

appliances. Authors and mentions of experts by name were also searched in the PubMed database for peer-reviewed articles of relevance. No additional articles specific to the use of speech characteristics for mandibular positioning were found.

## Steering committee

A steering committee was formed consisting of one board certified orthodontist (ML), one dentist board certified in dental sleep medicine (EN), and one professor of research methodology and qualitative research (APG). The steering committee created a list of experts to invite to participate within the Delphi process as well as the predetermined levels of agreement for acceptable consensus and the format for expert feedback. All members of the steering committee were precluded from being considered an expert in providing feedback within the Delphi process.

Based on information gathered from the literature review, the steering committee determined that the fields of speech language pathology, otolaryngology, physiotherapy, optometry, and dental sleep medicine would be of relevance in relation to the use of speech characteristics for mandibular positioning in dental sleep medicine.

An agreement level of 66% between Delphi panelists was preselected by the steering committee as an acceptable level of consensus.

Based on information gathered from the literature review, the use of speech characteristics for mandibular positioning in dental sleep medicine was subdivided into phases and steps for easier evaluation. A formalized template was created by the steering committee for structured feedback from potential panelists (Appendix A).

## Formulation of procedure for evaluation

Based on information gathered from the literature search/review, the steering committee aggregated the data and formulated it into phases that described the process of using speech characteristics to determine mandibular position. A total of five phases were identified by the steering committee. These phases were then further deconstructed into steps, with a total of 19 steps identified by the steering committee.

The five phases identified by the steering committee were (1) recording anatomic landmarks, (2) pre-procedural testing, (3) patient positioning, (4) identifying speech measurement limits, and (5) capturing occlusal relationships for mandibular position. The 19 steps were then assigned to the appropriate phase by the steering committee.

A structured template was created by the steering committee for expert panelists to provide their feedback. The template was designed with specific instructions

relevant to the evaluation of titles/names, inclusion or exclusion, additional lines, sequencing, and other suggestions. An example of this structured template can be found in Appendix A. The phases and steps were also organized into a list for expert panelist informational reference. The informational document can be found in Appendix B.

## Expert panelists

Eighteen experts in the fields of sleep medicine and otolaryngology, dental sleep medicine, speech language pathology and orofacial myofunctional therapy, physiotherapy, and optometry were invited by formal email to participate. All otolaryngologists were involved in sleep medicine and had a history of collaboration with dentists involved in sleep medicine. All speech language pathologists were also certified orofacial myologists. All physiotherapists had advanced training in temporomandibular joint dysfunction. All optometrists were also registered nurses and involved in the field of orofacial myofunctional therapy. All dentists were board certified in dental sleep medicine with the American Board of Dental Sleep Medicine and had been listed as an author in peer-reviewed publications related to the use of speech characteristics in mandibular positioning from articles revealed in the literature review. Of the 18 experts invited, 6 were dentists, 5 were otolaryngologists, 3 were physiotherapists, 3 were speech language pathologists also certified as orofacial myologists, and 1 was an optometrist.

Eleven of the 18 experts invited to participate responded with agreement to participate as experts on the Delphi panel. Four were dentists, two were otolaryngologists, two were physiotherapists, two were speech language pathologists also certified as orofacial myologists, and one was an optometrist. Both otolaryngologists who elected to participate requested their feedback be limited purely to aspects specific to nasal function.

## Expert feedback

The Delphi method is a well-established structured technique for reaching expert consensus for research questions that cannot be answered empirically. Through an iterative process with structured feedback from panelists, statements are modified and returned to experts for review; this process is repeated until consensus is reached. Panelists are generally selected for their expertise in relation to some or all of the questions being researched.

Panelists were asked to provide their expert opinion on the phases related to the use of speech in mandibular positioning and to return their feedback within 2 weeks. The formalized template was provided with instructions specific to the evaluation of the names of the phases, their importance in inclusion or exclusion, whether additional

phases should be included, and the sequencing of the phases. Panelists were provided with a summary of all proposed phases and steps for reference. Panelist feedback was reviewed and incorporated into the phases, which were then sent back to the panelists for review. A summary of changes was included within the feedback template. This process was then repeated for evaluation of the steps within each phase.

## RESULTS

### Phases

Nine experts provided feedback in evaluation of the phases related to use of speech characteristics for mandibular positioning. Both participating otolaryngologists declined to provide feedback, stating a preference to limit their feedback specific to nasal function. Two rounds of expert feedback were necessary to reach consensus threshold. The name of one phase was expanded (preprocedural testing was expanded to preprocedural screening and testing). The order sequencing of the phases did not change from what was originally proposed. No phases were removed and no additional phases were added. Although the evaluation of phases was not specific to the steps within each phase, based on panelist feedback steps were added into or updated within phases. These changes are summarized in Appendix C.

### Steps

#### **Recording anatomic landmarks**

Nine experts provided feedback in evaluation of the steps within the phase of recording anatomic landmarks. Both participating otolaryngologists declined to provide feedback stating a preference to limit their feedback specific to nasal function. Two rounds of expert feedback were necessary to reach consensus threshold. Two steps were added: *record dental and occlusal relationships (such as overjet, overbite, dental crowding, etc.)* and *recording mandibular ranges of motion (such as maximum opening, protrusion, deflection of opening, etc.)*. The two additional steps were placed in order positions one and two; the order sequencing of the rest of the steps did not change from what was originally proposed. No steps were removed. Consensus threshold was reached by the second round. These changes are summarized in Appendix D.

#### **Preprocedural screening and testing**

Eleven experts provided feedback in evaluation of the steps within the phase of preprocedural screening and testing. Two rounds were necessary to reach consensus threshold. The descriptions of multiple steps were expanded. One step was added: *visually screen for nasal obstructions (such as gross nasal deviations and enlarged*

*inferior turbinates)*. The order sequencing of the first three steps was modified from what was originally proposed and the additional step placed after the first step.

Consensus threshold was reached by the second round. These changes are summarized in Appendix E.

### **Patient positioning**

Nine experts provided feedback in evaluation of the steps within the phase of patient positioning. Both participating otolaryngologists declined to provide feedback stating a preference to limit their feedback specific to nasal function. Two rounds were necessary to reach consensus threshold. The descriptions of multiple steps were expanded; *measure baseline (habitual) posture and head position* was expanded to *measure baseline (habitual) posture and head position in both standing and sitting position, provide interventions to relax the patient's orofacial musculature* was expanded to *provide interventions to relax the patient's orofacial musculature (for example, by massage or cold laser), instruct patient to position arms hanging neutrally without support on either side of their body* was expanded to *instruct patient to position arms hanging neutrally without support on either side of their body (or hands on lap neutrally, if preferred for comfort by patient), and instruct patient to look straight ahead with eyes not focused on any particular object or landmark* was expanded to *instruct patient to look straight ahead with eyes directed towards a blank wall or blank paper and not focused on any particular object or landmark*. No steps were added. The last four steps were amalgamated into a single step. The order sequencing of the steps did not change from what was originally proposed. Consensus threshold was reached by the second round. These changes are summarized in Appendix F.

### **Identifying speech measurement limits**

Nine experts provided feedback in evaluation of the steps within the phase of identifying speech measurement limits. Both participating otolaryngologists declined to provide feedback stating a preference to limit their feedback specific to nasal function. Consensus threshold was met within the first round. The descriptions of two steps were clarified: *instruct patient to count the numbers out loud from 60 to 80 in English at a normal speed* was expanded to *instruct patient to count the numbers out loud from 60 to 80 in English at a normal conversational speed and volume* and the word *lisps* was removed from *note any lateral mandibular movements and any lateral tongue movements/lisps*. No steps were added or removed. The order sequencing of the steps did not change from what was originally proposed. These changes are summarized in Appendix G.

## APPENDICES

### Appendix A

#### Information Table

The following information about potential steps related to the proposed phases of using speech characteristics to determine mandibular positioning for dental appliances is provided for information purposes only. Please do not evaluate the potential steps at this time.

#### Proposed Phase 1: Recording anatomical landmarks

##### Proposed Steps

- Record the presence, grading, and grading method for maxillary ankylolabia (upper lip tie).
- Restriction has potential to affect lip seal
- Record the presence, grading, and grading method for mandibular ankylolabia (lower lip tie).
- Restriction has potential to affect lip seal
- Record the presence, grading, and grading method for ankyloglossia (tongue tie). Restriction has potential to affect speech and mandibular movement

#### Proposed Phase 2: Pre-Procedural testing

##### Proposed Steps

- Review cone beam computed tomography of the upper airway for potential pathology or obstructions
- Perform modified Cottle maneuver on each patient's nostril to screen for nasal valve compromise
- Instruct patient to use saline nasal rinse for debris removal to screen for improvements to nasal patency from debris removal
- Assess for potential effects of nasal valve patency on the patient's speech and mandibular movement

#### Proposed Phase 3: Patient positioning

##### Proposed Steps

- Seat patient in an upright manner on a stool or chair without back support
- Ensure patient's feet are firmly planted flatly and evenly on the floor
- Instruct patient to position arms hanging neutrally without support on either side of their body
- Instruct patient to look straight ahead with eyes not focused on any particular object or landmark

#### Proposed Phase 4: Identifying speech measurement limits

##### Proposed Steps

- Instruct patient to count the numbers out loud from 60 to 80 in English at a normal speed.
- Repeat if needed
- Note the maxillary and mandibular incisal edge positions in an anterior-posterior direction during the production of /s/ as the anterior limit of the mandible
- Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /s/ as the superior limit of the mandible
- Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /i/ as the inferior limit of the mandible
- Note the positions of the maxillary and mandibular midlines to one another as the lateral limits of positioning of the mandible

## **Proposed Phase 5: Capturing occlusal relationships for mandibular position**

### **Proposed Steps:**

- If the exact desired vertical dimension is known, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of thickness that matches the desired specific vertical dimension and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions and verify position again with the speech measurement limits previously noted
- If a specific vertical range is desired, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of thickness that matches the minimum desired specific vertical dimension and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions. Verify position again with the speech measurement limits previously noted. Note the maximum vertical range desired. Do not exceed the absolute maximum vertical range as denoted in the speech measurement limits
- If an unspecified vertical range is desired, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of minimal thickness that matches the inter-incisal distance during the production of /s/ sounds and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions. Verify position again with the speech measurement limits previously noted. Note the maximum vertical range as the inter-incisal distance during the production of /i/ sounds and capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object that matches the inter-incisal distance during the production of /i/ sounds and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions. Verify position again with the speech measurement limits previously noted

## Appendix B

### Expert consensus on the procedure of using speech characteristics for mandibular positioning in dental appliances

The purpose of this research is to define the procedure of using speech characteristics to determine mandibular positioning in dental appliances through expert consensus. You have been identified as an expert in this procedure (or part of it) considering your clinical and/or research experience. As you know, procedures are made up of phases and steps within those phases. In this second round of expert feedback, we would like to know your view about the STEPS of the phase “identifying speech measurement limits”. Your answers and comments will not be shared with other experts. In upcoming rounds, you will be asked about steps within other phases. Thank you in advance for your time and support. Please read the information provided in Table 1 before judging whether the following steps are sufficient and properly sequenced.

### Section 2: Identifying speech measurement limits

Please indicate whether the following steps, which were derived from the literature and other sources (eg, videos), should be part of the steps of the phase of identifying speech measurement limits for the procedure of using speech characteristics for mandibular positioning in dental appliances. Feel free to improve the name of the suggested steps if necessary and elaborate on your answer of including/excluding each phase using the comment box.

**Table 1.**

Steps	Include this Step	Exclude this step	Rename this step (if necessary)	Comment
Instruct patient to count the numbers out loud from 60 to 80 in English at a normal speed. Repeat if needed				
Note any lateral mandibular movements and any lateral tongue movements/lisps				
Note the maxillary and mandibular incisal edge positions in an anterior- posterior direction during the production of /s/ as the anterior limit of the mandible				
Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /s/ as the superior limit of the mandible				
Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /i/ as the inferior limit of the mandible				
Note the positions of the maxillary and mandibular midlines to one another as the lateral limits of positioning of the mandible				

**Section 2: Additional steps**

Please suggest additional steps if necessary and elaborate on your suggestion(s) using the comment box. Leave this section blank if no additional step(s) is/are needed.

<b>Suggested additional step</b>	<b>Reasoning for additional step</b>

**Section 3: Steps order**

Please order the steps in the sequence they should be performed, including those you may have suggested. If the order does not matter for certain or all steps, please indicate so.

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

4. \_\_\_\_\_

5. \_\_\_\_\_

6. \_\_\_\_\_

7. \_\_\_\_\_

8. \_\_\_\_\_

## Appendix C

Changes to phases and steps from the first round of expert feedback are shown below in redlined format

### Proposed Phase 1: Recording anatomic landmarks

#### Proposed Steps

- Record dental and occlusal relationships (such as overjet, overbite, dental crowding, etc.)
- Record mandibular ranges of motion (such as maximum opening, protrusion, deflection on opening, etc.)
- Record the presence, grading, and grading method for maxillary ankyolabia (upper lip tie).
- Restriction has potential to affect lip seal
- Record the presence, grading, and grading method for mandibular ankyolabia (lower lip tie).
- Restriction has potential to affect lip seal
- Record the presence, grading, and grading method for ankyloglossia (tongue tie). Restriction has potential to affect speech and mandibular movement

### Proposed Phase 2: Preprocedural screening and testing

#### Proposed Steps

- Assess orofacial musculature (for example, by palpation)
- Screen for temporomandibular joint dysfunction sign and symptoms
- Review CBCF of imaging (for example, cone beam computed tomography or magnetic resonance imaging) of the upper airway for potential pathology or obstructions as well as temporomandibular joint position and condition
- Perform modified Cottle maneuver on each patient's nostril to screen for nasal valve compromise
- Instruct patient to use saline nasal rinse for debris removal to screen for improvements to nasal patency from debris removal
- Assess for potential effects of nasal valve patency on the patient's speech and mandibular movement

### Proposed Phase 3: Patient positioning

#### Proposed Steps

- Measure baseline (habitual) posture and head position
- Provide interventions to relax the patient's orofacial musculature
- Seat patient in an upright position on a stool or chair without back support, with palms facing medially
- Ensure patient's feet are firmly planted flatly and evenly on the floor
- Instruct patient to position arms hanging neutrally without support on either side of their body
- Instruct patient to look straight ahead with eyes not focused on any particular object or landmark



#### **Proposed Phase 4: Identifying speech measurement limits**

##### **Proposed Steps**

- Instruct patient to count the numbers out loud from 60 to 80 in English at a normal speed.
- Repeat if needed
- Note the maxillary and mandibular incisal edge positions in an anterior-posterior direction during the production of /s/ as the anterior limit of the mandible
- Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /s/ as the superior limit of the mandible
- Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /i/ as the inferior limit of the mandible
- Note the positions of the maxillary and mandibular midlines to one another as the lateral limits of positioning of the mandible

#### **Proposed Phase 5: Capturing occlusal relationships for mandibular position**

##### **Proposed Steps:**

- If the exact desired vertical dimension is known, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of thickness that matches the desired specific vertical dimension and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions, and verify position again that the speech measurement limits previously noted
- If a specific vertical range is desired, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of thickness that matches the minimum desired specific vertical dimension and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions. Verify position again with the speech measurement limits previously noted. Note the maximum vertical range desired. Do not exceed the absolute maximum vertical range as denoted in the speech measurement limits
- If an unspecified vertical range is desired, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of minimal thickness that matches the inter-incisal distance during the production of /s/ sounds and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions. Verify position again with the speech measurement limits previously noted. Note the maximum vertical range as the interincisal distance during the production of /i/ sounds and capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object that matches the interincisal distance during the production of /i/ sounds and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions. Verify position again with the speech measurement limits previously noted
- [Perform post-bite registration confirmation and evaluation with additional testing if indicated](#)

## Appendix D – Changes to recording anatomic landmarks

Changes to the steps within the phase of “recording anatomic landmarks” from expert feedback are shown below in redlined format

### Proposed Phase 1: Recording anatomic landmarks

#### Proposed Steps

- Record dental and occlusal relationships (such as overjet, overbite, dental crowding, etc)
- Record mandibular ranges of motion (such as maximum opening, protrusion, deflection on opening, etc)
- Record the presence, grading, and grading method for maxillary ankylophobia (upper lip tie).
- Restriction has potential to affect lip seal
- Record the presence, grading, and grading method for mandibular ankylophobia (lower lip tie).
- Restriction has potential to affect lip seal
- Record the presence, grading, and grading method for ankyloglossia (tongue tie). Restriction has potential to affect speech and mandibular movement

## Appendix E – Changes to preprocedural screening and testing

Changes to the steps within the phase of “preprocedural screening and testing” from expert feedback are shown below in redlined format

### Proposed Phase 2: Preprocedural screening and testing

#### Proposed Steps

- Review of imaging (for example, cone beam computed tomography or magnetic resonance imaging) of the upper airway for potential pathology or obstructions as well as temporomandibular joint position and condition
- Visually screen for nasal obstructions (such as gross nasal deviations and enlarged inferior turbinates)
- Screen for temporomandibular joint dysfunction signs and symptoms (such as clicking, popping, deviation of mandibular movement, and pain)
- Assess orofacial musculature (for example, by palpation held for 5 seconds to include assessment of potential radiation of symptoms)
- Perform modified Cottle maneuver on each patient’s nostril to screen for nasal valve compromise
- Instruct patient to use saline nasal rinse to screen for improvements to nasal patency from debris removal (such as subjective improvement to airflow and/or breathing and visual decrease of inferior turbinate and septal swell body size). Repeat with nasal decongestant if possible
- Assess for the effects of changes to nasal patency on the patient’s speech and mandibular movement

## Appendix F – Changes to patient positioning

Changes to the steps within the phase of “patient positioning” from expert feedback are shown below in redlined format

### Proposed Phase 3: Patient positioning

#### Proposed Steps

- Measure baseline (habitual) posture and head position in both standing and sitting positions
- Provide interventions to relax the patient’s orofacial musculature (for example, by massage or cold laser)
- Seat patient in an upright position on a stool or chair without back support with palms facing medially. Ensure patient’s feet are firmly planted flatly and evenly on the floor. Instruct patient to position arms hanging neutrally without support on either side of their body (or hands on lap neutrally, if preferred for comfort by patient). Instruct patient to look straight ahead with eyes directed towards a blank wall or blank paper and not focused on any particular object or landmark

## Appendix G – Changes to identifying speech measurement limits

Changes to the steps within the phase of “identifying speech measurement limits” from expert feedback are shown below in redlined format

### Proposed Steps

- Instruct patient to count the numbers out loud from 60 to 80 in English at a normal conversational speed and volume. Repeat if needed
- Note any lateral mandibular movements and any lateral tongue movements/~~hisses~~
- Note the maxillary and mandibular incisal edge positions in an anterior-posterior direction during the production of /s/ as the anterior limit of the mandible
- Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /s/ as the superior limit of the mandible
- Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /i/ as the inferior limit of the mandible
- Note the positions of the maxillary and mandibular midlines to one another as the lateral limits of positioning of the mandible

## Appendix H – Changes to capturing occlusal relationships for mandibular position

Changes to the steps within the phase of “capturing occlusal relationships for mandibular position” from expert feedback are shown below in redlined format

### Proposed Steps

- If the exact desired vertical dimension is known, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of thickness that matches the desired specific vertical dimension and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions and verify position again with the speech measurement limits previously noted
- If a specific vertical range is desired, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of thickness that matches the minimum desired specific vertical dimension and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions. Verify position again with the speech measurement limits previously noted. Note the maximum vertical range desired. Do not exceed the absolute maximum vertical range as denoted in the speech measurement limits
- If an unspecified vertical range is desired, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of minimal thickness that matches the inter-incisal distance during the production of /s/ sounds and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions. Verify position again with the speech measurement limits previously noted. Note the maximum vertical range as the inter-incisal distance during the production of /i/ sounds and capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object that matches the inter-incisal distance during the production of /i/ sounds and that only allows for point contact in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions. Verify position again with the speech measurement limits previously noted.
- Perform post-bite registration confirmation and evaluation with additional testing if indicated

## Appendix I – Protocol on the use of speech characteristics for mandibular positioning in dental sleep medicine

### Phase 1: Recording anatomic landmarks

#### Proposed Steps:

1. Evaluate and record dental and occlusal relationships (such as overjet, overbite, teeth and gingival ratios, dental crowding, tooth ratios, skeletal and dental midlines, etc.)

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2. Evaluate and record mandibular ranges of motion (such as maximum opening, protrusion, deflection of opening, etc)

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3. Evaluate and record the presence, grading, and grading method for maxillary and mandibular ankyolabia (upper and lower lip tie). Restriction has potential to affect lip seal

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4. Evaluate and record the presence, grading, and grading method for ankyloglossia (tongue tie). Restriction has potential to affect speech and mandibular movement

### Phase 2: Preprocedural screening and testing

#### Proposed Steps:

1. Measure baseline (habitual) posture and head position in both standing and sitting position

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2. Review imaging (for example, cone beam computed tomography or magnetic resonance imaging) of the upper airway for potential pathology or obstructions as well as temporomandibular joint position and condition

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3. Visually screen for nasal obstructions (such as gross nasal deviations and enlarged inferior turbinates)

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4. Screen for temporomandibular joint dysfunction signs and symptoms (such as clicking, popping, deviation of mandibular movement, and pain)

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5. Assess orofacial musculature (for example, by palpation held for 5 seconds to include assessment of potential radiation of symptoms)

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6. Perform modified Cottle maneuver on each nostril to screen for nasal valve compromise. If positive, consider use of a nasal dilator (or similar) and referral to otolaryngology for evaluation

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7. Instruct patient to use saline nasal rinse to screen for improvements to nasal patency from debris removal (such as subjective improvement to airflow and/or breathing and visual decrease of inferior turbinate and/or septal swell body size). Repeat with nasal decongestant if possible

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8. Assess for the effects of changes to nasal patency on the patient's speech and mandibular movement (for example, visually or by validated questionnaires such as the NOSE or SNOT-22 at baseline and after nasal patency evaluative interventions)

### **Phase 3: Patient positioning**

#### **Proposed Steps:**

1. Reevaluate posture and head position in both standing and sitting position

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2. Provide interventions to relax the patient's orofacial musculature (for example, by massage or cold laser)

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Seat patient in an upright manner on a stool or chair without back support with arm and palms in a neutral position. Ensure patient's feet are firmly planted flatly and evenly on the floor.
3. Instruct patient to position arms hanging neutrally without support on either side of their body (or hands on lap neutrally, if preferred for comfort by patient). Instruct patient to look straight ahead with eyes directed toward a blank wall or blank paper and not focused on any particular object or landmark

### **Phase 4: Identifying speech measurement limits**

#### **Proposed Steps:**

1. Instruct patient to count the numbers out loud from 60 to 80 in English at a normal conversational speed and volume. Repeat if needed

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Note any lateral mandibular movements and any lateral tongue movements

Note the maxillary and mandibular incisal edge positions in an anterior-posterior direction during the production of /s/ as the anterior limit of the mandible
2. Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /s/ as the superior limit of the mandible

Note the maxillary and mandibular incisal edge positions in a superior-inferior direction during the production of /i/ as the inferior limit of the mandible

Note the positions of the maxillary and mandibular midlines to one another as the lateral limits of positioning of the mandible



## **Phase 5: Capturing occlusal relationships for mandibular position**

### **Proposed Steps:**

If the exact desired vertical dimension is known, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of thickness that matches the desired specific vertical dimension and that only allows for point contact of incisal edges in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions and verify both sufficient occlusal clearance and position for the speech measurement limits previously noted (for example, with injection of polyvinyl siloxane bite registration material between the teeth, digital intraoral scanning, or through digital recording of jaw and occlusion tracking)

1. If a specific vertical range is desired, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of thickness that matches the minimum desired specific vertical dimension and that only allows for point contact of incisal edges in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions and verify both sufficient occlusal clearance and position for the speech measurement limits previously noted (for example, with injection of polyvinyl siloxane bite registration material between the teeth, digital intraoral scanning, or through digital recording of jaw and occlusion tracking). Note the maximum vertical range desired with an absolute maximum as denoted in the speech measurement limits

If an unspecified vertical range is desired, capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object of minimal thickness that matches the interincisal distance during the production of /s/ sounds and that only allows for point contact of incisal edges in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions and verify both sufficient occlusal clearance and position for the speech measurement limits previously noted (for example, with injection of polyvinyl siloxane bite registration material between the teeth, digital intraoral scanning, or through digital recording of jaw and occlusion tracking). Note the maximum vertical range as the interincisal distance during the production of /i/ sounds and capture the relative positions of the mandibular occlusion to the maxillary occlusion using a round object that matches the inter- incisal distance during the production of /i/ sounds and that only allows for point contact of incisal edges in order to maintain proper orientation of the occlusal planes relative to each other in three dimensions and verify both sufficient occlusal clearance and position for the speech measurement limits previously noted

2. Perform post-bite registration confirmation and evaluation with additional testing if indicated