dome shape portion of each of the sector portions 11a to 11e overlaps with a dome shape portion of another such that a gap is not formed between the sector portions 11a to 11e when each of the sector portions 11a to 11e vibrates and the dome shape portion is for forming a surface of the tongue, the model of the tongue further has a structure where a tongue surface portion 11g that has both right and left sides extending in the radial direction and has a depression in a central portion between the right and left sides is overlapped with each of the sector portions 11a to 11e and each of the sector portions11a to 11e vibrates in a circumferential direction in the depression of the tongue surface portion 19 in a static state, the model of the tongue is configured to be set such that the sector portions 11a to 11e rotate by a predetermined angle toward a far side in a circumferential direction during swallowing and then the pseudo-orally-ingested product 20 is pushed toward the far side by the sector portion 11e at a farthest side of the tongue 11;

the dynamic three-dimensional model of the head-and-neck 10a has a structure where the head-and-neck includes a pharynx 14, a larynx portion 12c and a gullet 18, the larynx portion 12c is divided into an epiglottis 12a and a larynx 12, an esophageal entrance 18a of the gullet 18 is configured to be closed before swallowing is started, and the esophageal entrance 18a is configured to extend and the pharynx 14 is configured to contract during swallowing; and

the dynamic three-dimensional model of the head-and-neck is configured to be set such that the larynx 12 is configured to be moved in a direction to the mental region 16a of the mandible to open the esophageal entrance 18a, the pharynx is configured to contract, and then the epiglottis 12a is configured to be rotated by a predetermined angle toward the far side so as to close an esophageal entrance 18a during swallowing.

With this configuration, the flow passage of the pseudo-orally-ingested product 20 is formed in the depression without forming gaps between the respective sector portions 11a to 11e. Then, the pseudo-orally-ingested product 20 is smoothly transported to the far side. This allows providing the dynamic three-dimensional model of the head-and-neck that can approximately reproduce the behavior of the tongue 11, the pharynx 14, the larynx 12, and the gullet 18 during swallowing.

[0026]

To solve the above-described problem, a swallowing simulation method according to an eleventh aspect of the present invention, for example, as illustrated in FIG.23 (see FIG. 2 for configuration), comprises, a head-and-neck modeling step (S010) of forming a dynamic three-dimensional model of a head-and-neck 10a that

CLAIMS

1. A swallowing simulation apparatus, comprising:

a head-and-neck modeling unit configured to form a dynamic three-dimensional model of a head-and-neck that includes head-and-neck organs;

an organ movement setting unit configured to set a movement of each of the head-and-neck organs in the dynamic three-dimensional model of the head-and-neck;

an orally-ingested-product physical-property setting unit configured to set an orally-ingested product as an analysis target and a physical property of the orally-ingested product;

an input unit configured to input a pseudo-orally-ingested product formed by modeling the orally-ingested product to an oral cavity;

a movement analysis unit configured to analyze the movement of each of the head-and-neck organs in the dynamic three-dimensional model of the head-and-neck and a behavior of the pseudo-orally-ingested product during swallowed, in a three-dimensional space using a particle method; and

a display unit configured to display an analysis result of the movement of each of the head-and-neck organs and the behavior of the pseudo-orally-ingested product during swallowed that are analyzed by the movement analysis unit, on a movement screen.

2. The swallowing simulation apparatus according to claim 1, wherein

the head-and-neck modeling unit is configured to set the head-and-neck organ as a polygon or particles, and

the movement analysis unit is configured to treat the pseudo-orally-ingested product as a polygon or particles.

3. The swallowing simulation apparatus according to claim 2, wherein

the head-and-neck modeling unit is configured to set a model of a tongue as one of head-and-neck organs to have a structure divided into n pieces of sector portions in a near-far direction, wherein n is an integer equal to or more than 2, while a mental region of a mandible as an origin of a genioglossus is set to a pivot of sector, and

the organ movement setting unit is configured to set movements of organs such that each of the sector portions is configured to vibrate in cooperation with one another while vibrations of different sector portions have predetermined phase differences in a radial direction so as to perform a traveling wave movement by movements of organs to

transport the pseudo-orally-ingested product toward a far-side direction.

4. The swallowing simulation apparatus according to claim 3, wherein

the head-and-neck modeling unit is configured to form the model of the tongue having a structure where dome shape portions of each of the sector portions overlaps with a dome shape portion of another such that a gap is not formed between the sector portions when each of the sector portions vibrates, the dome shape portion being for forming a surface of the tongue, further the head-and-neck modeling unit is configured to form the model of the tongue having the structure where a tongue surface portion that has both right and left sides extending in the radial direction and has a depression in a central portion between the right and left sides is overlapped with each of the sector portions, and each of the sector portions vibrates in a radial direction in the depression of the tongue surface portion in a static condition; and

the organ movement setting unit is configured to set movements of organs such that each of the sector portions rotates by a predetermined angle toward a far side in a circumferential direction during swallowing and then the pseudo-orally-ingested product is pushed toward a far side by the sector portion at a farthest side of the tongue at an end of swallowing.

5. The swallowing simulation apparatus according to claim 3 or claim 4, wherein

the head-and-neck modeling unit is configured to set the model of the head-and-neck having a structure where the head-and-neck includes a pharynx, a larynx portion, and a gullet, the larynx portion is divided into an epiglottis and a larynx, an esophageal entrance of the gullet is configured to be closed before swallowing is started, and the esophageal entrance is configured to extend and the pharynx is configured to contract during swallowing; and

the organ movement setting unit is configured to set movements of organs such that the larynx is configured to be moved in a direction to the mental region of the mandible to open the esophageal entrance, the pharynx is configured to contract, and then the epiglottis is configured to be rotated by a predetermined angle toward the far side during swallowing so as to close an entrance of the larynx.

6. The swallowing simulation apparatus according to any one of claim 1 to claim 5, wherein

the orally-ingested-product physical-property setting unit is configured to set a plurality of pseudo-orally-ingested products of liquid, semisolid, or solid as the analysis

target, the pseudo-orally-ingested products having different physical properties; and

the movement analysis unit is configured to determine free surfaces of the plurality of pseudo-orally-ingested products and boundaries between the plurality of pseudo-orally-ingested products so as to analyze an interlocking behavior of the plurality of pseudo-orally-ingested products.

7. The swallowing simulation apparatus according to any one of claim 1 to claim 6, further comprising

an evaluation/diagnosis unit configured to evaluate or diagnose easiness of eating and/or easiness of drinking of the orally-ingested product based on the behavior of the pseudo-orally-ingested product during swallowed on the movement screen, wherein

the movement screen is a virtual movement screen formed in a virtual space by the swallowing simulation apparatus to simulatively display the analysis result of the movement of each of the head-and-neck organs and the behavior of the pseudo-orally-ingested product during swallowed that are analyzed by the movement analysis unit, and

the evaluation/diagnosis unit is configured to make evaluation or diagnosis based on whether or not a behavior of the pseudo-orally-ingested product in the virtual movement screen satisfies a predetermined condition.

8. The swallowing simulation apparatus according to claim 1 or claim 7, further comprising:

an evaluation/diagnosis-result recording unit configured to record an evaluation result or a diagnosis result related to easiness of eating and/or easiness of drinking of the orally-ingested product based on the analysis result of the behavior of the pseudo-orally-ingested product during swallowed; and

a physical property determiner configured to determine a physical property of the orally-ingested product regarded as appropriate based on the evaluation or diagnosis result recorded in the evaluation/diagnosis-result recording unit.

9. A dynamic three-dimensional model of a head-and-neck including head-and-neck organs, comprising:

a model of a tongue as one of head-and-neck organs, the model of the tongue having a structure divided into n pieces of sector portions in a near-far direction, wherein n is an integer equal to or more than 2, while a mental region of a mandible as

an origin of a genioglossus is set to a pivot of sector;

wherein each of the sector portions is configured to vibrate in cooperation with one another while having a predetermined phase difference in a radial direction so as to perform a traveling wave movement by movements of organs to transport the pseudo-orally-ingested product toward a far-side direction.

10. The dynamic three-dimensional model of the head-and-neck according to claim 9,

wherein the model of the tongue has a structure where a dome shape portion of each of the sector portions overlaps with a dome shape portion of another such that a gap is not formed between the sector portions when each of the sector portions vibrates, the dome shape portion being for forming a surface of the tongue, the model of the tongue further has a structure where a tongue surface portion that has both right and left sides extending in the radial direction and has a depression in a central portion between the right and left sides is overlapped with each of the sector portions, and each of the sector portions vibrates in a circumferential direction in the depression of the tongue surface portion in a static state;

wherein the model of the tongue is configured to be set such that the sector portions rotate by a predetermined angle toward a far side in a circumferential direction during swallowing and then the pseudo-orally-ingested product is pushed toward the far side by the sector portion at a farthest side of the tongue;

wherein the dynamic three-dimensional model of the head-and-neck has a structure where the head-and-neck includes a pharynx, a larynx portion, and a gullet, the larynx portion is divided into an epiglottis and a larynx, an esophageal entrance of the gullet is configured to be closed before swallowing is started, and the esophageal entrance is configured to extend and the pharynx is configured to contract during swallowing; and

wherein the dynamic three-dimensional model of the head-and-neck is configured to be set such that the larynx is configured to be moved in a direction to the mental region of the mandible to open the esophageal entrance, the pharynx is configured to contract, and then the epiglottis is configured to be rotated by a predetermined angle toward the far side so as to close an esophageal entrance during swallowing.

11. A swallowing simulation method, comprising:

a head-and-neck modeling step of forming a dynamic three-dimensional model

of head-and-neck that includes head-and-neck organs;

an organ-movement setting step of setting a movement of each of the head-and-neck organs in the dynamic three-dimensional model of the head-and-neck;

an orally-ingested-product physical-property setting step of setting an orally-ingested product as an analysis target and a physical property of the orally-ingested product;

an input step of inputting a pseudo-orally-ingested product formed by modeling the orally-ingested product to an oral cavity;

a movement analyzing step of analyzing the movement of each of the head-and-neck organs in the dynamic three-dimensional model of the head-and-neck and a behavior of the pseudo-orally-ingested product during swallowed using a particle method; and

a display step of displaying an analysis result of the movement of each of the head-and-neck organs and the behavior of the pseudo-orally-ingested product during swallowed that are analyzed in a three-dimensional space in the movement analyzing step, on a movement screen.

12. The swallowing simulation method according to claim 11, further comprising:

an evaluation step of evaluating easiness of eating and/or easiness of drinking of the orally-ingested product based on the analysis result of the behavior of the pseudo-orally-ingested product during swallowed; and

a physical property determination step of determining a physical property of the orally-ingested product regarded as appropriate based on an evaluation result evaluated in the evaluation step.

13. A program readable by a computer, wherein

the program is configured to make the computer execute the swallowing simulation method according to claim 11 or claim 12.

14. An orally-ingested-product development assistance apparatus, comprising:

the swallowing simulation apparatus according to claim 8;

an orally-ingested-product prototype result recording unit configured to record a result of an experimental production performed under an appropriately-set production condition to have the physical property determined as appropriate by the physical property determiner; and

a production condition determiner configured to determine a production

condition that sets a physical property of the orally-ingested product to the physical property determined as appropriate by the physical property determiner based on a prototype result recorded in the orally-ingested-product prototype result recording unit.

15. The orally-ingested-product development assistance apparatus according to claim 14, further comprising

an evaluation/diagnosis unit configured to evaluate or diagnose easiness of eating and/or easiness of drinking of the orally-ingested product based on the behavior of the pseudo-orally-ingested product during swallowed, on the movement screen, wherein

the movement screen is a virtual movement screen formed in a virtual space by the swallowing simulation apparatus to simulatively display the analysis result of the movement of each of the head-and-neck organs and the behavior of the pseudo-orally-ingested product during swallowed that are analyzed by the movement analysis unit, and

the evaluation/diagnosis unit is configured to make evaluation or diagnosis based on whether or not a behavior of the pseudo-orally-ingested product in the virtual movement screen satisfies a predetermined condition.

16. An orally-ingested-product development method, comprising

the swallowing simulation method according to claim 12, wherein

the orally-ingested-product physical-property setting step includes a step of changing the physical property of the orally-ingested product to set, and a step of repeatedly performing a subsequent process up to the physical property determination step, or a step of changing the physical property of the orally-ingested product to set, a step of repeatedly performing a subsequent process up to the evaluation step, and then collectively performing the physical property determination step,

further comprising:

an orally-ingested-product prototype production step of performing an experimental production under an appropriately-set production condition to have the physical property determined as appropriate in the physical property determination step; and

a production condition determination step of determining a production condition that gives a physical property of the orally-ingested product to the physical property determined as appropriate in the physical property determination step based on the result in the orally-ingested-product prototype production step.

17. The orally-ingested-product development method according to claim 16, wherein

the movement screen is a virtual movement screen formed at a virtual space by a swallowing simulation apparatus to simulatively display an analysis result of a movement of each of the head-and-neck organs and a behavior of the pseudo-orally-ingested product during swallowed, the analysis result being analyzed in the movement analysis step,

the display step is a virtual display step to simulatively display the analysis result on the virtual movement screen, and

the evaluation/diagnosis step is configured to evaluate whether the behavior of the pseudo-orally-ingested product on the virtual movement screen simulatively displayed in the virtual display step meets a predetermined condition or not.

18. An orally-ingested-product production method, comprising

a step of producing the orally-ingested product using a production condition determined in the production condition determination step of the orally-ingested-product development method according to claim 16 or claim 17.

19. A dietary education assistance apparatus, comprising:

the swallowing simulation apparatus according to claim 1 or claim 7;

an evaluation/diagnosis-result recording unit configured to record an evaluation result or a diagnosis result of easiness of eating and easiness of drinking of the orally-ingested product based on the analysis result of the behavior of the pseudo-orally-ingested product during swallowed; and

a teaching unit configured to explain the behavior of the pseudo-orally-ingested product during swallowed displayed on the movement screen by the display unit associating with the evaluation result or the diagnosis result of the orally-ingested product recorded in the evaluation/diagnosis-result recording unit.

20. A dietary education method, comprising:

the swallowing simulation method according to claim 11;

an evaluation step of evaluating easiness of eating and/or easiness of drinking of the orally-ingested product based on the analysis result of the behavior of the pseudo-orally-ingested product during swallowed; and

a teaching step of explaining the behavior of the pseudo-orally-ingested

product during swallowed displayed on the movement screen in the display step associating with the evaluation result of the orally-ingested product evaluated in the evaluation step.

21. The swallowing simulation apparatus according to any one of claim 1 to claim 8, further comprising

an organ movement determiner configured to determine an organ movement parameter fitting to a behavior or a symptom of an organ of a diagnosed person based on the analysis result analyzed in the movement analysis unit in the organ movement parameters set in the organ movement setting unit.

22. A diagnosis assistance apparatus; comprising

the swallowing simulation apparatus according to claim 21.

dome shape portion of each of the sector portions 11a to 11e overlaps with a dome shape portion of another such that a gap is not formed between the sector portions 11a to 11e when each of the sector portions 11a to 11e vibrates and the dome shape portion is for forming a surface of the tongue, the model of the tongue further has a structure where a tongue surface portion 11g that has both right and left sides extending in the radial direction and has a depression in a central portion between the right and left sides is overlapped with each of the sector portions 11a to 11e and each of the sector portions 11a to 11e vibrates in a circumferential direction in the depression of the tongue surface portion 19 in a static state, the model of the tongue is configured to be set such that the sector portions 11a to 11e rotate by a predetermined angle toward a far side in a circumferential direction during swallowing and then the pseudo-orally-ingested product 20 is pushed toward the far side by the sector portion 11e at a farthest side of the tongue 11;

the dynamic three-dimensional model of the head-and-neck 10a has a structure where the head-and-neck includes a tongue 11, a palate 15, a pharynx 14, a larynx portion 12c, a trachea 13 and a gullet 18, the larynx portion 12c is divided into an epiglottis 12a and a larynx 12, an esophageal entrance 18a of the gullet 18 is configured to be closed before swallowing is started, and the esophageal entrance 18a is configured to extend and the pharynx 14 is configured to contract during swallowing; and

the dynamic three-dimensional model of the head-and-neck is configured to be set such that the larynx 12 is configured to be moved in a direction to the mental region 16a of the mandible to open the esophageal entrance 18a, the pharynx is configured to contract, and then the epiglottis 12a is configured to be rotated by a predetermined angle toward the far side so as to close an esophageal entrance 18a during swallowing.

With this configuration, the flow passage of the pseudo-orally-ingested product 20 is formed in the depression without forming gaps between the respective sector portions 11a to 11e. Then, the pseudo-orally-ingested product 20 is smoothly transported to the far side. This allows providing the dynamic three-dimensional model of the head-and-neck that can approximately reproduce the behavior of the tongue 11, the pharynx 14, the larynx 12, and the gullet 18 during swallowing.

[0026]

To solve the above-described problem, a swallowing simulation method according to an eleventh aspect of the present invention, for example, as illustrated in FIG.23 (see FIG. 2 for configuration), comprises, a head-and-neck modeling step (S010) of forming a dynamic three-dimensional model of a head-and-neck 10a that

CLAIMS

1. A swallowing simulation apparatus, comprising:

a head-and-neck modeling unit configured to form a dynamic three-dimensional model of a head-and-neck that includes head-and-neck organs;

an organ movement setting unit configured to set a movement of each of the head-and-neck organs in the dynamic three-dimensional model of the head-and-neck;

an orally-ingested-product physical-property setting unit configured to set an orally-ingested product as an analysis target and a physical property of the orally-ingested product;

an input unit configured to input a pseudo-orally-ingested product formed by modeling the orally-ingested product to an oral cavity;

a movement analysis unit configured to analyze the movement of each of the head-and-neck organs in the dynamic three-dimensional model of the head-and-neck and a behavior of the pseudo-orally-ingested product during swallowed, in a three-dimensional space using a particle method; and

a display unit configured to display an analysis result of the movement of each of the head-and-neck organs and the behavior of the pseudo-orally-ingested product during swallowed that are analyzed by the movement analysis unit, on a movement screen.

2. The swallowing simulation apparatus according to claim 1, wherein

the head-and-neck modeling unit is configured to set the head-and-neck organ as a polygon or particles, and

the movement analysis unit is configured to treat the pseudo-orally-ingested product as a polygon or particles.

3. The swallowing simulation apparatus according to claim 2, wherein

the head-and-neck modeling unit is configured to set a model of a tongue as one of head-and-neck organs to have a structure divided into n pieces of sector portions in a near-far direction, wherein n is an integer equal to or more than 2, while a mental region of a mandible as an origin of a genioglossus is set to a pivot of sector, and

the organ movement setting unit is configured to set movements of organs such that each of the sector portions is configured to vibrate in cooperation with one another while vibrations of different sector portions have predetermined phase differences in a radial direction so as to perform a traveling wave movement by movements of organs to

transport the pseudo-orally-ingested product toward a far-side direction.

4. The swallowing simulation apparatus according to claim 3, wherein

the head-and-neck modeling unit is configured to form the model of the tongue having a structure where dome shape portions of each of the sector portions overlaps with a dome shape portion of another such that a gap is not formed between the sector portions when each of the sector portions vibrates, the dome shape portion being for forming a surface of the tongue, further the head-and-neck modeling unit is configured to form the model of the tongue having the structure where a tongue surface portion that has both right and left sides extending in the radial direction and has a depression in a central portion between the right and left sides is overlapped with each of the sector portions, and each of the sector portions vibrates in a radial direction in the depression of the tongue surface portion in a static condition; and

the organ movement setting unit is configured to set movements of organs such that each of the sector portions rotates by a predetermined angle toward a far side in a circumferential direction during swallowing and then the pseudo-orally-ingested product is pushed toward a far side by the sector portion at a farthest side of the tongue at an end of swallowing.

5. The swallowing simulation apparatus according to claim 3 or claim 4, wherein

the head-and-neck modeling unit is configured to set the model of the head-and-neck having a structure where the head-and-neck includes a tongue, a palate, a pharynx, a larynx portion, a trachea and a gullet, the larynx portion is divided into an epiglottis and a larynx, an esophageal entrance of the gullet is configured to be closed before swallowing is started, and the esophageal entrance is configured to extend and the pharynx is configured to contract during swallowing; and

the organ movement setting unit is configured to set movements of organs such that the larynx is configured to be moved in a direction to the mental region of the mandible to open the esophageal entrance, the pharynx is configured to contract, and then the epiglottis is configured to be rotated by a predetermined angle toward the far side during swallowing so as to close an entrance of the larynx.

6. The swallowing simulation apparatus according to any one of claim 1 to claim 5, wherein

the orally-ingested-product physical-property setting unit is configured to set a plurality of pseudo-orally-ingested products of liquid, semisolid, or solid as the analysis

target, the pseudo-orally-ingested products having different physical properties; and

the movement analysis unit is configured to determine free surfaces of the plurality of pseudo-orally-ingested products and boundaries between the plurality of pseudo-orally-ingested products so as to analyze an interlocking behavior of the plurality of pseudo-orally-ingested products.

7. The swallowing simulation apparatus according to any one of claim 1 to claim 6, further comprising

an evaluation/diagnosis unit configured to evaluate or diagnose easiness of eating and/or easiness of drinking of the orally-ingested product based on the behavior of the pseudo-orally-ingested product during swallowed on the movement screen, wherein

the movement screen is a virtual movement screen formed in a virtual space by the swallowing simulation apparatus to simulatively display the analysis result of the movement of each of the head-and-neck organs and the behavior of the pseudo-orally-ingested product during swallowed that are analyzed by the movement analysis unit, and

the evaluation/diagnosis unit is configured to make evaluation or diagnosis based on whether or not a behavior of the pseudo-orally-ingested product in the virtual movement screen satisfies a predetermined condition.

8. The swallowing simulation apparatus according to claim 1 or claim 7, further comprising:

an evaluation/diagnosis-result recording unit configured to record an evaluation result or a diagnosis result related to easiness of eating and/or easiness of drinking of the orally-ingested product based on the analysis result of the behavior of the pseudo-orally-ingested product during swallowed; and

a physical property determiner configured to determine a physical property of the orally-ingested product regarded as appropriate based on the evaluation or diagnosis result recorded in the evaluation/diagnosis-result recording unit.

9. A dynamic three-dimensional model of a head-and-neck including head-and-neck organs, comprising:

a model of a tongue as one of head-and-neck organs, the model of the tongue having a structure divided into n pieces of sector portions in a near-far direction, wherein n is an integer equal to or more than 2, while a mental region of a mandible as

an origin of a genioglossus is set to a pivot of sector;

wherein each of the sector portions is configured to vibrate in cooperation with one another while having a predetermined phase difference in a radial direction so as to perform a traveling wave movement by movements of organs to transport the pseudo-orally-ingested product toward a far-side direction.

10. The dynamic three-dimensional model of the head-and-neck according to claim 9,

wherein the model of the tongue has a structure where a dome shape portion of each of the sector portions overlaps with a dome shape portion of another such that a gap is not formed between the sector portions when each of the sector portions vibrates, the dome shape portion being for forming a surface of the tongue, the model of the tongue further has a structure where a tongue surface portion that has both right and left sides extending in the radial direction and has a depression in a central portion between the right and left sides is overlapped with each of the sector portions, and each of the sector portions vibrates in a circumferential direction in the depression of the tongue surface portion in a static state;

wherein the model of the tongue is configured to be set such that the sector portions rotate by a predetermined angle toward a far side in a circumferential direction during swallowing and then the pseudo-orally-ingested product is pushed toward the far side by the sector portion at a farthest side of the tongue;

wherein the dynamic three-dimensional model of the head-and-neck has a structure where the head-and-neck includes a tongue, a palate, a pharynx, a larynx portion, a trachea and a gullet, the larynx portion is divided into an epiglottis and a larynx, an esophageal entrance of the gullet is configured to be closed before swallowing is started, and the esophageal entrance is configured to extend and the pharynx is configured to contract during swallowing; and

wherein the dynamic three-dimensional model of the head-and-neck is configured to be set such that the larynx is configured to be moved in a direction to the mental region of the mandible to open the esophageal entrance, the pharynx is configured to contract, and then the epiglottis is configured to be rotated by a predetermined angle toward the far side so as to close an esophageal entrance during swallowing.

11. A swallowing simulation method, comprising:

a head-and-neck modeling step of forming a dynamic three-dimensional model

of head-and-neck that includes head-and-neck organs;

an organ-movement setting step of setting a movement of each of the head-and-neck organs in the dynamic three-dimensional model of the head-and-neck;

an orally-ingested-product physical-property setting step of setting an orally-ingested product as an analysis target and a physical property of the orally-ingested product;

an input step of inputting a pseudo-orally-ingested product formed by modeling the orally-ingested product to an oral cavity;

a movement analyzing step of analyzing the movement of each of the head-and-neck organs in the dynamic three-dimensional model of the head-and-neck and a behavior of the pseudo-orally-ingested product during swallowed using a particle method; and

a display step of displaying an analysis result of the movement of each of the head-and-neck organs and the behavior of the pseudo-orally-ingested product during swallowed that are analyzed in a three-dimensional space in the movement analyzing step, on a movement screen.

12. The swallowing simulation method according to claim 11, further comprising:

an evaluation step of evaluating easiness of eating and/or easiness of drinking of the orally-ingested product based on the analysis result of the behavior of the pseudo-orally-ingested product during swallowed; and

a physical property determination step of determining a physical property of the orally-ingested product regarded as appropriate based on an evaluation result evaluated in the evaluation step.

13. A program readable by a computer, wherein

the program is configured to make the computer execute the swallowing simulation method according to claim 11 or claim 12.

14. An orally-ingested-product development assistance apparatus, comprising:

the swallowing simulation apparatus according to claim 8;

an orally-ingested-product prototype result recording unit configured to record a result of an experimental production performed under an appropriately-set production condition to have the physical property determined as appropriate by the physical property determiner; and

a production condition determiner configured to determine a production

condition that sets a physical property of the orally-ingested product to the physical property determined as appropriate by the physical property determiner based on a prototype result recorded in the orally-ingested-product prototype result recording unit.

15. The orally-ingested-product development assistance apparatus according to claim 14, further comprising

an evaluation/diagnosis unit configured to evaluate or diagnose easiness of eating and/or easiness of drinking of the orally-ingested product based on the behavior of the pseudo-orally-ingested product during swallowed, on the movement screen, wherein

the movement screen is a virtual movement screen formed in a virtual space by the swallowing simulation apparatus to simulatively display the analysis result of the movement of each of the head-and-neck organs and the behavior of the pseudo-orally-ingested product during swallowed that are analyzed by the movement analysis unit, and

the evaluation/diagnosis unit is configured to make evaluation or diagnosis based on whether or not a behavior of the pseudo-orally-ingested product in the virtual movement screen satisfies a predetermined condition.

16. An orally-ingested-product development method, comprising

the swallowing simulation method according to claim 12, wherein

the orally-ingested-product physical-property setting step includes a step of changing the physical property of the orally-ingested product to set, and a step of repeatedly performing a subsequent process up to the physical property determination step, or a step of changing the physical property of the orally-ingested product to set, a step of repeatedly performing a subsequent process up to the evaluation step, and then collectively performing the physical property determination step,

further comprising:

an orally-ingested-product prototype production step of performing an experimental production under an appropriately-set production condition to have the physical property determined as appropriate in the physical property determination step; and

a production condition determination step of determining a production condition that gives a physical property of the orally-ingested product to the physical property determined as appropriate in the physical property determination step based on the result in the orally-ingested-product prototype production step.

17. The orally-ingested-product development method according to claim 16, wherein

the movement screen is a virtual movement screen formed at a virtual space by a swallowing simulation apparatus to simulatively display an analysis result of a movement of each of the head-and-neck organs and a behavior of the pseudo-orally-ingested product during swallowed, the analysis result being analyzed in the movement analysis step,

the display step is a virtual display step to simulatively display the analysis result on the virtual movement screen, and

the evaluation/diagnosis step is configured to evaluate whether the behavior of the pseudo-orally-ingested product on the virtual movement screen simulatively displayed in the virtual display step meets a predetermined condition or not.

18. An orally-ingested-product production method, comprising

a step of producing the orally-ingested product using a production condition determined in the production condition determination step of the orally-ingested-product development method according to claim 16 or claim 17.

19. A dietary education assistance apparatus, comprising:

the swallowing simulation apparatus according to claim 1 or claim 7;

an evaluation/diagnosis-result recording unit configured to record an evaluation result or a diagnosis result of easiness of eating and easiness of drinking of the orally-ingested product based on the analysis result of the behavior of the pseudo-orally-ingested product during swallowed; and

a teaching unit configured to explain the behavior of the pseudo-orally-ingested product during swallowed displayed on the movement screen by the display unit associating with the evaluation result or the diagnosis result of the orally-ingested product recorded in the evaluation/diagnosis-result recording unit.

20. A dietary education method, comprising:

the swallowing simulation method according to claim 11;

an evaluation step of evaluating easiness of eating and/or easiness of drinking of the orally-ingested product based on the analysis result of the behavior of the pseudo-orally-ingested product during swallowed; and

a teaching step of explaining the behavior of the pseudo-orally-ingested product

during swallowed displayed on the movement screen in the display step associating with the evaluation result of the orally-ingested product evaluated in the evaluation step.

21. The swallowing simulation apparatus according to any one of claim 1 to claim 8, further comprising

an organ movement determiner configured to determine an organ movement parameter fitting to a behavior or a symptom of an organ of a diagnosed person based on the analysis result analyzed in the movement analysis unit in the organ movement parameters set in the organ movement setting unit.

22. A diagnosis assistance apparatus; comprising

the swallowing simulation apparatus according to claim 21.

23. A non-transitory computer readable medium containing program instructions for making a computer to execute the swallowing simulation method according to claim 11.