted maxilla or a skeletal Class III relationship were first treated with an expansive arch and/or facemask. These children as well as those who refused the treatment or did not cooperate were excluded from the present analyses.[9] The mean active treatment time was 3.3 years (range 5.1 to 8.4 years).

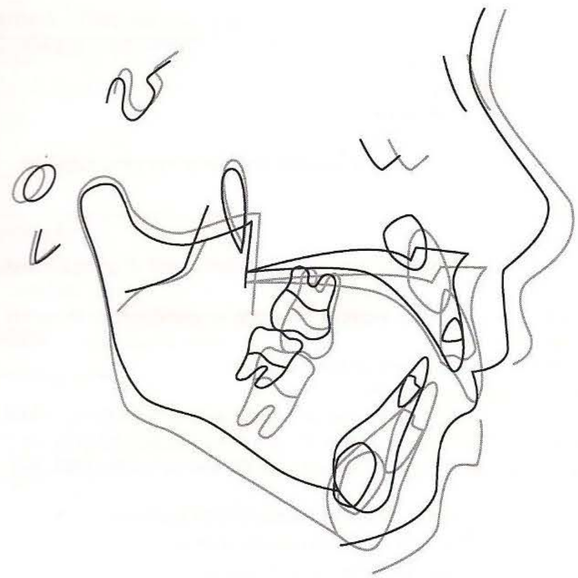

Figure 4. Control child (AJ) at T1 (6.3 years) and T2 (8.1 years). Superimposition on Frankfort horizontal at pterygoid verticale.

The control group was a random sample of 104 children from Seinäjoki (population 30,000) who fulfilled the same criteria, ie, they represented the 1992 and 1993 age cohorts, were screened during the late deciduous dentition period, and had similar occlusal deviations. The children in the control sample received a full clinical examination, including collection of dental casts and lateral cephalograms at the onset of the mixed dentition period; but their treatment was not started until the late mixed dentition in accordance with the treatment protocol that was followed in the dental clinics of Seinäjoki. The treatment and control samples were all healthy Finnish children and none had undergone orthodontic treatment previously. Children and their parents were free to decline participation in the study at any time.

The timing of the examinations and interventions was based individually on the stage of dental development of each child and not on chronologic age. Treatment was started at the beginning of the mixed dentition period, ie, when the first deciduous incisor was exfoliated (T1). Active treatment was completed after all permanent incisors and first molars were fully erupted (T2). The present investigation evaluates the skeletal changes that occurred from T1 to T2 in 115 consecutively treated children in the treatment group (62 boys and 53 girls) and 104 children in the control group (52 boys and 52 girls).

The mean age in both treatment and control groups was 5.1 years (SD ± 0.5) at T1 and 8.4 years (SD ± 0.5) at T2. During active treatment, each child wore two to three prefabricated eruption guidance appliances of different sizes (Nite-Guide or Occlus-o-Guide, Ortho-Tain Inc).[11] The appliances were worn during sleeping hours only. If difficulties were encountered, daytime wear of 1 hour was recommended until the problems with night-wear disappeared.[9] The average duration of active treatment was 3.3 years. At point T2 all treated children entered a retention period during which the last of the appliances was used as a retainer, two nights per week. The retention was continued until all permanent canines, premolars, and second molars were fully erupted. No further treatment was normally required or planned.

The lateral cephalograms were taken with standard cephalostats.[12] Computer assisted analysis of the cephalograms was carried out by the first author. The landmarks and measurements used in the analysis are listed in Table 1. The cephalometric assessment was carried out as described previously.[12] Occlusal characteristics were measured as described earlier.[10] The differences between the sample means were tested with Student's *t*-test. The relationships between continuous variables were further tested with simple linear regression and correlation analysis. A *P*-value difference $< .05$ was interpreted as statistically significant.

RESULTS

No statistically significant differences were detected between the treatment and control groups in the occlusal or cephalometric variables at the beginning of the study (Table 2). From T1 to T2, overjet and overbite decreased in the treatment group and increased in the control group (Table 2). In the treatment group, the sagittal relationship of molars improved by 1.9 mm and the canines by 1.5 mm. In the control group, the molar and canine relationship remained virtually unchanged showing a tendency to a Class II occlusion. Differences between the groups in overjet, overbite, and molar and canine relationship were statistically significant at T2.

In most skeletal variables an equal amount of growth took place in the treatment and control children during the observation period (Table 2). In addition, the growth direction of the mandible, measured by the facial axis angle, was similar on both groups. In midfacial length, mandibular length, and maxillomandibular differential, the treatment children showed a significantly greater increase compared with the controls. In mandibular length, the growth increment was 11.1 mm in the treatment group and 7.2 mm in the control group. The greater mandibular growth in the treatment group also largely explains the difference in midfacial length and the maxillomandibular differential. The Wits appraisal was significantly smaller in the treatment

Table 1. Landmarks and Measurements

Points	
Nasion (Na)	Anterior limit of the nasofrontal suture
Orbitale (Or)	Lowest point on external border of orbital cavity
Porion (Por)	Most superior point of external auditory meatus
Basion (Ba)	Most inferior posterior point of occipital bone at anterior margin of occipital foramen
Sella (Se)	Midpoint of sella turcica
Anterior nasal spine (ANS)	Tip of anterior nasal spine
Posterior nasal spine (PNS)	Tip of posterior nasal spine
Pt point (Pt)	Intersection of inferior border of foramen rotundum with posterior wall of pterygomaxillary fissure
Gonion (Go)	Intersection of line connecting most distal aspect of condyle to distal border of ramus and line at base of mandible
Condylion (Co)	Most posterior-superior point on head of mandibular condyle
Pogonion (Pog)	Most anterior point on mandibular symphysis
Menton (Me)	Most caudal point in outline of symphysis, formed at intersection of mandibular plane
Gnathion (Gn)	Cephalometric landmark formed by intersection of (1) tangent of most inferior point of symphysis and most inferior point of gonial region and (2) line connecting NA and Pog
Point CC (center of cranium)	Cephalometric landmark formed by intersection of Ba-Na and Pt-Gn lines
Point A	Deepest point of curve of maxilla between ANS and dental alveolus
Point B	Deepest point of curve of mandible between Pog and dental alveolus
PM (protuberance menti or supra pogonion)	Point selected where curvature of anterior border of symphysis changes from concave to convex
XI point	Point at geographic center of ramus
AI incisor	Incisal tip of maxillary incisor
BI incisor	Incisal tip of mandibular incisor
Planes and angles	
Maxilla to cranium	Distance from Point A to NA-perpendicular (constructed by dropping line vertically inferior to An and perpendicular to Frankfort horizontal); describes sagittal position of anterior border of maxilla to cranium
Mandible to cranium	Distance from Pog to NA-perpendicular; describes sagittal position of chin in relation to cranium
Anterior cranial length	Measured from Point CC to Na along the Ba-Na plane; describes length of anterior cranial base
Convexity	Point A to plane from Na to Pog; describes sagittal relation of maxilla to mandible
Lower facial height	Angle formed by XI-ANS plane and XI-Pog plane
Condylion to point A	Describes effective midfacial length
Condylion-gnathion	Describes effective mandibular length
Maxillomandibular differential	Difference between distance from Co to Point A and distance from Co to Gn; evaluates sagittal skeletal imbalance
Menton-ANS	Describes lower anterior face height
Facial axis angle	Angle formed by Point CC-Gn plane and Ba-Na plane; describes growth direction of mandible
Mandibular plane to Frankfort horizontal	Angle formed by mandibular plane and Frankfort horizontal; describes shape mandible
PNS-ANS	Measure of maxillary length
PNS-A	Measure of maxillary length
Interincisal angle	Angle formed by long axes of maxillary and mandibulary incisors
B1 to A-pogonion plane	Measured from tip of mandibular incisor to plane from Point A to Pog; describes protrusion of mandibular incisors
A1 to A-pogonion plane	Measured from tip of maxillary incisor to plane from Point A to Pog; describes protrusion of maxillary incisors
IMPA	Angle formed by long axis of mandibular incisor and mandibular plane; describes inclination of mandibular incisors
A1 to S-Na	Angle formed by long axis of maxillary incisor and Se-Na plane; describes inclination of maxillary incisors
Wits appraisal, mm	Distance between perpendicular projection from Point A to occlusal plane and perpendicular projection from Point B to occlusal plane (measured along the occlusal plane); evaluates horizontal skeletal relationship

Table 2. Occlusal and Cephalometric Variables in the Treatment and Control Groups at T1 and T2. The Differences Between the Groups at T1 Were Nonsignificant

	Treatment Group at T1		Control Group at T1		Treatment Group at T2		Control Group at T2		Difference Between Treatment and Control Group at T2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P*	95% Confidence Interval
Occlusal										
Overjet (mm)	3.0	1.4	2.9	1.8	1.9	0.6	4.1	1.9	<.001	2.7 to 3.5
Overbite (mm)	3.2	1.6	3.3	1.9	2.0	1.0	4.1	1.9	<.001	1.8 to 2.6
Molar relationship (mm)	0.6	1.7	0.5	1.7	−1.3	1.0	0.4	1.9	<.001	−2.0 to 1.4
Canine relationship (mm)	1.6	1.6	1.4	1.7	0.1	0.7	1.4	1.6	<.001	−1.5 to 1.0
Maxillary skeletal										
A/Na-verticale (mm)	−0.7	2.6	−0.4	2.5	−1.4	3.0	−1.2	2.8	.562	−1.0 to 0.6
Condylion-A (mm)	80.6	3.9	80.8	4.7	86.3	4.3	84.7	4.5	.010	0.4 to 2.7
SNP-SNA (mm)	46.8	2.5	47.6	2.5	49.8	2.9	49.7	2.5	.931	0.7 to 0.8
SNP-A (mm)	43.8	2.4	44.5	2.2	46.1	2.9	45.9	2.4	.565	0.5 to 0.9
Anterior cranial length (mm)	54.9	3.0	55.3	3.1	54.9	3.0	55.4	3.2	.277	1.3 to 0.4
Mandibular skeletal										
Pogonion/NA-verticale (mm)	−9.4	4.9	−8.5	4.2	−9.0	6.5	−8.0	5.8	.260	−2.6 to 0.7
Condylion-gnathion (mm)	96.9	5.1	98.2	5.9	108.0	5.4	105.4	5.8	<.001	1.2 to 4.1
Facial axis angle (°)	92.5	3.4	92.3	3.2	91.0	3.8	91.6	3.4	.235	1.6 to 0.4
Mandibular plane/Frankfort horizontal	24.6	4.9	24.2	4.9	27.6	18.0	24.4	5.2	.089	−0.3 to 6.6
Maxilla to mandible										
Maxillomandibular differential (mm)	16.3	3.2	17.3	3.6	21.8	3.2	20.7	4.0	.031	0.1 to 2.1
Convexity (mm)	4.6	1.9	4.3	2.1	3.2	2.3	2.9	2.3	.449	−0.4 to 0.9
Facial height										
Menton-ANS (mm)	56.0	3.8	57.0	3.9	61.2	4.6	60.4	4.3	.183	−0.4 to 2.0
Lower facial height (mm)	44.8	3.9	44.3	5.8	44.4	4.2	43.6	3.8	.166	−0.3 to 1.8
Incisal relationships										
A1/A-Pogonion (mm)	3.7	1.7	4.0	1.9	6.7	7.6	6.5	2.3	.838	−1.4 to 1.7
B1/A-Pogonion (mm)	−0.2	2.3	−0.1	2.3	3.8	1.8	1.0	2.5	<.001	2.3 to 3.5
Interincisal angle (°)	148.6	13.9	145.0	13.9	126.2	6.8	130.7	10.8	<.001	−6.9 to −2.0
Wits appraisal (mm)	0.5	2.8	0.1	3.2	−1.9	2.4	−0.6	3.0	<.001	−2.0 to 0.5
IMPA (°)	87.8	7.5	89.7	7.3	97.0	6.0	94.0	8.1	.002	1.1 to 4.9
AI to S-Na (°)	91.7	10.5	92.7	14.2	104.1	5.6	103.7	7.9	.680	−1.5 to 2.2

group at T2, indicating a better intermaxillary relationship in comparison to the control group.

The treatment did not seem to have any effects on the protrusion or angulation of the upper incisors (Table 2). The lower incisors, on the other hand, became more protruded and more labially inclined in the treatment group. At the same time, the interincisal angle decreased.

Correlations between the occlusal characteristics at T1 and skeletal variables at T2 were analyzed in the control group where no intervention was carried out. In general, the correlations were low and of little clinical relevance. However, a moderate and statistically significant positive correlation ($r = .4$, $P < .0001$) was found between the width of the upper dental arch at T1 and the length of the mandible at T2. This suggests that a narrow upper deciduous dental arch was associated with less growth of the mandible. Tracings of two treatment children and one control are shown as Figures 2, 3, and 4 respectively.

DISCUSSION

The eruption guidance appliance has been shown to be capable to correct many aspects of the developing occlusion including overjet and overbite, openbite, spatial deficiencies, and Class II molar relationship.[9,13–16] The present results are consistent with earlier findings indicating that the skeletal changes induced by the eruption guidance appliance are largely restricted to the dentoalveolar region.[14,15] However, treatment with the eruption guidance appliance seems to significantly enhance mandibular growth. The mandibular length, measured from condylion to gnathion, increased 3.9 mm more in the present treatment sample compared to the controls during the study period; this is equivalent to extra growth of 1.2 mm per year. Janson et al[15] studied a group of 30 patients who were treated with the eruption guidance appliance for 26 months and reported a similar annual enhancement in mandibular length. The present results are in agreement with the earlier findings[15] in that the maxillary growth is not affected. Similarly, direction of the facial growth remained unaffected.

Many studies have indicated that the growth of the mandible can be influenced by functional appliances in the middle or late mixed dentition.[15,17–22] The present results indicate that an orthopedic effect on mandibular growth can be achieved even earlier, in the early mixed dentition. In an analysis of treatment effects of the FR-2 appliance of Fränkel, McNamara et al[18] found that the growth response was greater in the older patients with a starting age of 11.5 years compared to the younger patients with a starting age of 8.5 years. The annual growth increment was 1.8 mm in the older group and 1.2 mm in the younger group.[18] The growth rate in the present treatment sample was 1.2 mm per year. These figures are in line with suggestions that the best response to functional therapy in terms of mandibular growth rate is achieved at or near the peak of the pubertal growth spurt.[23,24] However, it seems obvious that a clinically significant orthopedic effect that contributes to the correction of the Class II molar relationship can be obtained at almost any age in growing children.

The eruption guidance appliance is designed to solve crowding by expanding the dental arches.[11] Because a transverse deficiency of the upper dental arch is a common finding in Class II patients,[25] it is possible that this expansion,[9] in addition to the mandibular growth, enhanced the transition from a Class II to a Class I relationship. It is of interest that a moderate but significant correlation was found between the width of the upper dental arch at T1 and mandibular length at T2. This suggests that a narrow upper arch tends to restrict anterior mandibular growth in early mixed dentition.

A recent analysis of untreated Class II subjects indicated that the effect of mandibular growth that potentially could bring the lower dentition forward, seems to be lost because of intercuspal locking and subsequent adaptive movements of the dentoalveolar complex.[26] Earlier, Johnston[27] suggested that the key effect of a functional appliance is to displace the mandible forward and let the condyle grow into the fossae without producing maxillary dentoalveolar compensations.

In the present study, the changes in occlusion and Wits appraisal toward a Class I relationship were significantly greater in the treatment group compared to controls. On the other hand, no differences were found in measurements that describe the position of the anterior border of the maxilla and mandible in relation to the cranium. It thus seems that a major effect of the eruption guidance appliance was indeed to induce a change in the dentoalveolar component without significantly affecting the position of the basal skeletal components. Johnston[27] further suggested that the forward displacement of the mandible, typical to functional appliances, would cause a relative retrusive effect on maxillary dentition. However, no such effect was evident in the present study as the maxillary dentition seemed to move forward equally in both groups. The present findings are thus in agreement with the previous results indicating that the eruption guidance appliance does not cause a significant restriction of anterior growth of maxilla.[15]

A significantly smaller overjet, overbite, and interincisal angle were observed in the treatment group compared to the controls at the end of the study. More pronounced labial inclination and more anterior position of the lower incisors in the treatment group seem to be the main factors that affected the incisor relationships. There seemed to be no treatment effect on inclination or protrusion of the maxillary incisors. These findings differ from those of a previous study that showed bodily protrusion, but unchanged inclination of the lower incisors and protrusion and labial inclination of the upper incisors after treatment with the eruption guidance appliance.[15] Linear retrusion and lingual tipping of the maxillary incisors seem to be frequent findings also with other functional appliances.[18,22,28–31] The different response of the incisors observed in the present study may relate to the fact that the present patients were younger and that the treatment took place during the period when the permanent incisors were erupting.

On the basis of the existing literature, Proffit[31] suggested that early Class II treatment is indicated only for a selected group of children. However, many studies have shown that a Class II relationship does not show spontaneous correction with growth.[9,26,32–35] Instead, the skeletal and occlusal features of Class II tend to become exaggerated with age. It would, therefore, be logical to seek a treatment modality that would offer a method to intercept and correct Class II development at an early stage of occlusal development. The eruption guidance appliance seems to be a promising candidate for such a purpose.[9] Not only Class II relationships but many other signs of disturbed occlusal development such as crowding, excess overjet, deep bite, and openbite can be treated simultaneously with this appliance in the early mixed dentition.[9]

Long-term results of the present trial are not yet available, but clinical data, accumulated on the treatment effects of the eruption guidance appliance, suggest that an early intervention can produce results efficiently and consistently. After treatment and proper retention, children who have undergone early orthodontic therapy with the eruption guidance appliance do not normally require further treatment.

CONCLUSIONS

- Occlusal correction brought about by the eruption guidance appliance was achieved mainly through changes in the dentoalveolar region of the mandible.
- Condylar growth was enhanced resulting in a clinically significant increase in mandibular length.
- No effect was observed on maxillary position, maxillary size, inclination, or protrusion of the maxillary incisors, or facial height.

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A Summary of "Dentofacial Changes after Orthodontic Intervention with Eruption Guidance Appliance in the Early Mixed Dentition";

Keski-Nisula, K. Keski-Nisula, L., Salo, H., Volpio, K. & Varrela, J., Angle Orthodontist, 78: 324-331, 2008.

A study of the Nite-Guide® technique from 5 to 8½ years of age. Mean treatment time 3.3 years.

Sample size: Treatment sample = 115 (62 males, 53 females)
Control sample = 104 (52 males, 52 females)
(No statistical differences between groups at 5.1 years of age).
Appliances worn only passively while sleeping. 69% wore appliances to completion.
No charges made to patients for treatment.
Appointments: every 3 months at 5 to 10 min. each; every 6 months during retention.

All results at 8.4 yrs.significant $P < .001$: unless indicated by N.S.= not significant.

		5.1 yrs	8.4 yrs	change	
Mandibular length	treatment	96.9	108.0	+11.1	+54.2%
(condylion-gnathion mm)	control	98.2	105.4	+ 7.2	
Overbite (mm)	treatment	3.2	2.0	- 1.2	
	control	3.3	4.1	+ 0.8	
Overjet (mm)	treatment	3.0	1.9	- 1.1	
	control	2.9	4.1	+ 1.2	
Wits Analysis (mm)	treatment	0.5	- 1.9	- 2.4	
	control	0.1	- 0.6	- 0.7	
Maxillary Length	treatment	43.8	46.1	N.S.	
PNS-A (mm)	control	44.5	45.9		
Lower Face Height	treatment	56.0	61.2	N.S.	
Me-ANS (mm)	control	57.0	60.4		
Lower Incisor to	treatment	--	97.0°	N.S.	
Mand. Plane (°)	control	--	94.0°		
Class II Canine	treatment	1.6	0.1	-1.5	
Relation (mm)	control	1.7	1.4	-0.3	
Class II Molar	treatment	0.6	-1.3	-1.9	
Relation (mm)	control	0.5	0.4	-0.1	

Conclusions: The length of the mandible increased greater in the treatment group by 3.9mm as compared to the control sample over a 3-year period with passive wear of the appliance only while sleeping. The overbite and overjet also had a significant decrease compared to the control sample while there were no differences in the maxillary height or length when compared to the control group.

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Class II treatment in early mixed dentition with the eruption guidance appliance: effects and long-term stability

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Summary

Objectives: Our aim was to analyse dentoskeletal effects and long-term stability of Class II treatment carried out with an eruption guidance appliance (EGA) in early mixed dentition.

Materials and methods: Sixty-five Class II patients (38 females and 27 males), treated with an EGA in early mixed dentition, were compared with 58 children (26 females and 32 males) with untreated Class II malocclusion. The mean age in the treatment group at the start (T1) and end of treatment (T2) was 5.4 years (±0.4) and 8.5 years (±0.9), respectively, and at the final examination in the early permanent dentition (T3) 16.7 years (±0.4). In the control group, the mean age at T1 and T2 were 5.1 years (±0.5) and 8.4 years (±0.5), respectively. The independent and dependent sample *t*-tests, Chi-square test, and Fisher's test were used in the statistical evaluation.

Results: In the treatment group, the frequency of Class II decreased from 100 to 14% during the treatment (T1–T2) and a significant correction took place in all occlusal variables. At T2, the treatment and control groups showed statistically significant differences ($P < 0.05$) in all occlusal variables. In the treated children, mandibular length increased 5 mm more ($P < 0.001$) from T1 to T2 compared to the control children, and the ANB angle became significantly smaller ($P = 0.006$). During the post-treatment period (T2–T3), the frequency of Class II in the treatment group decreased from 14 to 2% ($P < 0.05$), overbite increased from 2.2 to 3.1 mm ($P < 0.05$), and lower crowding increased from 2to 14% ($P < 0.05$). Post-treatment changes in overjet and upper crowding were not statistically significant. At T3, the mean values of the SNA, SNB, and ANB angles were 83.0° (SD 3.9°), 81.3° (SD 3.8°), and 2.4° (SD 1.5°), respectively.

Conclusions: A clinically significant correction of the molar relationship, overjet, overbite, incisor alignment, and growth enhancement of the mandible were observed after treatment in early mixed dentition. The treatment results remained largely stable in the early permanent dentition. However, an increase was observed in overbite and lower crowding. None of the children treated in early mixed dentition needed a second treatment phase.

Introduction

Diagnostic signs of Class II malocclusion are frequently detectable already in deciduous or early mixed dentition, and once established, the Class II developmental pattern seems to persist with only limited capacity for spontaneous correction during growth (1–5). In spite of the early onset of the condition, benefits of early intervention remain controversial. Interceptive treatment in mixed dentition has been shown to produce favorable results but it has been frequently questioned whether clinically relevant long-term changes can be gained by early intervention (3, 6–15).

Eruption guidance appliance (EGA) has been shown to be effective in the early treatment of many types of malocclusions including excess overjet and overbite, anterior crowding, and Class II malocclusion (13–14, 16–19). The effects of the appliance are largely dentoalveolar but significant skeletal changes have been reported (14–16, 18). In particular, EGA treatment seems to affect mandibular growth and position thereby contributing to the Class II correction (14, 16, 18).

The EGA effects have mainly been investigated in patient groups that underwent treatment in late mixed dentition, with only a few where the onset of the treatment was in early mixed dentition (13–14, 16–17, 19–20). Stable treatment results have been reported in short-term but only one long-term follow-up study has been carried out (16, 19–20).

The aim of the present study was to evaluate occlusal and skeletal effects of Class II treatments that were carried out in early mixed dentition with EGA, and to investigate the stability of the treatment results in the early permanent dentition.

Materials and methods

This investigation is part of a prospective cohort study evaluating the effectiveness of EGA in early orthodontic treatment. The participating individuals were orthodontic patients at three municipal health centres in the western part of Finland. The treatment group were obtained from two rural municipalities, Jalasjärvi and Kurikka, where all children born 1992 and 1993 were examined. Of the 315 children who needed treatment, 33 were excluded because they were treated with other appliances; families of 27 declined treatment. The remaining 255 children started treatment with EGA (Figure 1) in early mixed dentition. No records were available for the 50 children who discontinued the treatment due to moving, non-compliance, or other reasons (see the flow chart, Figure 1). The control group was obtained from the neighbouring town of Seinäjoki and it comprised children randomly selected among those who fulfilled the same occlusal criteria for EGA treatment as the children in the treatment group. The present analysis is based on the records of the remaining 65 children who all completed the treatment successfully. The control children were followed-up from early mixed dentition to middle mixed dentition, and all of them received orthodontic treatment starting during middle mixed dentition, following the treatment guidelines of Seinäjoki where early treatment was not available at the time. All subjects were ethnic Finns. Further details of the treatment and control groups have been published earlier (13, 21). All children in the treatment group were treated according to a pre-established early treatment protocol in the orthodontic clinics of Jalasjärvi and Kurikka, with minor adjustments to ensure timely and controlled data collection as described earlier (21).

The present analysis is based on the records of 65 Class II children (38 girls and 27 boys) treated during early mixed dentition and 58 control children (26 girls and 32 boys), all fulfilling the following inclusion criteria: a distal step equal or larger than 1 mm and/or Class II type canine relationship equal or larger than 2 mm, bi- or unilaterally. The fact that the sex distribution was not equal between the treatment and control groups may have affected the results.

The children were examined at the beginning (T1) and at the end of the early mixed dentition period (T2). The mean age of the children in the treatment group was 5.4 years (SD 0.4) at T1 and 8.5 years (SD 0.9) at T2, and in the control group 5.1 years (SD 0.5) at T1 and 8.4 years (SD 0.5) at T2. The early treatment was carried out with EGA from T1 to T2, followed by retention. Retention was continued until the permanent canines, premolars, and second molars had erupted using an EGA as the retainer. During the active treatment, the appliance was used every night, and during retention, two nights per week. A detailed description of the treatment protocol has been published earlier (13). The children in the treatment group were further examined close to their 17th birthday (T3). The mean age of the children at T3 was 16.7 years (SD 0.4). The mean retention time was 4.9 years (SD 1.6, range 1.3–7.1 years) and mean out-of-retention time at T3 was 3.1 years (SD 2.1).

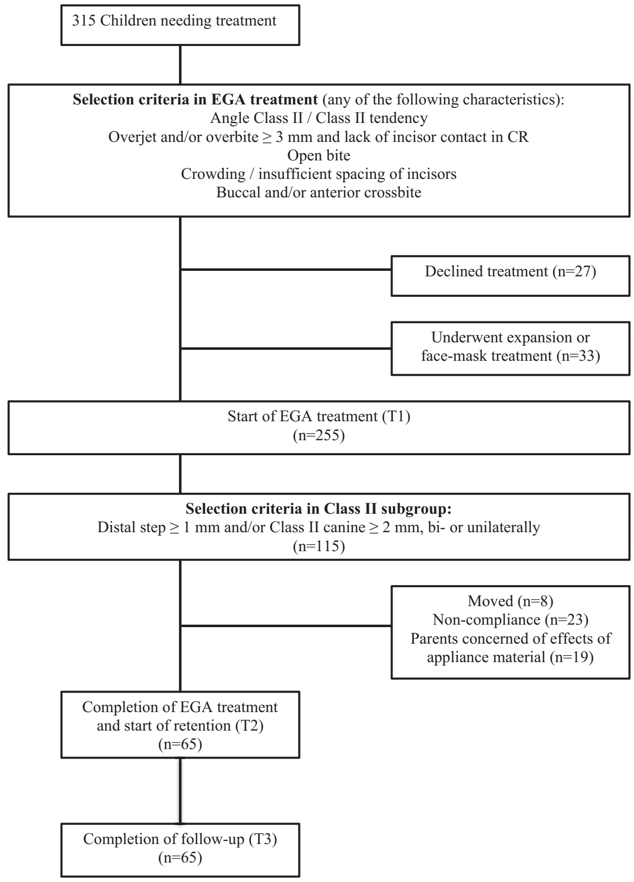

Figure 1. Flow chart of the treatment group.

Overbite and overjet were measured directly in the mouth by two calibrated orthodontists, all other occlusal features were assessed and measured from dental casts, taken at T1, T2, and T3, by the first author (KKN) as described earlier (22). Occlusal contacts of the incisors were assessed directly in the centric relation; a non-occlusion was recorded if both overjet and overbite were positive but no tooth-tooth contact was detected. Space conditions were assessed from dental casts, and the arch was recorded as crowded if overlapping incisors were present or distemas between incisors were lacking. To estimate the accuracy of measuring, 30 randomly selected cases were measured twice and the Dahlberg measurement error (23) was calculated for each variable. The error varied between 0.11 and 0.14. Cephalometric analysis was performed by the first author (KNN) using the RMO Jiffy Orthodontic Evaluation 32-program. A detailed description of the cephalometric landmarks and measurements has been published earlier (24). Measurement error was evaluated digitizing and measuring 30 randomly selected cephalograms twice at an interval of 6 months. The intra-class correlation of repeated measurements, tested by Bland–Altman method (25, 26), varied between 0.92 and 0.99 indicating good accuracy. The Student *t*-tests for independent and dependent samples were used in the statistical evaluation of the continuous variables, and the Chi-square and Fisher's tests for categorical variables; a *P*-value less than 0.05 was considered to be statistically significant.

Results

Occlusal findings in the treatment and control groups at T1, T2, and T3 are given in Table 1. At T1, no statistically significant differences between the treatment group and control group or between boys and girls were detected. During the active treatment period, while the permanent incisors were erupting, overjet, overbite, frequency of non-occlusion, and crowding showed significant improvement in the treatment group. The frequency of Class II decreased from 100 to 14% and in the control group from 100 to 78%. At T2, all differences in occlusal variables between treatment and control groups were statistically significant. During the post-treatment period, overbite increased from 2.2 to 3.1 mm ($P < 0.001$), frequency of Class II decreased from 14 to 1% ($P = 0.02$), and frequency of lower crowding increased from 2 to 14% ($P = 0.02$). Changes in overjet or in the frequencies of non-occlusion and upper crowding were not statistically significant.

The cephalometric findings are given in Table 2. At T1, the treatment and control samples were skeletally similar with the exception of facial axis angle, the angle between the mandibular plane and Frankfort horizontal, and the angle of lower facial height, all indicating that in the treatment group, mandible showed greater tendency towards opening growth direction. Furthermore, the labial inclination of the upper incisors and the interincisal angle were larger in the treatment group at T1. The baseline differences may have acted as confounding factors.

In maxilla, the changes from T1 to T2 were similar in the treatment and control groups and seemed to reflect normal growth during this period. The SNA angle indicated a neutral position of the maxilla with only minor changes between T1 and T3. From T1 to T2, the mandibular length increased 11.4 mm (SD 4.3) in the treatment group and 6.4 mm (SD 3.5) in the control group. The difference of 5.0 mm between the treatment and control groups was highly significant ($P < 0.001$). The mean annual growth increments in the treatment and control groups between T1 and T2 were 3.5 mm and 1.9 mm, respectively. In the treatment group, significant mandibular growth continued after T2. The length of the mandible at T1, T2, and T3 is given separately for boys and girls in Table 3.

Many variables in the treatment group, for example the position of pogonion, mandibular base angle, maxillo-mandibular differential, and SNB and ANB angles showed more pronounced and statistically significant changes from T2 to T3. At T3, the SNB angle was 81.3 degrees (SD 3.8) and the ANB angle 2.4 degrees (SD 1.5). The lower incisors moved forward between T1 and T2, and became slightly less prominent from T2 to T3. Labial inclination of the upper and lower incisors increased both in the treatment and control group between T1 and T2, reflecting the normal development from deciduous to permanent dentition. In the treatment group, the lower incisors showed further labial tilting from T2 to T3 whereas inclination of the upper incisors showed a slight, non-significant lingual change. At T3, the mean interincisal angle in the treatment group was 130.6°.

Discussion

Proffit (11) suggested that an early Class II treatment is indicated only for a selected group of children and recommended adolescent growth spurt as the best time for treatment. As a contrasting approach, the present study investigates short- and long-term effectiveness of a Class II treatment that was carried out with EGA in early mixed dentition, during a period that coincides with the juvenile growth spurt. Earlier studies have indicated that EGA is effective in Class II treatment but the patients in these studies were older (16–18, 20, 27). An intervention in early mixed dentition was of interest because it could potentially prevent an increase in the severity of the malocclusion. Several studies have shown that very little if any correction of Class II relationship can be expected with growth (1–4, 28). A longitudinal analysis from 7 to 15 years of age showed that while both positive and negative changes occurred in occlusion, the need for treatment increased not decreased with age (29). A follow-up study of untreated children with Class II, Division I deep bite malocclusion reported statistically significant

Table 1. Overjet, overbite, non-occlusion, molar relationship, and crowding at T1, T2, and T3.

	T1			T2			T3	
	Treatment group (*N* = 65)	Control group (*N* = 58)	Treated vs. control *P*	Treatment group (*N* = 65)	Control group (*N* = 58)	Treated vs. control *P*	Treatment group (*N* = 65)	Treated at T2 vs. treated at T3 *P*
Overjet (mm)								
Mean (SD)	3.4 (1.4)	3.4 (2.0)	0.8	2.2 (0.8)	4.7 (2.0)	0.001	2.1 (0.8)	0.8
95% CL	3.1–3.8	2.8–3.9		2.0–2.4	4.2–5.2		1.9–2.3	
Overbite (mm)								
Mean (SD)	2.9 (2.0)	3.5 (2.1)	0.1	2.2 (1.0)	4.4 (2.2)	0.001	3.1 (1.1)	0.001
95% CL	2.4–3.4	2.9–4.0		1.9–2.4	3.8–5.0		2.8–3.4	
Non-occlusion at centric relation	34 (52%)	22 (38%)	0.16	1 (2%)	26 (45%)	0.001	0	1
Class II	65 (100%)	58 (100%)	1	9 (14%)	45 (78%)	0.001	1 (1%)	0.02
Crowding (%)								
Upper	5 (8%)	5 (9%)	1	2 (3%)	29 (50%)	0.001	2 (3%)	0.3
Lower	23 (35%)	29 (50%)	0.15	1 (2%)	29 (50%)	0.001	9 (14%)	0.02

Continuous variables were statistically evaluated with the Student *t*-test and categorical variables with the X^2-test or the Fisher's test.

Table 2. Cephalometric variables in the treatment group and in the control group at T1, T2, and T3.

	Treatment at T1	Control at T1	Difference between treatment and control group at T1		Treatment group at T2	Control group at T2	Difference between treatment and control group at T2		Treatment group at T3
	Mean (SD)	Mean (SD)	95% CI	*P*	Mean (SD)	Mean (SD)	95% CI	*P*	Mean (SD)
Maxillary skeletal position									
A/Na-verticale (mm)	−0.7 (2.3)	−0.2 (2.1)	−1.23 to 0.3	0.22	−1.4 (2.9)	−0.6 (2.2)	−1.81 to 0.17	0.11	−0.6 (3.2)
Condylion-A (mm)	75.4 (3.8)	76.2 (4.4)	−2.34 to 0.61	0.25	80.5 (3.9)	80.4 (3.9)	−1.36 to 1.7	0.85	95.4 (8.2)
Anterior cranial length (mm)	50.6 (7.0)	52.3 (3.0)	−3.59 to 0.2	0.08	51.7 (3.1)	52.3 (3.1)	−1.82 to 0.53	0.28	62.4 (5.1)
SNA (°)	83.0 (3.7)	82.8 (3.5)	−1.09 to 1.5	0.75	81.9 (3.6)	81.9 (3.6)	−1.24 to 1.38	0.91	83.0 (3.9)
Mandibular skeletal position									
Pogonion/NA-verticale (mm)	−8.6 (4.6)	−7.7 (3.8)	−2.38 to 0.61	0.24	−7.9 (6.7)	−7.2 (4.9)	−2.95 to 1.61	0.56	−2.8 (7.1)
Condylion-Gnathion (mm)	90.8 (5.1)	92.1 (5.3)	−3.11 to 0.61	0.19	102.0 (6.4)	98.7 (4.8)	1.19 to 5.42	<0.001	125.3 (10.3)
Facial axis angle (°)	92.5 (3.3)	86.8 (3.1)	4.57 to 6.86	<0.001	90.9 (3.6)	86.2 (3.3)	3.38 to 6.04	<0.001	93.5 (4.6)
Mandibular plane/ Frankfort horizontal (°)	25.0 (4.5)	22.1 (4.9)	1.31 to 4.65	<0.001	26.0 (5.0)	22.1 (4.6)	2.04 to 5.74	<0.001	21.2 (5.0)
SNB (°)	77.6 (3.3)	77.3 (3.3)	−9.4 to 1.4	0.7	78.4 (3.3)	77.4 (3.5)	−0.2 to 2.26	0.1	81.3 (3.8)
Maxilla to mandible									
Maxillo-mandibular differential (mm)	14.9 (3.3)	15.2 (2.8)	−1.35 to 0.82	0.63	20.0 (3.5)	18.4 (3.4)	0.22 to 2.86	0.02	29 (5.7)
Convexity (mm)	4.3 (1.9)	4.1 (1.9)	−0.48 to 0.87	0.58	2.9 (2.2)	2.6 (1.9)	−0.5 to 1.1	0.46	1.1 (3.0)
ANB (°)	5.5 (2.3)	5.5 (1.9)	−0.73 to 0.79	0.94	3.4 (1.8)	4.4 (2.1)	−1.73 to −0.3	0.006	2.4 (1.5)
Lower facial height									
Menton-ANS (mm)	52.5 (4.0)	53.5 (3.6)	−2.31 to 0.41	0.17	57.0 (4.9)	56.8 (3.5)	−1.48 to 1.83	0.83	67.5 (7.7)
Lower facial height (°)	44.8 (3.8)	40.8 (6.3)	2.33 to 6.11	<0.001	41.6 (4.1)	40.4 (3.3)	−0.22 to 2.63	0.1	42.0 (4.8)
Wits appraisal (mm)	1.1 (2.2)	1.0 (2.8)	−1.02 to 1.09	0.95	−1.1 (2.4)	0.4 (2.5)	−2.24 to −0.58	0.002	−0.31 (2.5)
Dental relations									
A1/A-Pogonion (mm)	3.7 (1.8)	3.6 (1.8)	−0.6 to 0.71	0.87	5.2 (1.8)	6.0 (2.2)	−1.59 to −0.03	0.043	5.3 (2.4)
B1/A-Pogonion (mm)	−0.4 (2.2)	−0.5 (2.1)	−0.67 to 0.89	0.78	3.3 (1.8)	0.4 (2.5)	2.07 to 3.75	<0.001	2.6 (2.2)
Interincisal angle (°)	148.3 (14.7)	136.5 (13.4)	6.76 to 16.85	<0.001	127.1 (7.2)	122.2 (10.7)	1.37 to 8.41	0.007	130.6 (9.9)
IMPA (°)	88.9 (8.0)	84.5 (7.0)	1.38 to 7.43	0.005	97.6 (7.0)	88.8 (6.6)	6.19 to 11.45	<0.001	96.0 (7.6)
A1 to S-Na (°)	88.7 (11.4)	86.9 (10.7)	−2.71 to 6.22	0.44	103.8 (5.7)	97.7 (7.7)	3.46 to 8.65	<0.001	106.4 (7.4)

Variables were statistically evaluated with the Student *t*-test.

Table 3. Mandibular length in 65 Class II children at T1, T2, and T3.

		T1	T2	T3
mm	*N*	Mean (SD)	Mean (SD)	Mean (SD)
Girls	38	89.8 (5.2)	100.5 (5.1)	121.5 (8.2)
Boys	27	92.2 (4.7)	103.9 (7.4)	130.6 (10.8)

improvements from adolescence to adulthood (30) but clinically the changes were only marginal.

The present study showed that a treatment modality of Class II malocclusion that was based on the use of EGA during early mixed dentition gave consistently good results that were relatively stable in the early permanent dentition. None of the 65 Class II children that participated the present study showed moderate or severe signs of malocclusion such as tooth malpositions, crowding, excess overjet or overbite, openbite, crossbite, scissorsbite (buccal crossbite), or Class II relationship at T2. Therefore, they were not considered to need a second treatment phase after the initial treatment period during early mixed dentition. EGA treatment during the eruption of the permanent incisors resulted in good incisor alignment, and overjet and overbite close to 2 mm. In case of predicted space deficiencies, a good alignment of the incisors was achieved by using a series of consequently larger appliances until sufficient space for the incisors was created. In early permanent dentition, at the age of 16.7 years, a decrease of 0.1 mm was observed in overjet and an increase of 0.9 mm in overbite. This is in line with the results of an earlier study (20). No change was seen in the alignment of the upper incisors but crowding of the lover incisors increased from 2 to 14%. The late lower crowding typically occurs in both treated and untreated subjects. In the present study, it might have been possible to avoid this by using a different retention protocol, for example fixed retainers.

In the present group of 65 children that underwent early Class II treatment, the assessment of treatment need was based on the sagittal relationship of the second deciduous molars and canines. The Class II diagnosis was further supported by the finding that the mean ANB angle was 5.5° at the age of 5. As a result of the EGA treatment, the sagittal relationship was corrected from Class II to Class I in 86% of the cases during the active treatment, and it showed further improvement post-treatment. At the age of 16.7 years, 98% of the treatment children, who all had a Class II relationship at the onset of the early mixed dentition, had a Class I relationship. Similar stable Class II correction with EGA has been reported earlier in older patients (19, 20).

As a result of the treatment, the mandible of the treated children grew 5 mm more compared to controls during the period of early mixed dentition. The EGA treatment had no effect on the position or size of the maxilla. These findings are in line with those reported earlier (16). The higher mandibular growth rate seemed to be a major factor contributing to the shift from a Class II to Class I molar relationship in the treatment group. There was no indication that the enhanced growth of the mandible would have been only temporary. Comparison to the Burlington Growth Study standards (31), 118.9 mm for girls and 127.2 mm for boys at the age of 18 years, suggests that no slowing down took place in the mandibular growth after the active treatment period. It thus seems that the early EGA treatment not only corrected the occlusion but also set the skeletal development on a more normal Class I developmental path. However, a contrasting finding has been reported in older patients (32). In the RCTs that did not find long-term advantages in early growth modification, the modification phase was carried out during the period of minimum growth velocity (6–9). More consistent long-term skeletal responses were obtained when the orthopaedic treatment was initiated at the outset of the pubertal growth (33). On the other hand, our earlier findings indicated that a significant enhancement of mandibular growth resulted from a functional treatment during early mixed dentition (14). It therefore seems that the best time to carry out an orthopaedic intervention would be during a period of rapid growth, either during the juvenile growth spurt or the adolescent growth spurt.

In addition to EGA, many orthodontic appliances, for example orthopaedic headgear, twin-block, and the Fränkel appliance, can be used for growth modification in Class II treatment (6, 9, 32, 34–37). While prefabricated appliances may be less effective than custom-made activators (38, 39), the wide scope of action of the EGAs offers advantages over other appliances (40). In addition to enhancement of the mandibular growth, EGA can be used to adjust the upper and lower arch perimeter and positions of the permanent teeth. If the EGA treatment is carried out during early mixed dentition, as was the case in the present study, growth modification takes place during the juvenile growth spurt and the erupting incisors can simultaneously be guided in good alignment, with favourable overjet and overbite. With the early growth modification and adjustment of the arch perimeter there was no need for orthodontic extractions or a second treatment phase in any of the present 65 Class II children.

The treatment time of 3.1 years might be considered lengthy but during this period it was possible to achieve growth modification, Class II correction, alignment of incisors, and correction of overjet and overbite. It might be possible to shorten the treatment time but in order to fully benefit from the effects of EGA, particularly in case of more severe Class II, it seems advisable to use the appliance during the entire length of early mixed dentition period. The present study did not include a cost-benefit analysis of the treatment but the clinical experience indicated that the costs remained low because EGA treatment allows long check-up intervals, up to 3 months, and short chair-side time at check-ups. Furthermore, the early EGA treatment eliminated need for a second treatment phase. The present results corroborate the earlier finding that early intervention seems particularly beneficial in public health care with limited resources (41).

The present treatment modality, where the treatment is carried using EGA during early mixed dentition, represents a single-phase early treatment as opposed to the more common two-phase treatment protocols consisting of an early growth modification phase and a subsequent second treatment phase in the early permanent dentition (6–9). The present treatment sample was obtained from entire age cohorts of children in two municipalities and it included all types of Class II cases from mild to severe that are normally encountered in orthodontic clinics (see Table 2). There was no selection of cases on the basis of the Class II severity. An early treatment with EGA seems therefore to be a suitable treatment strategy for all types of Class II patients regardless of severity of the condition or presence of other malocclusions. Nevertheless, several questions remain open including, for example the type and length of optimal retention.

Conclusions

1. Class II treatment with an EGA in early mixed dentition resulted in a clinically significant correction of the molar relationship, with a favourable overjet and overbite, and good incisor alignment.
2. The treatment results remained largely stable during early permanent dentition, at the age of 16.7 years. Overbite increased by 0.9 mm; late crowding of the lower incisors was observed in 14% of the children.
3. Enhancement of the mandibular growth was observed during the active treatment. Subsequently, the mandible continued to grow on a normal path resulting in Class I skeletal relationship in early permanent dentition.
4. The early intervention eliminated the need for a second treatment phase. The present treatment modality using EGA in the early mixed dentition represents a single-phase early treatment of Class II malocclusion.

The children in this study were not patients in a clinical trial but normal orthodontic patients in municipal clinics. This study uses patient records of these children, and according the rules of late 1990s when the study began, the permission to use patients records for research purposes, was granted by the local health authorities who considered the ethical aspects of the research before giving the permit, and their decision thereby was considered as the ethical committee approval.

Conflict of interest

The authors have no conflict of interest.

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