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Colby

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(54) **THERAPEUTIC TOOTH BUD ABLATION**

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This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

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(51) **Int. Cl.**

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H03M 1/66	(2006.01)
A61C 3/14	(2006.01)
A61B 18/00	(2006.01)
A61C 1/08	(2006.01)

(52) **U.S. Cl.**

CPC ***H03M 1/66*** (2013.01); ***A61C 3/14*** (2013.01); *A61B 2018/00321* (2013.01); *A61B 2018/00565* (2013.01); *A61B 2018/00577* (2013.01); *A61C 1/082* (2013.01)

(58) **Field of Classification Search**

CPC A61C 3/14; A61C 5/02; A61C 14/082; A61C 1/082; A61B 19/5244; A61B 19/5248; A61B 2018/00321; A61B 2018/00577; H03M 1/66

See application file for complete search history.

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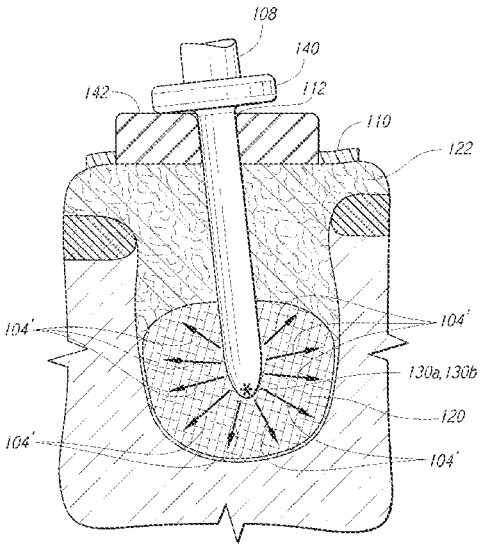
(57) **ABSTRACT**

Ablation probe tips (**108**, **148**, **320**, **360**) and physical and virtual stents (**110**) for use in tooth bud ablation procedures that result in tooth agenesis as well as tooth bud ablation methods are described herein.

20 Claims, 33 Drawing Sheets



specified functions. It will also be understood that each block of the flow charts, and combinations of blocks in the flow charts, may be divided and/or joined with other blocks of the flow charts without affecting the scope of the invention. This may result, for example, in computer-readable program code being stored in whole on a single memory, or various components of computer-readable program code being stored on more than one memory.

ADDITIONAL INFORMATION

It is to be understood that the inventions, examples, and embodiments described herein are not limited to particularly exemplified materials, methods, and/or structures. Further, all publications, patents, and patent applications cited herein, whether supra or infra, are hereby incorporated by reference in their entirety.

Please note that the terms and phrases may have additional definitions and/or examples throughout the specification. Where otherwise not specifically defined, words, phrases, and acronyms are given their ordinary meaning in the art. The following paragraphs provide some of the definitions for terms and phrases used herein.

The terms "fabricating" and/or "manufacturing" include any suitable means of making a component (e.g. stent **110**). Although the terms are used together throughout most of the specification (e.g. "manufacturing or fabricating"), the absence of one term or another is irrelevant because they are used herein synonymously.

The terms "proper," "correct," "optimal," and "ideal," are relative and may become more accurate as technology is developed. For example, when used in terms of the pre-defined angle (ϕ) and pre-defined depth (x) that are calculated and/or prescribed (e.g. the "proper angle and depth," the "correct angle and depth," the "optimal angle and depth," or the "ideal angle and depth"), these phrases are meant to include the best possible angle and depth that is calculated using the best available information and technology.

The terms "provide" and "providing" (and variations thereof) are meant to include standard means of provision including "transmit" and "transmitting," but can also be used for non-traditional provisions as long as the data is "received" (which can also mean obtained). The terms "transmit" and "transmitting" (and variations thereof) are meant to include standard means of transmission, but can also be used for non-traditional transmissions as long as the data is "sent." The terms "receive" and "receiving" (and variations thereof) are meant to include standard means of reception, but can also be used for non-traditional methods of obtaining as long as the data is "obtained."

It should be noted that the terms "may" and "might" are used to indicate alternatives and optional features and only should be construed as a limitation if specifically included in the claims. It should be noted that the various components, features, steps, phases, or embodiments thereof are all "preferred" whether or not it is specifically indicated. Claims not including a specific limitation should not be construed to include that limitation.

It should be noted that, unless otherwise specified, the term "or" is used in its nonexclusive form (e.g. "A or B" includes A, B, A and B, or any combination thereof, but it would not have to include all of these possibilities). It should be noted that, unless otherwise specified, "and/or" is used similarly (e.g. "A and/or B" includes A, B, A and B, or any combination thereof, but it would not have to include all of these possibilities). It should be noted that, unless otherwise specified, the term "includes" means "comprises" (e.g. a device that includes or comprises A and B contains A and B but optionally may contain C or additional components other than A and B). It should be noted that, unless otherwise specified, the singular forms "a," "an," and "the" refer to one or more than one, unless the context clearly dictates otherwise.

The terms and expressions that have been employed in the foregoing specification are used as terms of description and not of limitation, and are not intended to exclude equivalents of the features shown and described. This application is intended to cover any adaptations or variations of the present invention. It will be appreciated by those of ordinary skill in the art that any arrangement that is calculated to achieve the same purpose may be substituted for the specific embodiment shown. It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. A system for use in a tooth bud ablation procedure that results in tooth agenesis, said system comprising:

(a) a movement sensored ablation probe tip having an insertion end and a connection end, said movement sensored ablation probe tip having a center of ablation;

(b) a virtual stent comprising:

(i) at least one volume scan;

(ii) at least one virtual surgical guide angle, said at least one virtual surgical guide angle providing angle guidance to guide said movement sensored ablation probe tip at a pre-defined angle; and

(iii) at least one virtual stop, said at least one virtual stop providing stop information to limit the depth of said movement sensored ablation probe tip to a pre-defined depth; and

(c) said movement sensored ablation probe tip being guidable in relation to said at least one virtual surgical guide angle and said at least one virtual stop such that said center of ablation is within said tooth bud when said movement sensored ablation probe tip is guided at said pre-defined angle to said pre-defined depth.

2. The system of claim **1**, further comprising a display, said at least one virtual surgical guide angle being at least one virtual surgical guide angle marking displayed on said display, said at least one virtual stop being at least one virtual stop marking displayed on said display, said movement sensored ablation probe tip having a real-time representation displayed on said display.

3. The system of claim **1**, said movement sensored ablation probe tip being manually guidable.

4. The system of claim **1**, said movement sensored ablation probe tip being automatically guidable.

5. The virtual stent of claim **1**, said pre-defined angle being based on information obtained from a volume scan image, and said pre-defined depth being based on information obtained from a volume scan image.

6. The virtual stent of claim **1**, real-time representation of said movement sensored ablation probe tip being monitorable in relation to said at least one volume scan.

7. A tooth bud ablation method for ablating a tooth bud using a virtual stent, said method comprising the steps of:

(a) providing said virtual stent and a movement sensored ablation probe tip, said movement sensored ablation

probe tip having an insertion end and a connection end, said movement sensored ablation probe tip having a center of ablation;

(b) providing at least one volume scan;

(c) providing at least one virtual surgical guide angle, said at least one virtual surgical guide angle providing angle guidance to guide said movement sensored ablation probe tip at a pre-defined angle; and

(d) providing at least one virtual stop, said at least one virtual stop providing stop information to limit the depth of said movement sensored ablation probe tip to a pre-defined depth;

(e) introducing said movement sensored ablation probe tip to said tooth bud;

(f) using said at least one virtual surgical guide angle and said at least one virtual stop, guiding said movement sensored ablation probe tip towards the position where said center of ablation substantially within said tooth bud; and

(g) using ablation means, ablating said tooth bud when said center of ablation is within said tooth bud.

8. The method of claim **7**, further comprising the step of providing a display on which representations of said movement sensored ablation probe tip having a center of ablation, said at least one virtual surgical guide angle, and said at least one virtual stop are displayed.

9. The method of claim **7**, further comprising the step of providing a display on which representations of said at least one volume scan, said movement sensored ablation probe tip having a center of ablation, said at least one virtual surgical guide angle, and said at least one virtual stop are displayed.

10. The method of claim **7**, further comprising the steps of:

(a) providing a display;

(b) displaying said at least one volume scan on said display; and

(c) overlaying on said at least one volume scan at least one representation selected from the group consisting of:

(i) a representation of said movement sensored ablation probe tip having a center of ablation;

(ii) a representation of said at least one virtual surgical guide angle; and

(iii) a representation of said at least one virtual stop.

11. The method of claim **7**, further comprising the steps of:

(a) providing a display;

(b) displaying said at least one volume scan on said display;

(c) overlaying on said at least one volume scan displayed on said display at least one representation selected from the group consisting of:

(i) a representation of said at least one virtual surgical guide angle; and

(ii) a representation of said at least one virtual stop; and

(d) displaying a real-time representation of said movement sensored ablation probe tip having a center of ablation overlaid on said at least one volume scan displayed on said display.

12. The method of claim **7**, said step of guiding said movement sensored ablation probe tip being performed manually.

13. The method of claim **7**, said step of guiding said movement sensored ablation probe tip being performed automatically.

14. The method of claim **7**, wherein said step of ablating results in tooth agenesis.

15. The method of claim **7** further comprising the step of providing indications to indicate that said center of ablation is within said tooth bud.

16. The method of claim **7**, during said step of ablating said tooth bud, monitoring progress of the ablating, and providing constant feedback pertaining to said progress.

17. The method of claim **7** further comprising the step of providing monitoring and override safeguards to allow automatic cessation of ablation.

18. The method of claim **7** further comprising the step of providing monitoring and override safeguards to allow manual cessation of ablation.

19. The method of claim **7** further comprising the step of ceasing the delivery of ablation means.

20. The method of claim **7** further comprising the step of preventing activation until said center of ablation is within said tooth bud.

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