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Developing an Index for the Orthodontic Treatment Need in Pediatric Patients with Obstructive Sleep Apnea: A Protocol for a Novel Communication Tool between Physicians and Orthodontists

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ABSTRACT

Introduction: Sleep disordered breathing in the pediatric population can manifest as an array of different systemic symptoms; among them is a distinct malocclusion and craniofacial phenotype. Emerging research suggests that the treatment of this malocclusion and/or craniofacial phenotype through orthodontic intervention may help with the symptoms of these patients. Selecting the patients that would benefit from orthodontic treatment can be a difficult task for the physician with minimal dental training. Therefore the aim of this study is to develop a simple index to be used by medical professionals, to identify those pediatric patients with orthodontic treatment needs that may benefit their obstructive sleep apnea (OSA) symptoms.

Methods and analysis: The methodology in this project has been devised through the World Health Organization's (WHO) recommendations on developing an index, with modifications based on the specific needs of this study. Based on the available literature, a draft index will be produced, and subjected to multiple iterative revisions based on the feedback from: the Index Development Group, a group of multidisciplinary and internationally acclaimed experts in the field; the External Review Group, a group of potential end-users and interested parties; and the Steering Committee. Once the index has been formalized, it will be subjected to a pair of reliability tests using physicians and orthodontists scored 2-weeks apart. Subsequently the index will be validated using dichotomous responses from orthodontists on whether they would treat a patient for OSA symptoms, and comparing the responses to the score of the index on the same patient.

Ethics and dissemination: The index will be translated into French, and will be presented in orthodontic and medical conferences, workshops, seminars, round table discussions and free copies for download will be made available on the website of the University of Alberta Interdisciplinary Airway Research Clinic (iarc.ualberta.ca). Furthermore, the index will be published in a peer-reviewed medical journal to further increase the exposure of the index.

Article Summary

Article focus

- To develop a simple index for medical professionals to identify children and adolescents with obstructive sleep apnea who may experience functional airway benefit from orthodontic treatment.

Strength and limitations of this study

- This index will help physicians and other medical professionals understand and identify which obstructive sleep apnea patients with malocclusions and craniofacial phenotypes are likely to benefit from targeted orthodontic treatment, and will allow them to refer these patients accordingly.

- This index development acknowledges the multi-factorial nature of SDB and the need for multi-disciplinary care. The ideal end result of this index is to facilitate and enhance effective collaboration between invested dental and medical specialties.

- Development of a validated index will facilitate future epidemiology studies, allow for quality assurance, and guide funding allocation. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

INTRODUCTION

Snoring, although ubiquitous in the adult population, is considered abnormal in children and adolescents.[1] More importantly, it may serve as an indicator of a more severe respiratory problem that presents as a continuum, from primary snoring to obstructive sleep apnea (OSA). Reports vary on the prevalence of obstructive sleep apnea ranging from 0.7% to 5% of the population under 18 years old.[2-8] Moreover, breathing induced sleep disorders have been proven to have a profound effect on the child's behavior, growth and development; the myriad of symptoms include: morning tension-type headaches, excessive morning thirst, excessive fatigue and sleepiness, abnormal shyness, withdrawn and depressive presentation, pattern of attention-deficit/hyperactivity disorder (ADHD), memory impairments, aggressiveness, irritability, among many others.[9 10 11-13] Other physiologic processes that can be affected include stunted growth,[14] high blood pressure,[15] damage to the heart: ventricular hypertrophy,[16] and cor pulminale[17].

In addition to behavioral and systemic health consequences, craniofacial development is also affected. These patients generally have a craniofacial component contributing to their OSA, which would manifest as a retrognathic maxilla[18] or mandible, a long lower face height and restriction in the space of the upper airway[19 20]. Furthermore, when evaluating the polysomnography of these patients, the evidence suggests that palatal expansion, and mandibular advancement appliances[21-26] can be of benefit at reducing the severity of OSA. Reverse pull headgear[27-32], and maxillary & mandibular advancement surgery[33] have also been shown to have great promise at helping this group of patients. Since orthodontic treatment of the OSA craniofacial phenotype is an integral component to multidisciplinary care, it is essential for medical professionals (physicians, nurses, etc.) to recognize the phenotype that would benefit from orthodontic treatment. Unfortunately, there are no guidelines for non-dental trained practitioners to help identify which children with SDB would benefit from orthodontic treatment.

Therefore this study aims to develop an index that can summarize the need for orthodontic treatment, in select cases of children with OSA, to physicians, and adjunct medical professionals. Once the index is developed, it will be assessed for reliability and will be validated. Upon completion, this index will equip medical professionals with a simple way to assess which patients have a malocclusion that contribute to their OSA and may benefit from orthodontic treatment.

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METHODS AND ANALYSIS

A) Initial Development

In accordance with the World Health Organization's recommendations on developing an index,[34] development of the index will be achieved through the following objectives:

1- Establishing a Steering Committee
2- Scoping the index
3- Reviewing the literature
4- Drafting the index
5- Organizing an Index Development Group
6- Organizing an External Review Group

Steering Committee

The Steering Committee will be established apriori and is responsible for overseeing every aspect of the study. It will be composed of a representative group of 3 experts in orthodontics, pediatric sleep medicine, and a methodologist specializing in psychometric property analysis. Their responsibilities include: scoping the index, overseeing evidence retrieval, drafting the index, selecting members of the index development group and external review group, finalizing the index.

Scoping the Index

Scoping is the process of defining what factors will be investigated in the literature for inclusion in the index. Scoping will be achieved through the combined experience and expertise of the Steering Committee, and each factor that is suggested will be further investigated in the literature to establish an evidence-based approach to the development of the index.

Reviewing the Literature

For each of the scoped factors the literature will be reviewed to establish relevance. Specifically, the evidence must demonstrate that appropriate treatment of the craniofacial factor in question will lead to an improvement in the OSA symptoms. Priority will be given to the results of well-conducted and well-reported systematic reviews and randomized control trials. Each of the factors will be assessed on its effect on pediatric OSA. Furthermore, the literature will be searched for the craniofacial morphology of pediatric OSA patients. All of this

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information will be brought back to the Steering Committee for discussion of inclusion / elimination of factors in the index.

Drafting the Index

Since this index will have visual-rating scales for each of the craniofacial and occlusal factors, the steering committee will devise an outline suitable for displaying each of the factors representing the index. The factors in the drafted index will also have a number of levels that will divide the factor into categories of severity. The number of levels for a given factor will also be determined by the Steering Committee. Details describing the nature of the illustrations, the amount of levels that each of the factors will have, and the general layout of the index will be agreed upon by the steering committee, and the graphic artist will then design a preliminary version of the index based on the relevant factors and the feedback from the steering committee.

The Index Development Meeting

The Index Development Group (IDG) is formed by a group of external multidisciplinary experts who provide evidence-based recommendations, on the content, layout and development process of the index. This eclectic group should be small enough to be able to have effective discussions, while large enough to ensure the appropriate representation from all the stakeholders. In this study we plan on including a broad spectrum of medical specialists, family physicians, orthodontists, and methodologists. The goals of this meeting are to gain additional information to strengthen the index, as well as gaining the professional credibility of a broad range of experts on the topic of pediatric OSA.

Once the members have been chosen by the Steering Committee and accept the invitation to participate, the IDG members will be emailed a document 4 days prior to the meeting, explaining: the purpose of the index and meeting, how the meeting will proceed, what to expect in the meeting, and a brief literature review of the orthodontic techniques currently available to help with the symptoms of OSA. Moreover, every member will be randomly assigned a number in order to maintain anonymity of the responses.

Procedure of the IDG Meeting

The meeting will commence with a brief introduction summarizing the literature review, the purpose of the index and its relevance. The meeting will then proceed to collect feedback

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(APPENDIX 1) on the aforementioned chosen factors using a modified Delphi technique[35 36], which is a communication technique that structures the meeting and minimizes bias in responses. Participants' responses will be collected through a web-based response portal. Each factor will be explored through yes or no questions, and yes responses followed-up with a scale of 1-9 based on its importance for decision-making. Once all the feedback is received on a particular factor, the summary of the results will be displayed for everyone to see. Discussion will ensue for a maximum of 5 minutes, with each person talking no more than 1 minute. Then everyone will be asked to re-enter their feedback on the website for the same factor in light of the discussion. This cycle will continue until a consensus of greater than 80% of the members is reached. Once consensus is reached, then we will move on to the next factor and the participants will be asked to give feedback on this new factor in a similar manner.

In addition, two negative control factors will be used to calibrate the responses. The first negative control will be of orthodontic relevance but have no effect on the amelioration of the symptoms of OSA (ie. crowding, or impacted canine). The second negative control will be of relevance to OSA symptoms, but cannot be changed by orthodontic treatment (ie. BMI or neck circumference).

Once all the factors have been discussed and consensus reached, we will get feedback through the website on the: alignment - importance of the index, and if the development process is appropriate; relevance – content analysis, and whether all the factors identified are important; representation – if there is anything that needs to be added to the index (APPENDIX 2). Finally, additional written feedback will be accepted at the very end of the session.

All the feedback from the IDM will be summarized and presented to the Steering Committee, and decisions will be made to remove factors, modify factors, and /or modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a second draft will be procured.

The External Review Group

The External Review Group (ERG) is composed of end-users and interested parties. This group is not responsible for any content analysis, instead it will be responsible for reviewing the layout, simplicity and ease of use. It will also be responsible to assess usefulness of the index in the healthcare setting and give feedback on the feasibility of implementing the index in practice.

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The goal of this meeting is to gain the end-user approval for the ease and feasibility of administering the index. This group should be large enough to be a representative sample of the population, yet small enough to allow for ease of explanation and healthy discussion. It is not as structured as the IDM, and allows for the participants to freely express their opinions in an open forum.

In this meeting we will explain the theory behind the index by briefly reviewing the literature and then explain the purpose of the index. Subsequently we will show the group a pilot version of the index and a paper will be distributed to receive for their feedback based on the following questions:

1- Do you understand the purpose of the index?
2- Do you understand what each factor is assessing?
    a. If not which one(s) do you not understand and why?
3- On a scale of 1 to 10, how simple would you rate this index to understand and use?
4- Would you use this index in your practice?
5- Other recommendations:

All the feedback from the ERG will be summarized and presented to the Steering Committee, and decisions will be made to modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a third draft will be procured.

B) Reliability

Reliability of the index will be tested within a group that represents the typical end-user population. This includes physicians of family medicine, pediatricians, pediatric ENT, or pediatric sleep physicians. Reliability will also be assessed within a group of orthodontists, who by their training are experts at assessing malocclusion and craniofacial morphology. Therefore 10-20 physicians and orthodontists will be recruited as examiners in this study.

A pool of 15-40 randomly selected patient charts from the University of Alberta Inter-disciplinary Airway Research Clinic (I-ARC) will be recruited as reliability test subjects, and their intra-oral and extra-oral photographs will be used in the reliability assessment. After a brief explanation about the use and application of the index, the physicians as well as the orthodontists

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will apply the developed index to the sample patient pool's pictures once. In order to diminish recall bias, application of the index will be repeated 2 weeks later.

Intra-rater reliability and inter-rater reliability between the physicians, between the orthodontists and between the physicians and orthodontists will be compared. The reliability will be assessed using Interclass Correlation coefficients (ICC) and Bland –Altman Plots.

C) Validation

The Index will be validated using dichotomous responses from orthodontists on whether specific patients would require orthodontic treatment to help their obstructive sleep apnea symptoms and comparing it to the score that the index gave those same patients. This will be achieved by setting up a website where 30 orthodontists with experience in dealing with pediatric OSA will be recruited to take the assessment. The website will contain extra-oral and intra-oral pictures of patients randomly selected from the Interdisciplinary Airway Research Clinic diagnosed with OSA, and the orthodontists will be asked to rate these patients, using a "yes" or "no" response, whether they would benefit from orthodontic treatment for their OSA symptoms. The index will then be applied on the same patients by the principal investigator and the score of each patient will be recorded. Using a stepwise multiple-logistic regression each of the identified factors will be given a weight; this will represent the relative importance of the factor. Once analyzed if the correlation is high between the expert scores and the cluster groups, then the clusters are meaningful and valid. Furthermore, a cutoff for most efficient score above which to refer will be chosen using a graph and observing the value that optimizes the sensitivity, specificity and overall accuracy of the index. Finally, four grades of treatment-need will be determined using the twenty-five percentile ranges. The grades will be:

1- Minimal Need
2- Mild Need
3- Moderate Need
4- Severe Need

DISCUSSION

The development plan of this index has been conceived through a modification of the WHO Handbook for guideline development,[34] as well as reviewing the orthodontic literature for

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ways indices have been previously developed. The WHO provided an excellent starting point, from there modifications were made to cater to the specifics of this study, given that there are differences between developing a guideline and an index for orthodontic treatment need. The literature was useful, and among the index development protocols reviewed, certain assessed the orthodontic treatment need within the entire population,[37-40] while others assessed it for a given subpopulation[41-46]; each had strengths and weaknesses, and thus we further modified our methods, synthesizing a protocol for our particular needs from the available literature and using the experience and expertise of the authors. Through this protocol we aim to develop an index that fulfills all of the following criteria:[47]

1. Gradient of Numeric Values: The severity of the orthodontic treatment need within the pediatric OSA patients should be defined within a numerical scheme that demonstrates a finite and progressive gradient from low need to high need.

2. Equal Sensitivity: should demonstrate equal sensitivity throughout the scale.

3. Clinical Importance: The numerical scale should correspond with the clinically appraised orthodontic treatment need of pediatric OSA patients.

4. Statistical Ease: should be amendable to statistical analysis.

5. Reliability: Should have a high intra- and inter-rater reliability.

6. Practical: The instruments required to score the index should be practical to the setting in which it will be administered.

7. Minimal Judgment: Applying the index should require minimal judgment.

8. Simple: The index shouldn't have a high financial or time cost, therefore should be simple enough to administer to many patients.

9. Detect Change: The index should be able to detect changes in orthodontic treatment need in pediatric OSA patients.

10. Validity: should be valid over time.

Validity can be characterized into different types: Face Validity, Content Validity, Construct Validity, and Criterion Validity.[48] In this study, we will examine these kinds of validity at different stages of development. The first draft of the index will focus on establishing face validity. Feedback from the steering committee and IDG will assist in establishing content and construct validity. Assuming that the "gold standard" in assessing the orthodontic treatment-need in pediatric patients with OSA is an orthodontist with experience in dealing with pediatric

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OSA patients, then the subsequent modification of the index based on the reliability tests and the dichotomous responses from the orthodontists provide the index with the necessary criterion-related validity evidence through statistical means.[49]

Significance

This index will help physicians and other medical professionals identify which craniofacial phenotypes may benefit from orthodontic treatment as part of their multi-disciplinary OSA management. Furthermore, due to the diverse medical effects of sleep deprivation, there will be a trend to make sleep apnea into a centralized service, where the main focus is for a highly trained multidisciplinary team to treat a high volume of patients to a standardized protocol, where meticulous documentation is exercised. This index is part of that documentation process. It will allow for quality assurance, funding allocation and epidemiologic studies to be performed. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

Dissemination Plan

The dissemination of this index will be done through a variety of ways in order to maximize its reach. Primarily, it will be published in a peer-reviewed journal, which will allow its introduction to the scientific literature. The journal should be a respected medical journal with broad reach, in order to allow the greatest number of physicians to be exposed to the index. Subsequently it will be translated to French, in order for it to be accessible to the entire Canadian and American population of medical professionals. Moreover, the index will be presented at national and international conferences to increase the awareness of the index among the scientific community. Finally, the index will be used at the University of Alberta's Interdisciplinary Airway Research Center, and more research, so that future research in this center will incorporate it. It will also be placed on the University of Alberta's Interdisciplinary Airway Research Center's website under the physician section, to further educate the doctors who visit the site on the index.

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Authors' Contributions

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MA HS MRR MM JM PM conceived and designed the study; MA drafted the manuscript and integrated critical feedback from all of the other authors. All of the authors approved the final version of the manuscript.

Ethics approval

Ethical approval has been submitted to the Research Ethics Board at the University of Alberta (expected May 2014).

Competing Interests

The authors declare no conflicts of interests.

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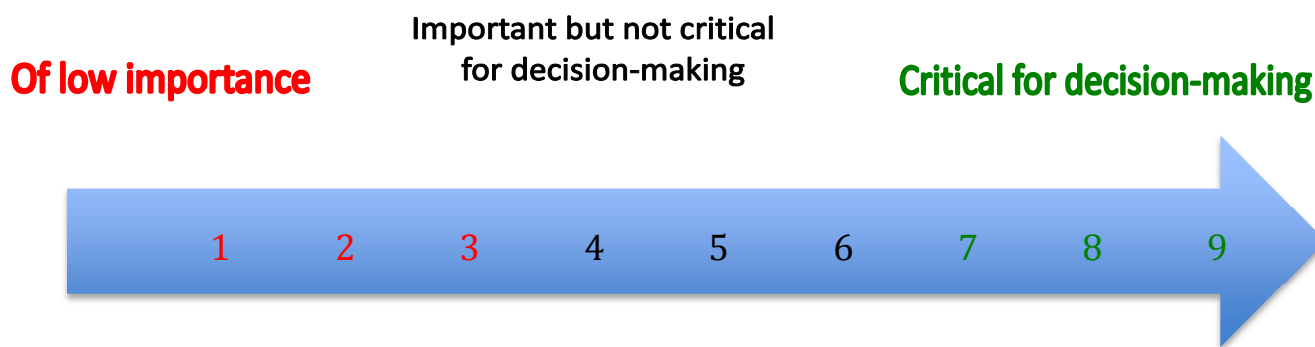
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Assigned Number_____

Factor Being Evaluated:_____

Of low importance   **Important but not critical
for decision-making**   **Critical for decision-making**

1   2   3   4   5   6   7   8   9

Circle the "Yes" or "No" answers. If "Yes" rate the importance from 1-9 by circling the appropriate number.

1-   In your opinion, is this factor commonly observed in Pediatric Obstructive Sleep Apnea patients?
Yes   1   2   3   4   5   6   7   8   9

No

2-   In your opinion, does this factor contribute to Pediatric Obstructive Sleep Apnea symptoms?
Yes   1   2   3   4   5   6   7   8   9

No

3-   In your opinion, would correcting this factor help diminish the symptoms of Pediatric Obstructive Sleep Apnea?
Yes   1   2   3   4   5   6   7   8   9

No

4-   In your opinion, does this factor contribute to orthodontic treatment need?
Yes   1   2   3   4   5   6   7   8   9

No

5-   In your opinion, is the 5-point scale appropriate for this factor?
Yes   1   2   3   4   5   6   7   8   9

No; How would you correct it?

_____

6-   Are the points on the scale attributed correctly for this factor?

Yes   1   2   3   4   5   6   7   8   9

No; How would you correct it?

_____

7-   In your opinion, are the pictures appropriate for this factor?

Yes   1   2   3   4   5   6   7   8   9

No; How would you correct it?

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Assigned Number_____

Important but not critical
for decision-making

Of low importance

Critical for decision-making

1   2   3   4   5   6   7   8   9

Circle the "Yes" or "No" answers. If "Yes" rate the importance from 1-9 by circling the appropriate number.

1. Do you think that this index is useful in fulfilling the goals of having an easy to use index that helps non-dentally trained professionals assess the orthodontic treatment need to help the symptoms in pediatric patients with OSA?

    Yes   1   2   3   4   5   6   7   8   9

    No; How would you improve it?

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2. Do you believe that the organizing committee is developing this index in the appropriate way? (i.e. Reviewing the recommendations in the literature, seeking expert opinions, gaining end-user approval and testing its reliability)

    Yes   1   2   3   4   5   6   7   8   9

    No; How would you improve it?

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3. In your opinion were all the factors, identified in this meeting, important for this index?

    Yes   1   2   3   4   5   6   7   8   9

    No; Which factors were not important?

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4. In your opinion, have all the important areas concerning orthodontic treatment need to help symptoms of OSA been identified?

    Yes   1   2   3   4   5   6   7   8   9

    No; Which ones were missed?

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5. Is the layout of the index easy to navigate?

    Yes   1   2   3   4   5   6   7   8   9

    No; How would you improve it?

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Please provide any other feedback below that may help improve the index:

BMJ Open

Developing an Index for the Orthodontic Treatment Need in Pediatric Patients with Obstructive Sleep Apnea: A Protocol for a Novel Communication Tool between Physicians and Orthodontists

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Developing an Index for the Orthodontic Treatment Need in Pediatric Patients with Obstructive Sleep Apnea: A Protocol for a Novel Communication Tool between Physicians and Orthodontists

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ABSTRACT

Introduction: Sleep disordered breathing in the pediatric population can manifest as an array of different systemic symptoms; among them is a distinct malocclusion and craniofacial phenotype. Emerging research suggests that the treatment of this malocclusion and/or craniofacial phenotype through orthodontic intervention may help with the symptoms of these patients. Selecting the patients that would benefit from orthodontic treatment can be a difficult task for the physician with minimal dental training. Therefore the aim of this study is to develop a simple index to be used by medical professionals, to identify those pediatric patients with orthodontic treatment needs that may benefit their obstructive sleep apnea (OSA) symptoms.

Methods and analysis: The methodology in this project has been devised through the World Health Organization's (WHO) recommendations on developing an index, with modifications based on the specific needs of this study. Based on the available literature, a draft index will be produced, and subjected to multiple iterative revisions based on the feedback from: the Index Development Group, a group of multidisciplinary and internationally acclaimed experts in the field; the External Review Group, a group of potential end-users and interested parties; and the Steering Committee. Once the index has been formalized, it will be subjected to a pair of reliability tests using physicians and orthodontists scored 2-weeks apart. Subsequently the index will be validated using dichotomous responses from orthodontists on whether they would treat a patient for OSA symptoms, and comparing the responses to the score of the index on the same patient.

Ethics and dissemination: The index will be translated into French, and will be presented in orthodontic and medical conferences, workshops, seminars, round table discussions and free copies for download will be made available on the website of the University of Alberta Interdisciplinary Airway Research Clinic (iarc.ualberta.ca). Furthermore, the index will be published in a peer-reviewed medical journal to further increase the exposure of the index.

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Article Summary

Article focus

- To develop a simple index for medical professionals to identify children and adolescents with obstructive sleep apnea who may experience functional airway benefit from orthodontic treatment.

Strength and limitations of this study

- This index will help physicians and other medical professionals understand and identify which obstructive sleep apnea patients with malocclusions and craniofacial phenotypes are likely to benefit from targeted orthodontic treatment, and will allow them to refer these patients accordingly.

- This index development acknowledges the multi-factorial nature of SDB and the need for multi-disciplinary care. The ideal end result of this index is to facilitate and enhance effective collaboration between invested dental and medical specialties.

- Development of a validated index will facilitate future epidemiology studies, allow for quality assurance, and guide funding allocation. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

INTRODUCTION

Snoring, although ubiquitous in the adult population, is considered abnormal in children and adolescents.[1] More importantly, it may serve as an indicator of a more severe respiratory problem that presents as a continuum, from primary snoring to obstructive sleep apnea (OSA). Reports vary on the prevalence of obstructive sleep apnea ranging from 0.7% to 5% of the population under 18 years old.[2-8] Moreover, breathing induced sleep disorders have been proven to have a profound effect on the child's behavior, growth and development; the myriad of symptoms include: morning tension-type headaches, excessive morning thirst, excessive fatigue and sleepiness, abnormal shyness, withdrawn and depressive presentation, pattern of attention-deficit/hyperactivity disorder (ADHD), memory impairments, aggressiveness, irritability, among many others.[9] [10] [11-13] Other physiologic processes that can be affected include stunted growth,[14] high blood pressure,[15] damage to the heart: ventricular hypertrophy,[16] and cor pulmonale[17].

In addition to behavioral and systemic health consequences, craniofacial development is also affected. These patients generally have a craniofacial component contributing to their OSA, which would manifest as a retrognathic maxilla[18] or mandible, a long lower face height and restriction in the space of the upper airway[19] [20]. Furthermore, when evaluating the polysomnogrophy of these patients, the evidence suggests that palatal expansion, and mandibular advancement appliances[21-26] can be of benefit at reducing the severity of OSA. Reverse pull headgear[27-32], and maxillary & mandibular advancement surgery[33] have also been shown to have great promise at helping this group of patients. Since orthodontic treatment of the OSA craniofacial phenotype is an integral component to multidisciplinary care, it is essential for medical professionals (physicians, nurses, ect) to recognize the phenotype that would benefit from orthodontic treatment. Unfortunately, there are no guidelines for non-dental trained practitioners to help identify which children with SDB would benefit from orthodontic treatment.

Therefore this study aims to develop an index that can summarize the need for orthodontic treatment, in select cases of children with OSA, to physicians, and adjunct medical professionals. Once the index is developed, it will be assessed for reliability and will be validated. Upon completion, this index will equip medical professionals with a simple way to assess which patients have a malocclusion that contribute to their OSA and may benefit from orthodontic treatment.

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METHODS AND ANALYSIS

This research is classified as an applied interdisciplinary medical research. The overall study design involves components of qualitative analysis and quantitative analysis. The qualitative components comprise focus groups and committee meetings. The quantitative components comprise reliability tests and a cross sectional validity test.

A)   Initial Development

In accordance with the World Health Organization's recommendations on developing an index,[34] development of the index will be achieved through the following objectives:

1- *Establishing a Steering Committee*
2- *Scoping the index*
3- *Reviewing the literature*
4- *Drafting the index*
5- *Organizing an Index Development Group*
6- *Organizing an External Review Group*

Steering Committee

The Steering Committee will be established apriori and is responsible for overseeing every aspect of the study. It will be composed of a representative group of 3 experts in orthodontics, pediatric sleep medicine, and a methodologist specializing in psychometric property analysis. Their responsibilities include: scoping the index, overseeing evidence retrieval, drafting the index, selecting members of the index development group and external review group, finalizing the index.

Scoping the Index

Scoping is the process of defining what factors will be investigated in the literature for inclusion in the index. Scoping will be achieved through the combined experience and expertise of the Steering Committee, and each factor that is suggested will be further investigated in the literature to establish an evidence-based approach to the development of the index.

Reviewing the Literature

For each of the scoped factors the literature will be reviewed to establish relevance. Specifically, the evidence must demonstrate that appropriate treatment of the craniofacial factor in question will lead to an improvement in the OSA symptoms. Priority will be given to the results of

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well-conducted and well-reported systematic reviews and randomized control trials. Each of the factors will be assessed on its effect on pediatric OSA. Furthermore, the literature will be searched for the craniofacial morphology of pediatric OSA patients. All of this information will be brought back to the Steering Committee for discussion of inclusion / elimination of factors in the index.

Drafting the Index

Since this index will have visual-rating scales for each of the craniofacial and occlusal factors, the steering committee will devise an outline suitable for displaying each of the factors representing the index. The factors in the drafted index will also have a number of levels that will divide the factor into categories of severity. The number of levels for a given factor will also be determined by the Steering Committee. Details describing the nature of the illustrations, the amount of levels that each of the factors will have, and the general layout of the index will be agreed upon by the steering committee, and the graphic artist will then design a preliminary version of the index based on the relevant factors and the feedback from the steering committee.

The Index Development Meeting

The Index Development Group (IDG) is formed by a group of external multidisciplinary experts who provide evidence-based recommendations, on the content, layout and development process of the index. This eclectic group should be small enough to be able to have effective discussions, while large enough to ensure the appropriate representation from all the stakeholders. In this study we plan on including a broad spectrum of medical specialists, family physicians, orthodontists, and methodologists. The goals of this meeting are to gain additional information to strengthen the index, as well as gaining the professional credibility of a broad range of experts on the topic of pediatric OSA.

Once the members have been chosen by the Steering Committee and accept the invitation to participate, the IDG members will be emailed a document 4 days prior to the meeting, explaining: the purpose of the index and meeting, how the meeting will proceed, what to expect in the meeting, and a brief literature review of the orthodontic techniques currently available to help with the symptoms of OSA. Moreover, every member will be randomly assigned a number in order to maintain anonymity of the responses.

Procedure of the IDG Meeting

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The meeting will commence with a brief introduction summarizing the literature review, the purpose of the index and its relevance. The meeting will then proceed to collect feedback (APPENDIX 1) on the aforementioned chosen factors using a modified Delphi technique[35][36], which is a communication technique that structures the meeting and minimizes bias in responses. Participants' responses will be collected through a web-based response portal. Each factor will be explored through yes or no questions, and yes responses followed-up with a scale of 1-9 based on its importance for decision-making. Once all the feedback is received on a particular factor, the summary of the results will be displayed for everyone to see. Discussion will ensue for a maximum of 5 minutes, with each person talking no more than 1 minute. Then everyone will be asked to re-enter their feedback on the website for the same factor in light of the discussion. This cycle will continue until a consensus of greater than 80% of the members is reached. Once consensus is reached, then we will move on to the next factor and the participants will be asked to give feedback on this new factor in a similar manner.

In addition, two negative control factors will be used to calibrate the responses. The first negative control will be of orthodontic relevance but have no effect on the amelioration of the symptoms of OSA (ie. crowding, or impacted canine). The second negative control will be of relevance to OSA symptoms, but cannot be changed by orthodontic treatment (ie. BMI or neck circumference).

Once all the factors have been discussed and consensus reached, we will get feedback through the website on the: alignment - importance of the index, and if the development process is appropriate; relevance – content analysis, and whether all the factors identified are important; representation – if there is anything that needs to be added to the index (APPENDIX 2). Finally, additional written feedback will be accepted at the very end of the session.

All the feedback from the IDM will be summarized and presented to the Steering Committee, and decisions will be made to remove factors, modify factors, and /or modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a second draft will be procured.

The External Review Group Meeting

The External Review Group (ERG) is composed of end-users and interested parties. This group is not responsible for any content analysis, instead it will be responsible for reviewing the

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layout, simplicity and ease of use. It will also be responsible to assess usefulness of the index in the healthcare setting and give feedback on the feasibility of implementing the index in practice. The goal of this meeting is to gain the end-user approval for the ease and feasibility of administering the index. This group should be large enough to be a representative sample of the population, yet small enough to allow for ease of explanation and healthy discussion. It is not as structured as the IDM, and allows for the participants to freely express their opinions in an open forum.

In this meeting we will explain the theory behind the index by briefly reviewing the literature and then explain the purpose of the index. Subsequently we will show the group a pilot version of the index and a paper will be distributed to receive for their feedback based on the following questions:

1- Do you understand the purpose of the index?
2- Do you understand what each factor is assessing?
    a. If not which one(s) do you not understand and why?
3- On a scale of 1 to 10, how simple would you rate this index to understand and use?
4- Would you use this index in your practice?
5- Other recommendations:

All the feedback from the ERG will be summarized and presented to the Steering Committee, and decisions will be made to modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a third draft will be procured.

B)   Reliability

Reliability of the index will be tested within a group that represents the typical end-user population. This includes physicians of family medicine, pediatricians, pediatric ENT, or pediatric sleep physicians. Reliability will also be assessed within a group of orthodontists, who by their training are experts at assessing malocclusion and craniofacial morphology. Therefore 10-20 physicians and orthodontists will be recruited as examiners in this study.

A pool of 15-40 randomly selected patient charts from the University of Alberta Inter-disciplinary Airway Research Clinic (I-ARC) will be recruited as reliability test subjects, and their intra-oral and extra-oral photographs will be used in the reliability assessment. After a brief explanation about the use and application of the index, the physicians as well as the orthodontists will apply the developed index to the sample patient pool's pictures once. In order to diminish

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recall bias, application of the index will be repeated 2 weeks later.

Intra-rater reliability and inter-rater reliability between the physicians, between the orthodontists and between the physicians and orthodontists will be compared. The reliability will be assessed using Interclass Correlation coefficients (ICC) and Bland –Altman Plots.

C)   Validation

The Index will be validated using dichotomous responses from orthodontists on whether specific patients would require orthodontic treatment to help their obstructive sleep apnea symptoms and comparing it to the score that the index gave those same patients. This will be achieved by setting up a website where 30 orthodontists with experience in dealing with pediatric OSA will be recruited to take the assessment. The website will contain extra-oral and intra-oral pictures of patients randomly selected from the Interdisciplinary Airway Research Clinic diagnosed with OSA, and the orthodontists will be asked to rate these patients, using a "yes" or "no" response, whether they would benefit from orthodontic treatment for their OSA symptoms. The index will then be applied on the same patients by the principal investigator and the score of each patient will be recorded. Using a stepwise multiple-logistic regression each of the identified factors will be given a weight; this will represent the relative importance of the factor. Once analyzed if the correlation is high between the expert scores and the cluster groups, then the clusters are meaningful and valid. Furthermore, a cutoff for most efficient score above which to refer will be chosen using a graph and observing the value that optimizes the sensitivity, specificity and overall accuracy of the index. Finally, four grades of treatment-need will be determined using the twenty-five percentile ranges. The grades will be:

1- Minimal Need

2- Mild Need

3- Moderate Need

4- Severe Need

DISCUSSION

The development plan of this index has been conceived through a modification of the WHO Handbook for guideline development,[34] as well as reviewing the orthodontic literature for ways indices have been previously developed. The WHO provided an excellent starting point, from there modifications were made to cater to the specifics of this study, given that there are differences

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between developing a guideline and an index for orthodontic treatment need. The literature was useful, and among the index development protocols reviewed, certain assessed the orthodontic treatment need within the entire population,[37-40] while others assessed it for a given subpopulation[41-46]; each had strengths and weaknesses, and thus we further modified our methods, synthesizing a protocol for our particular needs from the available literature and using the experience and expertise of the authors. Through this protocol we aim to develop an index that fulfills all of the following criteria:[47]

1. Gradient of Numeric Values: The severity of the orthodontic treatment need within the pediatric OSA patients should be defined within a numerical scheme that demonstrates a finite and progressive gradient from low need to high need.

2. Equal Sensitivity: should demonstrate equal sensitivity throughout the scale.

3. Clinical Importance: The numerical scale should correspond with the clinically appraised orthodontic treatment need of pediatric OSA patients.

4. Statistical Ease: should be amendable to statistical analysis.

5. Reliability: Should have a high intra- and inter-rater reliability.

6. Practical: The instruments required to score the index should be practical to the setting in which it will be administered.

7. Minimal Judgment: Applying the index should require minimal judgment.

8. Simple: The index shouldn't have a high financial or time cost, therefore should be simple enough to administer to many patients.

9. Detect Change: The index should be able to detect changes in orthodontic treatment need in pediatric OSA patients.

10. Validity: should be valid over time.

Validity can be characterized into different types: Face Validity, Content Validity, Construct Validity, and Criterion Validity.[48] In this study, we will examine these kinds of validity at different stages of development. The first draft of the index will focus on establishing face validity. Feedback from the steering committee and IDG will assist in establishing content and construct validity. Assuming that the "gold standard" in assessing the orthodontic treatment-need in pediatric patients with OSA is an orthodontist with experience in dealing with pediatric OSA patients, then the subsequent modification of the index based on the reliability tests and the dichotomous responses from the orthodontists provide the index with the necessary criterion-related validity

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evidence through statistical means.[49]

Significance

This index will help physicians and other medical professionals identify which craniofacial phenotypes may benefit from orthodontic treatment as part of their multi-disciplinary OSA management. Furthermore, due to the diverse medical effects of sleep deprivation, there will be a trend to make sleep apnea into a centralized service, where the main focus is for a highly trained multidisciplinary team to treat a high volume of patients to a standardized protocol, where meticulous documentation is exercised. This index is part of that documentation process. It will allow for quality assurance, funding allocation and epidemiologic studies to be performed. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

Dissemination Plan

The dissemination of this index will be done through a variety of ways in order to maximize its reach. Primarily, it will be published in a peer-reviewed journal, which will allow its introduction to the scientific literature. The journal should be a respected medical journal with broad reach, in order to allow the greatest number of physicians to be exposed to the index. Subsequently it will be translated to French, in order for it to be accessible to the entire Canadian and American population of medical professionals. Moreover, the index will be presented at national and international conferences to increase the awareness of the index among the scientific community. Finally, the index will be used at the University of Alberta's Interdisciplinary Airway Research Center, and more research, so that future research in this center will incorporate it. It will also be placed on the University of Alberta's Interdisciplinary Airway Research Center's website under the physician section, to further educate the doctors who visit the site on the index.

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Authors' Contributions

MA HS MRR MM JM PM conceived and designed the study; MA drafted the manuscript and integrated critical feedback from all of the other authors. All of the authors approved the final version of the manuscript.

Ethics approval

The proposed research has received ethical approval numbered Pro00045067 from the University of Alberta Ethics Board.

Competing Interests

The authors declare no conflicts of interests.

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Developing an Index for the Orthodontic Treatment Need in Pediatric Patients with Obstructive Sleep Apnea: A Protocol for a Novel Communication Tool between Physicians and Orthodontists

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ABSTRACT

Introduction: Sleep disordered breathing in the pediatric population can manifest as an array of different systemic symptoms; among them is a distinct malocclusion and craniofacial phenotype. Emerging research suggests that the treatment of this malocclusion and/or craniofacial phenotype through orthodontic intervention may help with the symptoms of these patients. Selecting the patients that would benefit from orthodontic treatment can be a difficult task for the physician with minimal dental training. Therefore the aim of this study is to develop a simple index to be used by medical professionals, to identify those pediatric patients with orthodontic treatment needs that may benefit their obstructive sleep apnea (OSA) symptoms.

Methods and analysis: The methodology in this project has been devised through the World Health Organization's (WHO) recommendations on developing an index, with modifications based on the specific needs of this study. Based on the available literature, a draft index will be produced, and subjected to multiple iterative revisions based on the feedback from: the Index Development Group, a group of multidisciplinary and internationally acclaimed experts in the field; the External Review Group, a group of potential end-users and interested parties; and the Steering Committee. Once the index has been formalized, it will be subjected to a pair of reliability tests using physicians and orthodontists scored 2-weeks apart. Subsequently the index will be validated using dichotomous responses from orthodontists on whether they would treat a patient for OSA symptoms, and comparing the responses to the score of the index on the same patient.

Ethics and dissemination: The index will be translated into French, and will be presented in orthodontic and medical conferences, workshops, seminars, round table discussions and free copies for download will be made available on the website of the University of Alberta Interdisciplinary Airway Research Clinic (iarc.ualberta.ca). Furthermore, the index will be published in a peer-reviewed medical journal to further increase the exposure of the index.

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Article Summary

Article focus

- To develop a simple index for medical professionals to identify children and adolescents with obstructive sleep apnea who may experience functional airway benefit from orthodontic treatment.

Strength and limitations of this study

- This index will help physicians and other medical professionals understand and identify which obstructive sleep apnea patients with malocclusions and craniofacial phenotypes are likely to benefit from targeted orthodontic treatment, and will allow them to refer these patients accordingly.

- This index development acknowledges the multi-factorial nature of SDB and the need for multi-disciplinary care. The ideal end result of this index is to facilitate and enhance effective collaboration between invested dental and medical specialties.

- Development of a validated index will facilitate future epidemiology studies, allow for quality assurance, and guide funding allocation. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

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INTRODUCTION

Snoring, although ubiquitous in the adult population, is considered abnormal in children and adolescents.[1] More importantly, it may serve as an indicator of a more severe respiratory problem that presents as a continuum, from primary snoring to obstructive sleep apnea (OSA). Reports vary on the prevalence of obstructive sleep apnea ranging from 0.7% to 5% of the population under 18 years old.[2-8] Moreover, breathing induced sleep disorders have been proven to have a profound effect on the child's behavior, growth and development; the myriad of symptoms include: morning tension-type headaches, excessive morning thirst, excessive fatigue and sleepiness, abnormal shyness, withdrawn and depressive presentation, pattern of attention-deficit/hyperactivity disorder (ADHD), memory impairments, aggressiveness, irritability, among many others.[9 10 11-13] Other physiologic processes that can be affected include stunted growth,[14] high blood pressure,[15] damage to the heart: ventricular hypertrophy,[16] and cor pulmonale[17].

In addition to behavioral and systemic health consequences, craniofacial development is also affected. These patients generally have a craniofacial component contributing to their OSA, which would manifest as a retrognathic maxilla[18] or mandible, a long lower face height and restriction in the space of the upper airway[19 20]. Furthermore, when evaluating the polysomnogrophy of these patients, the evidence suggests that palatal expansion, and mandibular advancement appliances[21-26] can be of benefit at reducing the severity of OSA. Reverse pull headgear[27-32], and maxillary & mandibular advancement surgery[33] have also been shown to have great promise at helping this group of patients. Since orthodontic treatment of the OSA craniofacial phenotype is an integral component to multidisciplinary care, it is essential for medical professionals (physicians, nurses, ect) to recognize the phenotype that would benefit from orthodontic treatment. Unfortunately, there are no guidelines for non-dental trained practitioners to help identify which children with SDB would benefit from orthodontic treatment.

Therefore this study aims to develop an index that can summarize the need for orthodontic treatment, in select cases of children with OSA, to physicians, and adjunct medical professionals. Once the index is developed, it will be assessed for reliability and will be validated. Upon completion, this index will equip medical professionals with a simple way to assess which patients have a malocclusion that contribute to their OSA and may benefit from orthodontic treatment.

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METHODS AND ANALYSIS

This research is classified as an applied interdisciplinary medical research. The overall study design involves components of qualitative analysis and quantitative analysis. The qualitative components comprise focus groups and committee meetings. The quantitative components comprise reliability tests and a cross sectional validity test.

A)   Initial Development

In accordance with the World Health Organization's recommendations on developing an index,[34] development of the index will be achieved through the following objectives:

1- Establishing a Steering Committee
2- Scoping the index
3- Reviewing the literature
4- Drafting the index
5- Organizing an Index Development Group
6- Organizing an External Review Group

Steering Committee

The Steering Committee will be established apriori and is responsible for overseeing every aspect of the study. It will be composed of a representative group of 3 experts in orthodontics, pediatric sleep medicine, and a methodologist specializing in psychometric property analysis. Their responsibilities include: scoping the index, overseeing evidence retrieval, drafting the index, selecting members of the index development group and external review group, finalizing the index.

Scoping the Index

Scoping is the process of defining what factors will be investigated in the literature for inclusion in the index. Scoping will be achieved through the combined experience and expertise of the Steering Committee, and each factor that is suggested will be further investigated in the literature to establish an evidence-based approach to the development of the index.

Reviewing the Literature

For each of the scoped factors the literature will be reviewed to establish relevance. Specifically, the evidence must demonstrate that appropriate treatment of the craniofacial factor in question will lead to an improvement in the OSA symptoms. Priority will be given to the results of

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well-conducted and well-reported systematic reviews and randomized control trials. Each of the factors will be assessed on its effect on pediatric OSA. Furthermore, the literature will be searched for the craniofacial morphology of pediatric OSA patients. All of this information will be brought back to the Steering Committee for discussion of inclusion / elimination of factors in the index.

Drafting the Index

Since this index will have visual-rating scales for each of the craniofacial and occlusal factors, the steering committee will devise an outline suitable for displaying each of the factors representing the index. The factors in the drafted index will also have a number of levels that will divide the factor into categories of severity. The number of levels for a given factor will also be determined by the Steering Committee. Details describing the nature of the illustrations, the amount of levels that each of the factors will have, and the general layout of the index will be agreed upon by the steering committee, and the graphic artist will then design a preliminary version of the index based on the relevant factors and the feedback from the steering committee.

The Index Development Meeting

The Index Development Group (IDG) is formed by a group of external multidisciplinary experts who provide evidence-based recommendations, on the content, layout and development process of the index. This eclectic group should be small enough to be able to have effective discussions, while large enough to ensure the appropriate representation from all the stakeholders. In this study we plan on including a broad spectrum of medical specialists, family physicians, orthodontists, and methodologists. The goals of this meeting are to gain additional information to strengthen the index, as well as gaining the professional credibility of a broad range of experts on the topic of pediatric OSA.

Once the members have been chosen by the Steering Committee and accept the invitation to participate, the IDG members will be emailed a document 4 days prior to the meeting, explaining: the purpose of the index and meeting, how the meeting will proceed, what to expect in the meeting, and a brief literature review of the orthodontic techniques currently available to help with the symptoms of OSA. Moreover, every member will be randomly assigned a number in order to maintain anonymity of the responses.

Procedure of the IDG Meeting

The meeting will commence with a brief introduction summarizing the literature review, the purpose of the index and its relevance. The meeting will then proceed to collect feedback (APPENDIX 1) on the aforementioned chosen factors using a modified Delphi technique[35][36], which is a communication technique that structures the meeting and minimizes bias in responses. Participants' responses will be collected through a web-based response portal. Each factor will be explored through yes or no questions, and yes responses followed-up with a scale of 1-9 based on its importance for decision-making. Once all the feedback is received on a particular factor, the summary of the results will be displayed for everyone to see. Discussion will ensue for a maximum of 5 minutes, with each person talking no more than 1 minute. Then everyone will be asked to re-enter their feedback on the website for the same factor in light of the discussion. This cycle will continue until a consensus of greater than 80% of the members is reached. Once consensus is reached, then we will move on to the next factor and the participants will be asked to give feedback on this new factor in a similar manner.

In addition, two negative control factors will be used to calibrate the responses. The first negative control will be of orthodontic relevance but have no effect on the amelioration of the symptoms of OSA (ie. crowding, or impacted canine). The second negative control will be of relevance to OSA symptoms, but cannot be changed by orthodontic treatment (ie. BMI or neck circumference).

Once all the factors have been discussed and consensus reached, we will get feedback through the website on the: alignment - importance of the index, and if the development process is appropriate; relevance – content analysis, and whether all the factors identified are important; representation – if there is anything that needs to be added to the index (APPENDIX 2). Finally, additional written feedback will be accepted at the very end of the session.

All the feedback from the IDM will be summarized and presented to the Steering Committee, and decisions will be made to remove factors, modify factors, and /or modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a second draft will be procured.

The External Review Group Meeting

The External Review Group (ERG) is composed of end-users and interested parties. This group is not responsible for any content analysis, instead it will be responsible for reviewing the

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layout, simplicity and ease of use. It will also be responsible to assess usefulness of the index in the healthcare setting and give feedback on the feasibility of implementing the index in practice. The goal of this meeting is to gain the end-user approval for the ease and feasibility of administering the index. This group should be large enough to be a representative sample of the population, yet small enough to allow for ease of explanation and healthy discussion. It is not as structured as the IDM, and allows for the participants to freely express their opinions in an open forum.

In this meeting we will explain the theory behind the index by briefly reviewing the literature and then explain the purpose of the index. Subsequently we will show the group a pilot version of the index and a paper will be distributed to receive for their feedback based on the following questions:

1- Do you understand the purpose of the index?
2- Do you understand what each factor is assessing?
   a. If not which one(s) do you not understand and why?
3- On a scale of 1 to 10, how simple would you rate this index to understand and use?
4- Would you use this index in your practice?
5- Other recommendations:

All the feedback from the ERG will be summarized and presented to the Steering Committee, and decisions will be made to modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a third draft will be procured.

B)   Reliability

Reliability of the index will be tested within a group that represents the typical end-user population. This includes physicians of family medicine, pediatricians, pediatric ENT, or pediatric sleep physicians. Reliability will also be assessed within a group of orthodontists, who by their training are experts at assessing malocclusion and craniofacial morphology. Therefore 10-20 physicians and orthodontists will be recruited as examiners in this study.

A pool of 15-40 randomly selected patient charts from the University of Alberta Inter-disciplinary Airway Research Clinic (I-ARC) will be recruited as reliability test subjects, and their intra-oral and extra-oral photographs will be used in the reliability assessment. After a brief explanation about the use and application of the index, the physicians as well as the orthodontists will apply the developed index to the sample patient pool's pictures once. In order to diminish

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recall bias, application of the index will be repeated 2 weeks later.

Intra-rater reliability and inter-rater reliability between the physicians, between the orthodontists and between the physicians and orthodontists will be compared. The reliability will be assessed using Interclass Correlation coefficients (ICC) and Bland –Altman Plots.

C)   Validation

The Index will be validated using dichotomous responses from orthodontists on whether specific patients would require orthodontic treatment to help their obstructive sleep apnea symptoms and comparing it to the score that the index gave those same patients. This will be achieved by setting up a website where 30 orthodontists with experience in dealing with pediatric OSA will be recruited to take the assessment. The website will contain extra-oral and intra-oral pictures of patients randomly selected from the Interdisciplinary Airway Research Clinic diagnosed with OSA, and the orthodontists will be asked to rate these patients, using a "yes" or "no" response, whether they would benefit from orthodontic treatment for their OSA symptoms. The index will then be applied on the same patients by the principal investigator and the score of each patient will be recorded. Using a stepwise multiple-logistic regression each of the identified factors will be given a weight; this will represent the relative importance of the factor. Once analyzed if the correlation is high between the expert scores and the cluster groups, then the clusters are meaningful and valid. Furthermore, a cutoff for most efficient score above which to refer will be chosen using a graph and observing the value that optimizes the sensitivity, specificity and overall accuracy of the index. Finally, four grades of treatment-need will be determined using the twenty-five percentile ranges. The grades will be:

1- Minimal Need

2- Mild Need

3- Moderate Need

4- Severe Need

DISCUSSION

The development plan of this index has been conceived through a modification of the WHO Handbook for guideline development,[34] as well as reviewing the orthodontic literature for ways indices have been previously developed. The WHO provided an excellent starting point, from there modifications were made to cater to the specifics of this study, given that there are differences

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between developing a guideline and an index for orthodontic treatment need. The literature was useful, and among the index development protocols reviewed, certain assessed the orthodontic treatment need within the entire population,[37-40] while others assessed it for a given subpopulation[41-46]; each had strengths and weaknesses, and thus we further modified our methods, synthesizing a protocol for our particular needs from the available literature and using the experience and expertise of the authors. Through this protocol we aim to develop an index that fulfills all of the following criteria:[47]

1. Gradient of Numeric Values: The severity of the orthodontic treatment need within the pediatric OSA patients should be defined within a numerical scheme that demonstrates a finite and progressive gradient from low need to high need.
2. Equal Sensitivity: should demonstrate equal sensitivity throughout the scale.
3. Clinical Importance: The numerical scale should correspond with the clinically appraised orthodontic treatment need of pediatric OSA patients.
4. Statistical Ease: should be amendable to statistical analysis.
5. Reliability: Should have a high intra- and inter-rater reliability.
6. Practical: The instruments required to score the index should be practical to the setting in which it will be administered.
7. Minimal Judgment: Applying the index should require minimal judgment.
8. Simple: The index shouldn't have a high financial or time cost, therefore should be simple enough to administer to many patients.
9. Detect Change: The index should be able to detect changes in orthodontic treatment need in pediatric OSA patients.
10. Validity: should be valid over time.

Validity can be characterized into different types: Face Validity, Content Validity, Construct Validity, and Criterion Validity.[48] In this study, we will examine these kinds of validity at different stages of development. The first draft of the index will focus on establishing face validity. Feedback from the steering committee and IDG will assist in establishing content and construct validity. Assuming that the "gold standard" in assessing the orthodontic treatment-need in pediatric patients with OSA is an orthodontist with experience in dealing with pediatric OSA patients, then the subsequent modification of the index based on the reliability tests and the dichotomous responses from the orthodontists provide the index with the necessary criterion-related validity

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evidence through statistical means.[49]

Significance

This index will help physicians and other medical professionals identify which craniofacial phenotypes may benefit from orthodontic treatment as part of their multi-disciplinary OSA management. Furthermore, due to the diverse medical effects of sleep deprivation, there will be a trend to make sleep apnea into a centralized service, where the main focus is for a highly trained multidisciplinary team to treat a high volume of patients to a standardized protocol, where meticulous documentation is exercised. This index is part of that documentation process. It will allow for quality assurance, funding allocation and epidemiologic studies to be performed. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

Dissemination Plan

The dissemination of this index will be done through a variety of ways in order to maximize its reach. Primarily, it will be published in a peer-reviewed journal, which will allow its introduction to the scientific literature. The journal should be a respected medical journal with broad reach, in order to allow the greatest number of physicians to be exposed to the index. Subsequently it will be translated to French, in order for it to be accessible to the entire Canadian and American population of medical professionals. Moreover, the index will be presented at national and international conferences to increase the awareness of the index among the scientific community. Finally, the index will be used at the University of Alberta's Interdisciplinary Airway Research Center, and more research, so that future research in this center will incorporate it. It will also be placed on the University of Alberta's Interdisciplinary Airway Research Center's website under the physician section, to further educate the doctors who visit the site on the index.

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Authors' Contributions

MA HS MRR MM JM PM conceived and designed the study; MA drafted the manuscript and integrated critical feedback from all of the other authors. All of the authors approved the final version of the manuscript.

Ethics approval

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The proposed research has received ethical approval numbered Pro00045067 from the University of Alberta Ethics Board.

Competing Interests

The authors declare no conflicts of interests.

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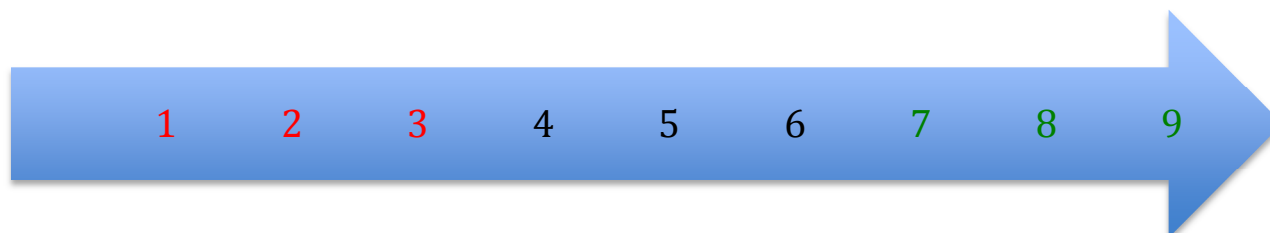
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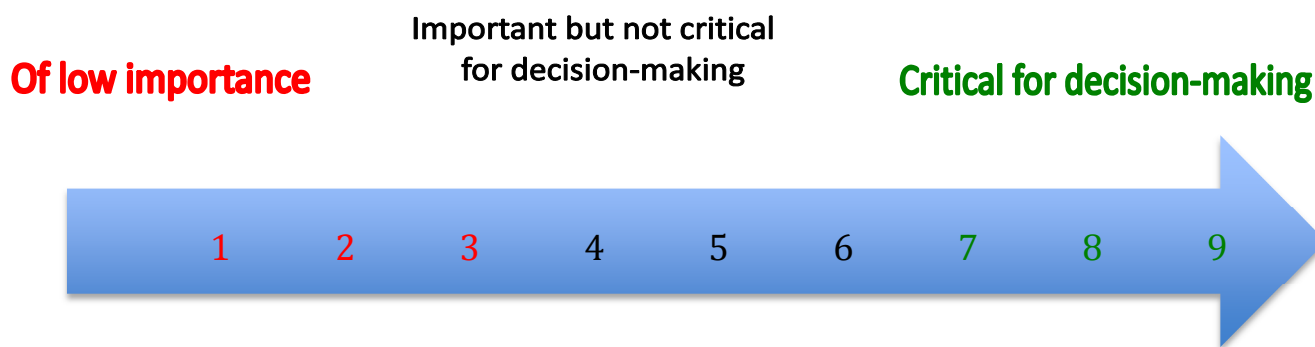
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Assigned Number_____

Factor Being Evaluated:_____

Important but not critical
for decision-making

Of low importance

Critical for decision-making

1   2   3   4   5   6   7   8   9

Circle the "Yes" or "No" answers. If "Yes" rate the importance from 1-9 by circling the appropriate number.

1- In your opinion, is this factor commonly observed in Pediatric Obstructive Sleep Apnea patients?

Yes   1   2   3   4   5   6   7   8   9

No

2- In your opinion, does this factor contribute to Pediatric Obstructive Sleep Apnea symptoms?

Yes   1   2   3   4   5   6   7   8   9

No

3- In your opinion, would correcting this factor help diminish the symptoms of Pediatric Obstructive Sleep Apnea?

Yes   1   2   3   4   5   6   7   8   9

No

4- In your opinion, does this factor contribute to orthodontic treatment need?

Yes   1   2   3   4   5   6   7   8   9

No

5- In your opinion, is the 5-point scale appropriate for this factor?

Yes   1   2   3   4   5   6   7   8   9

No; How would you correct it?

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6- Are the points on the scale attributed correctly for this factor?

Yes   1   2   3   4   5   6   7   8   9

No; How would you correct it?

_____

7- In your opinion, are the pictures appropriate for this factor?

Yes   1   2   3   4   5   6   7   8   9

No; How would you correct it?

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Assigned Number_____

**Important but not critical
for decision-making**

Of low importance

Critical for decision-making

1   2   3   4   5   6   7   8   9

Circle the "Yes" or "No" answers. If "Yes" rate the importance from 1-9 by circling the appropriate number.

1. Do you think that this index is useful in fulfilling the goals of having an easy to use index that helps non-dentally trained professionals assess the orthodontic treatment need to help the symptoms in pediatric patients with OSA?

   Yes   1   2   3   4   5   6   7   8   9

   No; How would you improve it?

   _____

2. Do you believe that the organizing committee is developing this index in the appropriate way? (i.e. Reviewing the recommendations in the literature, seeking expert opinions, gaining end-user approval and testing its reliability)

   Yes   1   2   3   4   5   6   7   8   9

   No; How would you improve it?

   _____

3. In your opinion were all the factors, identified in this meeting, important for this index?

   Yes   1   2   3   4   5   6   7   8   9

   No; Which factors were not important?

   _____

4. In your opinion, have all the important areas concerning orthodontic treatment need to help symptoms of OSA been identified?

   Yes   1   2   3   4   5   6   7   8   9

   No; Which ones were missed?

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5. Is the layout of the index easy to navigate?

   Yes   1   2   3   4   5   6   7   8   9

   No; How would you improve it?

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Please provide any other feedback below that may help improve the index:

BMJ Open

Developing an Index for the Orthodontic Treatment Need in Pediatric Patients with Obstructive Sleep Apnea: A Protocol for a Novel Communication Tool between Physicians and Orthodontists

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Developing an Index for the Orthodontic Treatment Need in Pediatric Patients with Obstructive Sleep Apnea: A Protocol for a Novel Communication Tool between Physicians and Orthodontists

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Word Count: 2807

Key Words: Obstructive Sleep Apnea; Pediatric; Index; Orthodontic Treatment Need; Visual Analogue Scale; Development; Validation; Reliability.

ABSTRACT

Introduction: Sleep disordered breathing in the pediatric population can manifest as an array of different systemic symptoms; among them is a distinct malocclusion and craniofacial phenotype. Emerging research suggests that the treatment of this malocclusion and/or craniofacial phenotype through orthodontic intervention may help with the symptoms of these patients. Selecting the patients that would benefit from orthodontic treatment can be a difficult task for the physician with minimal dental training. Therefore the aim of this study is to develop a simple index to be used by medical professionals, to identify those pediatric patients with orthodontic treatment needs that may benefit their obstructive sleep apnea (OSA) symptoms.

Methods and analysis: The methodology in this project has been devised through the World Health Organization's (WHO) recommendations on developing an index, with modifications based on the specific needs of this study. Based on the available literature, a draft index will be produced, and subjected to multiple iterative revisions based on the feedback from: the Index Development Group, a group of multidisciplinary and internationally acclaimed experts in the field; the External Review Group, a group of potential end-users and interested parties; and the Steering Committee. Once the index has been formalized, it will be subjected to a pair of reliability tests using physicians and orthodontists scored 2-weeks apart. Subsequently the index will be validated using dichotomous responses from orthodontists on whether they would treat a patient for OSA symptoms, and comparing the responses to the score of the index on the same patient.

Ethics and dissemination: The index will be translated into French, and will be presented in orthodontic and medical conferences, workshops, seminars, round table discussions and free copies for download will be made available on the website of the University of Alberta Interdisciplinary Airway Research Clinic (iarc.ualberta.ca). Furthermore, the index will be published in a peer-reviewed medical journal to further increase the exposure of the index.

Article Summary

Article focus

- To develop a simple index for medical professionals to identify children and adolescents with obstructive sleep apnea who may experience functional airway benefit from orthodontic treatment.

Strength and limitations of this study

- This index will help physicians and other medical professionals understand and identify which obstructive sleep apnea patients with malocclusions and craniofacial phenotypes are likely to benefit from targeted orthodontic treatment, and will allow them to refer these patients accordingly.

- This index development acknowledges the multi-factorial nature of SDB and the need for multi-disciplinary care. The ideal end result of this index is to facilitate and enhance effective collaboration between invested dental and medical specialties.

- Development of a validated index will facilitate future epidemiology studies, allow for quality assurance, and guide funding allocation. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

INTRODUCTION

Snoring, although ubiquitous in the adult population, is considered abnormal in children and adolescents.[1] More importantly, it may serve as an indicator of a more severe respiratory problem that presents as a continuum, from primary snoring to obstructive sleep apnea (OSA). Reports vary on the prevalence of obstructive sleep apnea ranging from 0.7% to 5% of the population under 18 years old.[2-8] Moreover, breathing induced sleep disorders have been proven to have a profound effect on the child's behavior, growth and development; the myriad of symptoms include: morning tension-type headaches, excessive morning thirst, excessive fatigue and sleepiness, abnormal shyness, withdrawn and depressive presentation, pattern of attention-deficit/hyperactivity disorder (ADHD), memory impairments, aggressiveness, irritability, among many others.[9 10 11-13] Other physiologic processes that can be affected include stunted growth,[14] high blood pressure,[15] damage to the heart: ventricular hypertrophy,[16] and cor pulminale[17]. In addition to behavioral and systemic health consequences, craniofacial development is also affected. These patients generally have a craniofacial component contributing to their OSA, which would manifest as a retrognathic maxilla[18] or mandible, a long lower face height and restriction in the space of the upper airway[19 20]. Furthermore, when evaluating the polysomnogrophy of these patients, the evidence suggests that palatal expansion, and mandibular advancement appliances[21-26] can be of benefit at reducing the severity of OSA. Reverse pull headgear[27-32], and maxillary & mandibular advancement surgery[33] have also been shown to have great promise at helping this group of patients. Since orthodontic treatment of the OSA craniofacial phenotype is an integral component to multidisciplinary care, it is essential for medical professionals (physicians, nurses, ect) to recognize the phenotype that would benefit from orthodontic treatment. Unfortunately, there are no guidelines for non-dental trained practitioners to help identify which children with SDB would benefit from orthodontic treatment. Therefore this study aims to develop an index that can summarize the need for orthodontic treatment, in select cases of children with OSA, to physicians, and adjunct medical professionals. Once the index is developed, it will be assessed for reliability and will be validated. Upon completion, this index will equip medical professionals with a simple way to assess which patients have a malocclusion that contribute to their OSA and may benefit from orthodontic treatment.

METHODS AND ANALYSIS

This research is classified as an applied interdisciplinary medical research. The overall study design involves components of qualitative analysis and quantitative analysis. The qualitative components

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comprise focus groups and committee meetings. The quantitative components comprise reliability tests and a cross sectional validity test.

A)   Initial Development

In accordance with the World Health Organization's recommendations on developing an index,[34] development of the index will be achieved through the following objectives:

1- *Establishing a Steering Committee*
2- *Scoping the index*
3- *Reviewing the literature*
4- *Drafting the index*
5- *Organizing an Index Development Group*
6- *Organizing an External Review Group*

Steering Committee

The Steering Committee will be established apriori, and will be identified by the principal investigator based on the required expertise in the involved fields and based on availability and access. The Steering Committee will be responsible for overseeing every aspect of the study. It will be composed of a representative group of 3 experts in orthodontics, pediatric sleep medicine, and a methodologist specializing in psychometric property analysis. Their responsibilities include: scoping the index, overseeing evidence retrieval, drafting the index, selecting members of the index development group and external review group, finalizing the index. In these meetings unanimous consensus through discussion must be reached on all decisions before proceeding to the next step.

Scoping the Index

Scoping is the process of defining what factors will be investigated in the literature for inclusion in the index. Scoping will be achieved through the combined experience and expertise of the Steering Committee, and each factor that is suggested will be further investigated in the literature to establish an evidence-based approach to the development of the index.

Reviewing the Literature

For each of the scoped factors the literature will be reviewed to establish relevance. Specifically, the evidence must demonstrate that appropriate treatment of the craniofacial factor in

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question will lead to an improvement in the OSA symptoms. The literature search will not be a systematic review, and will include results from PubMed, Medline, EMBASE, Web of Science, Scopus, the Cochrane Library and grey literature. The search strategy including: inclusion criteria, exclusion criteria and key words, will be devised through the advice of the steering committee. The searches themselves will be done in duplicate, using 2 different assessors. Of the relevant articles, hand searches will be performed on the bibliography lists. The results will be discussed and consensus will be reached between both assessors for the results of the search. Priority will be given to the results of well-conducted and well-reported systematic reviews and randomized control trials. Each of the factors will be assessed on its effect on pediatric OSA. Furthermore, the literature will be searched for the craniofacial morphology of pediatric OSA patients. All of this information will be brought back to the Steering Committee for discussion of inclusion / elimination of factors in the index.

Drafting the Index

Since this index will have visual-rating scales for each of the craniofacial and occlusal factors, the steering committee will devise an outline suitable for displaying each of the factors representing the index. The factors in the drafted index will also have a number of levels that will divide the factor into categories of severity. The number of levels for a given factor will also be determined by the Steering Committee. Details describing the nature of the illustrations, the amount of levels that each of the factors will have, and the general layout of the index will be agreed upon by the steering committee, and the graphic artist will then design a preliminary version of the index based on the relevant factors and the feedback from the steering committee.

The Index Development Meeting

The Index Development Group (IDG) is formed by a group of external multidisciplinary experts who provide evidence-based recommendations, on the content, layout and development process of the index. This eclectic group will be chosen by the Steering committee based on experience in the field, expertise and ability to contribute, availability and access. The group should be small enough to be able to have effective discussions, while large enough to ensure the appropriate representation from all the stakeholders. In this study we plan on including a broad spectrum of medical specialists, family physicians, orthodontists, and methodologists. The goals of this meeting are to gain additional information to strengthen the index, as well as gaining the professional credibility of a broad range of experts on the topic of pediatric OSA.

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Once the members have been chosen by the Steering Committee and accept the invitation to participate, the IDG members will be emailed a document 4 days prior to the meeting, explaining: the purpose of the index and meeting, how the meeting will proceed, what to expect in the meeting, and a brief literature review of the orthodontic techniques currently available to help with the symptoms of OSA. Moreover, every member will be randomly assigned a number in order to maintain anonymity of the responses.

Procedure of the IDG Meeting

The meeting will commence with a brief introduction summarizing the literature review, the purpose of the index and its relevance. The meeting will then proceed to collect feedback (DIX 1) on the aforementioned chosen factors using a modified Delphi technique[35 36] , which is a communication technique that structures the meeting and minimizes bias in responses. Participants' responses will be collected through a web-based response portal. Each factor will be explored through yes or no questions, and yes responses followed-up with a scale of 1-9 based on its importance for decision-making. Once all the feedback is received on a particular factor, the summary of the results will be displayed for everyone to see. Discussion will ensue for a maximum of 5 minutes, with each person talking no more than 1 minute. Then everyone will be asked to re-enter their feedback on the website for the same factor in light of the discussion. This cycle will continue until a consensus of greater than 80% of the members is reached. Once consensus is reached, then we will move on to the next factor and the participants will be asked to give feedback on this new factor in a similar manner.

In addition, two negative control factors will be used to calibrate the responses. The first negative control will be of orthodontic relevance but have no effect on the amelioration of the symptoms of OSA (ie. crowding, or impacted canine). The second negative control will be of relevance to OSA symptoms, but cannot be changed by orthodontic treatment (ie. BMI or neck circumference).

Once all the factors have been discussed and consensus reached, we will get feedback through the website on the: alignment - importance of the index, and if the development process is appropriate; relevance – content analysis, and whether all the factors identified are important; representation – if there is anything that needs to be added to the index (APPENDIX 2). Finally, additional written feedback will be accepted at the very end of the session.

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All the feedback from the IDM will be summarized and presented to the Steering Committee, and decisions will be made to remove factors, modify factors, and /or modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a second draft will be procured.

The External Review Group Meeting

The External Review Group (ERG) is composed of end-users and interested parties. The group will also be identified based on the advice of the steering committee based on the ability of the group to assess the index and contribute to its development, availability and access. This group is not responsible for any content analysis, instead it will be responsible for reviewing the layout, simplicity and ease of use. It will also be responsible to assess usefulness of the index in the healthcare setting and give feedback on the feasibility of implementing the index in practice. The goal of this meeting is to gain the end-user approval for the ease and feasibility of administering the index. This group should be large enough to be a representative sample of the population, yet small enough to allow for ease of explanation and healthy discussion. It is not as structured as the IDM, and allows for the participants to freely express their opinions in an open forum.

In this meeting we will explain the theory behind the index by briefly reviewing the literature and then explain the purpose of the index. Subsequently we will show the group a pilot version of the index and a paper will be distributed to receive for their feedback based on the following questions:

1- Do you understand the purpose of the index?
2- Do you understand what each factor is assessing?
    a. If not which one(s) do you not understand and why?
3- On a scale of 1 to 10, how simple would you rate this index to understand and use?
4- Would you use this index in your practice?
5- Other recommendations:

By compiling all the comments and scores onto a table, the results will display all the feedback from the ERG meeting. All these results will be presented to the Steering Committee, and decisions will be made to modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a third draft will be procured.

B)   Reliability

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Reliability of the index will be tested within a group that represents the typical end-user population. This includes physicians of family medicine, pediatricians, pediatric ENT, or pediatric sleep physicians. Reliability will also be assessed within a group of orthodontists, who by their training are experts at assessing malocclusion and craniofacial morphology. Therefore 10-20 physicians and orthodontists will be recruited as examiners in this study.

A pool of 15-40 randomly selected patient charts from the University of Alberta Inter-disciplinary Airway Research Clinic (I-ARC) will be recruited as reliability test subjects, and their intra-oral and extra-oral photographs will be used in the reliability assessment. After a brief explanation about the use and application of the index, the physicians as well as the orthodontists will apply the developed index to the sample patient pool's pictures once. In order to diminish recall bias, application of the index will be repeated 2 weeks later.

Intra-rater reliability and inter-rater reliability between the physicians, between the orthodontists and between the physicians and orthodontists will be compared. The reliability will be assessed using Interclass Correlation coefficients (ICC) and Bland –Altman Plots.

C)   Validation

The Index will be validated using dichotomous responses from orthodontists on whether specific patients would require orthodontic treatment to help their obstructive sleep apnea symptoms and comparing it to the score that the index gave those same patients. This will be achieved by setting up a website where 30 orthodontists with experience in dealing with pediatric OSA will be recruited to take the assessment. The website will contain extra-oral and intra-oral pictures of patients randomly selected from the Interdisciplinary Airway Research Clinic diagnosed with OSA, and the orthodontists will be asked to rate these patients, using a "yes" or "no" response, whether they would benefit from orthodontic treatment for their OSA symptoms. The index will then be applied on the same patients by the principal investigator and the score of each patient will be recorded. Using a stepwise multiple-logistic regression each of the identified factors will be given a weight; this will represent the relative importance of the factor. Once analyzed if the correlation is high between the expert scores and the cluster groups, then the clusters are meaningful and valid. Furthermore, a cutoff for most efficient score above which to refer will be chosen using a graph and observing the value that optimizes the sensitivity, specificity and overall accuracy of the index. Finally, four grades of treatment-need will be determined using the twenty-five percentile ranges. The grades will be:

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1- Minimal Need

2- Mild Need

3- Moderate Need

4- Severe Need

DISCUSSION

The development plan of this index has been conceived through a modification of the WHO Handbook for guideline development,[34] as well as reviewing the orthodontic literature for ways indices have been previously developed. The WHO provided an excellent starting point, from there modifications were made to cater to the specifics of this study, given that there are differences between developing a guideline and an index for orthodontic treatment need. The literature was useful, and among the index development protocols reviewed, certain assessed the orthodontic treatment need within the entire population,[37-40] while others assessed it for a given subpopulation[41-46]; each had strengths and weaknesses, and thus we further modified our methods, synthesizing a protocol for our particular needs from the available literature and using the experience and expertise of the authors. Through this protocol we aim to develop an index that fulfills all of the following criteria:[47]

1. Gradient of Numeric Values: The severity of the orthodontic treatment need within the pediatric OSA patients should be defined within a numerical scheme that demonstrates a finite and progressive gradient from low need to high need.

2. Equal Sensitivity: should demonstrate equal sensitivity throughout the scale.

3. Clinical Importance: The numerical scale should correspond with the clinically appraised orthodontic treatment need of pediatric OSA patients.

4. Statistical Ease: should be amendable to statistical analysis.

5. Reliability: Should have a high intra- and inter-rater reliability.

6. Practical: The instruments required to score the index should be practical to the setting in which it will be administered.

7. Minimal Judgment: Applying the index should require minimal judgment.

8. Simple: The index shouldn't have a high financial or time cost, therefore should be simple enough to administer to many patients.

9. Detect Change: The index should be able to detect changes in orthodontic treatment need in pediatric OSA patients.

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10. Validity: should be valid over time.

Validity can be characterized into different types: Face Validity, Content Validity, Construct Validity, and Criterion Validity.[48] In this study, we will examine these kinds of validity at different stages of development. The first draft of the index will focus on establishing face validity. Feedback from the steering committee and IDG will assist in establishing content and construct validity. Assuming that the "gold standard" in assessing the orthodontic treatment-need in pediatric patients with OSA is an orthodontist with experience in dealing with pediatric OSA patients, then the subsequent modification of the index based on the reliability tests and the dichotomous responses from the orthodontists provide the index with the necessary criterion-related validity evidence through statistical means.[49]

Significance

This index will help physicians and other medical professionals identify which craniofacial phenotypes may benefit from orthodontic treatment as part of their multi-disciplinary OSA management. Furthermore, due to the diverse medical effects of sleep deprivation, there will be a trend to make sleep apnea into a centralized service, where the main focus is for a highly trained multidisciplinary team to treat a high volume of patients to a standardized protocol, where meticulous documentation is exercised. This index is part of that documentation process. It will allow for quality assurance, funding allocation and epidemiologic studies to be performed. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

Dissemination Plan

The dissemination of this index will be done through a variety of ways in order to maximize its reach. Primarily, it will be published in a peer-reviewed journal, which will allow its introduction to the scientific literature. The journal should be a respected medical journal with broad reach, in order to allow the greatest number of physicians to be exposed to the index. Subsequently it will be translated to French, in order for it to be accessible to the entire Canadian and American population of medical professionals. Moreover, the index will be presented at national and international conferences to increase the awareness of the index among the scientific community. Finally, the index will be used at the University of Alberta's Interdisciplinary Airway Research Center, and more research, so that future research in this center will incorporate it. It will

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also be placed on the University of Alberta's Interdisciplinary Airway Research Center's website under the physician section, to further educate the doctors who visit the site on the index.

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Authors' Contributions

MA HS MRR MM JM PM conceived and designed the study; MA drafted the manuscript and integrated critical feedback from all of the other authors. All of the authors approved the final version of the manuscript.

Ethics approval

The proposed research has received ethical approval numbered Pro00045067 from the University of Alberta Ethics Board.

Competing Interests

The authors declare no conflicts of interests.

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Developing an Index for the Orthodontic Treatment Need in Pediatric Patients with Obstructive Sleep Apnea: A Protocol for a Novel Communication Tool between Physicians and Orthodontists

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ABSTRACT

Introduction: Sleep disordered breathing in the pediatric population can manifest as an array of different systemic symptoms; among them is a distinct malocclusion and craniofacial phenotype. Emerging research suggests that the treatment of this malocclusion and/or craniofacial phenotype through orthodontic intervention may help with the symptoms of these patients. Selecting the patients that would benefit from orthodontic treatment can be a difficult task for the physician with minimal dental training. Therefore the aim of this study is to develop a simple index to be used by medical professionals, to identify those pediatric patients with orthodontic treatment needs that may benefit their obstructive sleep apnea (OSA) symptoms.

Methods and analysis: The methodology in this project has been devised through the World Health Organization's (WHO) recommendations on developing an index, with modifications based on the specific needs of this study. Based on the available literature, a draft index will be produced, and subjected to multiple iterative revisions based on the feedback from: the Index Development Group, a group of multidisciplinary and internationally acclaimed experts in the field; the External Review Group, a group of potential end-users and interested parties; and the Steering Committee. Once the index has been formalized, it will be subjected to a pair of reliability tests using physicians and orthodontists scored 2-weeks apart. Subsequently the index will be validated using dichotomous responses from orthodontists on whether they would treat a patient for OSA symptoms, and comparing the responses to the score of the index on the same patient.

Ethics and dissemination: The index will be translated into French, and will be presented in orthodontic and medical conferences, workshops, seminars, round table discussions and free copies for download will be made available on the website of the University of Alberta Interdisciplinary Airway Research Clinic (iarc.ualberta.ca). Furthermore, the index will be published in a peer-reviewed medical journal to further increase the exposure of the index.

Article Summary

Article focus

- To develop a simple index for medical professionals to identify children and adolescents with obstructive sleep apnea who may experience functional airway benefit from orthodontic treatment.

Strength and limitations of this study

- This index will help physicians and other medical professionals understand and identify which obstructive sleep apnea patients with malocclusions and craniofacial phenotypes are likely to benefit from targeted orthodontic treatment, and will allow them to refer these patients accordingly.

- This index development acknowledges the multi-factorial nature of SDB and the need for multi-disciplinary care. The ideal end result of this index is to facilitate and enhance effective collaboration between invested dental and medical specialties.

- Development of a validated index will facilitate future epidemiology studies, allow for quality assurance, and guide funding allocation. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

INTRODUCTION

Snoring, although ubiquitous in the adult population, is considered abnormal in children and adolescents.[1] More importantly, it may serve as an indicator of a more severe respiratory problem that presents as a continuum, from primary snoring to obstructive sleep apnea (OSA). Reports vary on the prevalence of obstructive sleep apnea ranging from 0.7% to 5% of the population under 18 years old.[2-8] Moreover, breathing induced sleep disorders have been proven to have a profound effect on the child's behavior, growth and development; the myriad of symptoms include: morning tension-type headaches, excessive morning thirst, excessive fatigue and sleepiness, abnormal shyness, withdrawn and depressive presentation, pattern of attention-deficit/hyperactivity disorder (ADHD), memory impairments, aggressiveness, irritability, among many others.[9 10 11-13] Other physiologic processes that can be affected include stunted growth,[14] high blood pressure,[15] damage to the heart: ventricular hypertrophy,[16] and cor pulminale[17]. In addition to behavioral and systemic health consequences, craniofacial development is also affected. These patients generally have a craniofacial component contributing to their OSA, which would manifest as a retrognathic maxilla[18] or mandible, a long lower face height and restriction in the space of the upper airway[19 20]. Furthermore, when evaluating the polysomnogrophy of these patients, the evidence suggests that palatal expansion, and mandibular advancement appliances[21-26] can be of benefit at reducing the severity of OSA. Reverse pull headgear[27-32], and maxillary & mandibular advancement surgery[33] have also been shown to have great promise at helping this group of patients. Since orthodontic treatment of the OSA craniofacial phenotype is an integral component to multidisciplinary care, it is essential for medical professionals (physicians, nurses, ect) to recognize the phenotype that would benefit from orthodontic treatment. Unfortunately, there are no guidelines for non-dental trained practitioners to help identify which children with SDB would benefit from orthodontic treatment. Therefore this study aims to develop an index that can summarize the need for orthodontic treatment, in select cases of children with OSA, to physicians, and adjunct medical professionals. Once the index is developed, it will be assessed for reliability and will be validated. Upon completion, this index will equip medical professionals with a simple way to assess which patients have a malocclusion that contribute to their OSA and may benefit from orthodontic treatment.

METHODS AND ANALYSIS

This research is classified as an applied interdisciplinary medical research. The overall study design involves components of qualitative analysis and quantitative analysis. The qualitative components

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comprise focus groups and committee meetings. The quantitative components comprise reliability tests and a cross sectional validity test.

A)   Initial Development

In accordance with the World Health Organization's recommendations on developing an index,[34] development of the index will be achieved through the following objectives:

1- *Establishing a Steering Committee*
2- *Scoping the index*
3- *Reviewing the literature*
4- *Drafting the index*
5- *Organizing an Index Development Group*
6- *Organizing an External Review Group*

Steering Committee

The Steering Committee will be established apriori, and will be identified by the principal investigator based on the required expertise in the involved fields and based on availability and access. The Steering Committee will be responsible for overseeing every aspect of the study. It will be composed of a representative group of 3 experts in orthodontics, pediatric sleep medicine, and a methodologist specializing in psychometric property analysis. Their responsibilities include: scoping the index, overseeing evidence retrieval, drafting the index, selecting members of the index development group and external review group, finalizing the index. In these meetings unanimous consensus through discussion must be reached on all decisions before proceeding to the next step.

Scoping the Index

Scoping is the process of defining what factors will be investigated in the literature for inclusion in the index. Scoping will be achieved through the combined experience and expertise of the Steering Committee, and each factor that is suggested will be further investigated in the literature to establish an evidence-based approach to the development of the index.

Reviewing the Literature

For each of the scoped factors the literature will be reviewed to establish relevance. Specifically, the evidence must demonstrate that appropriate treatment of the craniofacial factor in

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question will lead to an improvement in the OSA symptoms. The literature search will not be a systematic review, and will include results from PubMed, Medline, EMBASE, Web of Science, Scopus, the Cochrane Library and grey literature. The search strategy including: inclusion criteria, exclusion criteria and key words, will be devised through the advice of the steering committee. The searches themselves will be done in duplicate, using 2 different assessors. Of the relevant articles, hand searches will be performed on the bibliography lists. The results will be discussed and consensus will be reached between both assessors for the results of the search. Priority will be given to the results of well-conducted and well-reported systematic reviews and randomized control trials. Each of the factors will be assessed on its effect on pediatric OSA. Furthermore, the literature will be searched for the craniofacial morphology of pediatric OSA patients. All of this information will be brought back to the Steering Committee for discussion of inclusion / elimination of factors in the index.

Drafting the Index

Since this index will have visual-rating scales for each of the craniofacial and occlusal factors, the steering committee will devise an outline suitable for displaying each of the factors representing the index. The factors in the drafted index will also have a number of levels that will divide the factor into categories of severity. The number of levels for a given factor will also be determined by the Steering Committee. Details describing the nature of the illustrations, the amount of levels that each of the factors will have, and the general layout of the index will be agreed upon by the steering committee, and the graphic artist will then design a preliminary version of the index based on the relevant factors and the feedback from the steering committee.

The Index Development Meeting

The Index Development Group (IDG) is formed by a group of external multidisciplinary experts who provide evidence-based recommendations, on the content, layout and development process of the index. This eclectic group will be chosen by the Steering committee based on experience in the field, expertise and ability to contribute, availability and access. The group should be small enough to be able to have effective discussions, while large enough to ensure the appropriate representation from all the stakeholders. In this study we plan on including a broad spectrum of medical specialists, family physicians, orthodontists, and methodologists. The goals of this meeting are to gain additional information to strengthen the index, as well as gaining the professional credibility of a broad range of experts on the topic of pediatric OSA.

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Once the members have been chosen by the Steering Committee and accept the invitation to participate, the IDG members will be emailed a document 4 days prior to the meeting, explaining: the purpose of the index and meeting, how the meeting will proceed, what to expect in the meeting, and a brief literature review of the orthodontic techniques currently available to help with the symptoms of OSA. Moreover, every member will be randomly assigned a number in order to maintain anonymity of the responses.

Procedure of the IDG Meeting

The meeting will commence with a brief introduction summarizing the literature review, the purpose of the index and its relevance. The meeting will then proceed to collect feedback (APPENDIX 1) on the aforementioned chosen factors using a modified Delphi technique[35][36], which is a communication technique that structures the meeting and minimizes bias in responses. Participants' responses will be collected through a web-based response portal. Each factor will be explored through yes or no questions, and yes responses followed-up with a scale of 1-9 based on its importance for decision-making. Once all the feedback is received on a particular factor, the summary of the results will be displayed for everyone to see. Discussion will ensue for a maximum of 5 minutes, with each person talking no more than 1 minute. Then everyone will be asked to re-enter their feedback on the website for the same factor in light of the discussion. This cycle will continue until a consensus of greater than 80% of the members is reached. Once consensus is reached, then we will move on to the next factor and the participants will be asked to give feedback on this new factor in a similar manner.

In addition, two negative control factors will be used to calibrate the responses. The first negative control will be of orthodontic relevance but have no effect on the amelioration of the symptoms of OSA (ie. crowding, or impacted canine). The second negative control will be of relevance to OSA symptoms, but cannot be changed by orthodontic treatment (ie. BMI or neck circumference).

Once all the factors have been discussed and consensus reached, we will get feedback through the website on the: alignment - importance of the index, and if the development process is appropriate; relevance – content analysis, and whether all the factors identified are important; representation – if there is anything that needs to be added to the index (APPENDIX 2). Finally, additional written feedback will be accepted at the very end of the session.

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All the feedback from the IDM will be summarized and presented to the Steering Committee, and decisions will be made to remove factors, modify factors, and /or modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a second draft will be procured.

The External Review Group Meeting

The External Review Group (ERG) is composed of end-users and interested parties. The group will also be identified based on the advice of the steering committee based on the ability of the group to assess the index and contribute to its development, availability and access. This group is not responsible for any content analysis, instead it will be responsible for reviewing the layout, simplicity and ease of use. It will also be responsible to assess usefulness of the index in the healthcare setting and give feedback on the feasibility of implementing the index in practice. The goal of this meeting is to gain the end-user approval for the ease and feasibility of administering the index. This group should be large enough to be a representative sample of the population, yet small enough to allow for ease of explanation and healthy discussion. It is not as structured as the IDM, and allows for the participants to freely express their opinions in an open forum.

In this meeting we will explain the theory behind the index by briefly reviewing the literature and then explain the purpose of the index. Subsequently we will show the group a pilot version of the index and a paper will be distributed to receive for their feedback based on the following questions:

1- Do you understand the purpose of the index?

2- Do you understand what each factor is assessing?

    a. If not which one(s) do you not understand and why?

3- On a scale of 1 to 10, how simple would you rate this index to understand and use?

4- Would you use this index in your practice?

5- Other recommendations:

By compiling all the comments and scores onto a table, the results will display all the feedback from the ERG meeting. All these results will be presented to the Steering Committee, and decisions will be made to modify the outline and layout of the index. These modifications will subsequently be presented to the graphic artist and a third draft will be procured.

B)   Reliability

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Reliability of the index will be tested within a group that represents the typical end-user population. This includes physicians of family medicine, pediatricians, pediatric ENT, or pediatric sleep physicians. Reliability will also be assessed within a group of orthodontists, who by their training are experts at assessing malocclusion and craniofacial morphology. Therefore 10-20 physicians and orthodontists will be recruited as examiners in this study.

A pool of 15-40 randomly selected patient charts from the University of Alberta Inter-disciplinary Airway Research Clinic (I-ARC) will be recruited as reliability test subjects, and their intra-oral and extra-oral photographs will be used in the reliability assessment. After a brief explanation about the use and application of the index, the physicians as well as the orthodontists will apply the developed index to the sample patient pool's pictures once. In order to diminish recall bias, application of the index will be repeated 2 weeks later.

Intra-rater reliability and inter-rater reliability between the physicians, between the orthodontists and between the physicians and orthodontists will be compared. The reliability will be assessed using Interclass Correlation coefficients (ICC) and Bland –Altman Plots.

C)   Validation

The Index will be validated using dichotomous responses from orthodontists on whether specific patients would require orthodontic treatment to help their obstructive sleep apnea symptoms and comparing it to the score that the index gave those same patients. This will be achieved by setting up a website where 30 orthodontists with experience in dealing with pediatric OSA will be recruited to take the assessment. The website will contain extra-oral and intra-oral pictures of patients randomly selected from the Interdisciplinary Airway Research Clinic diagnosed with OSA, and the orthodontists will be asked to rate these patients, using a "yes" or "no" response, whether they would benefit from orthodontic treatment for their OSA symptoms. The index will then be applied on the same patients by the principal investigator and the score of each patient will be recorded. Using a stepwise multiple-logistic regression each of the identified factors will be given a weight; this will represent the relative importance of the factor. Once analyzed if the correlation is high between the expert scores and the cluster groups, then the clusters are meaningful and valid. Furthermore, a cutoff for most efficient score above which to refer will be chosen using a graph and observing the value that optimizes the sensitivity, specificity and overall accuracy of the index. Finally, four grades of treatment-need will be determined using the twenty-five percentile ranges. The grades will be:

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1- Minimal Need

2- Mild Need

3- Moderate Need

4- Severe Need

DISCUSSION

The development plan of this index has been conceived through a modification of the WHO Handbook for guideline development,[34] as well as reviewing the orthodontic literature for ways indices have been previously developed. The WHO provided an excellent starting point, from there modifications were made to cater to the specifics of this study, given that there are differences between developing a guideline and an index for orthodontic treatment need. The literature was useful, and among the index development protocols reviewed, certain assessed the orthodontic treatment need within the entire population,[37-40] while others assessed it for a given subpopulation[41-46]; each had strengths and weaknesses, and thus we further modified our methods, synthesizing a protocol for our particular needs from the available literature and using the experience and expertise of the authors. Through this protocol we aim to develop an index that fulfills all of the following criteria:[47]

1. Gradient of Numeric Values: The severity of the orthodontic treatment need within the pediatric OSA patients should be defined within a numerical scheme that demonstrates a finite and progressive gradient from low need to high need.

2. Equal Sensitivity: should demonstrate equal sensitivity throughout the scale.

3. Clinical Importance: The numerical scale should correspond with the clinically appraised orthodontic treatment need of pediatric OSA patients.

4. Statistical Ease: should be amendable to statistical analysis.

5. Reliability: Should have a high intra- and inter-rater reliability.

6. Practical: The instruments required to score the index should be practical to the setting in which it will be administered.

7. Minimal Judgment: Applying the index should require minimal judgment.

8. Simple: The index shouldn't have a high financial or time cost, therefore should be simple enough to administer to many patients.

9. Detect Change: The index should be able to detect changes in orthodontic treatment need in pediatric OSA patients.

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10. Validity: should be valid over time.

Validity can be characterized into different types: Face Validity, Content Validity, Construct Validity, and Criterion Validity.[48] In this study, we will examine these kinds of validity at different stages of development. The first draft of the index will focus on establishing face validity. Feedback from the steering committee and IDG will assist in establishing content and construct validity. Assuming that the "gold standard" in assessing the orthodontic treatment-need in pediatric patients with OSA is an orthodontist with experience in dealing with pediatric OSA patients, then the subsequent modification of the index based on the reliability tests and the dichotomous responses from the orthodontists provide the index with the necessary criterion-related validity evidence through statistical means.[49]

Significance

This index will help physicians and other medical professionals identify which craniofacial phenotypes may benefit from orthodontic treatment as part of their multi-disciplinary OSA management. Furthermore, due to the diverse medical effects of sleep deprivation, there will be a trend to make sleep apnea into a centralized service, where the main focus is for a highly trained multidisciplinary team to treat a high volume of patients to a standardized protocol, where meticulous documentation is exercised. This index is part of that documentation process. It will allow for quality assurance, funding allocation and epidemiologic studies to be performed. It will also allow long-term follow up and audit in order to enter into comparisons with other centers.

Dissemination Plan

The dissemination of this index will be done through a variety of ways in order to maximize its reach. Primarily, it will be published in a peer-reviewed journal, which will allow its introduction to the scientific literature. The journal should be a respected medical journal with broad reach, in order to allow the greatest number of physicians to be exposed to the index. Subsequently it will be translated to French, in order for it to be accessible to the entire Canadian and American population of medical professionals. Moreover, the index will be presented at national and international conferences to increase the awareness of the index among the scientific community. Finally, the index will be used at the University of Alberta's Interdisciplinary Airway Research Center, and more research, so that future research in this center will incorporate it. It will

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also be placed on the University of Alberta's Interdisciplinary Airway Research Center's website under the physician section, to further educate the doctors who visit the site on the index.

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Authors' Contributions

MA HS MRR MM JM PM conceived and designed the study; MA drafted the manuscript and integrated critical feedback from all of the other authors. All of the authors approved the final version of the manuscript.

Ethics approval

The proposed research has received ethical approval numbered Pro00045067 from the University of Alberta Ethics Board.

Competing Interests

The authors declare no conflicts of interests.

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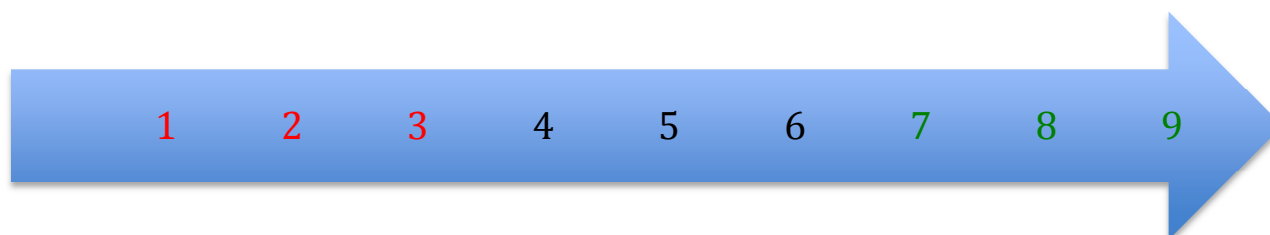
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Assigned Number_____
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Factor Being Evaluated:_____
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Important but not critical
8
for decision-making
9
Of low importance   Critical for decision-making
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1   2   3   4   5   6   7   8   9

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Circle the "Yes" or "No" answers. If "Yes" rate the importance from 1-9 by circling the appropriate number.

21
22   1-   In your opinion, is this factor commonly observed in Pediatric Obstructive Sleep Apnea patients?
23   **Yes**   1   2   3   4   5   6   7   8   9
24
25   **No**

26   2-   In your opinion, does this factor contribute to Pediatric Obstructive Sleep Apnea symptoms?
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28   **Yes**   1   2   3   4   5   6   7   8   9
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30   **No**

31   3-   In your opinion, would correcting this factor help diminish the symptoms of Pediatric Obstructive
32   Sleep Apnea?
33
34   **Yes**   1   2   3   4   5   6   7   8   9
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36   **No**

37   4-   In your opinion, does this factor contribute to orthodontic treatment need?
38   **Yes**   1   2   3   4   5   6   7   8   9
39
40   **No**

41
42   5-   In your opinion, is the 5-point scale appropriate for this factor?
43   **Yes**   1   2   3   4   5   6   7   8   9
44
45   **No; How would you correct it?**
46
47   _____
48
49   6-   Are the points on the scale attributed correctly for this factor?
50   **Yes**   1   2   3   4   5   6   7   8   9
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52   **No; How would you correct it?**
53
54   _____
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56   7-   In your opinion, are the pictures appropriate for this factor?
57   **Yes**   1   2   3   4   5   6   7   8   9
58
59   **No; How would you correct it?**
60
          _____

Assigned Number_____

Important but not critical
for decision-making

Of low importance

Critical for decision-making

1   2   3   4   5   6   7   8   9

Circle the "Yes" or "No" answers. If "Yes" rate the importance from 1-9 by circling the appropriate number.

1. Do you think that this index is useful in fulfilling the goals of having an easy to use index that helps non-dentally trained professionals assess the orthodontic treatment need to help the symptoms in pediatric patients with OSA?

   Yes   **1**   **2**   **3**   **4**   **5**   **6**   **7**   **8**   **9**

   No; How would you improve it?

   _____

2. Do you believe that the organizing committee is developing this index in the appropriate way? (i.e. Reviewing the recommendations in the literature, seeking expert opinions, gaining end-user approval and testing its reliability)

   Yes   **1**   **2**   **3**   **4**   **5**   **6**   **7**   **8**   **9**

   No; How would you improve it?

   _____

3. In your opinion were all the factors, identified in this meeting, important for this index?

   Yes   **1**   **2**   **3**   **4**   **5**   **6**   **7**   **8**   **9**

   No; Which factors were not important?

   _____

4. In your opinion, have all the important areas concerning orthodontic treatment need to help symptoms of OSA been identified?

   Yes   **1**   **2**   **3**   **4**   **5**   **6**   **7**   **8**   **9**

   No; Which ones were missed?

   _____

5. Is the layout of the index easy to navigate?

   Yes   **1**   **2**   **3**   **4**   **5**   **6**   **7**   **8**   **9**

   No; How would you improve it?

1
2   Please provide any other feedback below that may help improve the index:
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