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Colby

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(54) **THERAPEUTIC TOOTH BUD ABLATION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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A61C 3/14	(2006.01)
A61B 18/00	(2006.01)

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

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

(58) **Field of Classification Search**

CPC A61C 1/082; A61C 5/02; A61B 19/5244; A61B 2019/5248

See application file for complete search history.

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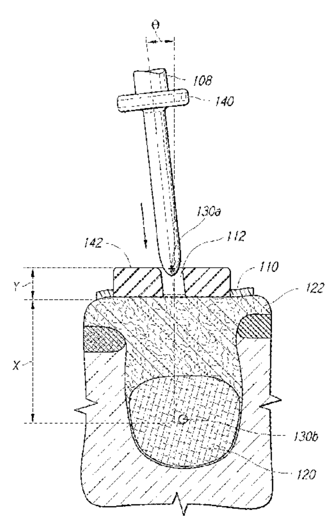
(57) **ABSTRACT**

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.

36 Claims, 33 Drawing Sheets



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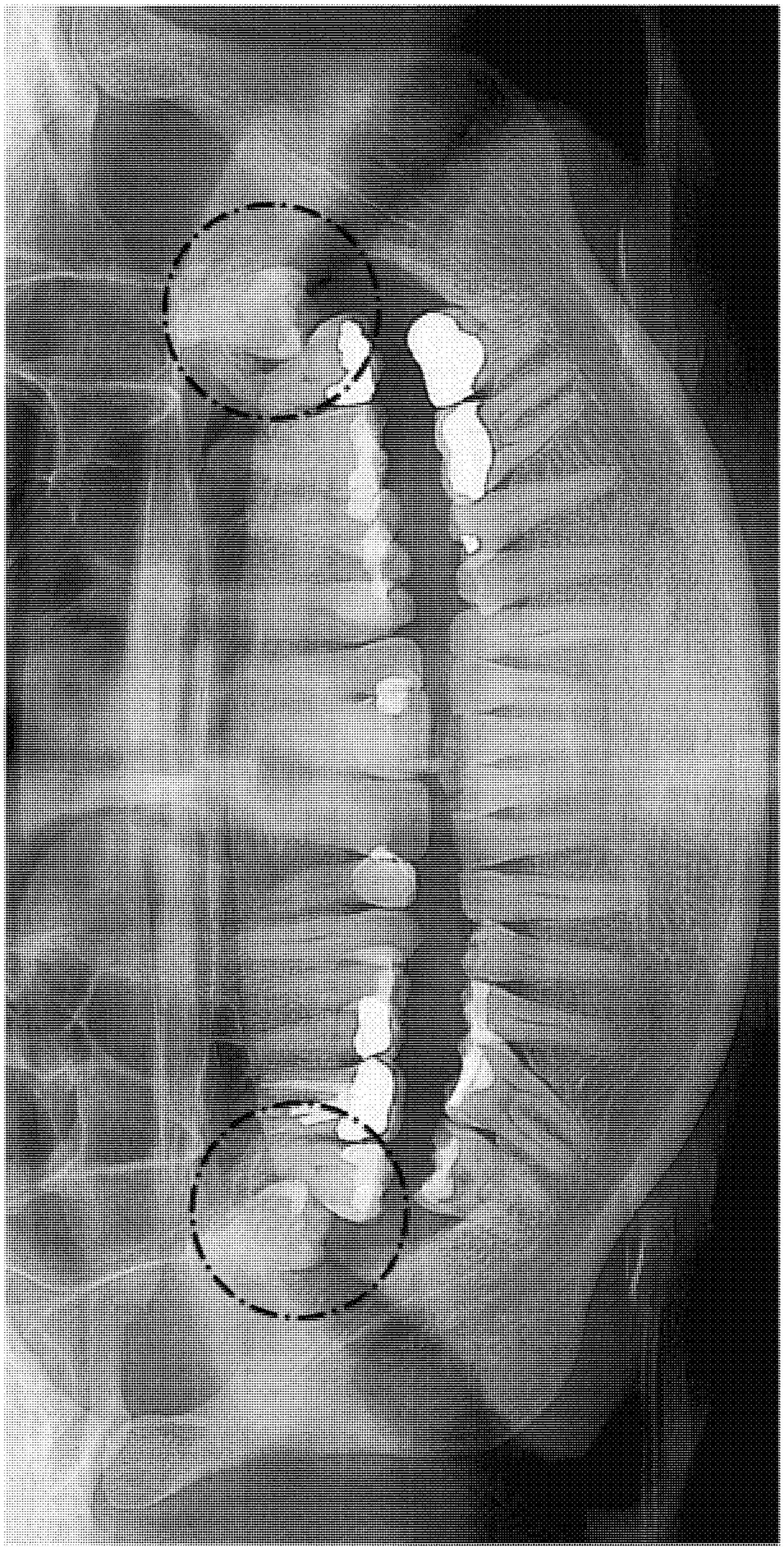
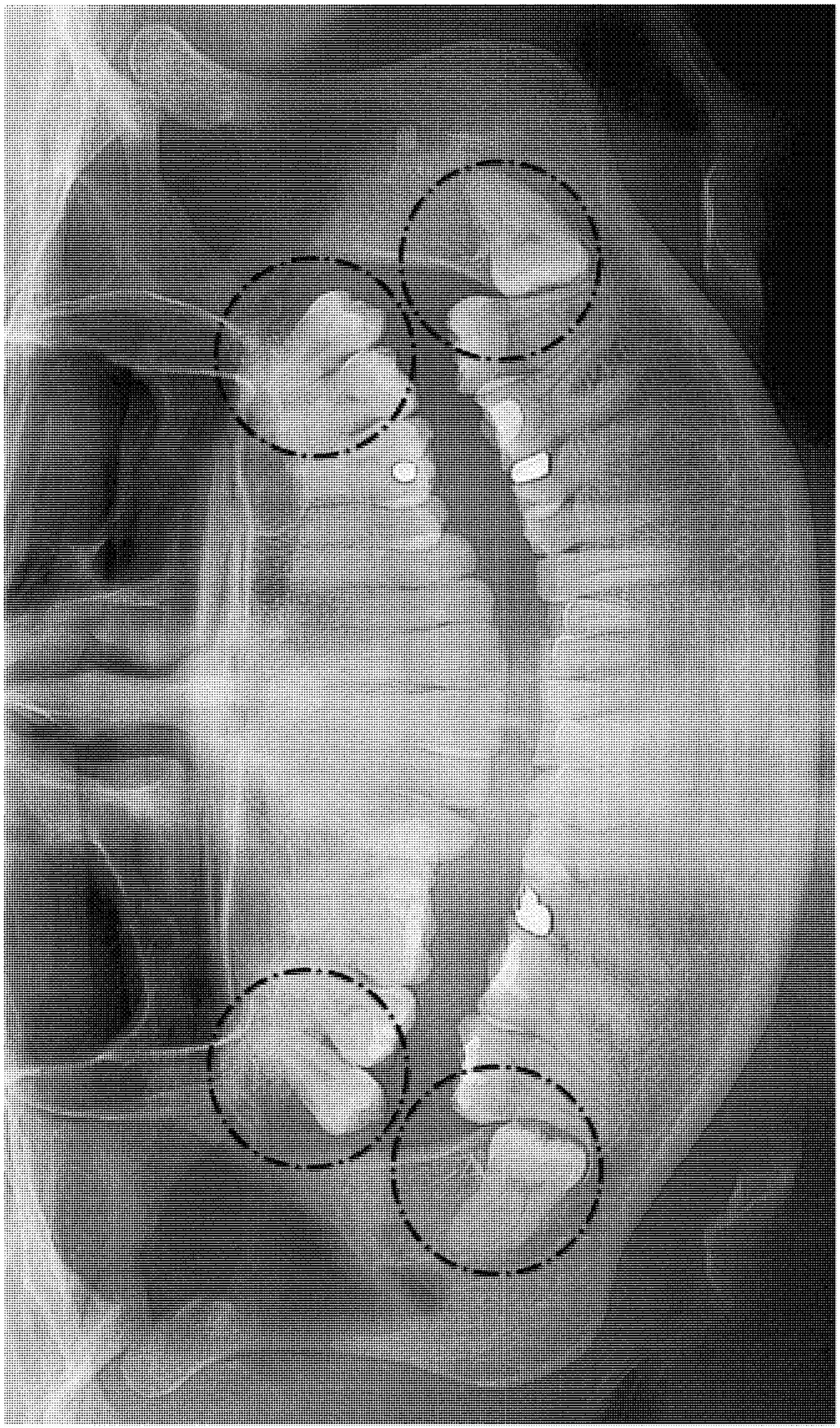


FIG. 1



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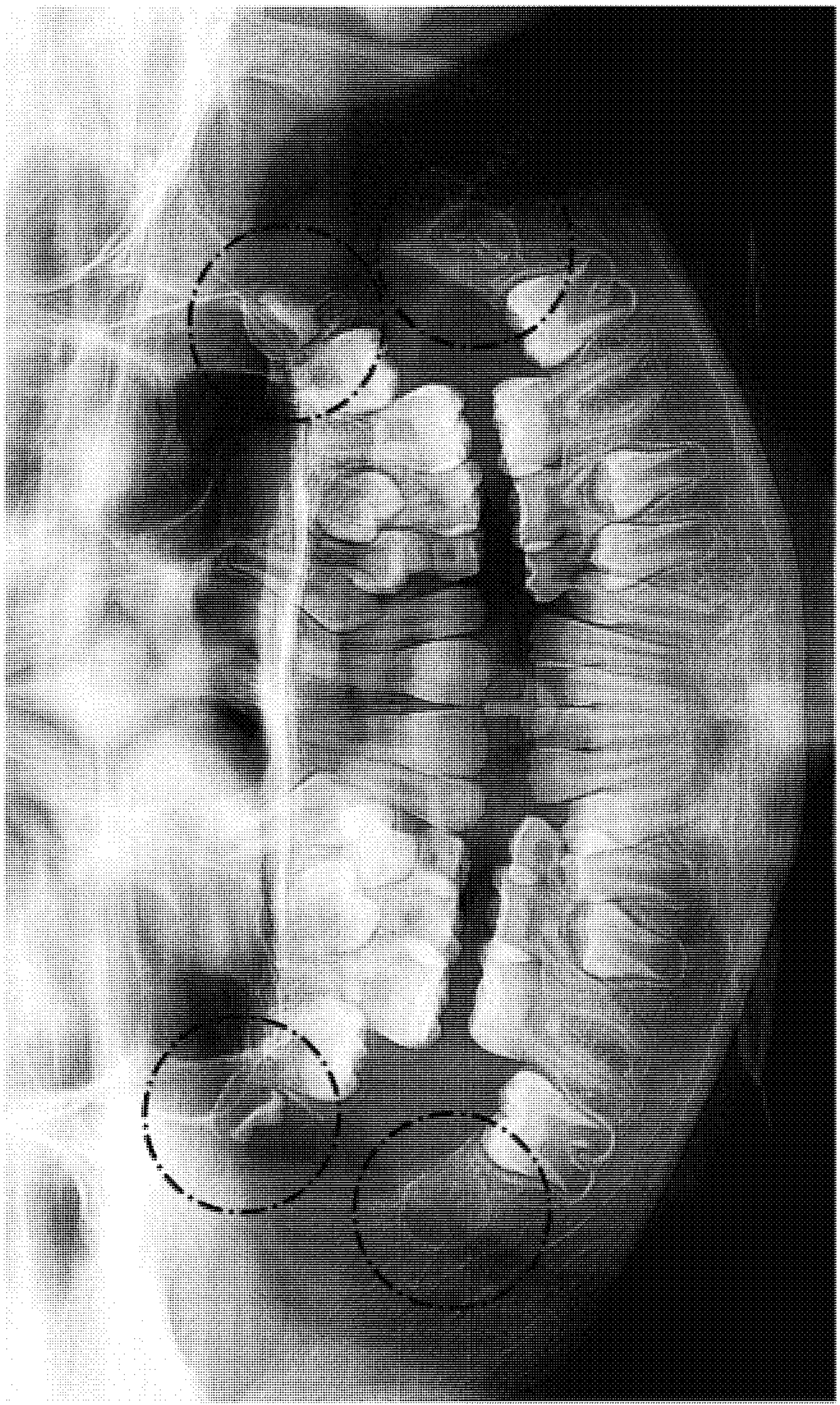

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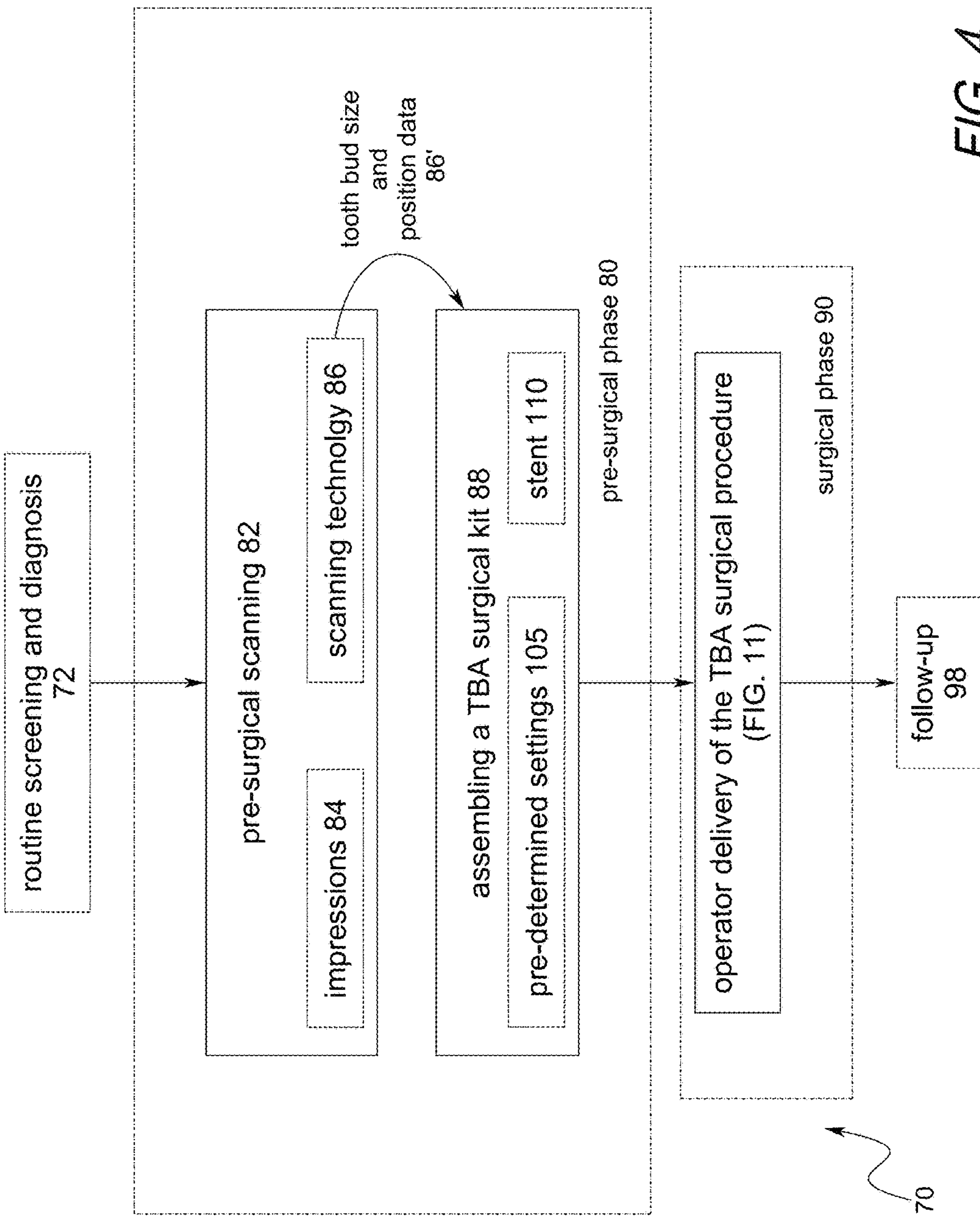
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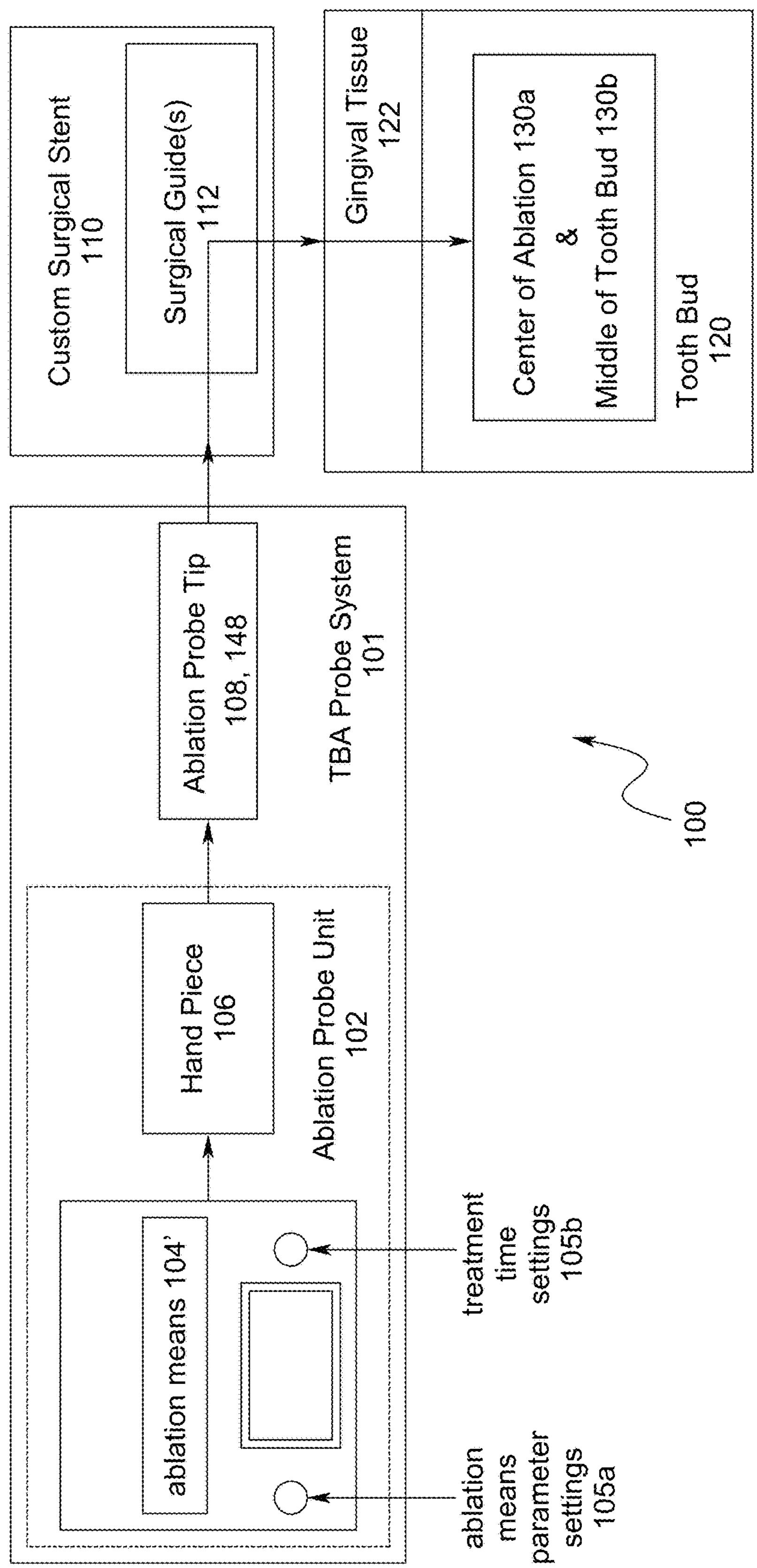
pre-surgical phase 80
operator delivery of the TBA surgical procedure (FIG. 11)
surgical phase 90
follow-up 98
70

FIG. 4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108, 148
TBA Probe System
101
100
Hand Piece
106
Ablation Probe Unit
102
ablation means 104'
treatment
time
settings
105b
ablation
means
parameter
settings
105a

FIG. 5

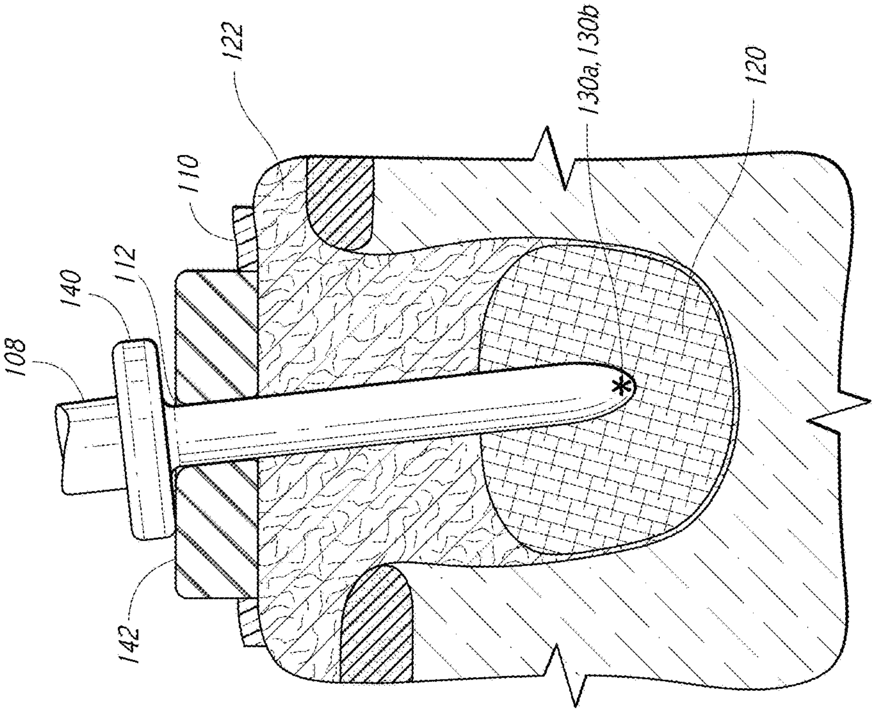
108
140
112
110
122
130a, 130b
120
142

FIG. 7

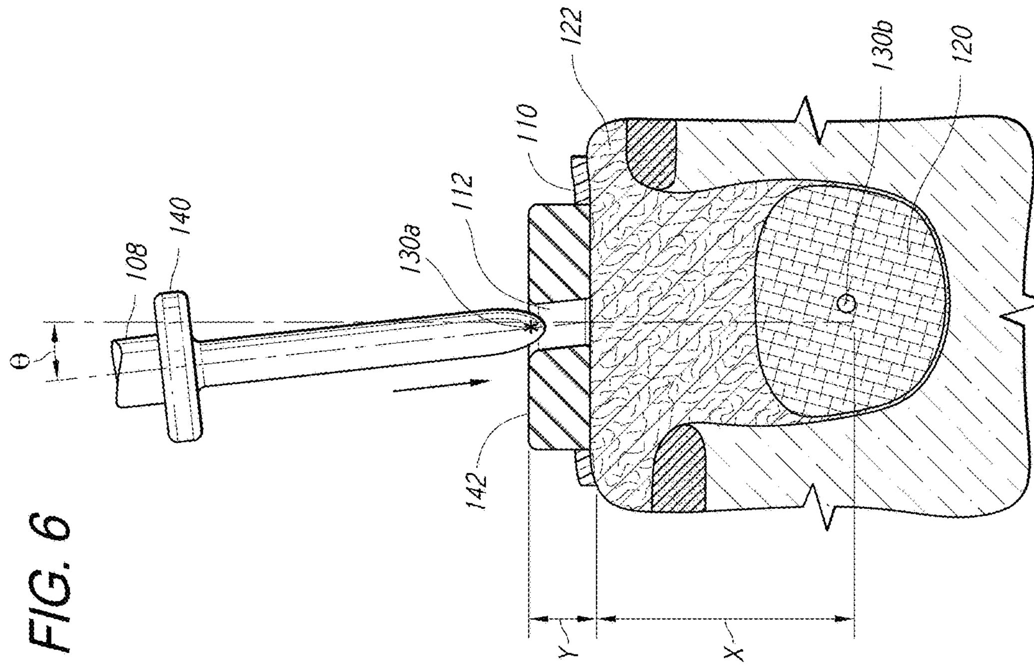
θ
108
140
130a
112
110
122
130b
120
142
Y
X

FIG. 6

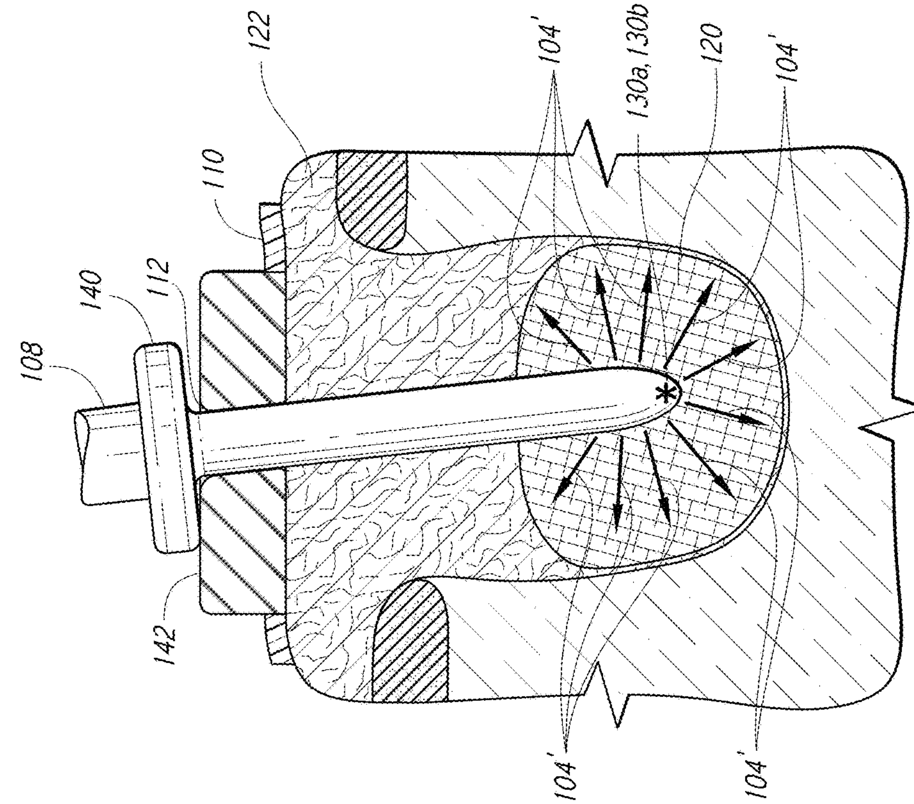
108
140
112
110
122
104'
130a,130b
120
104'
142
104'
104'

FIG. 9

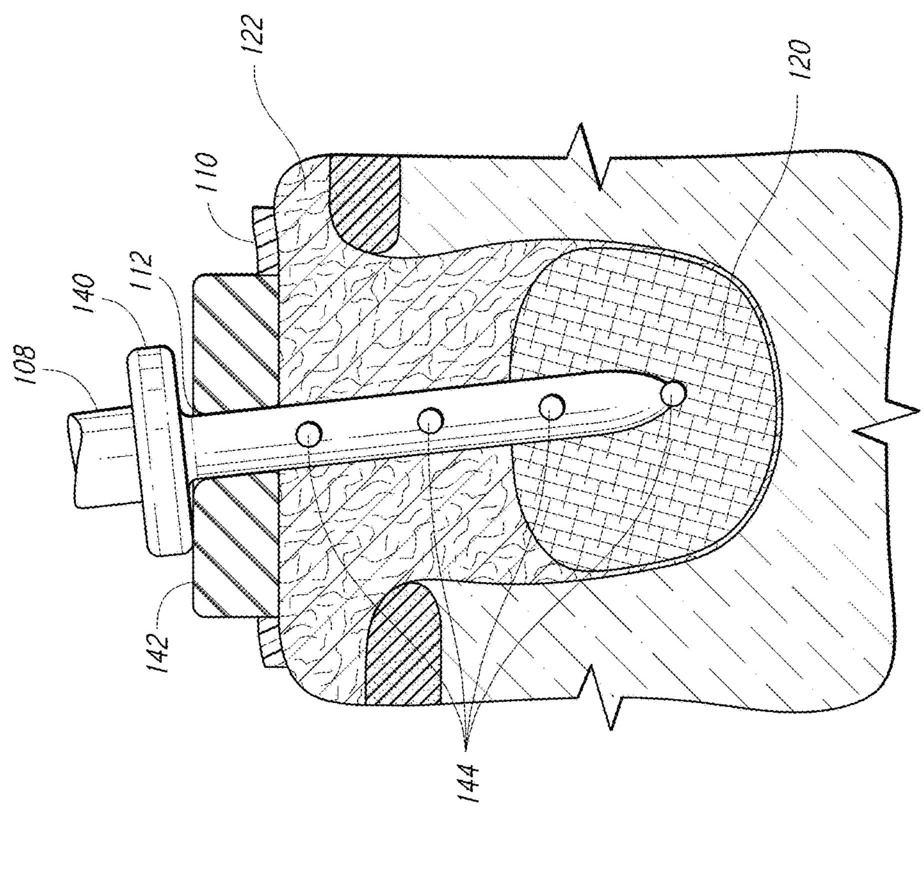
108
140
112
110
122
120
142
144

FIG. 8

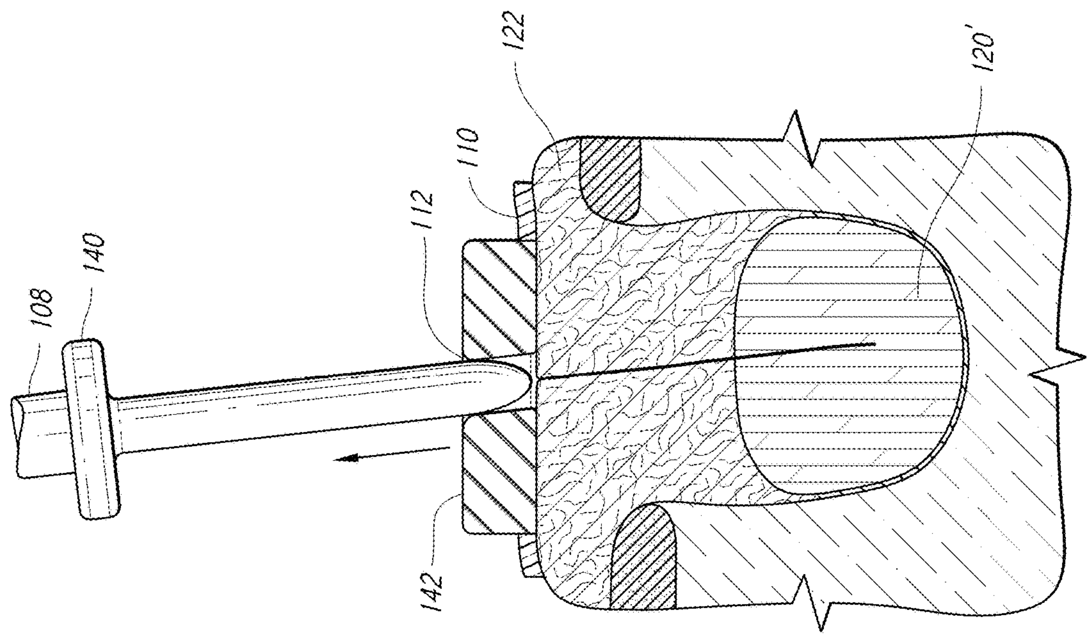

FIG. 10

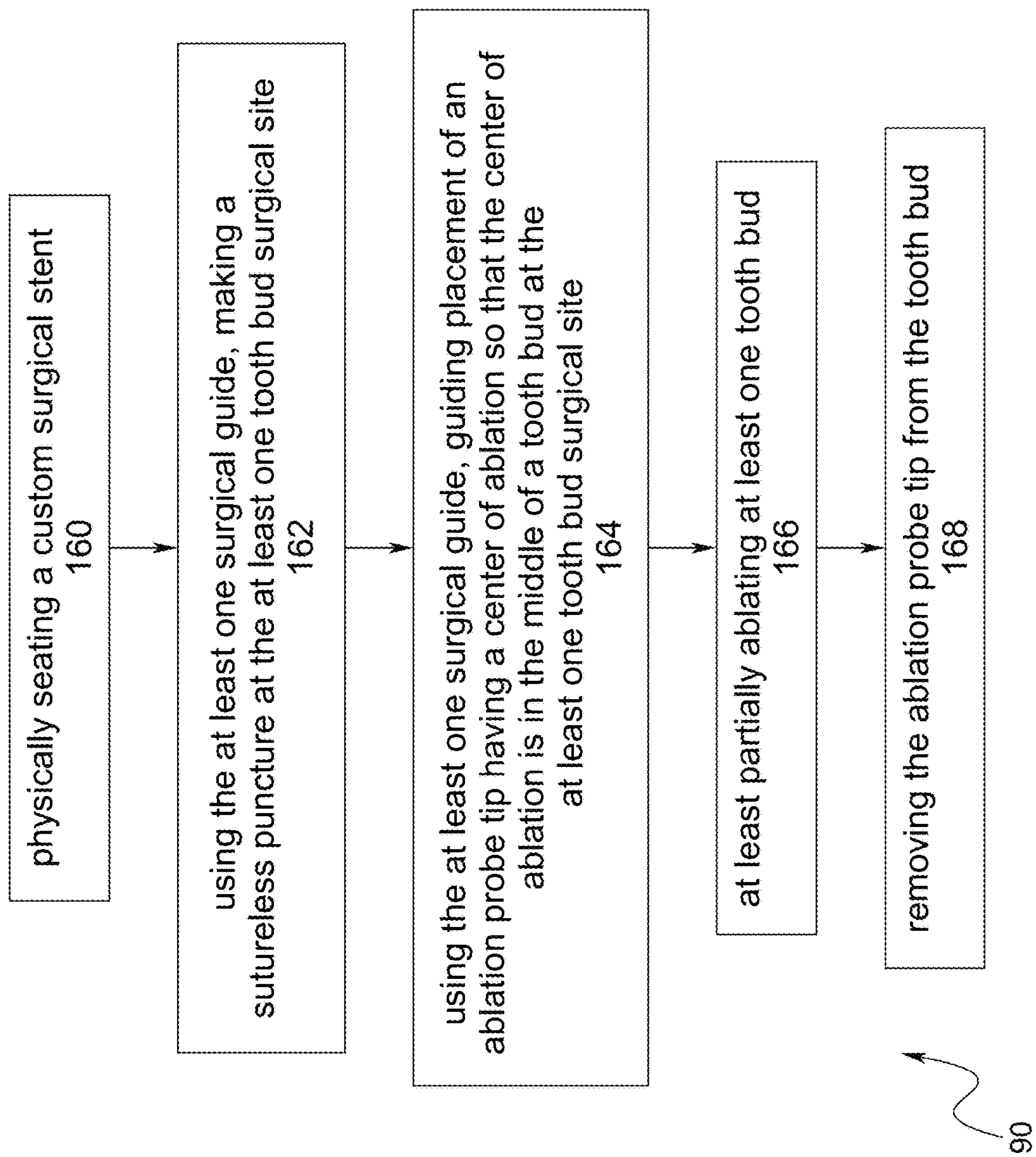
physically seating a custom surgical stent
160
using the at least one surgical guide, making a sutureless puncture at the at least one tooth bud surgical site
162
using the at least one surgical guide, guiding placement of an ablation probe tip having a center of ablation so that the center of ablation is in the middle of a tooth bud at the at least one tooth bud surgical site
164
at least partially ablating at least one tooth bud
166
removing the ablation probe tip from the tooth bud
168
90

FIG. 11

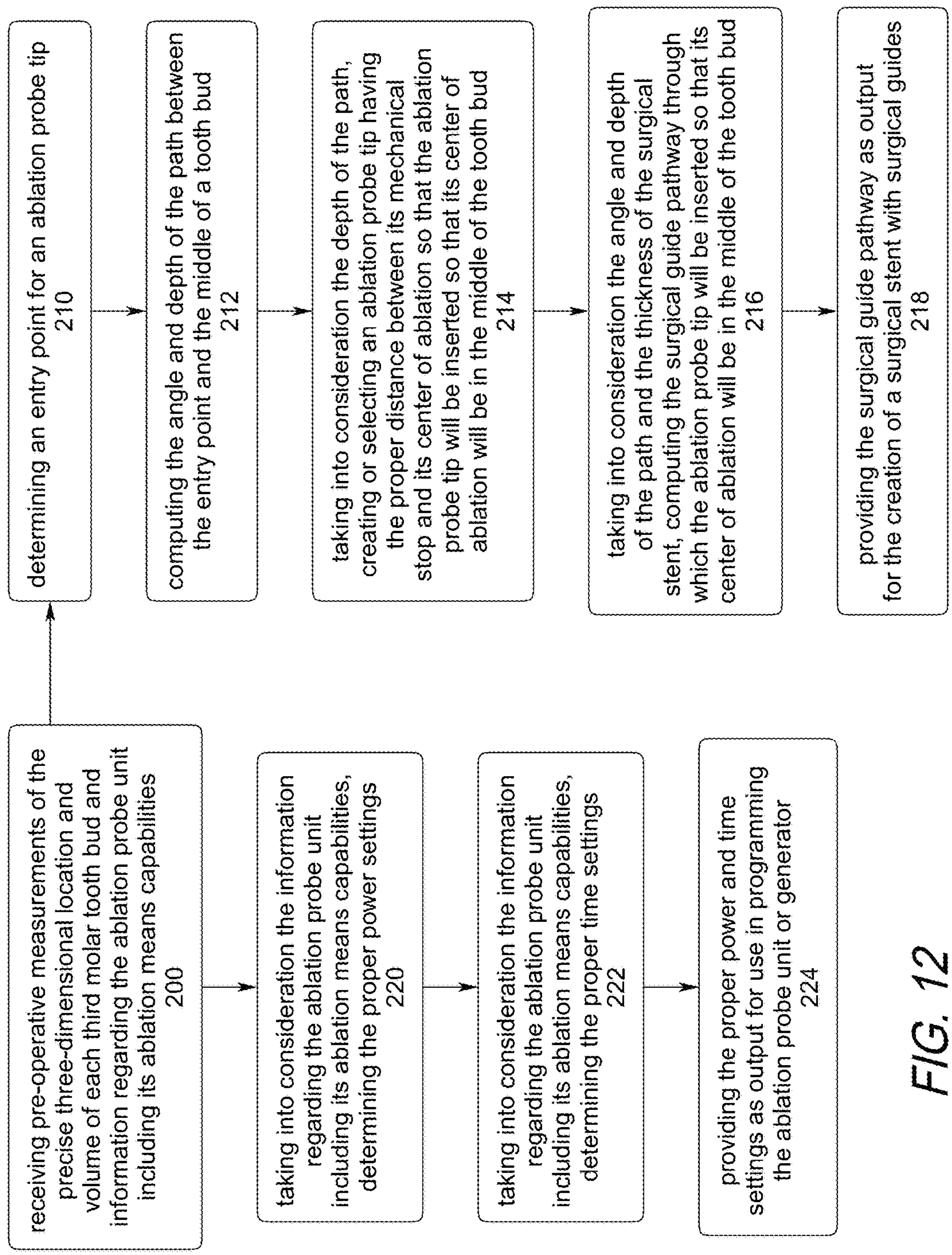
receiving pre-operative measurements of the precise three-dimensional location and volume of each third molar tooth bud and information regarding the ablation probe unit including its ablation means capabilities
200
determining an entry point for an ablation probe tip
210
computing the angle and depth of the path between the entry point and the middle of a tooth bud
212
taking into consideration the depth of the path, creating or selecting an ablation probe tip having the proper distance between its mechanical stop and its center of ablation so that the ablation probe tip will be inserted so that its center of ablation will be in the middle of the tooth bud
214
taking into consideration the angle and depth of the path and the thickness of the surgical stent, computing the surgical guide pathway through which the ablation probe tip will be inserted so that its center of ablation will be in the middle of the tooth bud
216
providing the surgical guide pathway as output for the creation of a surgical stent with surgical guides
218
taking into consideration the information regarding the ablation probe unit including its ablation means capabilities, determining the proper power settings
220
taking into consideration the information regarding the ablation probe unit including its ablation means capabilities, determining the proper time settings
222
providing the proper power and time settings as output for use in programming the ablation probe unit or generator
224

FIG. 12

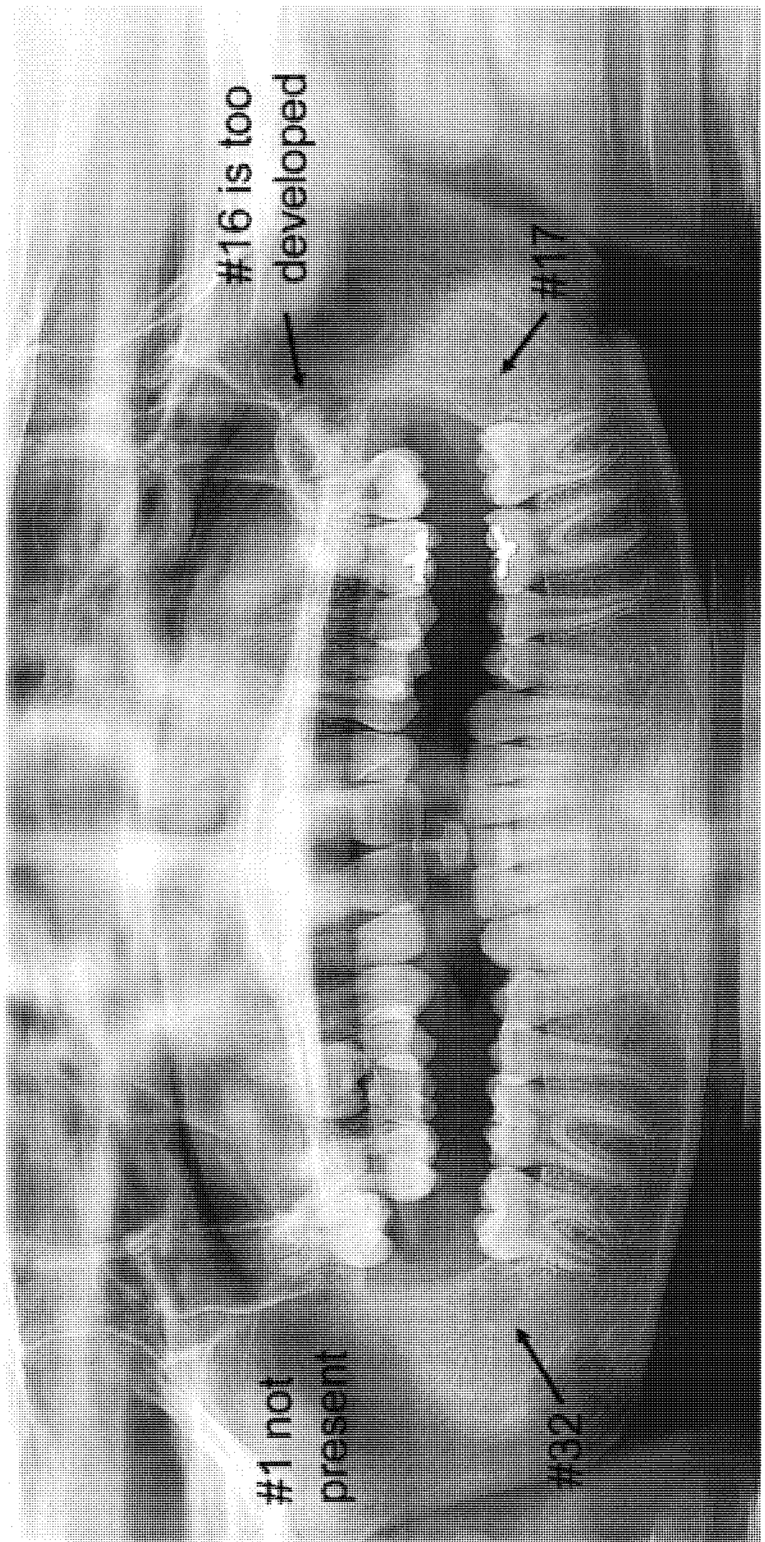

FIG. 13

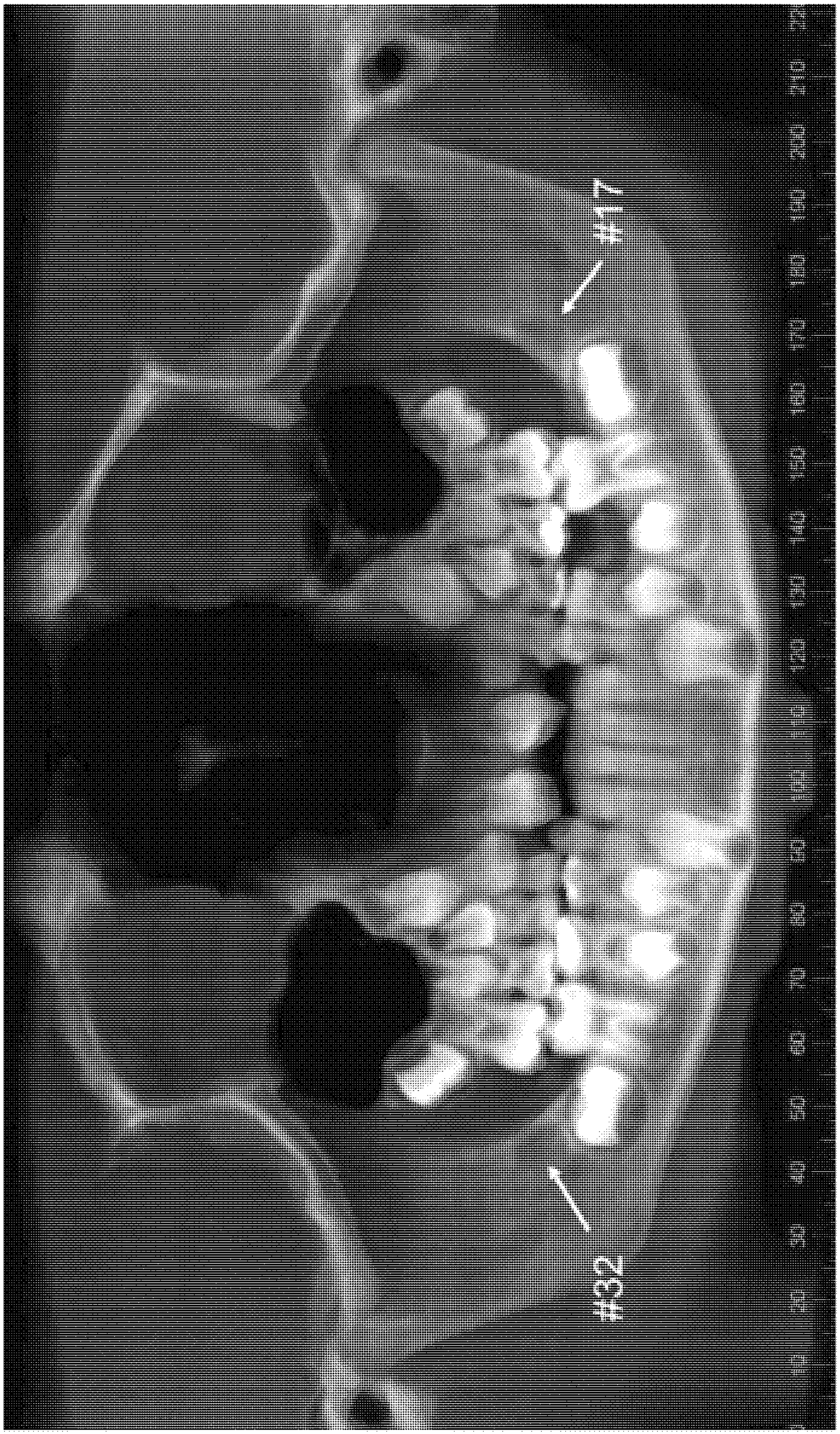

FIG. 14

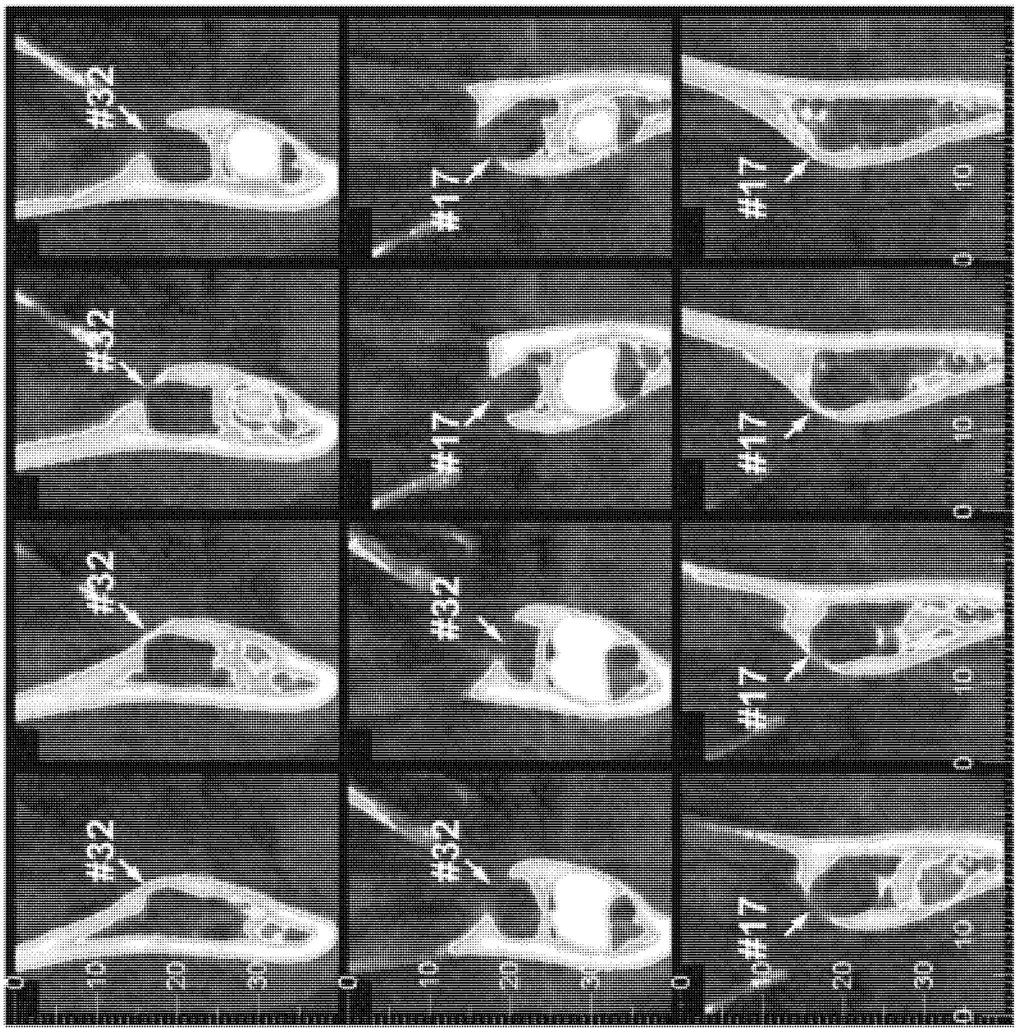

FIG. 15

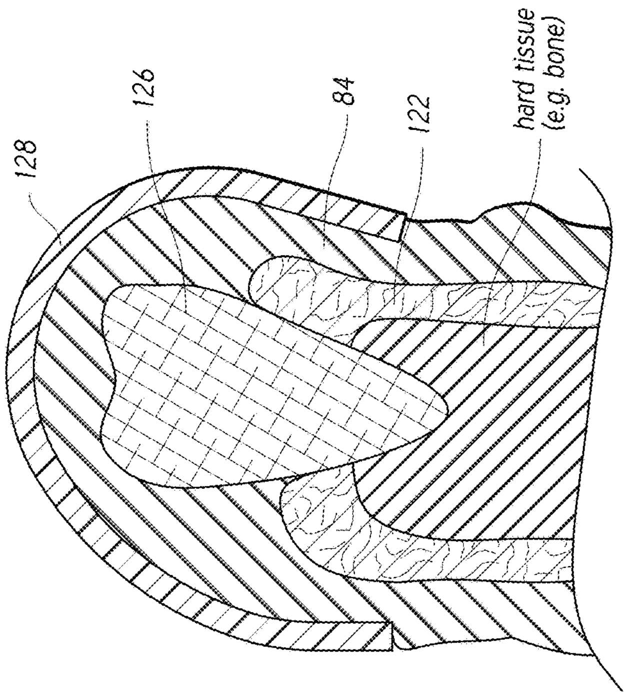

FIG. 17

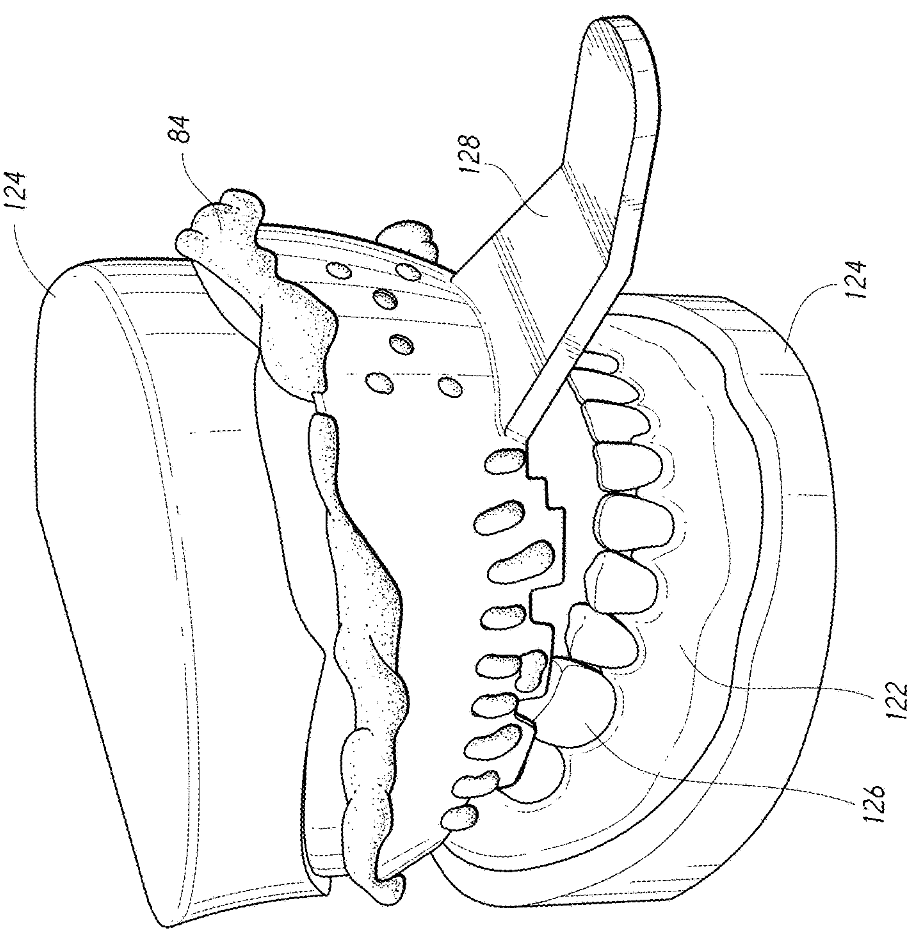

FIG. 16

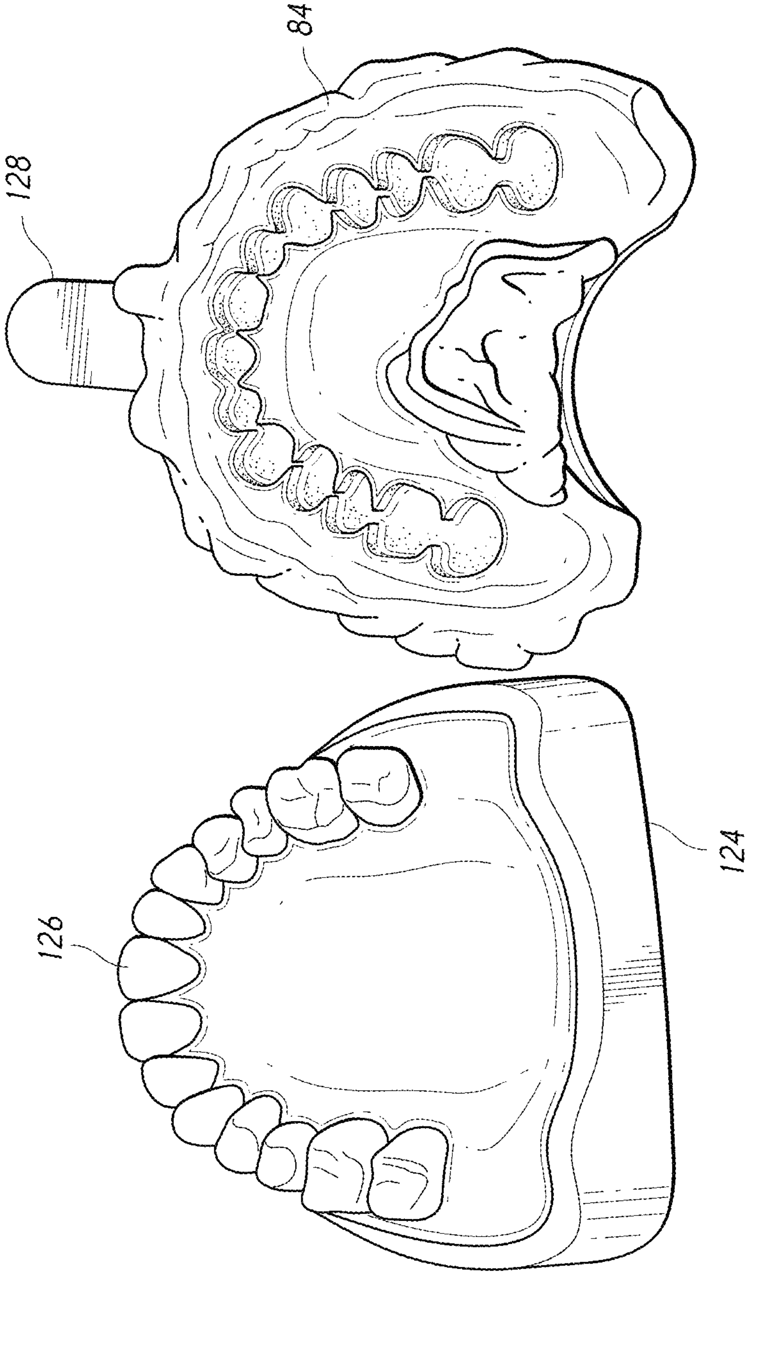

FIG. 18

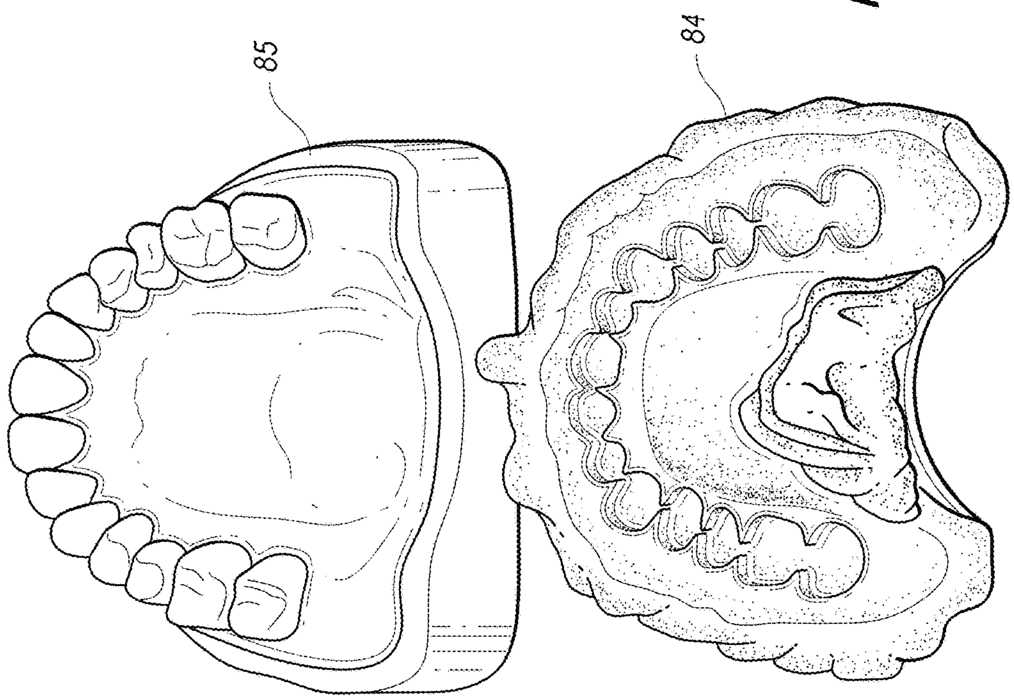

FIG. 19

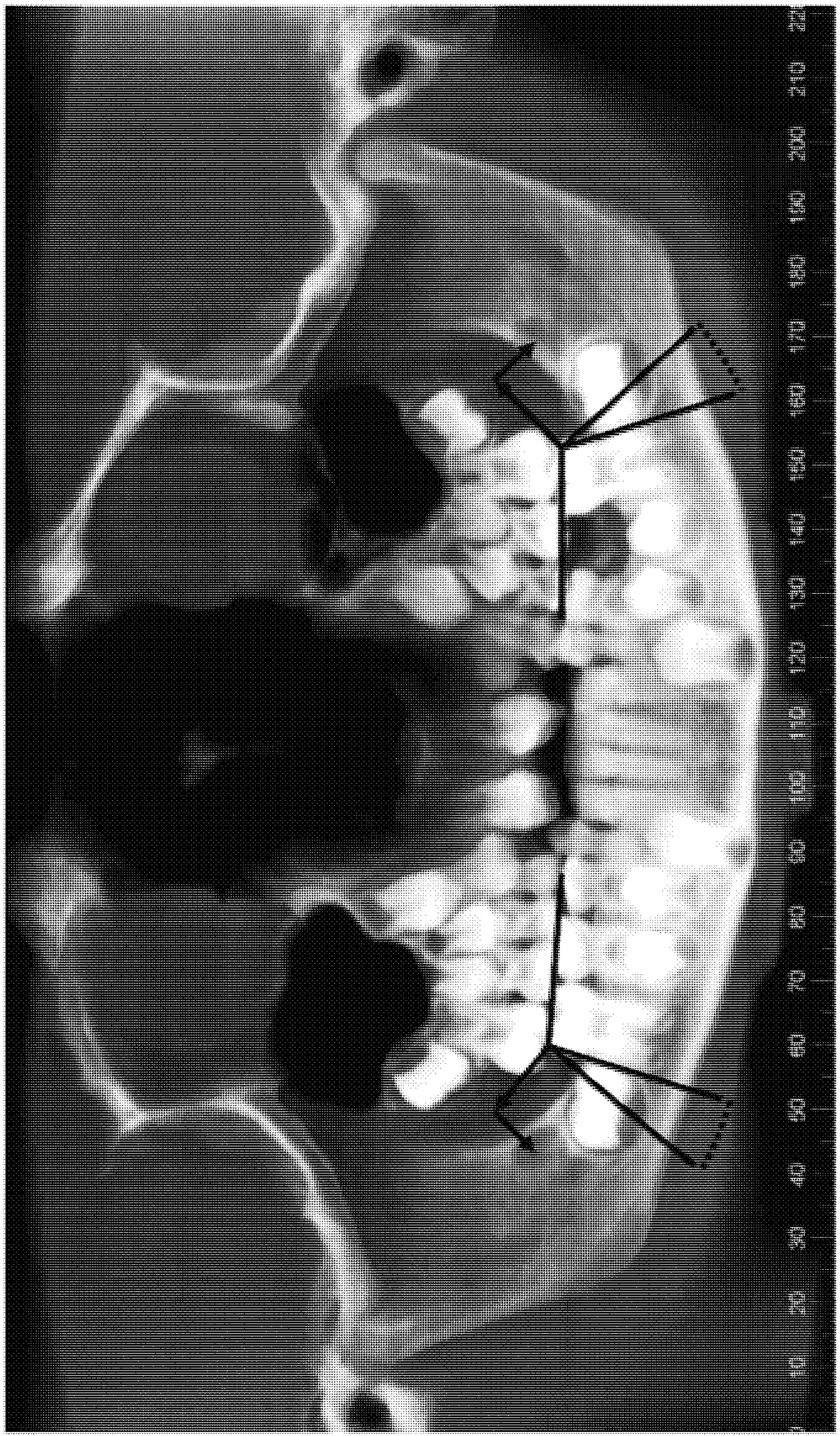

FIG. 20

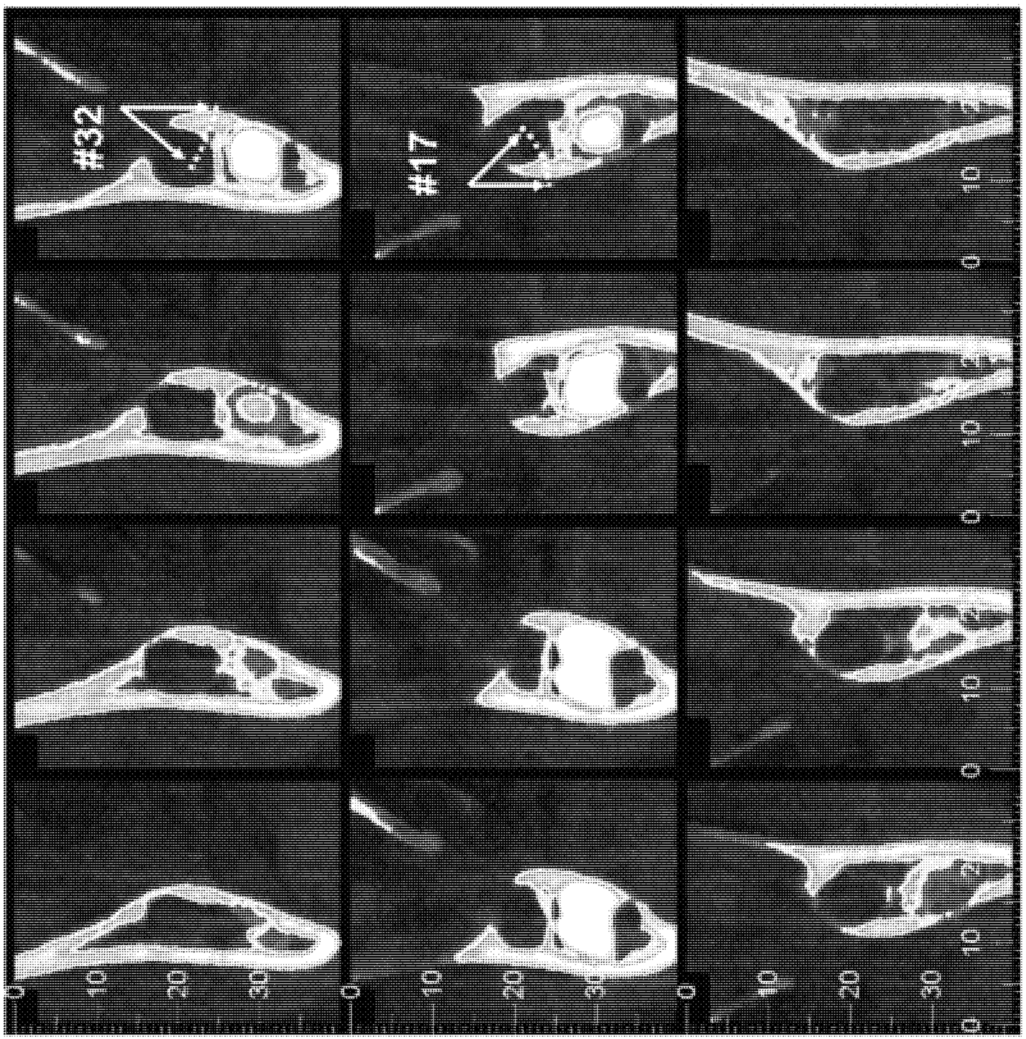

FIG. 21

FIG. 22

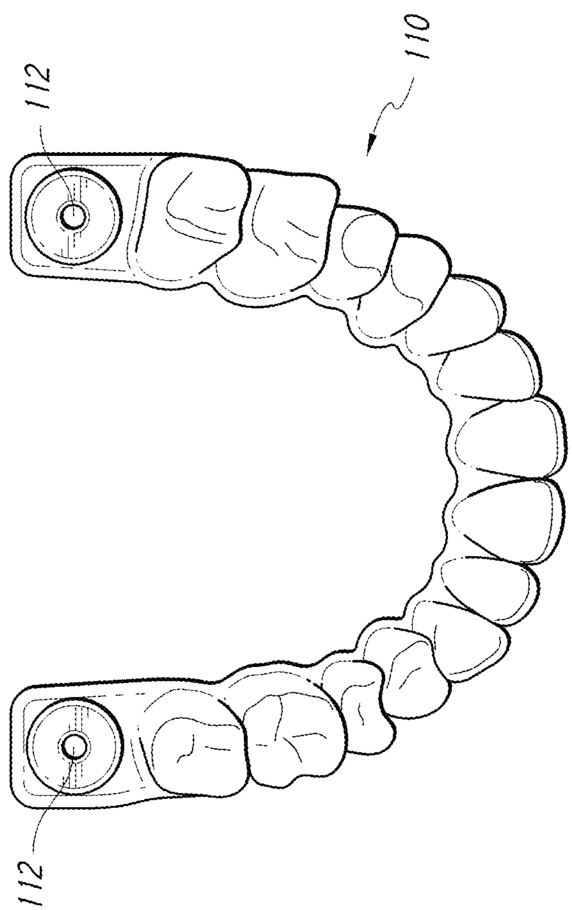

FIG. 23

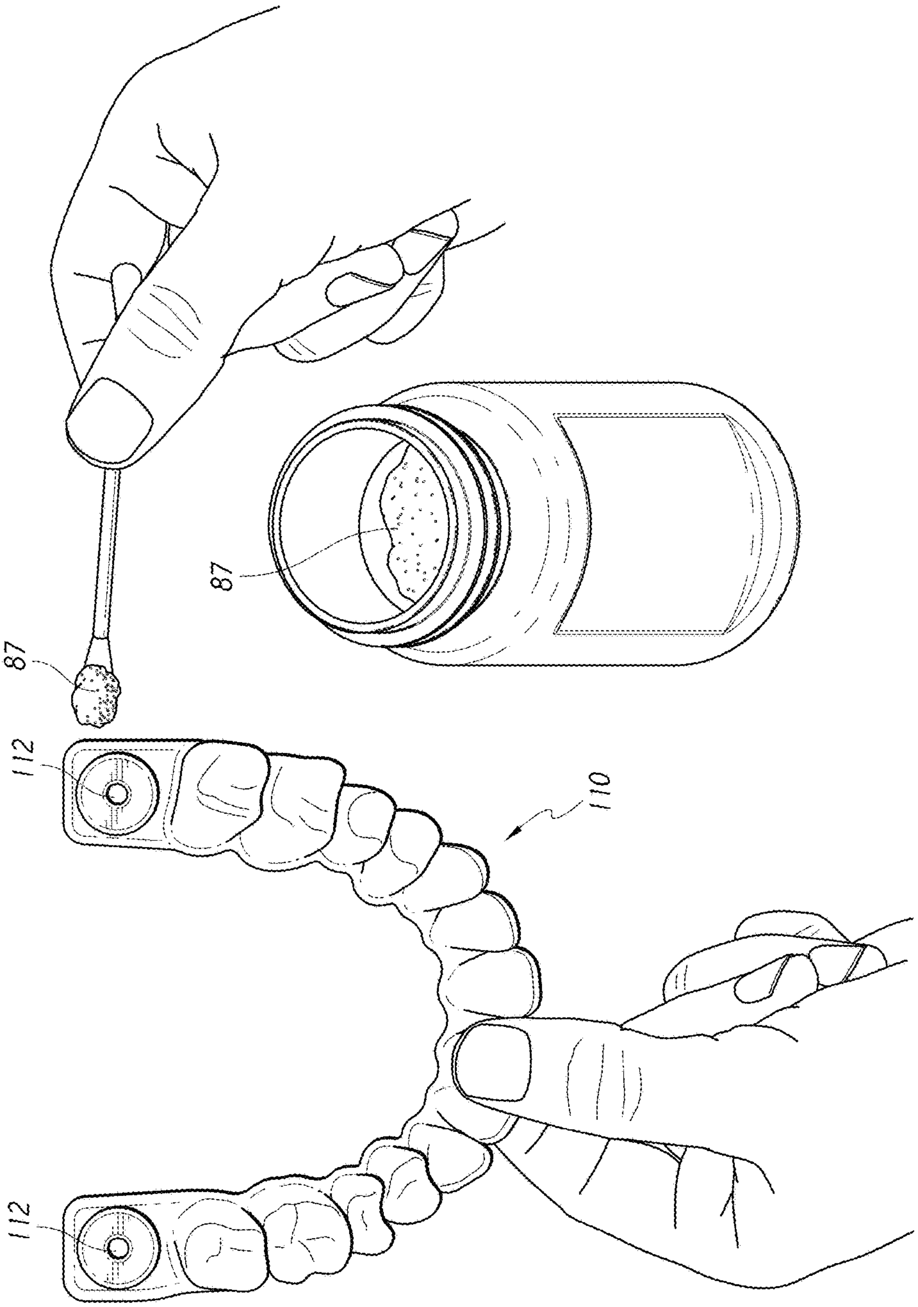

FIG. 24

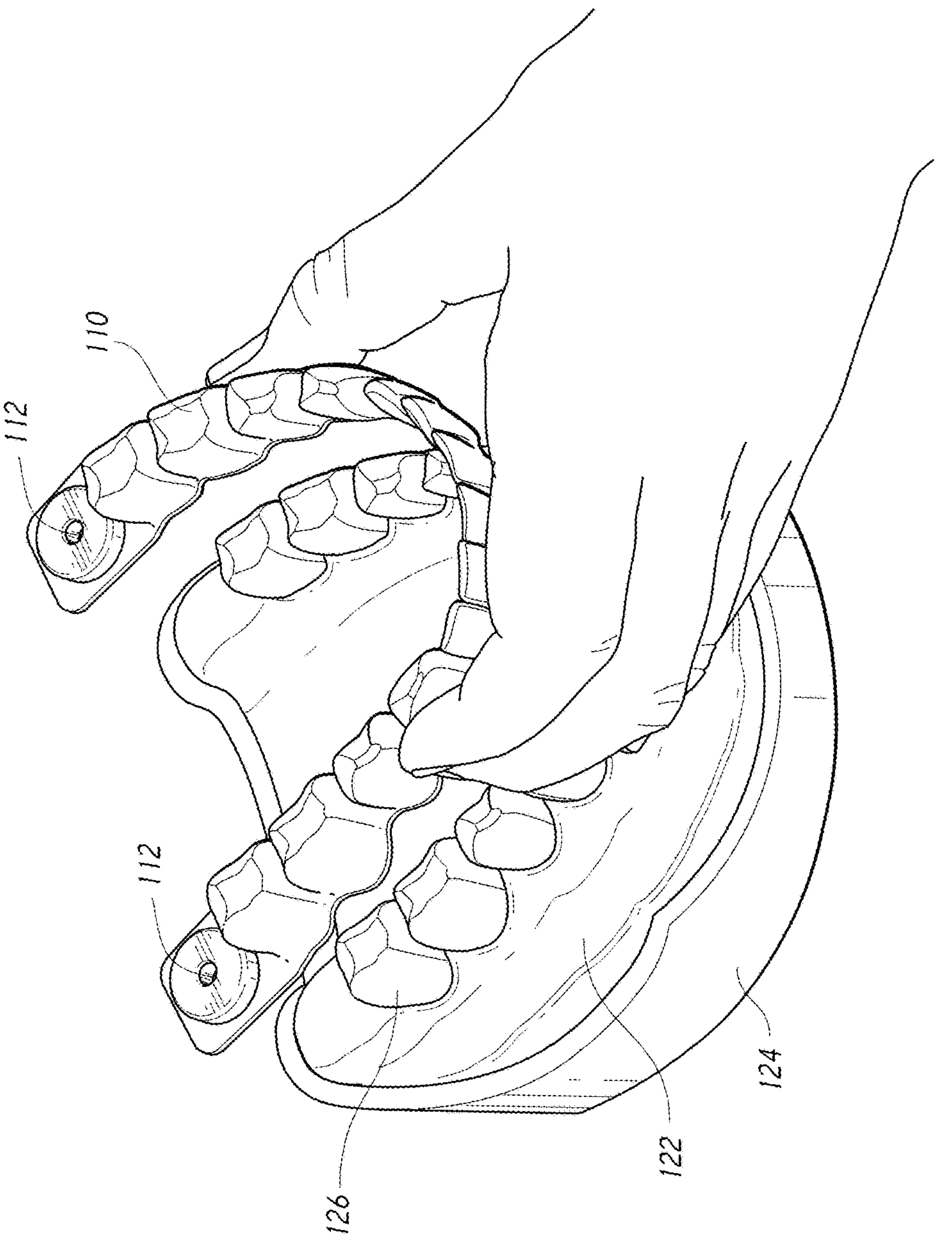

FIG. 25

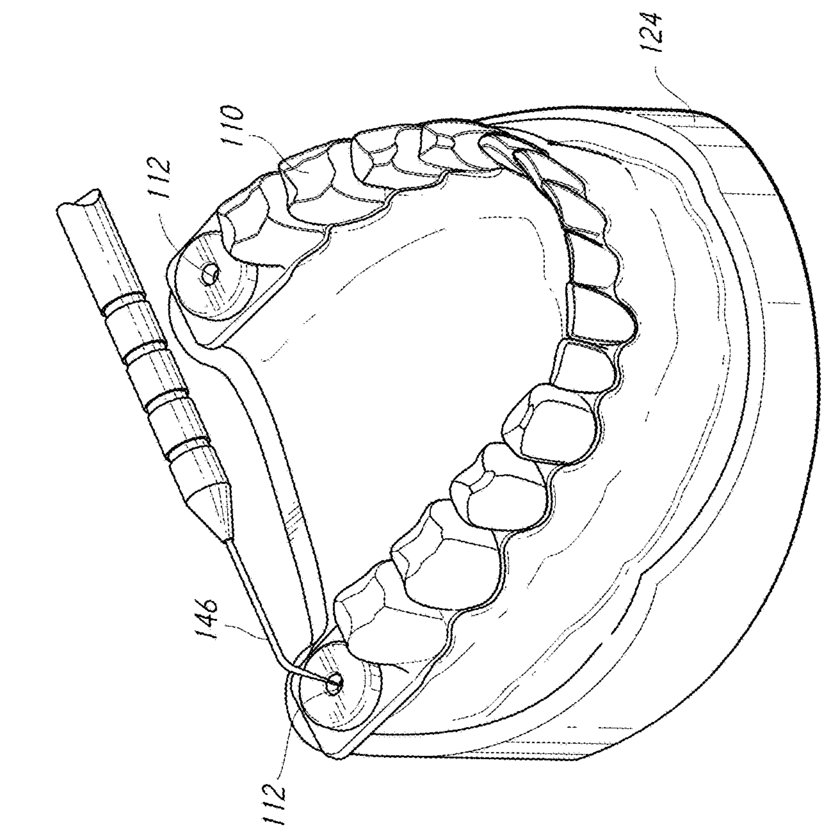

FIG. 27

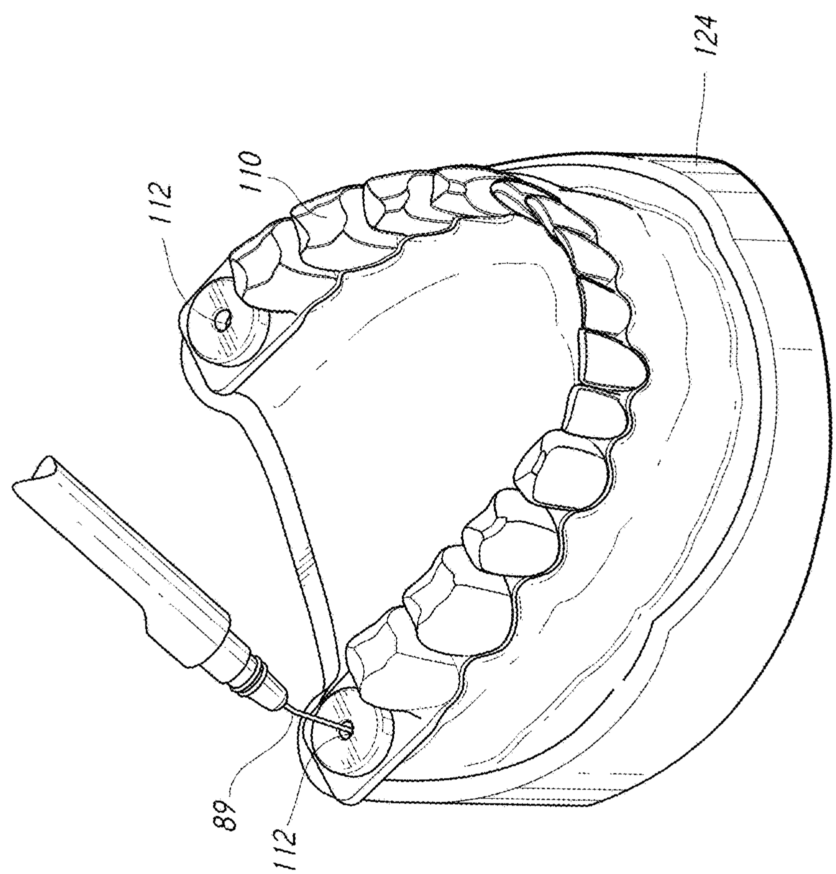

FIG. 26

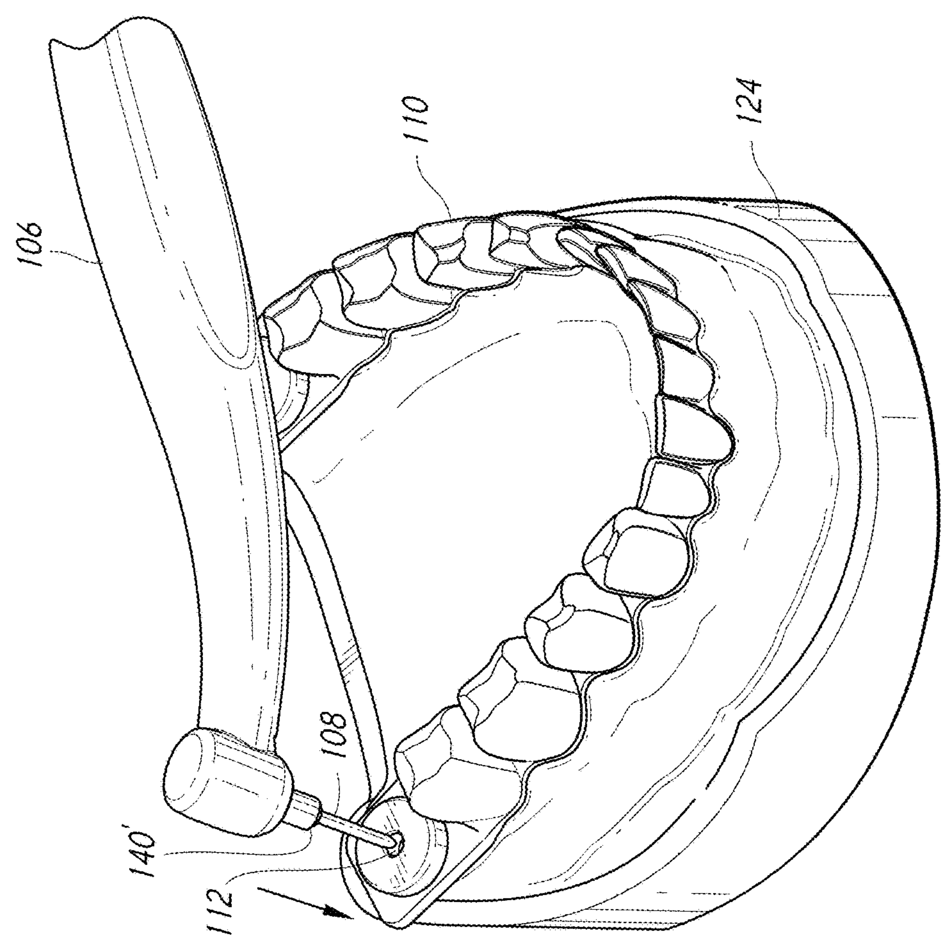

FIG. 28

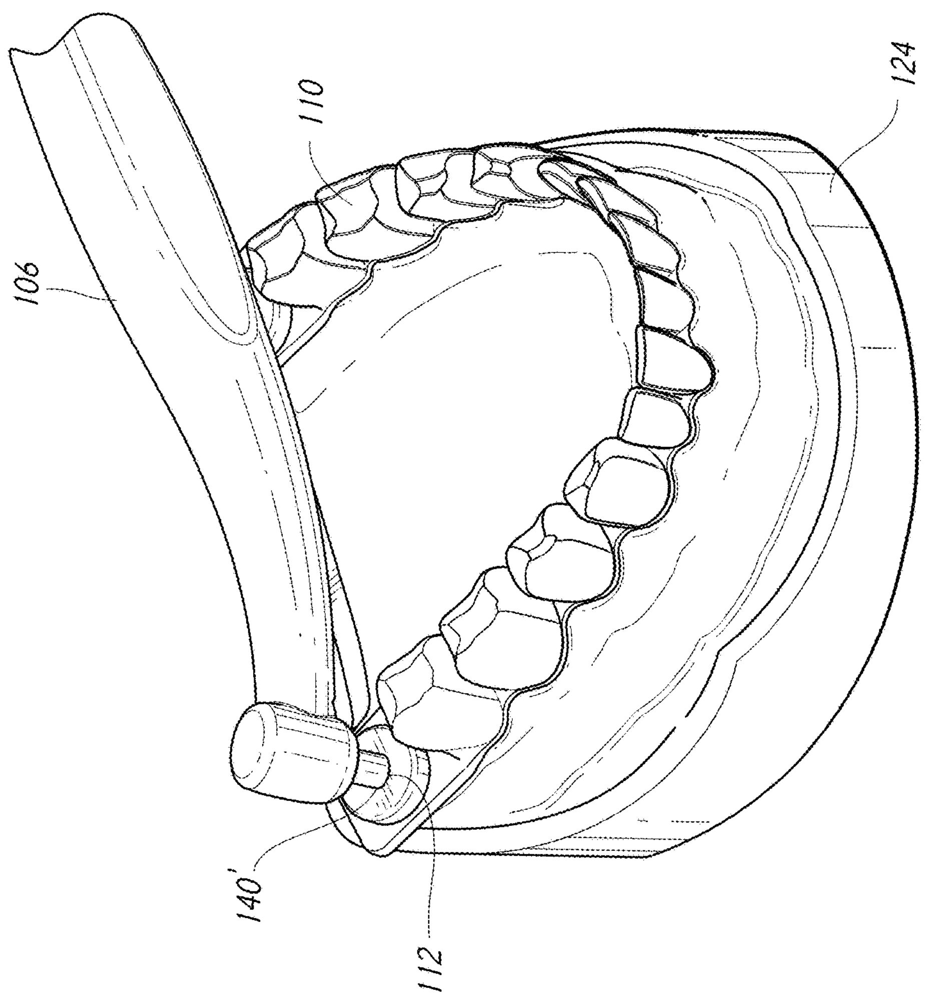

FIG. 29

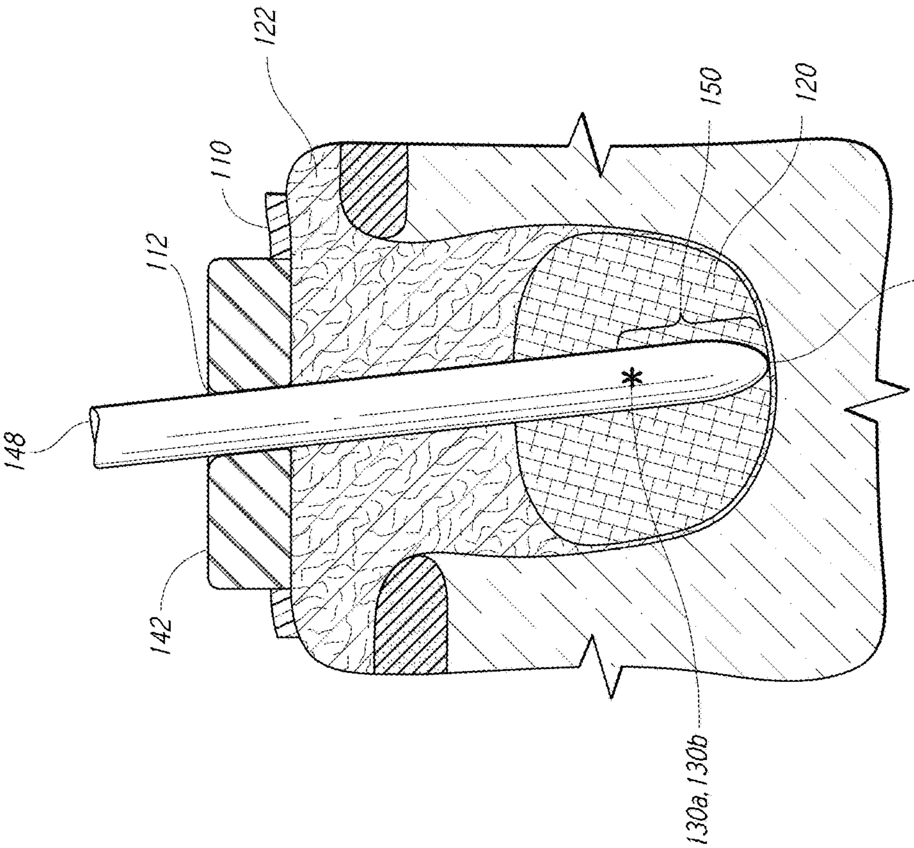
122
110
112
148
142
150
120
152
130a,130b

FIG. 31

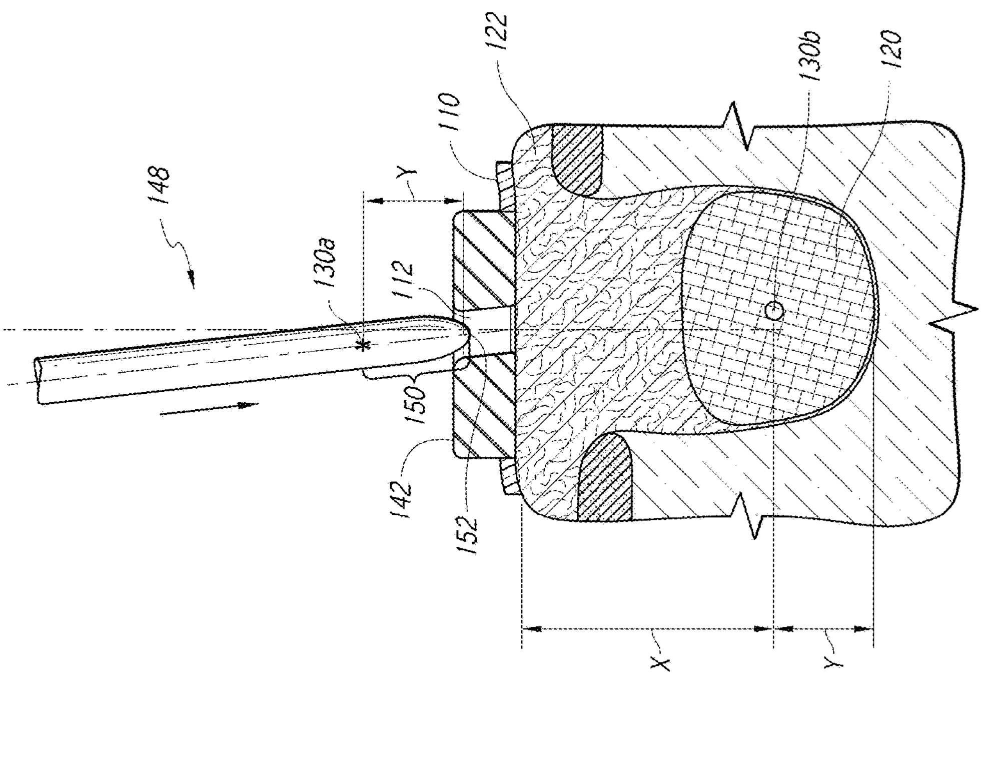
θ
148
Y
130a
112
110
122
130b
120
150
142
152
X
Y

FIG. 30

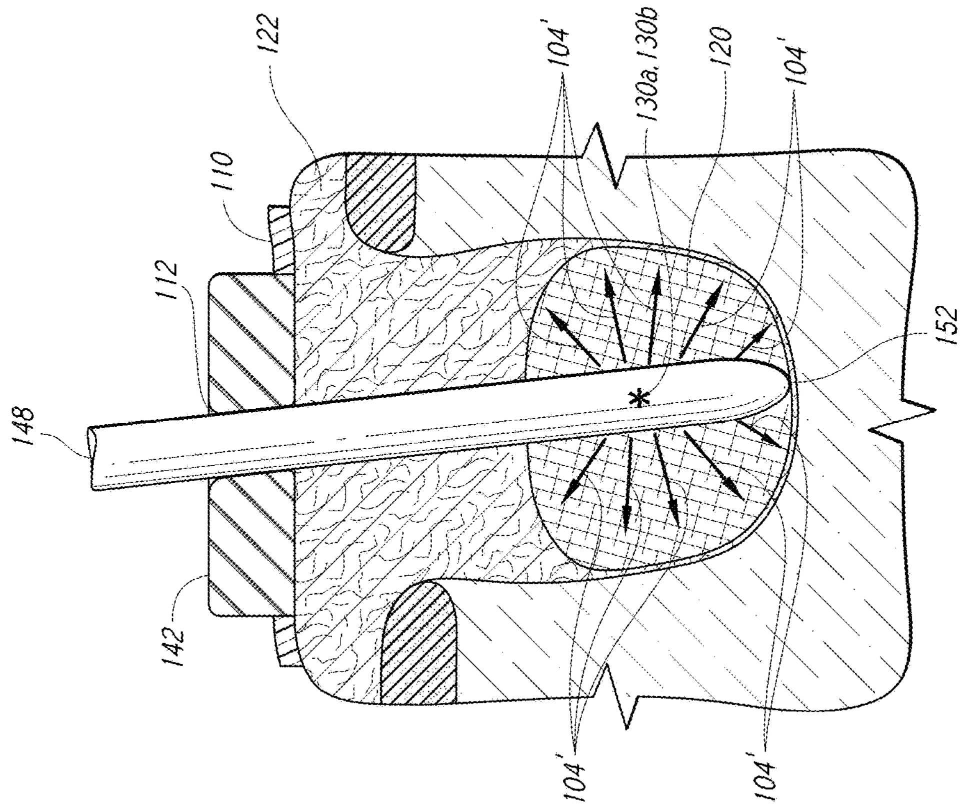
148
112
110
122
142
104'
130a, 130b
120
104'
152
104'
104'

FIG. 33

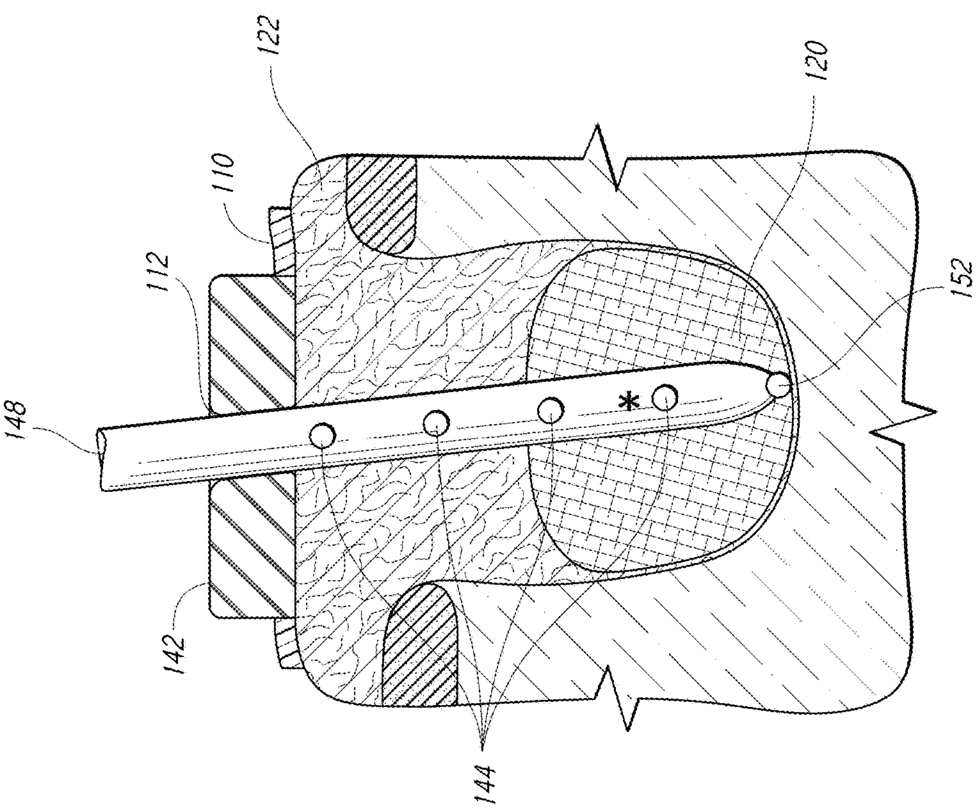
148
112
110
122
142
144
120
152

FIG. 32

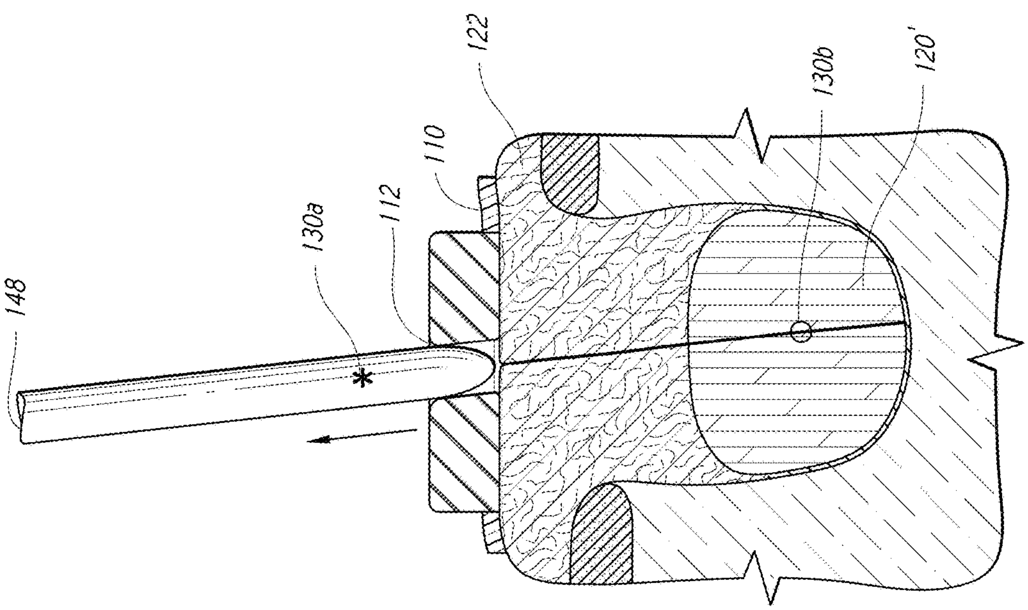

FIG. 34

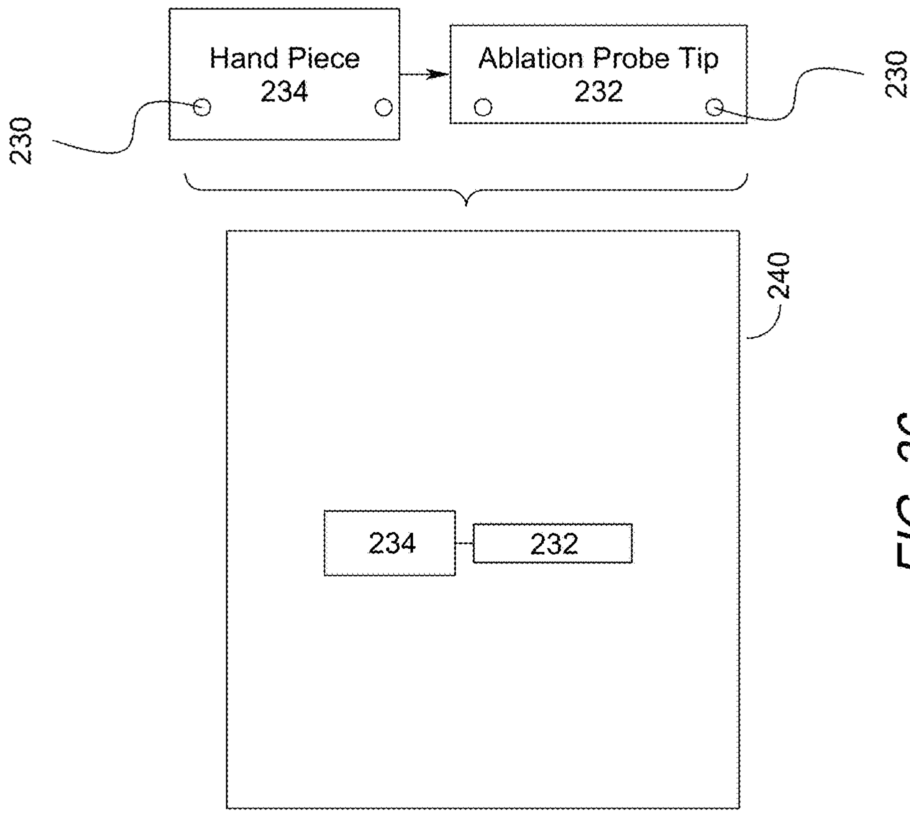
Hand Piece
234
Ablation Probe Tip
232
230
230
240
234
232

FIG. 36

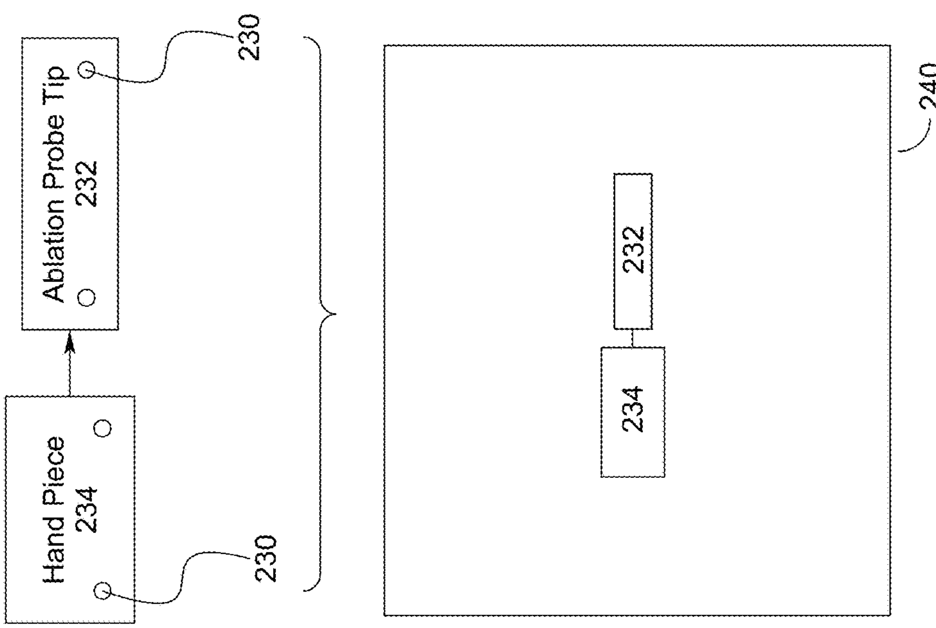
Ablation Probe Tip
232
230
Hand Piece
234
230
240
232
234

FIG. 35

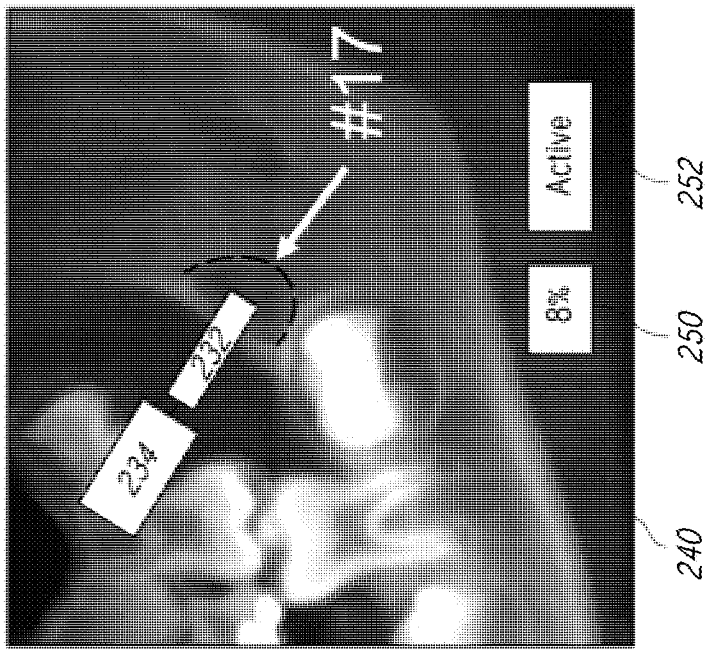
#17
Active
8%
232
234
240
250
252

FIG. 38

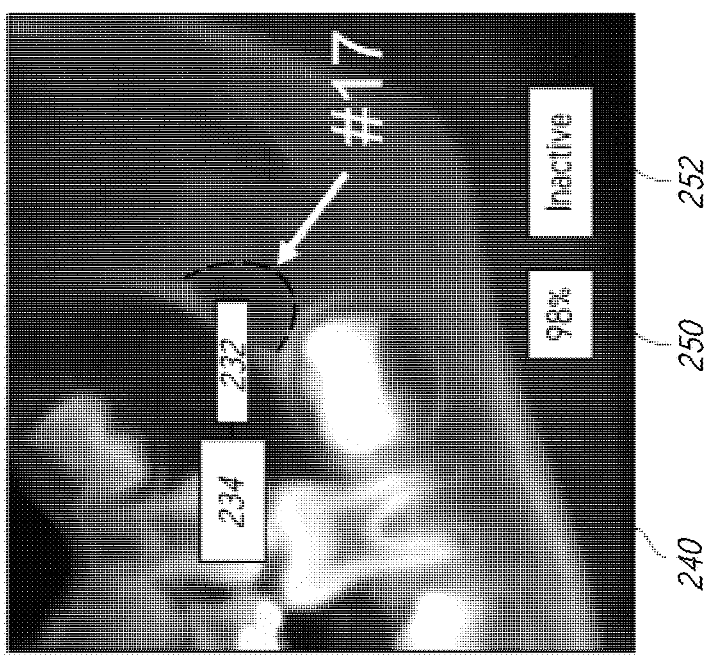
#17
Inactive
98%
232
234
240
250
252

FIG. 37

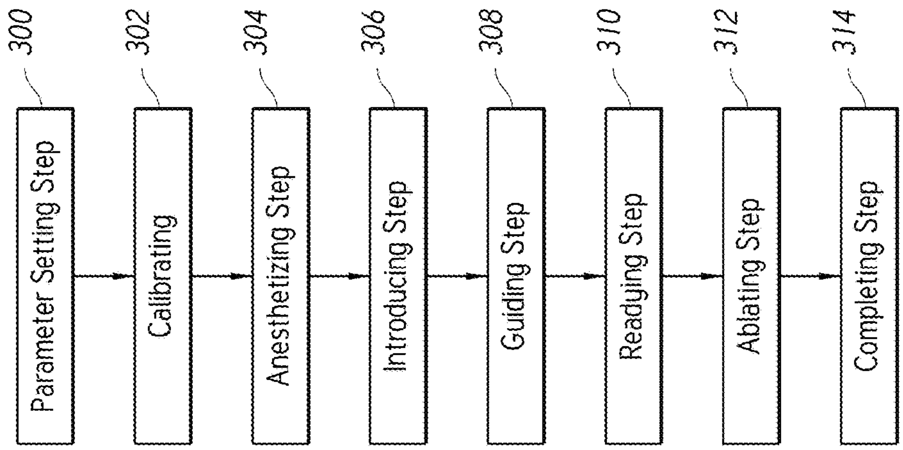
300
Parameter Setting Step
302
Calibrating
304
Anesthetizing Step
306
Introducing Step
308
Guiding Step
310
Readying Step
312
Ablating Step
314
Completing Step

FIG. 40

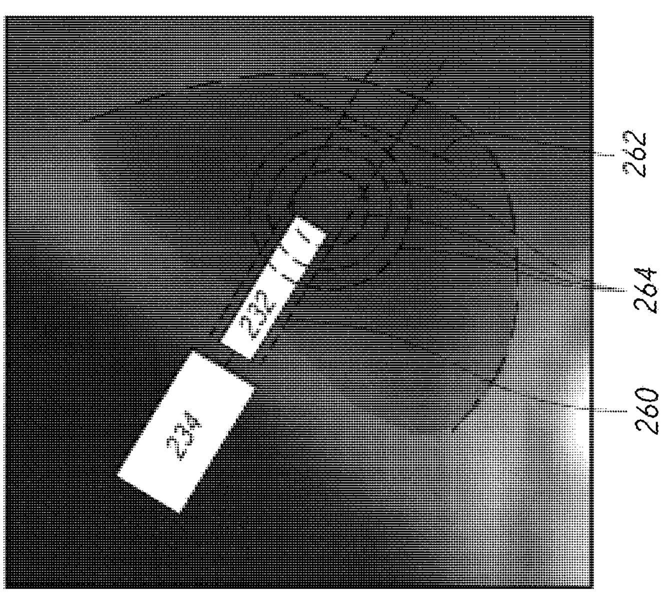
234
232
262
264
260

FIG. 39

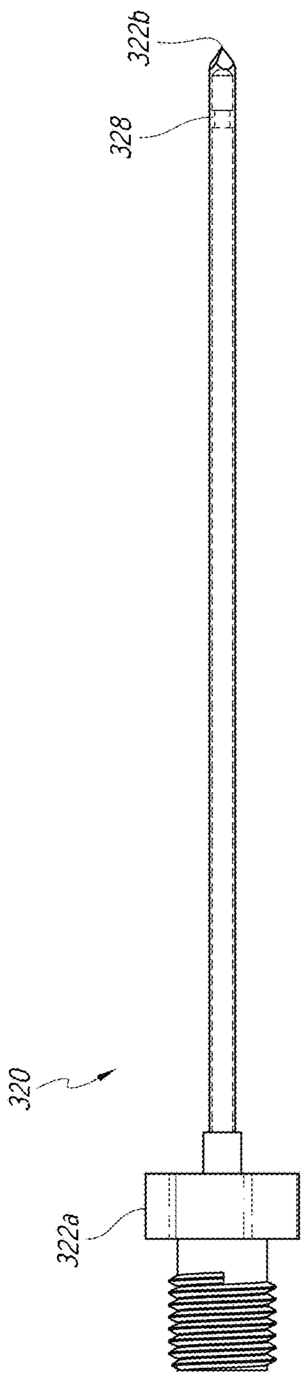

FIG. 41

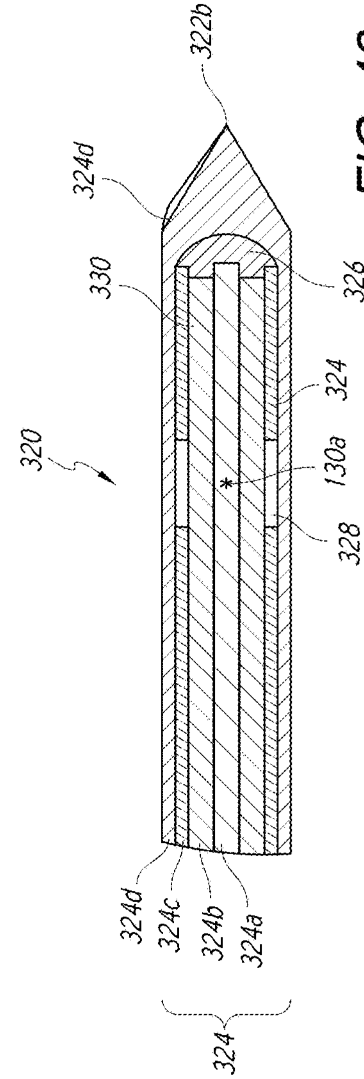

FIG. 42

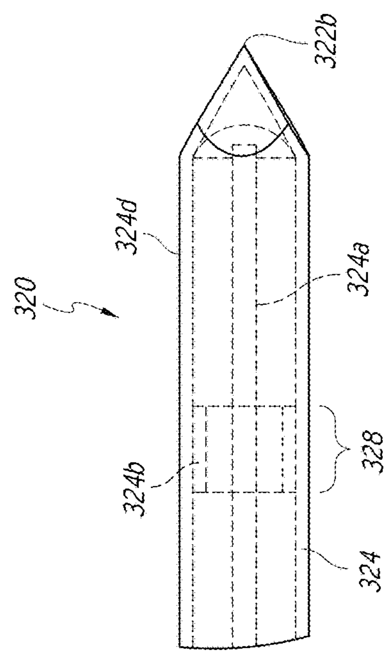

FIG. 43

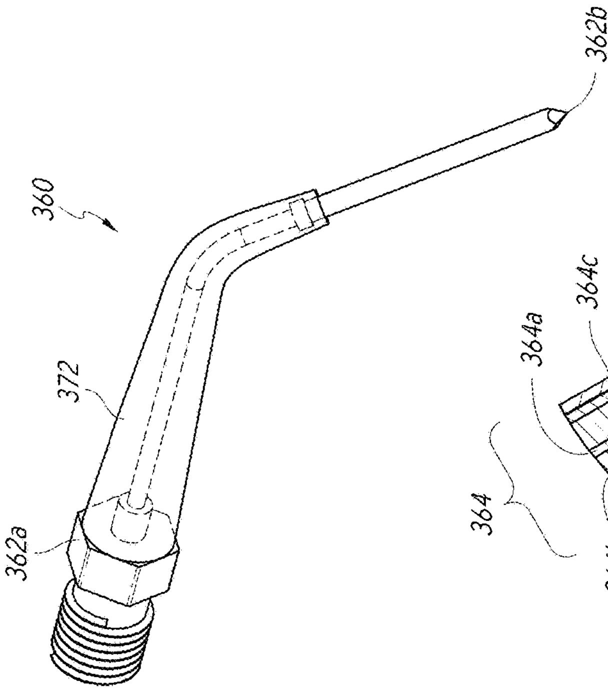

FIG. 44

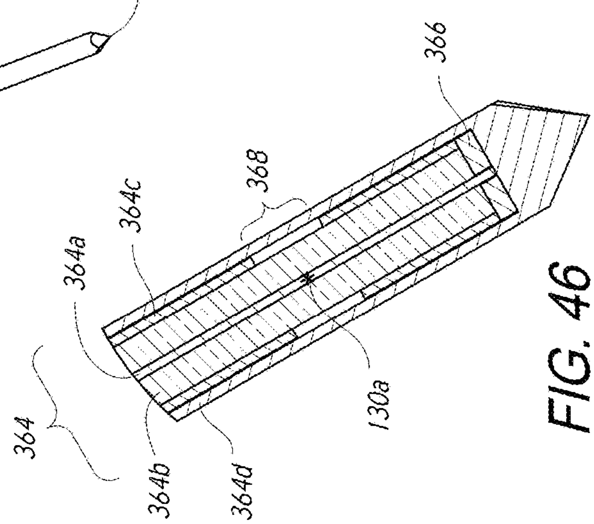

FIG. 46

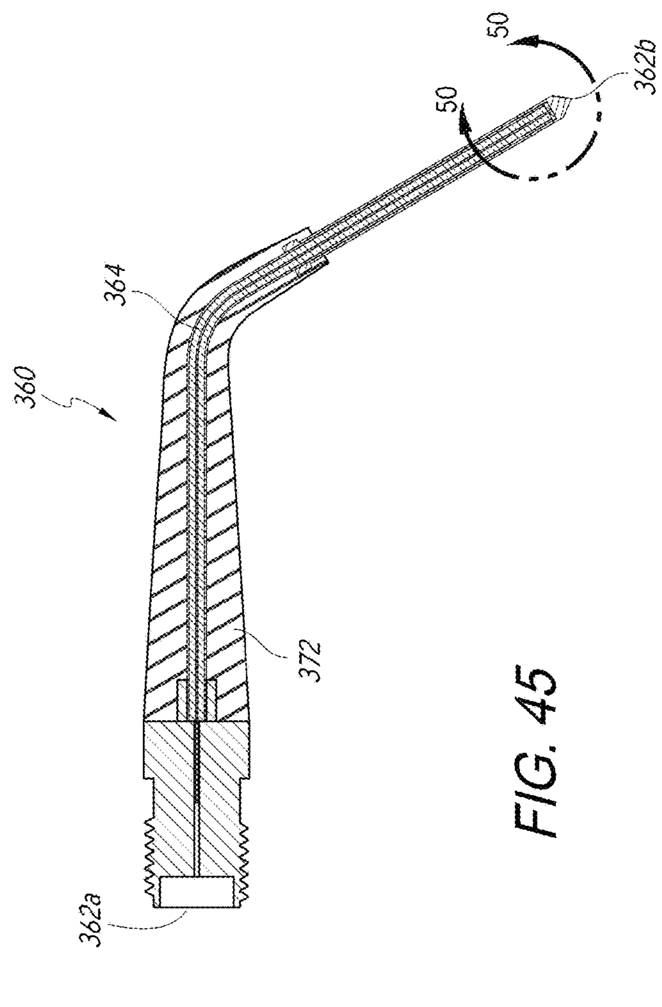

FIG. 45

THERAPEUTIC TOOTH BUD ABLATION

The present application is a continuation of Patent Cooperation Treaty (PCT) Application Number PCT/US13/32357, filed Mar. 15, 2013. The present application is based on and claims priority from this application, the disclosure of which is hereby expressly incorporated herein by reference in its entirety.

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TECHNICAL FIELD

Described herein are a tooth bud ablation (TBA) procedure and a tooth bud ablation (TBA) system.

BACKGROUND OF THE INVENTION

Approximately 3.5% of the total $100 billion spent on dental care in the United States in 2008 was for traditional surgical removal of third molars (i.e. "wisdom teeth" extractions), including the associated costs of imaging, sedation, and resulting complications. Traditional surgical removal of third molars, however, is a highly invasive, painful, and complication-ridden procedure. Further, third molar extraction represents the only procedure in the United States and Europe where it is considered "normal" to subject patients of any age group to such a highly invasive prophylactic surgery that carries significant lifelong risks for the excision of asymptotic or non-pathologic tissue. Dental practitioners (e.g. general dentists, pediatric dentists, and oral surgeons) have been trained to remove children's wisdom teeth (third molars) before the wisdom teeth cause problems, but this surgery carries significant pain, risks and costs.

The main problem associated with third molar tooth extractions—aside from the pain inflicted—is the serious risk of complications associated with such an invasive procedure. Each year "more than 11 million patient days of 'standard discomfort or disability'—pain, swelling, bruising, and malaise—result post-operatively, and more than 11,000 people suffer permanent paraesthesia—numbness of the lip, tongue, and cheek—as a consequence of nerve injury during the surgery. At least two thirds of these extractions, associated costs, and injuries are unnecessary, constituting a silent epidemic of iatrogenic injury that afflicts tens of thousands of people with lifelong discomfort and disability.

If you interview people under the age of 40 and ask them what has been the most invasive surgical procedure they have personally experienced (that is not trauma related), there is a greater than 90% chance that it will be their "wisdom teeth" extraction. The current standard of care in America for "managing" third molars (e.g. "wisdom teeth") in adolescents and young adults is generally to have all four third molars extracted once they are formed, unless it is absolutely clear that these teeth will erupt normally. General dentists and oral surgeons alike are complicit in their belief that third molars generally should be extracted because not all will erupt normally, thus causing future pathology.

Each year, an estimated 10 million third molar tooth extractions account for over 92% of all teeth extracted for

patients under the age of 40. This represents surgery on approximately 5 million people each year at an estimated cost of over $2.5 billion for third molar extraction fees alone in the United States. When IV sedation fees, X-ray imaging expenses, post-op medications, and unplanned post-operative expenses associated with treating complications are added in, the true United States health care cost is estimated to be well over $3.5 billion. In addition to fee inflation, it has been shown that "upcoding" of wisdom teeth extraction (i.e. using an insurance code for payment of a higher fee than is clinically justified) has become an increasing problem for insurers. Insurance claims patterns clearly show that this procedure is largely treated as an elective procedure. The average annual income per oral surgeon has been estimated to be approximately $500,000 for third molar extraction fees alone. Insurance companies have historically reported that reimbursement for third molar extractions has been the highest reimbursed surgical procedure—even higher than hysterectomies in years when medical insurance used to pay for both procedures.

The market demographics and associated expenses are compelling. Over 77% of children at age 6 have all four third molar tooth buds radiographically detectable on routine panographic X-rays (a type of volume scan). Over 90% of all teenagers in the United States have at least one third molar that will fully form. A typical cost for an oral surgeon to remove all four third molars on a teenager is generally $2,000 to $2,500 per patient once the teeth have at least partially formed—but before they have erupted—including the cost of IV sedation, consultations, and X-ray imaging costs.

There has been considerable controversy for the past fifty years regarding prophylactic extraction of third molars. A number of leading authorities have objectively tried to demonstrate that prophylactic extraction is a waste of healthcare dollars, citing studies that indicate there is no objective scientific evidence for such a procedure, while other groups vigorously argue that prophylactic extraction in the teens and early adult years greatly eliminates more serious problems later in life and is worth the cost and risk.

An important question to ask is, "What happens if no prophylactic third molar extractions occur?" For instance, "as many as 22% of all emergency department visits" at a United States military support facility were related to dental problems, most of which were third-molar specific. In third-world countries, where prophylactic extraction of wisdom teeth is simply not performed, a high percentage of patients will present with acute infections, decay, gum disease and other problems later in life. In Jordan—where prophylactic extraction is not performed—46% of adult patients had pathology (decay, infection, bone loss, etc.) detectable on their third molars on routine X-rays and volume scans. Numerous studies show that third molars are hard to clean, generally do not erupt fully, and are the single most-likely teeth to have problems associated with them.

Routine panographic X-rays of adults taken during a random two-week period are shown in FIGS. **1** and **2**. These X-rays show the examples of the range of problems that adult patients experience when they have third molars that are not extracted at an early age, including advanced decay and gum infections. For example, FIG. **1** shows a 48-year-old patient with both upper third molars present. There is a gum infection around both third molars that has caused 90% of the bone on the distal side of the second molars to be destroyed. In order to save the first molars, extraction of the second and third molars on the upper-arch will be necessary. FIG. **2** shows another example in which a 36-year-old patient has all four third molars present. The upper third molars are hyper-erupting because they have no opposing teeth to occlude against. They will eventually need to be extracted. The lower third molars are horizontally impacted and show no signs of infection, but if they become infected, then the patient will almost certainly loose the adjacent second molars because of the bone damage that will occur.

The problem all practitioners face is that it is practically impossible to tell in advance which impacted wisdom teeth will ultimately cause future pathology. The reality is that most wisdom teeth (well over 50%) are surgically extracted prophylactically with no real knowledge that they will actually cause future pathology.

If pathology appears in patients over the age of 40, however, the stakes are much different. According to two prospective studies in the United States, in 1997 10.5% and in 2002 17.3% of patients requiring third molar extractions were over the age of 40. If a patient is presenting later in life to have one or more third molars extracted, it is because active pathology has been diagnosed, making surgery no longer elective. The attendant complication rates are not just higher, but these patients were categorized as "very high risk patients" for surgery. These studies concluded, "[t]he risk to patients and to the profession can be dramatically reduced by considering early removal of abnormal third molars" and "based on our experience, we propose extraction of third molars during adolescence when the X-ray indicates normal eruption cannot be expected due to lack of space or an abnormal position."

The occurrence of post-operative complications is generally considered to be over 15% by most independent researchers. For instance, the formation of long-term periodontal pockets on the distal surfaces of second molars that results in gum disease, infection, and eventual second molar tooth loss is estimated to be over 10% due to the damage and poor bone morphology that result from third molar extraction surgery. The incidence of post-operative infections and "dry sockets" is generally accepted to be over 15%. Temporary paraesthia due to damage to the mandibular nerve or the lingual nerve is over 10%, with residual permanent numbness of the lip or tongue present in approximately 1.5% of all patients. Recently, it has been concluded that approximately 23% of all cases of long-term Temporomandibular Joint ("TMJ") dysfunction and chronic joint pain are attributable to third molar extraction surgeries.

Malpractice claims against dental practitioners relating to third molar extractions are at an all time high. Litigation for residual TMJ problems is increasing; in 2002 a North Carolina jury awarded $5 million in damages to a patient with TMJ pain following third molar extractions. The incidence of litigation over permanent numbness of the lip has dramatically increased in recent years. Malpractice claims with resulting payouts have been reported to be as high as two-thirds of all claims made against dental practitioners when nerve damage is involved.

If the wisdom teeth are not extracted in adolescence, the roots will fully form, making future extraction difficult and dramatically increasing the incidence of serious complications if surgery should later be required. The damage induced by long-standing, chronic infections in adults may necessitate the extraction not only of the third molars when they become symptomatic, but also of the adjacent second molars. Additional complications include the reduced healing response of adults as compared to adolescents, and the economic hardship induced by having to miss work. Many references indicate that prophylactic extraction of third molars in teens and young adults—in spite of the possibility of lifelong complications such as nerve damage—is justified to avoid the non-elective third molar extraction in adults over the age of 30.

Complications can be severe, even requiring hospitalization when teeth have been extracted on an out-patient basis. There have even been reports of patients who died as a direct result of wisdom tooth extractions.

As an example, FIG. **3** is an X-ray showing a 9-year-old patient with four third molar tooth buds present; three of them are in very early stages of enamel formation. The lower right third molar tooth bud does not have enamel formed yet, but will shortly. This X-ray shows an example of the early stages in which the tiny third molar tooth buds begin to form, begin to develop enamel, and finally begin to develop roots. Early signs of problems are almost always clearly evident by the time a patient is a teenager.

Once the tooth starts to form, the tooth bud starts to become encased in bone and appears to be "pushed down" into the mandible and maxilla as the child's jaw bone grows out and around the tooth bud with age. Future surgical access becomes far more invasive as the bone encases the forming third molar. Given the basic physiology involved, early intervention is the only approach that will eliminate the complications and high costs associated with extraction of fully formed third molars later in life.

The idea of prophylactic third molar tooth bud removal is not new. In 1936, Dr. Henry supported the surgical enucleation of tooth buds, and it was again supported in the mid 70s by several practitioners using somewhat invasive surgical techniques to physically access the tooth buds and mechanically cut them out. In 1979, Drs. Gordon and Laskin used cryoprobes to enucleate third molar tooth buds in dogs. However, at the *NIH Conference On Third Molars* in 1979 it was concluded that "[a]lthough there are cogent reasons for early removal of third molars, the group felt that the suggested practice of enucleation of third molar tooth buds, based on predictive studies at age 7 to 9, is not currently acceptable." (National Institutes of Health—*Removal Of Third Molars Consensus Development Conference Statement*—1979.)

Early removal of partially formed third molars (sometimes referred to as a "germectomy") where the enamel of the crown has completely formed but less than one-third of the root length has formed, is demonstrated to be somewhat less invasive and carries no demonstrated long-term complications or risks associated with early-stage surgery. However, it is still highly invasive and generally requires IV sedation of the teenage patient. The American Association of Oral & Maxillofacial Surgeon's *White Paper On Third Molar Data* references five studies involving over 1,100 germectomies with not a single case of a long-term complication (nerve injury, etc.) associated with the surgery. Further, since the germectomies were carried out on teenagers, there were no economic hardships induced by missing work. The White Paper understates the obvious conclusions associated with early intervention: "It does appear that early third molar removal may be associated with a lower incidence of morbidity and also less economic hardship from time off work for the patient." However, it can also be concluded that there was a tremendous conflict of interest because this paper was written by oral surgeons. To date there is still no measurable shift by dental practitioners to change the way in which third molars are screened, diagnosed, and extracted (i.e. early extraction), indicating that there is a need to fundamentally change the way this condition is being surgically managed.

There are a number of existing alternative technical approaches that can be considered for prophylactic enucleation of third molar tooth buds before the crown or root begins formation in children age 6 to 10. These technical approaches include ablation procedures using different types of ablation means. Exemplary ablation procedures include microwave ablation, radio frequency ablation, irreversible electroporation, electrosurge tissue ablation (rats), cryoablation (dogs), laser ablation (dogs), and the use of a scalpel (humans). All but the first three ablation procedures have significant limitations due to being highly invasive, high in cost, requiring cumbersome equipment, or due to the limited means of mechanical access in the oral cavity. Nor do these ablation procedures offer the potential for real-time feedback control to contain collateral tissue damage. To date, the only documented trial of any form of tooth bud ablation procedure utilizing ablation technology that is currently used in mainstream medicine is cryoablation (although preliminary animal trials have been completed using electrosurgical power and lasers).

The article entitled "Selectively Preventing Development Of Third Molars In Rats Using Electrosurgical Energy" by Silvestri et al. describes a pilot study that tests the hypothesis that third molars can be selectively prevented from developing. To test the hypothesis, a study was conducted in which thirty-three neonate rats received electrosurgical energy to the mucosal surfaces of one of their maxillary tuberosities. In this study, guides (insulating plastic positioning devices that housed the electrosurgical probes) were used. The guides were fabricated using the mouths of euthanized rat pups of the same age as the rats that were to be treated as a mold for creating the guides. Then, the electrosurgical probe placed so that its stainless steel tip extended less than 1.0 mm beyond the plastic positioning device to ensure contact with the external surface of the oral mucosa of the maxillary tuberosity. Finally, when in position, the rat pups received a single, unilateral, momentary pulse of monopolar electrosurgical energy to the external surface of the gum tissue of their maxillary tuberosity regions. It should be emphasized that this surface application of electrosurgical energy acted first to unnecessarily kill the overlying gum tissue, then bore a hole through the gum tissue, and otherwise damage not only the tooth buds, but other nearby tissue. The rats were cared for, but after the experimental period, were euthanized to determine the effectiveness of the procedure. The results were that ten rats showed no intra-oral or radiographic evidence of third molar development (and most of these rats subsequently developed palatal deformities), and six developed smaller-than-normal third molars. The conclusion was that maxillary third molars could be selectively prevented from developing in rat pups at or near the time of tooth bud initiation. It was recognized, however, that electrosurgical energy was too powerful and uncontrollable to reliably confine its damage to only the tooth-forming tissues.

U.S. Pat. No. 5,688,118 to Hayka et al. (the "Hayka reference") discloses image, sound, and feeling simulation system for dentistry. The system described in the Hayka reference can be thought of as a virtual system that may be used for implanting teeth. Such a virtual system connects the patient to the implant hand piece (i.e. "the drill"). Using three-dimensional scans on a display, the operator theoretically can guide movement of the drill bit relative to the patient for example, to allow the operator to guide the drill bit into the bone and place the implant. The Hayka reference includes a dental hand piece having a drill for drilling a cavity in a tooth, the drill having a drilling end; a first three-dimensional sensor attached to the dental handpiece, the first three-dimensional sensor providing the system with position and orientation in space of at least the drill; and a data processing and display unit for simulating at least the drilling end of the drill. Other patents and published patent applications that address aspects of virtual dentistry include U.S. Pat. No. 8,221,121 to Berckmans, III et al., U.S. Pat. No. 8,013,853 to Douglas, et al., U.S. Pat. No. 7,812,815 to Banerjee, et al., U.S. Pat. No. 7,457,443 to Persky, U.S. Pat. No. 7,249,952 to Ranta, et al., U.S. Patent Publication No. 20100316974 to Yau, et al., U.S. Patent Publication No. 20100311028 to Bell, et al., and U.S. Patent Publication No. 20090253095 to Salcedo, et al.

SUMMARY OF THE INVENTION

Disclosed herein is an ablation probe tip for use in a tooth bud ablation procedure that results in tooth agenesis. The ablation probe tip may be used with a stent and an ablation probe unit. The ablation probe tip preferably has a shaft and a center of ablation. The shaft preferably has an insertion end for inserting into a tooth bud and a connection end for connecting the ablation probe tip to the ablation probe unit. The ablation probe tip preferably has a center of ablation between the insertion end and the connection end. The ablation probe tip may be guidable at a pre-defined angle (preferably a three-dimensional angle) when used in conjunction with the stent. The ablation probe tip may be depth limited by stop information to a pre-defined depth. The center of ablation substantially coincides with or overlaps with the middle of the tooth bud when the ablation probe tip is guided at the pre-defined angle to the pre-defined depth.

The stent may be a physical stent that has mechanical stop structure and the ablation probe tip may have mechanical stop structure. The stop information in this situation would be a physical prevention of progression of the ablation probe tip provided by interaction of the mechanical stop structures.

The ablation probe tip may have extension stop structure between the center of ablation and an absolute tip at the insertion end of the ablation probe tip. The stop information in this situation would be physical prevention of progression of the ablation probe tip provided by interaction of the absolute tip with bone below or above the tooth bud.

The stent may be a virtual stent that has a display and the ablation probe tip may be a sensored ablation probe tip. A representation of the sensored ablation probe tip may be displayed on the display. The sensored ablation probe tip may be guidable at the pre-defined angle by virtual surgical guide angle markings displayed on the display.

The pre-defined angle may be a three-dimensional angle and the stent may be a virtual stent having a display. The ablation probe tip may be a sensored ablation probe tip, and a representation of the sensored ablation probe tip may be displayed on the display, the sensored ablation probe tip may be guidable at the three-dimensional pre-defined angle by virtual surgical guide angle markings displayed on the display.

The stent may be a virtual stent that has a display and the ablation probe tip may be a sensored ablation probe tip. A representation of the sensored ablation probe tip may be displayed on the display. The stop information in this situation would be provided by a virtual stop marking on the display.

The stent may be a virtual stent having a display and the hand piece may be a sensored hand piece. A representation of the sensored hand piece may be displayed on the display.

The stop information in this situation would be provided by a virtual stop marking on the display.

The stent may be a virtual stent, and the ablation probe tip may be a sensored ablation probe tip. The stop information in this situation would be provided by an indicator such as a visual indicator, an audible indicator, a tactile indicator, or a combination of indicators.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, a window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the window, and a reflector positioned between the window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the window, wherein the center of ablation is a focal point from which ablation means radiates through the window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, a window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the window, and a deposited reflector positioned between the window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the window, wherein the center of ablation is a focal point from which ablation means radiates through the window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, a window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the window, and a soldered reflector positioned between the window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the window, wherein the center of ablation is a focal point from which ablation means radiates through the window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, a window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the window, and a electroplated reflector positioned between the window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the window, wherein the center of ablation is a focal point from which ablation means radiates through the window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, a gap window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the gap window, and a reflector positioned between the gap window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the gap window, wherein the center of ablation is a focal point from which ablation means radiates through the gap window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, a gap window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the gap window, and a reflector positioned between the gap window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the gap window, wherein the center of ablation is a focal point from which ablation means radiates through the gap window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, a gap window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the gap window, and a reflector positioned between the gap window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the gap window, wherein the center of ablation is a focal point from which ablation means radiates through the gap window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, a gap window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the gap window, and a reflector positioned between the gap window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the gap window, wherein the center of ablation is a focal point from which ablation means radiates through the gap window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, an air gap window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the air gap window, and a reflector positioned between the air gap window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the air gap window, wherein the center of ablation is a focal point from which ablation means radiates through the air gap window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, an air gap window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the air gap window, and a deposited metal reflector positioned between the air gap window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the air gap window, wherein the center of ablation is a focal point from which ablation means radiates through the air gap window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, an air gap window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the air gap window, and a soldered reflector positioned between the air gap window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the air gap window, wherein the center of ablation is a focal point from which ablation means radiates through the air gap window.

The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, an air gap window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the air gap window, and a electroplated reflector positioned between the air gap window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the air gap window, wherein the center of ablation is a focal point from which ablation means radiates through the air gap window.

The pre-defined angle may be based on information obtained from a volume scan image. The pre-defined depth may be based on information obtained from a volume scan image.

The ablation probe tip may be used for gaining access to the at least one tooth bud without causing necrosis to surrounding gingival tissue. The ablation probe tip may be used for at least partially ablating at least one tooth bud by creating a zone of ablation that resides only within the at least one tooth bud. The ablation probe tip may be used for at least partially ablating at least one tooth bud without ablating surrounding gingival tissue. The ablation probe tip may be used for at least partially ablating at least one tooth bud without ablating surrounding tissue.

The ablation probe tip may have a center of ablation is positioned within approximately 50% of an average diameter of the tooth bud when the ablation probe tip is at the pre-defined angle and the pre-defined depth. The ablation probe tip may have a center of ablation is positioned within approximately 25% of an average diameter of the tooth bud when the ablation probe tip is at the pre-defined angle and the pre-defined depth. The ablation probe tip may have a center of ablation is positioned within approximately 10% of an average diameter of the tooth bud when the ablation probe tip is at the pre-defined angle and the pre-defined depth.

An ablation probe tip may be used for use in a tooth bud ablation procedure that results in tooth agenesis. The tooth bud preferably has a middle. The ablation probe tip may be used with an ablation probe unit. The ablation probe tip may preferably has a shaft, the shaft preferably having an insertion end for inserting into a tooth bud and a connection end for connecting the ablation probe tip to the ablation probe unit. The ablation probe tip preferably has a center of ablation between the insertion end and the connection end. The ablation probe tip preferably has a shaft inner conductor, shaft insulation surrounding the shaft inner conductor, a shaft outer shield surrounding the shaft insulation, a window defined in the shaft outer shield, a shaft outer cover surrounding the shaft outer shield and the window, and a reflector positioned between the window and the insertion end. The center of ablation is preferably positioned in the shaft inner conductor at the window. The center of ablation is preferably a focal point from which ablation means radiates through the window, the center of ablation may be positionable to substantially coincide with or overlap with the middle of the tooth bud.

The reflector may be a deposited metal reflector, a solder metal reflector, or an electroplate metal reflector. The window may be a gap window or an air gap window.

The ablation probe tip may be used for gaining access to the at least one tooth bud without causing necrosis to surrounding gingival tissue. The ablation probe tip may be used for at least partially ablating at least one tooth bud by creating a zone of ablation that resides only within the at least one tooth bud. The ablation probe tip may be used for at least partially ablating at least one tooth bud without ablating surrounding gingival tissue. The ablation probe tip may be used for at least partially ablating at least one tooth bud without ablating surrounding tissue.

The ablation probe tip may have a center of ablation positioned within approximately 50% of an average diameter of the tooth bud when the ablation probe tip is at the pre-defined angle and the pre-defined depth. The ablation probe tip may have a center of ablation positioned within approximately 25% of an average diameter of the tooth bud when the ablation probe tip is at the pre-defined angle and the pre-defined depth. The ablation probe tip may have a center of ablation positioned within approximately 10% of an average diameter of the tooth bud when the ablation probe tip is at the pre-defined angle and the pre-defined depth.

A virtual stent as described herein is preferably for use in a tooth bud ablation procedure that results in tooth agenesis. The tooth bud preferably has a middle. The virtual stent is preferably for use with a sensored ablation probe tip having an insertion end and a connection end. The sensored ablation probe tip preferably has a center of ablation between the insertion end and the connection end. The stent preferably includes a display upon which a representation of the sensored ablation probe tip may be displayed. At least one virtual surgical guide angle marking is preferably displayable on the display, the at least one virtual surgical guide angle marking providing angle guidance to guide the sensored ablation probe tip at a pre-defined angle. At least one virtual stop marking is preferably displayable on the display providing stop information to limit the depth of the sensored ablation probe tip to a pre-defined depth. The center of ablation substantially coincides with or overlaps with the middle of the tooth bud when the sensored ablation probe tip is guided at the pre-defined angle to the pre-defined depth.

The pre-defined angle may be a three-dimensional angle. The virtual stent may be used with a sensored hand piece connectable to the connection end of the sensored ablation probe tip. In such as case the representation of the sensored hand piece may be displayed on the display. The three-dimensional volume scan may be displayed on the display. The display may display a real time relationship between the center of ablation as compared to the middle of the tooth bud.

Stop information may be provided by an indicator selected from the group consisting of a visual indicator, an audible indicator, a tactile indicator, or a combination of indicators.

The pre-defined angle may be based on information obtained from a volume scan image. The stent pre-defined depth may be based on information obtained from a volume scan image.

A tooth bud ablation method for ablating a tooth bud using a virtual stent may include the following steps: providing the virtual stent and a sensored ablation probe tip; introducing the sensored ablation probe tip to the tooth bud, the introduction may be displayed in real time on the display; using the at least one virtual surgical guide angle marking and the at least one virtual stop marking; guiding the sensored ablation probe tip towards the position where the center of ablation substantially coincides with or overlaps with the middle of the tooth bud, the guidance may be displayed in real time on the display; and using ablation means, ablating the tooth bud when the center of ablation substantially coincides with or overlaps with the middle of the tooth bud.

The step of ablating preferably results in tooth agenesis.

The method may further include the step of setting parameters to be used for guiding the sensored ablation probe tip and for ablating the tooth bud. The method may further include the step of calibrating the display and the sensored ablation probe tip so that the sensored ablation probe tip is properly represented on the display.

The method may further include the following steps: introducing a sensored anesthetic needle to the tooth bud, the introduction may be displayed in real time on the display; using the at least one virtual surgical guide angle marking and the at least one virtual stop marking; guiding the sensored anesthetic needle towards the middle of the tooth bud, the guidance may be displayed in real time on the display; and anesthetizing the tooth bud when the sensored anesthetic needle reaches the middle of the tooth bud.

The method may further including the step of providing visual, audible, and/or tactile indications to indicate that center of ablation substantially coincides with or overlaps with the middle of the tooth bud.

The method further includes the step of monitoring progress of the ablating. Further, constant feedback pertaining to the progress may be provided.

The method may include the step of providing monitoring and override safeguards to allow automatic or manual cessation of ablation.

Described herein is an ablation probe tip for use in a tooth bud ablation procedure that results in tooth agenesis. The ablation probe tip may be used with a surgical stent or a virtual stent system. The ablation probe tip may be used with an ablation probe unit. The ablation probe tip has a shaft, the shaft having an insertion for inserting into a tooth bud and a connection end for connecting the ablation probe tip to the ablation probe unit. The ablation probe tip has a center of ablation between the insertion end and the connection end. The shaft of the ablation probe tip being guidable at a pre-defined angle when used in conjunction with the stent. The ablation probe tip has structure that limits the depth of the ablation probe tip to a pre-defined depth when used in conjunction with the surgical stent; wherein the center of ablation is in the middle of a tooth bud when the ablation probe tip is at the pre-defined angle and the pre-defined depth.

Described herein is a tooth bud ablation procedure that results in tooth agenesis, including the steps of: physically seating a custom surgical stent having at least one surgical guide so the at least one surgical guide corresponds to at least one tooth bud surgical site; using the at least one surgical guide, making a surgical access path at the at least one tooth bud surgical site; using the at least one surgical guide, guiding placement of an ablation probe tip having a center of ablation so that the center of ablation is in the middle of a tooth bud at the at least one tooth bud surgical site; and at least partially ablating at least one tooth bud.

Described herein is a tooth bud ablation system for use in a tooth bud ablation procedure that results in tooth agenesis, the system including: a custom surgical stent with at least one surgical guide corresponding to at least one tooth bud surgical site; an ablation probe tip having a center of ablation; and the at least one surgical guide having structure for guiding placement of the ablation probe tip so that the center of ablation is in the middle of a tooth bud by inserting the ablation probe tip through the at least one surgical guide.

Described herein is an ablation procedure including the steps of: physically seating a custom surgical stent having at least one surgical guide so the at least one surgical guide corresponds to at least one lesion or tumor surgical site; using the at least one surgical guide, making a surgical access path at the at least one lesion or tumor surgical site; using the at least one surgical guide, guiding placement of an ablation probe tip having a center of ablation so that the center of ablation is in the middle of a lesion or tumor at the at least one lesion or tumor surgical site; and at least partially ablating at least one lesion or tumor.

Described herein is an ablation procedure including the steps of: physically seating a custom surgical stent having at least one surgical guide so the at least one surgical guide corresponds to at least one lesion or tumor surgical site; using the at least one surgical guide, guiding placement of an ablation probe tip having a center of ablation so that the center of ablation is in the middle of a lesion or tumor at the at least one lesion or tumor surgical site; and at least partially ablating at least one lesion or tumor.

Described herein is a method for volume scanning both hard tissues and soft tissues of a patient, the method including the steps of: using a physical impression of a material visible in a volume scan; generating a volume scan in which hard tissue is visible and the physical impression is visible, and soft tissue being "visible" as the space between the visible hard tissue and the visible physical impression; and providing results of the step of generating a volume scan for the purpose of manufacturing or fabricating a custom surgical stent having at least one surgical guide for guiding placement of an ablation probe tip. An alternative method for volume scanning both hard tissues and soft tissues of a patient replaces the physical impression with a digital impression.

Described herein is a method for simultaneous volume scanning of both hard tissues and soft tissues, the method including the steps of: using a physical dental impression of a material visible in a volume scan; physically seating the physical dental impression in a patient's mouth; volume scanning the patient's mouth while the physical dental impression is seated therein; the step of volume scanning generating a volume scan in which hard tissue is visible and the physical dental impression is visible, and soft tissue is "visible" as the space between the visible hard tissue and the visible dental impression; and providing the results of the step of volume scanning for the purpose of manufacturing or fabricating a custom surgical stent having at least one surgical guide for guiding placement of an ablation probe tip. An alternative method for volume scanning both hard tissues and soft tissues of a patient replaces the physical dental impression with a digital impression.

Described herein is a method for manufacturing or fabricating a custom surgical stent, the method including the steps of: using a volume scan image in which hard tissue is visible and a physical dental impression is visible, and soft tissue is "visible" as the space between the visible hard tissue and the physical visible dental impression; and manufacturing or fabricating a custom surgical stent with at least one ablation probe tip guide for guiding at least one ablation probe tip to a pre-defined angle and depth of ablation based on information obtained from the volume scan image. An alternative method for volume scanning both hard tissues and soft tissues of a patient replaces the physical dental impression with a digital impression.

Described herein is a tooth bud ablation procedure that results in tooth agenesis, including the steps of: pre-operatively taking measurements to determine a three-dimensional location of the middle of a tooth bud; placing an ablation probe tip having a center of ablation so that the center of ablation is in the three-dimensional location of the middle of a tooth bud; and at least partially ablating at least one tooth bud.

Described herein is a custom surgical stent for use in a tooth bud ablation procedure that results in tooth agenesis, the custom surgical stent for use with an ablation probe tip having a center of ablation, the stent including: a custom surgical stent with at least one surgical guide corresponding to at least one tooth bud surgical site; the at least one surgical guide having guiding structure to guide placement of an ablation probe tip at a pre-defined angle so that a center of ablation of the ablation probe tip is in the middle of a tooth bud; and the at least one surgical guide having mechanical stop structure to limit the depth of the ablation probe tip to a pre-defined depth.

The foregoing and other objectives, features, and advantages of the invention will be more readily understood upon consideration of the following detailed description of the invention, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are incorporated in and constitute a part of this specification.

FIG. **1** is an X-ray showing a 48-year-old patient with both upper third molars present, the X-ray being presented to show examples of the range of problems that adult patients experience when they have third molars that are not extracted at an early age.

FIG. **2** is an X-ray showing a 36-year-old patient with all four third molars present, the X-ray being presented to show examples of the range of problems that adult patients experience when they have third molars that are not extracted at an early age.

FIG. **3** is an X-ray showing a 9-year-old patient with four third molar tooth buds present; three of them are in very early stages of enamel formation, but the lower right third molar tooth bud does not yet have enamel formed.

FIG. **4** is a flow chart showing steps in preferred TBA procedures including: (1) routine screening and diagnosis; (2) pre-surgical impressions and scanning; (3) assembling a TBA surgical kit; (4) operator delivery of the TBA procedure; and (5) follow-up.

FIG. **5** is a simplified block diagram of a TBA probe system, a custom surgical stent, and a tooth bud.

FIG. **6** is a cross-sectional side view of an ablation probe tip in the process of being inserted through a surgical guide of a stent.

FIG. **7** is a cross-sectional side view of an ablation probe tip inserted through a surgical guide of a stent into the tooth bud.

FIG. **8** is a cross-sectional side view of an ablation probe tip having a linear array of temperature sensors inserted in the tooth bud.

FIG. **9** is a cross-sectional side view of an ablation probe tip ablating the tooth bud.

FIG. **10** is a cross-sectional side view of an ablation probe tip being removed from the ablated tooth bud.

FIG. **11** is a flow chart showing the steps of a TBA procedure that results in tooth agenesis.

FIG. **12** is a flowchart showing the steps that a software program for manufacturing or fabricating custom surgical stents **110** and defining (and/or computing or calculating) the pre-determined parameter settings and/or treatment time settings.

FIG. **13** is a panographic X-ray showing a patient whose third molar tooth buds in the #17 and #32 positions are treatable by TBA.

FIG. **14** is a pre-operative cone beam computed tomography ("CBCT") scan of a different patient.

FIG. **15** is a series of X-rays showing successive 1.0 mm slices through both #17 and #32 in 1.0 mm increments.

FIG. **16** is a perspective view from a front corner showing a pre-operative upper-arch impression being taken of a simulated patient.

FIG. **17** is a cross-sectional view of an upper-arch impression being taken of a simulated patient.

FIG. **18** is a perspective view from above of the completed upper-arch impression.

FIG. **19** is a perspective view from above of the completed upper-arch impression, along with a stone model that will serve as a "positive" for manufacturing or fabricating of a custom surgical stent for that patient's upper-arch.

FIG. **20** is a CBCT scan with notations showing the measurement of the angle of entry into the tooth bud.

FIG. **21** is a series of X-rays with notations showing the measurement of the lateral angle of entry.

FIG. **22** is a CBCT scan with highlights showing the computed volume of each tooth bud.

FIG. **23** is a perspective view from above of a surgical stent with two surgical guides, the stent having been manufactured or fabricated using the CBCT positioning information.

FIG. **24** is a perspective view showing topical anesthetic being applied to the base of the surgical guide.

FIG. **25** is a perspective view from a front corner of a surgical stent being seated on the upper-arch of the simulated patient.

FIG. **26** is a perspective view from a front corner of a local anesthetic being injected into a tooth bud site.

FIG. **27** is a perspective view from a front corner of a tissue trocar being used to punch to the base of a tooth bud.

FIG. **28** is a perspective view from a front corner of an ablation probe tip with a mechanical (physical) stop being positioned through the surgical guide into the tooth bud.

FIG. **29** is a perspective view from a front corner of the ablation probe tip being positioned in each tooth bud through the surgical guide so that the ablation probe tip's effective center of ablation is in the middle of each tooth bud.

FIG. **30** is a cross-sectional side view of an alternative ablation probe tip in the process of being inserted through a surgical guide of a stent.

FIG. **31** is a cross-sectional side view of an alternative ablation probe tip inserted through a surgical guide of a stent into the tooth bud.

FIG. **32** is a cross-sectional side view of an alternative ablation probe tip having a linear array of temperature sensors inserted in the tooth bud.

FIG. **33** is a cross-sectional side view of an alternative ablation probe tip ablating the tooth bud.

FIG. **34** is a cross-sectional side view of an alternative ablation probe tip being removed from the ablated tooth bud.

FIG. **35** is a simplified block diagram of a horizontal hand piece and ablation probe tip with sensors and a display with a representation of the horizontal hand piece and ablation probe tip displayed thereon.

FIG. **36** is a simplified block diagram of a vertical hand piece and ablation probe tip with sensors and a display with a representation of the vertical hand piece and ablation probe tip displayed thereon.

FIG. **37** is a simplified block diagram with an exemplary patient X-ray volume scan shown on a display with a representation of the sensored hand piece and ablation probe tip displayed as well as exemplary indicators of position (in terms of percentage of the average diameter of the tooth bud) and status simultaneously shown on the display in real time, the position shown as 98% (far from the middle of the tooth bud) and the status shown as inactive.

FIG. **38** is a simplified block diagram with an exemplary patient X-ray volume scan shown on a display with a representation of the sensored hand piece and ablation probe tip displayed as well as exemplary indicators of position (in terms of percentage of the average diameter of the tooth bud) and status simultaneously shown on the display in real time, the position shown as 8% (close to the middle of the tooth bud) and the status shown as active.

FIG. **39** is a simplified block diagram with an enlarged exemplary patient X-ray volume scan shown on a display with a representation of the sensored hand piece and ablation probe tip displayed as well as virtual surgical guide angle markings, a virtual stop marking, and virtual target markings.

FIG. **40** is a flow chart showing exemplary steps in preferred TBA procedures using a virtual stent system including: (1) Parameter Setting; (2) Calibrating; (3) Anesthetizing; (4) Introducing; (5) Guiding; (6) Readying; (7) Ablating; and (8) Completing.

FIGS. **41-43** are side and cross-sectional views of a first exemplary ablation probe tip.

FIGS. **44-46** are perspective and cross-sectional views of a second exemplary ablation probe tip.

DETAILED DESCRIPTION OF THE INVENTION

The highly invasive surgical procedure of extracting third molars can be completely eliminated by prophylactically eliminating the small tooth buds that will eventually form the wisdom teeth. Children age 6 to 12 will generally have radiographically detectable tooth buds with no signs of tooth formation inside the tooth bud. Third molar tooth bud agenesis (the lack of third molar formation) can only be conclusively determined by age 14. Third molar tooth buds are lying just 2.0 mm to 3.0 mm beneath the surface of the attached gingival (gum) tissue, making them accessible for rapid anesthesia and minimally invasive ablation with the correct selection of soft tissue ablation and supporting scanning and stent-manufacturing technologies.

By successfully improving existing medical technology, the highly invasive, painful, and complication-ridden procedure of traditional surgical removal of third molars (i.e. "wisdom teeth" extractions) can be replaced with a minimally invasive tooth bud ablation (TBA) procedure **70** such as that shown in FIG. **4** that is risk free, painless post-operatively, and less expensive when compared to surgical extractions.

The TBA procedure **70** (FIG. **4**) and TBA system **100** (FIG. **5**) for use in the TBA procedure **70** seek to achieve: (1) a minimally invasive procedure consisting of a surgical access path at a surgical site (e.g. at each tooth bud surgical site), (2) that can predictably ablate all four third molar tooth buds **120** in thirty (30) minutes or less (including time to administer anesthesia) using either microwave ("MW") or radio frequency ("RF") ablation, (3) that can be administered by dental practitioners under normal office conditions, (4) with direct procedure costs reduced by 25% or more, and (5) with zero risks or complications when compared to traditional surgical extraction of fully developed third molars. It should be noted that the TBA procedure **70** is shown and described as a prophylactic third molar tooth bud ablation (TMTBA), but it is not limited thereto. For example, there may be supernumerary teeth that should not be in a patient's mouth (e.g. there may be two teeth #5), the removal of which would not be prophylactic in nature.

One preferred advantage of the surgical phase **90** described herein is that it is a minimally invasive surgical procedure. With a minimally invasive surgical procedure design coupled with electronic feedback controls using MW and RF ablation technology to limit soft tissue damage, performing this procedure on children aged 6-12 years old takes approximately thirty (30) (or fewer) minutes, including the time to administer local anesthetics.

Another preferred advantage of the surgical phase **90** described herein is that it will not accidentally disrupt adjacent second molar tooth development, even though the formation of second molars are well under way because these tooth buds **120** have started to form before birth. The use of relatively new scanning technologies (e.g. computed tomography volume scanning such as cone beam computed tomography (CBCT) scanning and MRI volume scanning) and accurate custom surgical stents **110** to guide ablation probe tip **108**, **148** placement will eliminate the risk of accidentally disrupting the second molars by minimizing collateral tissue damage.

Summarily, the TBA procedure **70** (FIG. **4**) preferably includes a screening phase **72**, a pre-surgical phase **80** (also referred to as TBA pre-surgical phase **80**) that includes pre-surgical scanning **82** and the assembling of a TBA surgical kit **88** (that includes pre-determined settings **105** as well as a surgical stent **110**), a surgical phase **90** (also referred to as TBA surgical phase **90**), and a follow-up phase **98**.

A TBA system **100** (FIG. **5**) is preferably used during the surgical phase **90** (shown graphically in FIGS. **6-10** and as a flow chart in FIG. **11**) of the TBA procedure **70**. Summarily, the TBA system **100** includes a TBA probe system **101** (including a generator **104** capable of emitting one or more types of ablation means **104'**, a hand piece **106**, and an ablation probe tip **108**, **148**) and at least one surgical stent **110** (which was manufactured or fabricated during the pre-surgical phase **80**). Each stent **110** has at least one surgical guide **112** to guide the placement of the ablation probe tip **108**, **148** so that its center of ablation **130***a* is placed into the middle of the tooth bud **130***b*. This is accomplished by positioning ablation probe tip **108**, **148** through the surgical guide **112** at a pre-defined angle and pre-defined depth (which may be done, for example, using a mechanical relationship of the ablation probe tip **108** and the surgical guide **112** to form a "stop" therebetween or in other manners disclosed herein). FIGS. **6-10** show (and FIG. **11** describes) one procedure of inserting the ablation probe tip **108** through the surgical guide **112** of a stent **110**, ablating the tooth bud **120**, and removing the ablation probe tip **108** from the ablated tooth bud **120'**. FIGS. **30-34** show an alternative procedure of inserting the alternative ablation probe tip **148** through a surgical guide **112** of a stent **110**, ablating the tooth bud **120**, and removing the ablation probe tip **108** from the ablated tooth bud **120'**. FIGS. **35-39** show a sensored ablation probe tip **232** for use with a virtual stent system. FIG. **40** shows an exemplary preferred TBA procedure using a virtual stent system.

The TBA System 100

The TBA system **100** described herein is the system that is used during the surgical phase **90** of the TBA procedure **70**. Some of the components (e.g. the custom surgical stent **110** and the pre-determined settings **105**) used in the TBA system **100** are part of the TBA surgical kit assembled during the pre-surgical phase **80**.

The TBA system **100**, as shown in FIG. **5**, includes a TBA probe system **101** (including a generator **104**, a hand piece **106**, and an ablation probe tip **108**, **148**) and at least one surgical stent **110** (each stent **110** has at least one surgical guide **112** to guide (direct) the placement of the ablation probe tip **108**, **148** to the middle of the tooth bud **130***b*). The generator **104** and the hand piece **106** may be jointly referred to as the ablation probe unit **102** (or the programmable ablation probe unit **102**). The generator **104** and hand piece **106** may be integral or functionally connected together. The generator **104** (and/or the ablation probe unit **102**) may be programmed with pre-determined parameter settings **105***a* and/or treatment time settings **105***b* (referred to jointly as pre-determined settings **105**). The generator **104** (and/or the ablation probe unit **102**) provides an ablation means **104'** for ablating the tooth bud **120** based on the pre-determined settings **105**. Central to the TBA system **100**, is the interaction between the ablation probe tip **108**, **148** and the surgical stents **110** (and specifically the surgical guides **112**).

Generator **104**

The generator **104** provides the ablation means **104'** suitable for ablating a tooth bud **120** during the surgical phase **90** of the TBA procedure **70**. MW energy and RF energy are discussed as exemplary preferred ablation means **104'**. Another alternative preferred ablation means **104'** is irreversible electroporation because it has subsecond activation times that can reduce collateral tissue damage. Other alternative preferred ablation means **104'** include, but are not limited to, cryoablation, ultra-high intensity ultrasound, laser, chemical, thermal or hot tip (e.g. a tip having any source of heat including, but not limited to, a light bulb, a soldering iron, or steam heat), and/or mechanical means. These ablation means **104'** may also be combined either simultaneously or consecutively. It should also be noted that other known and yet-to-be-developed ablation means **104'** may also be used. It should be noted that although discussed primarily in terms of MW and RF, unless specifically set forth otherwise, the use of other ablation means **104'** is possible.

The generator **104** (alone or as part of an ablation probe unit **102**) may be programmed by the operator and/or at the laboratory and/or factory and may be accomplished automatically or manually. The programming of the generator **104** may include programming at least one pre-determined setting **105**.

The following bulleted points are exemplary details and/or features that may be incorporated in preferred generators **104**.

- Preferred generators **104** may be multi-use devices designed as 110V counter-top units.
- Preferred generators **104** may be MW/RF generators with output levels determined initially through finite element analysis models or experimentally derived functions that exist for tumor ablation.
- Preferred generators **104** (and/or ablation probe units **102**) may have operator input mechanisms (e.g. knobs, dials, key pads, keyboards, I/O interfaces, connections to the internet, or other means for inputting or programming) in which the operator inputs (or allows input of) the pre-determined settings **105**.
- Preferred generators **104** (and/or ablation probe units **102**) may have output mechanisms (e.g. a display or audio) for providing setting feedback (e.g. calibration cycles and pre-determined settings **105**), warning feedback (e.g. to prevent operator mishandling), and intra-operative feedback on the progress of the procedure such as time remaining (e.g. a count down or a series of beeps to alert the operator to procedure completion) and/or temperature (e.g. to alert the operator to overheating).
- Preferred output displays may be digital readout displays (that may be color and/or in a large format) that permit the operator to easily see feedback intra-operatively from across a standard dental operatory (approximately 6-8 feet viewing distance).

Hand Piece **106**

The hand piece **106** is the functional intermediary between the generator **104** and the ablation probe tip **108**, **148**. The hand piece **106** may be connected substantially at one end to the generator **104**. Substantially at the other end of the hand piece **106**, opposite the generator **104**, the end of the hand piece **106** (the surgical end) is adapted to accept the ablation probe tip **108**, **148**. The hand piece **106** is preferably detachable from the generator **104** (if they are not an integral unit) and the ablation probe tip **108**, **148** (having an insertion end and a connection end) is preferably detachable from the hand piece **106**.

The following bulleted points are exemplary details and/or features that may be incorporated in preferred hand pieces **106**.

- Preferred hand pieces **106** preferably hold or secure an ablation probe tip **108**, **148** by latching the ablation probe tip **108**, **148** into the hand piece head. In some hand pieces **106**, the ablation probe tip **108**, **148** latches into the hand piece head at an angle (e.g. a 90 degree angle). It should be noted that the terms "latching" and "latch" are used to describe any type of secure fit including, but not limited to, clipping, snapping, or holding.
- Preferred hand pieces **106** preferably have a hand piece head (attached or integral) that is at an approximately 20 degree angle to the rest of the hand piece. This bend emulates a standard dental high-speed hand piece to facilitate easy access of both upper and lower surgical sites. In some preferred hand pieces **106**, the 20 degree bend can be adjusted intra-operatively to permit improved operator access to both upper and lower arches.
- Preferred hand pieces **106** preferably are rapidly detachable from the generator **104**. Preferably the connectors are ultra-reliable for repeated removal/attachment from the generator **104**.
- Preferred hand pieces **106** are preferably fully steam autoclavable. Alternative preferred hand pieces **106** are disposable or have disposable covers.
- Preferred hand pieces **106** preferably have actuators to allow operator activation. The actuators may be separate from the hand pieces **106** or integral therewith. Exemplary actuators include, but are not limited to, a wireless foot control or a hand-operated switch on the hand piece **106**.
- The hand piece **106** may be integral with the generator **104** to form a hand-held integrated generator unit (hand-held integrated ablation probe unit).

Ablation Probe Tips **108**, **148**

The ablation probe tip **108**, **148** has a "shaft" having a connection end and an insertion end. The connection end has structure suitable for connecting the ablation probe tip **108**, **148** to the hand piece **106**. The insertion end is insertable into the tooth bud **120**. The ablation means **104'** flows from the generator **104** through the ablation probe tip **108**, **148** and out to a center of ablation **130***a* (the focal point of the ablation). The ablation probe tip **108**, **148** is insertable through the surgical guide **112**, through the gingival tissue **122**, and into the middle of the tooth bud **130***b*. Some ablation probe tips **108** have the center of ablation **130***a* at or near the insertion end of the ablation probe tip **108** such that when the insertion end of the ablation probe tip **108** is positioned at the pre-defined angle (φ) and pre-defined depth (x) during the surgical phase **80**, the center of ablation **130***a* substantially coincides with or overlaps the middle of the tooth bud **130***b*. Alternative ablation probe tips **148** have the center of ablation **130***a* further from the insertion end and along the shaft of the ablation probe tip **148** such that when the center of ablation **130***a* of the ablation probe tip **148** is positioned so that the center of ablation **130***a* substantially coincides with or overlaps the middle of the tooth bud **130***b*.

The pre-defined angle (φ) is the angle at which the ablation probe tip's effective center of ablation **130***a* is in the "middle" of the tooth bud **130***b* as calculated (during the pre-surgical phase **80**) as described herein or using an alternative method. The pre-defined depth (x) is the depth at which the ablation probe tip's effective center of ablation **130***a* is in the "middle" of the tooth bud **130***b* as calculated as described herein or using an alternative method. The phrase "middle of the tooth bud **130***b*" is meant to include the three-dimensional area within the tooth bud **120** and, in particular, the three-dimensional area within the tooth bud **120** that is more towards the absolute middle point than towards the outer periphery of the tooth. The pre-defined angle (φ) and pre-defined depth (x) together define a three-dimensional (including an up/down dimension (depth (x)), a front/back dimension (y), and a side/side dimension (z)) path of insertion through which the ablation probe tip **108**, **148** accesses the gingival tissue **122** and the tooth bud **120** so that the center of ablation **130***a* substantially coincides with or overlaps the middle of the tooth bud **130***b*. The pre-defined angle (φ) and pre-defined depth (x) can also be referred to as the "calculated angle and depth," the "prescribed angle and depth," the "proper angle and depth," the "correct angle and depth," the "optimal angle and depth," or the "ideal angle and depth."

One preferred ablation probe tip **108** includes a mechanical stop structure **140** (e.g. a band, protrusion, or shoulder) designed to physically limit the depth of the ablation probe tip **108** when used in conjunction with mechanical stop structure **142** (e.g. the upper surface, a protrusion on the upper surface, or a notch in the upper surface) of the surgical stent **110** and/or surgical guide **112**. In other words, the mechanical stop structure **142** of the surgical guide **112** and the mechanical stop structure **140** of the ablation probe tip **108** together limit how much of the ablation probe tip **108** can pass through the surgical guide **112** until there is a mechanical stop between the mechanical stop structure **142** of the surgical guide **112** and the mechanical stop structure **140** of the ablation probe tip **108**. The physical prevention of further progression of the ablation probe tip **108** provided by the interaction of the mechanical stop structures **140**, **142** is a type of "stop information," the ablation probe tip **108** being depth limited to the depth indicated by the stop information (which would be the depth at which the center of ablation **130***a* substantially coincides with or overlaps with the middle of the tooth bud **130***b*).

Each ablation probe tip **108** may be individually custom made (e.g. manufactured or fabricated) or may be selected from a family of ablation probe tips **108** (i.e. there may be a "family" of probe tips **108** that will cover all clinical possibilities for tooth bud diameters and depths). In the manufacturing or fabricating of the surgical stents **110**, however, the characteristics of the ablation probe tip **108** (custom made or selected) that may be taken into consideration include, for example, length, shape, angle, position of a mechanical stop structure **140**, diameter, and size, shape, and location of the center of ablation **130***a*. For example, if a particular ablation probe tip **108** had mechanical stop structure **140** (shown as the bottom surface of an annular ring or shoulder in FIGS. **6-10** and **28-29**) is 10.0 mm from the absolute tip of the ablation probe tip **108** (and the center of ablation **130***a* is substantially adjacent to the absolute tip), but the center of ablation **130***a* was only 8.0 mm from the surface of the gingival tissue **122** (shown as (x) in FIG. **6**), then the surgical guide **112** would have to be 2.0 mm thick (shown as (y) in FIG. **6**). On the other hand, if all surgical guides **112** being made by the procedure were exactly 0.5 mm thick, the ablation probe tip **108** would either have to be made or selected so that the mechanical stop structure **140** is 2.5 mm from the center of ablation **130***a* of the ablation probe tip **108**. The appropriate ablation probe tip **108** preferably will result in the intra-operative placement of the effective center of ablation **130***a* of the ablation probe tip **108** into the targeted middle of the tooth bud **130***b*±0.5 mm.

FIGS. **30-34** show an alternative ablation probe tip **148** with alternative stop structure **150** (shown as the portion of the alternative ablation probe tip **148** between the center of ablation **130***a* and the absolute tip **152**). The alternative stop structure **150** may also be referred to as "extension stop structure **150**." This alternative stop structure **150** uses the bottom of the gingival tissue **122** (or the top of the bone upon which the tooth bud **120** is positioned) as the limiting structure used in conjunction with the alternative stop structure **150** to position the alternative ablation probe tip **148** at the proper pre-defined depth (x). (It should be noted that the "top of the bone" may be above or below the tooth bud **120** depending on whether the tooth bud is in the lower jaw or the upper jaw.) Once the pre-defined depth (x) is calculated, the distance (y) between the center of ablation **130***a* and the bottom of the gingival tissue **122** (or the top of the bone upon which the tooth bud **120** is positioned) can be measured and/or calculated. The alternative stop structure **150** is an extension of the alternative ablation probe tip **148** from the center of ablation **130***a* and should be the same length as the distance (y). In use, an alternative ablation probe tip **148** would be inserted through the surgical guide **112** of a surgical stent **110** at proper pre-defined angle (φ), but would come to a stop when the absolute tip **152** touched the bottom of the gingival tissue **122** (or the top of the bone upon which the tooth bud **120** is positioned). In this position, the center of ablation **130***a* would be the distance (y) from the bottom of the gingival tissue **122** (or the top of the bone upon which the tooth bud **120** is positioned). The effective center of ablation **130***a* targeted middle of the tooth bud **130***b* would be substantially overlapping. The physical prevention of further progression of the ablation probe tip **148** provided by the interaction absolute tip **152** touched the bottom of the gingival tissue **122** (or the top of the bone upon which the tooth bud **120** is positioned) is a type of "stop information," the ablation probe tip **148** being depth limited to the depth indicated by the stop information (which would be the depth at which the center of ablation **130***a* substantially coincides with or overlaps with the middle of the tooth bud **130***b*).

These alternative ablation probe tips **148** may also be individually custom made (e.g. manufactured or fabricated) or may be selected from a family of ablation probe tips **148** (i.e. there may be a "family" of probe tips **148** that will cover all clinical possibilities for tooth bud diameters and depths). Although the surgical stent **110** is not used for limiting structure to position the alternative ablation probe tip **148** at the proper pre-defined depth (x), it is still used to guide the alternative ablation probe tip **148** in the proper pre-defined angle (φ). As previously set forth, the manufacturing or fabricating of the surgical stents **110** may take into consideration the characteristics of the alternative ablation probe tip **148** (custom made or selected). The characteristics that may be taken into consideration include, for example, length, shape, angle, diameter, and position of the mechanical stop structure **150**. The size, shape, and location of the center of ablation **130***a* of the alternative ablation probe tip **148** may also be taken into consideration in the manufacturing or fabricating of the surgical stents **110**. The alternative ablation probe tip **148** preferably will result in the intra-operative placement of the effective center of ablation **130***a* of the alternative ablation probe tip **148** into the targeted middle of the tooth bud **130***b*±0.5 mm.

It should be noted that for either type of ablation probe tip **108**, **148**, another variation would include either a movable center of ablation **130***a* or multiple centers of ablation **130***a*. A movable center of ablation **130***a* variation would mean that the actual center of ablation **130***a* could move up or down within the ablation probe tip **108**, **148** for fine adjustments or for gross adjustments in position. The movability and/or position of the center of ablation **130***a* could be controlled by the operator or automatically (e.g. by a computer). For example, if the alternative ablation probe tip **148** had a movable center of ablation **130***a*, the alternative ablation probe tip **148** would be inserted through the surgical guide **112** of a surgical stent **110** at proper pre-defined angle (φ), but would come to a stop when the absolute tip **152** touched the bottom of the gingival tissue **122** (or the top of the bone upon which the tooth bud **120** is positioned). The movable center of ablation **130***a* would be moved to the distance (y) from the absolute tip **152** such that the effective center of ablation **130***a* targeted middle of the tooth bud **130***b* would be substantially overlapping.

A multiple centers of ablation **130***a* variation would mean that there would be more than one center of ablation **130***a* within the ablation probe tip **108**, **148**. Which of the multiple centers of ablation **130***a* was used for a particular tooth bud could be controlled by the operator or automatically (e.g. by a computer). For example, if the alternative ablation probe tip **148** had multiple centers of ablation **130***a*, the alternative ablation probe tip **148** would be inserted through the surgical guide **112** of a surgical stent **110** at proper pre-defined angle (φ), but would come to a stop when the absolute tip **152** touched the bottom of the gingival tissue **122** (or the top of the bone upon which the tooth bud **120** is positioned). Which of the multiple centers of ablation **130***a* would be actuated would be determined by which center of ablation **130***a* was the closest to the distance (y) from the absolute tip **152** such that the effective center of ablation **130***a* targeted middle of the tooth bud **130***b* would be substantially overlapping.

The ablation probe tips **108**, **148** may be sharp enough and/or may be strong enough so that the ablation probe tips **108**, **148** can be "self-introducing" in that the ablation probe tips **108**, **148** can be pushed through the gingival tissue **122**.

Alternatively, if tissue trocars **146** (described herein) are to be used, the ablation probe tips **108**, **148** would not have to be as sharp and/or strong.

The following bulleted points are exemplary details and/or features that may be incorporated in preferred ablation probe tips **108**, **148**.

- Preferred ablation probe tips **108**, **148** are preferably disposable (e.g. single-use).
- Preferred ablation probe tips **108**, **148** may be specially designed to work with the specific ablation means **104'** produced by the generator **104**. Other preferred ablation probe tips **108**, **148** may be designed to work with multiple types of ablation means **104'** produced by the generator **104** or generators **104**.
- The design of the ablation probe tip **108**, **148** may be dependent on the physics involved with transmitting ablation means **104'** through the smallest possible diameter with an ideal maximum diameter. For example, an MW/RF ablation probe tip may be designed for transmitting MW/RF energy through the smallest possible diameter with an ideal maximum diameter of 0.5 mm to 1.0 mm targeted.

- The "family" of probe tips **108**, **148** may include probe tips **108**, **148** having a variety of characteristics. For example, the family might have probe tips **108**, **148** of different lengths ranging from 5.0 mm to 25.0 mm. This range would accommodate the various diameters of the tooth buds **120** and overlying gingival tissue **122** thicknesses.
- Intra-operative temperature sensing (shown as being performed by a linear array of temperature sensors **144** in FIG. **8**) is preferably provided at or near the apex of the ablation probe tip **108**, **148** (assuming placement in the ideal middle of the tooth bud **130***b*) and/or along the shaft of the probe tip **108**, **148**. Temperature sensors **144** provide core temperatures for feedback control purposes (so that the operator can monitor the temperature and/or for software feedback control loops and emergency shutdown) and/or for safety controls to reduce or eliminate collateral tissue damage. Intra-operative tissue temperature is preferably measured, both to assure complete ablation and to prevent over-heating of tissues; this may require additional set up data or programming. If temperature sensors **144** are used, the appropriate ablation probe tip **108**, **148** preferably will result in the intra-operative placement of the effective center of ablation **130***a* of the ablation probe tip **108**, **148** into the targeted middle of the tooth bud **130***b*±1.0 mm.

FIGS. **41-46** show specific exemplary ablation probe tips **320**, **360** (that could be constructed as ablation probe tip **108** or ablation probe tip **148**) that would work in the TBA systems **100** discussed herein. Each exemplary ablation probe tip **320**, **360** has a shaft with a connection end **322***a*, **362***a* (shown as a female SMA connector for connecting directly or indirectly to a generator **104** via a hand piece **106**) and an insertion end **322***b*, **362***b* (for inserting into the tooth bud **120**). These exemplary ablation probe tips **320**, **360** have microwave ablation means (e.g. microwave energy, waves, and/or radiation) that flow from the generator **104** to and through the exemplary ablation probe tip **320**, **360** (from the connection end **322***a*, **362***a* towards the insertion end **322***b*, **362***b*, and reflecting back from a reflector **326**, **366**) and to a center of ablation **130***a* (the focal point of the ablation) from which it radiates through the window **328**, **368**. The shown exemplary ablation probe tips **320**, **360** preferably include "structure for transmitting microwave ablation means" **324**, **364** and a reflector **326**, **366**. The structure for transmitting microwave ablation means **324**, **364** may be a coaxial cable (coax cable) **324**, **364** or other structure having an inner conductor **324***a*, **364***a* (also referred to as a center core), insulation **324***b*, **364***b* (e.g. a dielectric insulator such as polytetrafluoroethylene (PTFE)) surrounding the inner conductor, an outer conductor or shield **324***c*, **364***c* (e.g. a metallic or copper annular layer) surrounding the insulation, and an optional outer sheath, protector, or cover **324***d*, **364***d* (the outer cover is "optional" in that it may be distinct from the main "coaxial cable" so that it is added in a separate step) surrounding the outer shield. Microwave ablation means that "hit" the reflector **326**, **366** bounce (reflect) back up the coax cable **324**, **364** creating two "signals" (the incoming microwave ablation means and the reflected microwave ablation means). Put another way, the reflector **326**, **366** creates an electrically conductive end treatment between the inner conductor **324***a*, **364***a* and the outer conductor or shield **324***c*, **364***c* such that act the inner conductor **324***a*, **364***a* and the outer conductor or shield **324***c*, **364***c* like reflector surfaces that redirect the microwave to create the standing wave. A 360 degree opening or window **328**, **368** is positioned near the insertion end **322***b*, **362***b* (shown as approximately 2 mm from the insertion end **322***b*, **362***b*). The reflector **326**, **366** allows the microwave ablation means to create a standing wave as the two signals (the incoming and reflected) interact through interference patterns and are efficiently radiated laterally (90 degrees) to the coax cable **324**, **364**. The center of ablation **130***a* is located at least substantially centered in the coax inner conductor **324***a*, **364***a* at the point where it is surrounded by the window **328**, **368**.

FIGS. **41-43** show first exemplary ablation probe tips **320** having a connection end **322***a* and an insertion end **322***b*. FIGS. **48-50** show a second exemplary ablation probe tip **360** having a connection end **362***a* and an insertion end **362***b*. The first and second exemplary ablation probe tips **320**, **360** have many similar features. Both the first and the second exemplary ablation probe tips **320**, **360** include a coax cable **364** (or structure equivalent thereto), a reflector **326**, **366**, and a gap window **328**, **368** (shown as being approximately 1 mm). The gap window **328**, **368** is created by removing (by known removal methods) a portion of the coax outer shield **324***c*, **364***c*. The coax outer shield **324***d*, **364***d* covers the coax outer shield **324***c*, **364***c*, but leaves a gap where the coax outer shield **324***c*, **364***c* has been removed. The outer cover **324***d*, **364***d* forms the point or sharp edge of the insertion end **322***b*, **362***b*. The outer cover **324***d*, **364***d* may be a molded sheath made from a polymer material having properties such as strength, hardness, injection-moldability, slipperiness, ability to hold a sharp point, and/or radiolucency (transparency to microwave energy) such as, for example, PEEK, Ultem, Nylon, and/or Polycarbonate.

As mentioned, both the first exemplary ablation probe tip **320** and the second exemplary ablation probe tip **360** include a gap window **328**, **368**. An air gap window has proven to be effective and economically efficient and, therefore would be suitable for either the first exemplary ablation probe tip **320** or the second exemplary ablation probe tip **360**. Alternative gap windows **328**, **368** could be made of any material that is sufficiently transparent to the microwave radiation and has the appropriate mechanical properties. One exemplary alternative to the air gap window is a ceramic gap window.

One difference between the first exemplary ablation probe tips **320** and the second exemplary ablation probe tip **360** is the specific shown reflector **326**, **366**. FIGS. **41-43** show first exemplary ablation probe tips **320** having a soldered reflector **326**. FIGS. **48-50** show a second exemplary ablation probe tip **360** having a "deposited" reflector **326**. A deposited reflector may have many different types of depositions resulting from deposition techniques including, but not limited to, "electroplating" techniques, "electroless" plating techniques, mechanical application of particulate techniques, "plasma deposition" techniques, "ion beam implantation" techniques, "sputter coating" techniques, "vacuum deposition" techniques, and any known or yet to be discovered technique for depositing a surface that is sufficiently electrically conductive to serve as a reflector directly to the surface of the coax cable. It should be noted that although the first exemplary ablation probe tip **320** is shown as having a soldered reflector **326**, it could have a deposited reflector. Similarly, although the second exemplary ablation probe tip **360** is shown as having a deposited reflector **326**, it could have a soldered reflector. Replacing expensive components (e.g. machined metal reflectors) with more economical alternatives (e.g. soldered, electroplated, or otherwise deposited reflectors) significantly reduced manufacturing time (plating being suitable to large scale automated processing) and the resulting exemplary ablation probe tips **320**, **360** worked as well or better than more complicated and expensive versions.

There are also superficial differences such as the shape. For example, the first exemplary ablation probe tip **320** is straight and the second exemplary ablation probe tip **360** is angled. Another superficial difference is the presence in the second exemplary ablation probe tip **360** of an overmolded support **372** that is added to the exterior of the coax cable **364**.

It should be noted that FIGS. **41-46** show specific exemplary ablation probe tips **320**, **360**. Dimensions and angles specified thereon (either written, measurable, or implied) are for purposes of enablement of these specific exemplary ablation probe tips. They are not meant to limit the scope of the invention. Further, specific features of two of the exemplary ablation probe tips may be used to create additional exemplary ablation probe tips. The specific materials and shapes of the exemplary ablation probe tips **320**, **360** and the style/dimensions of puncturing portion of the ablation probe tip (the insertion end **322***b*, **362***b*) may be adapted for a particular intended use without effecting the scope of the invention.

Stent **110**

The at least one custom surgical stent **110** (also referred to as a "stent **110**" or a "surgical stent **110**") has at least one surgical guide **112** (also referred to as "guides **112**" or "ablation probe tip guides **112**"). Two surgical stents **110** would be used, for example, if both upper and lower tooth buds **120** were to be ablated. The surgical stents **110** are designed to seat in a patient's mouth and may be supported by at least one tooth (a tooth-supported surgical stent), soft tissue (a soft tissue-supported surgical stent), and/or bone (a bone-supported surgical stent). If the surgical stent **110** is supported by more than one of these, it could be considered a combination-supported surgical stent. Preferred surgical stents **110** may "snap" into the mechanical undercuts inherent in the patient's erupted teeth. A surgical stent **110** would have more than one surgical guide **112** if more than one tooth bud were to be ablated on either the upper or lower jaw.

The surgical stents **110** and the guides **112** therein are used to control one or both the pre-defined angle (φ) and the pre-defined depth (x) of the ablation probe tip **108**, **148** in order to assure that the ablation probe tip's effective center of ablation **130***a* is in the middle of the tooth bud **130***b*±0.5 mm. The pre-defined angle (φ) is primarily controlled by the angle of the surgical guides **112** (the passageways through the stent **110**). For some types of ablation probe tips **108**, the pre-defined depth (x) is primarily controlled by the interaction between the mechanical stop structure **142** of the surgical stent **110** (and/or surgical guide **112**) and the mechanical stop structure **140** of the ablation probe tip **108**. For other types of ablation probe tips **148**, the pre-defined depth (x) is primarily controlled by the interaction between the alternative stop structure **150** and the bottom of the gingival tissue **122** (or the top of the bone upon which the tooth bud **120** is positioned). The operator inserts the ablation probe tip **108**, **148** at the entry angle (φ) defined by the guide **112** and to the depth (x) limited by the appropriate mechanical stop structure.

The surgical guides **112** are passageways through the surgical stent (the passageways being a type of guiding structure). The pre-defined angle (φ) for each passageway (guide **112**) is determined by the position of the middle of the tooth bud **130***b*. For example, if the middle of the tooth bud **130***b* is "slightly forward" the angle (φ) of the passageway (guide **112**) would be "slightly forward" so that the ablation probe tip **108**, **148** is angled "slightly forward" so that the center of ablation **130***a* is positioned substantially at the middle of the tooth bud **130***b*. The angle (φ) of the passageway is determined (e.g. calculated) by the software based upon tooth bud volumes determined in pre-surgical volume scanning **82**. In addition to providing a path through which the ablation probe tip **108**, **148** accesses the gingival tissue and the tooth bud, the guides **110** may also be used to provide access for administering local anesthetic and to provide access to a tissue trocar **146** (if necessary).

In the shown preferred example, the mechanical stop structure **142** is the upper surface of the surgical stent **110** and/or surgical guide **112**. The mechanical stop structure **142** is substantially adjacent to or near the surgical guide **112**. The mechanical stop structure **142**, however, could be positioned at locations of the surgical stent **110** beyond the surgical guide **112**. Alternative preferred mechanical stop structure **142** includes a protrusion on the upper surface or a notch in the upper surface. The size and shape of the mechanical stop structure **142** is determined (calculated or designed) by a process that may be implemented as software or as a program and is based upon tooth bud volumes determined in pre-surgical volume scanning **82** as well as the length between the ablation probe tip mechanical stop structure **140** and its center of ablation **130***a*. For example, if the middle of the tooth bud **130***b* is 2.5 mm below the surface (determined in pre-surgical volume scanning **82**), and the available ablation probe tips **108** have a length (between their respective mechanical stop structure **140** and its center of ablation **130***a*) of 2.4 mm and 2.6 mm, the process (that may be implemented by software or a program) would determine that the 2.6 mm ablation probe tip **108** is the appropriate ablation probe tip **108** (the 2.4 mm ablation probe tip **108** being too short), but that the surgical stent **110** and/or surgical guide **112** would have to be approximately 0.1 mm thick to make up the difference or the 2.6 mm ablation probe tip **108** would be able to be pushed in too far.

FIG. **12** is a flowchart showing the steps of a process (that may be implemented as one or more software programs or subprograms if the shown steps are divided) that, in part, determines the pre-defined angle (φ) and the pre-defined depth (x) (see steps **200**, **210**, **212**, **214**, **216**, and **218**). Using this process, patient volume scans are used to accurately manufacture or fabricate custom surgical stents **110** with the correct ablation probe tip angle (φ) and depth (x) manufactured into them. More specifically, using this process with the volume scans will permit accurate placement of the distal surgical guides **112** onto the custom surgical stents **110** so that both angle (φ) of insertion and depth (x) of insertion of the ablation probe tip **108**, **148** are controlled to +0.5 mm, placing the ablation probe tip's effective center of ablation **130***a* in the middle of the tooth bud **130***b*.

The following bulleted points are exemplary details and/or features that may be incorporated in preferred stents **110**.

- Preferred surgical stents **110** are preferably disposable (e.g. single-use).
- Manufacturing or fabricating of the custom surgical stents **110** may be based upon physical (e.g. Poly Vinyl Siloxane (PVS)) full arch impressions of the patient's erupted teeth using either conventional lab fabrication techniques or direct-digital manufacturing (including digital impressions) or fabricating techniques. If an operator has a CBCT unit in his office, it may be possible to directly scan the physical (PVS) impressions and email the volume scan of the impression to eliminate the need to physically send them to the lab. The impression materials may include materials other than PVS and preferably will be contrast-optimized through the addition of X-ray contrast agents (such as barium or iodine) to provide optimized volume scans of the dental impression for resolving the fine surface detail of the teeth and gingival tissue **122**. This unique material would be a radiographic contrast-optimized dental impression material for high resolution X-ray CT volume scanning. An alternative method for volume scanning replaces the physical impression with a digital impression.
- Preferred surgical stents **110** are preferably made of any appropriate material including, but not limited to, plastic, acrylic, or other nontoxic sturdy material suitable for use in a patient's mouth. One exemplary surgical stent **110** composition may be, for example, clear acrylic (polymethyl methacrylate). It should be noted that materials suitable for additive-type manufacturing (or other direct-digital manufacturing or fabricating techniques) that resulted in nontoxic sturdy stents would be preferable.
- Preferred surgical stents **110** preferably have markings such as color codes or numbering clearly marking or identifying the tooth bud numbering sites.
- Once the surgical stent **110** is seated onto the patient's teeth, it preferably will remain firmly in place throughout the surgical phase **90** of the TBA procedure **70**.
- The operator may administer local anesthetic through the guides **112**.

Pre-Determined Settings **105**

The pre-determined settings **105** include, for example, pre-determined parameter settings **105***a* and/or treatment time settings **105***b* that are needed to control (provide instructions to) the generator **104** (alone or as part of an ablation probe unit **102**) to provide sufficient ablation means **104'** to ablate the tooth bud **120**, but not so much as to incur significant collateral soft tissue damage (e.g. to the gingival tissue **122**). For example, the pre-determined parameter settings **105***a* might control the quantity and quality ablation means **104'** delivered to the tooth bud **120**. The actual pre-determined parameter settings **105***a* will be highly dependent on the type of ablation means **104'** to be delivered. For example, MW and RF ablation means might have parameters relating to wavelength and/or frequency, hot tip ablation means might have parameters relating to temperature, chemical ablation means might have parameters relating to the strength of the chemical and how fast the chemical is flowing into the tooth bud, and mechanical ablation means might have parameters relating to speed.

The pre-determined settings **105** are determined (which includes computing, calculating, looking up, processing, or otherwise determining) by a process (that may be implemented as software or a program) based upon tooth bud volumes determined in pre-surgical volume scanning **82**. It should be noted that the pre-determined settings **105** may take into consideration factors other than tooth bud volume including, but not limited to, image recognition programs to measure tooth bud location, age and size of the patient, and other relevant factors to successfully image the patient for the TBA procedure **70**. FIG. **12** is a flowchart showing the steps of a process (that may be implemented as one or more software programs or subprograms if the shown steps are divided) that, in part, determine the pre-determined parameter settings **105***a* and/or treatment time settings **105***b* (see steps **200**, **220**, **222**, and **224**).

The generator **104** (and/or the ablation probe unit **102**) may be programmed by the operator and/or technicians at the laboratory and/or factory. The programming may be automatic or manual. "Programming" includes having the pre-determined settings **105** pre-entered and/or entering (inputting) the pre-determined settings **105** manually or automatically into the generator **104** (and/or the ablation probe unit **102**) via operator input mechanisms. For example, the pre-determined settings **105** may be preprogrammed into an ablation probe unit **102**, transmitted to the operator in the form of a programming signal (e.g. over the internet to be downloaded and installed in the ablation probe unit **102** or the generator **104**), provided in the form of computer-readable media (e.g. a disc or a solid state USB drive), and/or provided as data (or a code) that may be manually entered into the ablation probe unit **102** (or the generator **104**). Ideally, whichever method of entering/programming the ablation probe unit **102** (or the generator **104**) is used, operator error is considered and eliminated as much as possible and appropriate checks are used. Preprogramming and some of the other means for programming the ablation probe unit **102** (or the generator **104**) with the pre-determined settings would help to eliminate operator input errors. Another example of means for eliminating errors is that even if the ablation probe unit **102** (or the generator **104**) is preprogrammed by the laboratory, the pre-determined settings might be displayed to the operator for independent "verification" as the operator could notice variations from normal pre-determined settings (e.g. the literature provided might provide a range and the operator would notice if the provided pre-determined settings **105** fell outside of the range). Yet another example is that the pre-determined settings might be provided as a code that, when input, would only function if it corresponded with a logical setting (e.g. if the person's age was also input into the ablation probe unit **102** and the code was not a logical setting based on the age, the ablation probe unit **102** would not function).

The pre-determined settings **105** for each TBA site may be included in the TBA surgical kit as a print out, on a disk or other computer readable storage media, or with instructions on how to obtain or download the information.

The pre-determined ablation means parameter settings **105***a* can also be referred to as "parameter settings **105***a*," "preferred parameter settings **105***a*," "optimal parameter settings **105***a*," "ideal parameter settings **105***a*," "pre-determined parameter settings **105***a*," "recommended parameter settings **105***a*," or "prescribed parameter settings **105***a*."

Tissue Trocar **146**

If the ablation probe tip **108**, **148** is not self-introducing, at least one sharp instrument (that is preferably disposable) such as a tissue trocar **146** (and sometimes a plurality of tissue trocars) may be used by the operator to introduce (initially create) the access opening through the thick attached gingival tissue **122** that overlays third molar tooth buds **120**. The tissue trocar tips are preferably sharp enough to be pushed and/or punched through the gingival tissue **122** into the base of the tooth bud. The diameter of the tissue trocar **146** rapidly increases up to 100% of the size of the ablation probe tip **108**, **148**. After the tissue trocar **146** has created the access opening, the tissue trocar **146** is removed and the ablation probe tip **108**, **148** is immediately placed into the access opening.

TBA Surgical Kit

The TBA surgical kit is a package that includes the majority of the necessary components and information for the surgical phase **90** of the TBA procedure **70**. The TBA kit will be assembled (or the assembly will be completed) based on the patient's impressions and volume scans. Preferably the TBA surgical kit has attractive packaging.

- An exemplary TBA surgical kit may consist of (a) a custom surgical stent **110** for each arch as required, (b) at least one ablation probe tip **108**, **148** labeled its respective surgical site, (c) at least one tissue trocar **146** (if necessary), and (d) pre-determined settings **105** for each TBA site along with patient and operator identification.
- If feedback controls are a part of the ablation probe tip design, then the correct in situ tissue temperature settings are preferably computed and supplied with the ablation probe tips **108**, **148** as part of the surgical kit.
- The generator **104** and/or the hand pieces **106** are standard equipment in a dental office and/or can be purchased separately.
- The ablation probe tips **108**, **148** may be pre-purchased (or extras may be kept in a practitioner's office) in which case the TBA surgical kit would provide a part number or other identifying information so that the practitioner would know which ablation probe tip **108**, **148** should be used with each guide **112**.
- It should be noted some of the components may not be part of the physical TBA surgical kit. For example the pre-determined settings **105** may be provided electronically.

The TBA Procedure **70**

Using the TBA procedure **70** described herein, the effective center of ablation **130***a* of the ablation probe tip **108**, **148** can be positioned at a pre-defined angle (φ) and pre-defined depth (x) so that the ablation probe tip's effective center of ablation **130***a* is positioned substantially in the "middle" of the tooth bud **130***b* within approximately 50%, 25%, or even less than 10% of the average diameter of the tooth bud **120**. This is extremely accurate as compared to previous procedures.

FIG. **4** shows the steps and/or phases in an exemplary preferred TBA procedure **70**: (1) routine screening and diagnosis **72**; (2) pre-surgical scanning **82** (including taking impressions **84** and using scanning technology **86**); (3) assembling a TBA surgical kit **88** (including pre-determined settings **105** and a stent **110**); (4) operator delivery of the surgical phase **90** of the TBA procedure **70** (shown in more detail in FIG. **11**); and (5) post-surgical steps **98**. Steps (2) and (3) are also referred to jointly as the pre-surgical phase **80** during which steps are taken to create (including calculating, manufacturing, fabricating, selecting, and/or assembling) components of the TBA system **100** and/or the TBA surgical kit to be provided to the operator. Step (4) is also referred to as the surgical phase **90** of the TBA procedure **70** during which the steps shown in FIG. **11** are taken to ablate tooth buds **120**.

(1) Screening Phase **72**

Routine screening using panographic or intra-oral X-ray imaging techniques is necessary to identify the presence of forming tooth buds **120** starting at age 6 through age 12 because of the wide range of ages involved with the formation of third molar tooth buds **120**.

(2) Impressions and Scanning of Pre-Surgical Phase **80**

Once third molar tooth buds **120** have been identified to be present using standard screening methods (screening phase **72**), the next step is to pre-operatively measure the precise three-dimensional location and volume of each third molar tooth bud **120**. As will be discussed, the pre-surgical phase **80**, includes both impressions and scanning. The impressions **84** may be physical impressions, digital (virtual) impressions, and/or any other impressions known or yet to be discovered. The scanning technology **86** used be may be any of the scanning technology discussed herein and/or any scanning technology known or yet to be discovered. Further, multiple types of technologies may be used in combination.

One practical way to accomplish the pre-operative measurement of the precise three-dimensional location and volume of each third molar tooth bud **120** is to use scanning technology **86** (e.g. computed tomography volume scanning such as dental cone beam computed tomography (CBCT)). Scanning technology **86** can be used to accurately generate the necessary three-dimensional volume scans (computed tomography volume scans) and measurements ±0.2 mm using, for example, the distal side of erupted first molars as durable physical landmarks (although it is possible to use soft tissue over bone as landmarks). The scanning technology **86** produces tooth bud size and position data **86'** (also referred to as "volume scans" and/or "measurements") that is provided for the step of producing the TBA surgical kit **88**. The tooth bud size and position data **86'** may be provided as a scanning technology file that can be any data file generated by the scanning technology **86** with the data necessary to manufacture or fabricate a stent **110**. One exemplary type of scanning technology file is a three-dimensional computer aided design (CAD) file.

To accomplish the pre-operative measurement, an impression **84** (that can also be used for making a model for creating the stent **110**) is used. A physical impression **84** of the patient's teeth and gum tissue (gingival tissue **122**) is made using traditional or standard impression materials such as polyvinyl siloxane (PVS)-type or alginate-type impression material (although other impression materials can be used) that use a chemical-basis for physically obtaining a dental impression of a patient. The impressions **84** are then processed and/or scanned using scanning technology (e.g. CBCT imaging by dentists and/or CT imaging in the laboratory), and the resulting volume scan of the impression is emailed (or otherwise transmitted or delivered) to a laboratory and/or factory where the volume scan is used for manufacturing or fabricating. It is still possible to physically mail the PVS dental impressions **84** to the designated laboratory and/or factory for manufacturing or fabricating.

Although the scanning technology is discussed primarily in terms of computed tomography volume scanning (e.g. cone beam computed tomography (CBCT) technology), alternative scanning technologies including, but not limited to, ultrasound scanning technologies and future developed scanning technologies are included in the scope of the invention. Specialty software or programs may be used with the scanning technology **86** to accomplish the purpose described herein. It should be noted that alternative scanning technology **86** (including future developed scanning technology) may be used if it is able to accurately generate the necessary three-dimensional volume scans and measurements ±0.2 mm using the distal side of erupted first molars (or other landmarks) as durable physical landmarks. It should be noted that alternative scanning technology (including future developed scanning technology) may also be used as long as two- or three-dimensional scanning results in the positioning of the effective center of ablation **130*a*** within approximately 50%, 25%, or even less than 10% of the average diameter of the tooth bud **120**.

At this pre-surgical phase **80**, scanning may be performed for the purpose of obtaining "digital" impressions instead of traditional physical impressions. In other words, for purposes of this disclosure, digital impressions **84** should be considered to be an alternative to physical impressions **84** and the term "impressions," unless modified by "digital" or "physical" (or variations thereof) should be considered to include both digital and/or physical impressions. Digital impressions do not necessarily use actual impression material, but instead scan the oral surfaces—including hard tooth structures and soft tissues such as gum tissue and the mucosal tissue overlying the immediate structure of the tooth bud. Digital impressions (like physical impressions) may be used to fabricate a physical and/or virtual surgical guide or stent. Using digital impressions has exemplary advantages such as improving accuracy and/or eliminating the need to physically mail (or post) the physical dental impressions.

Digital impressions may be taken using digital imaging systems such as "confocal" imaging systems (e.g. iOC and iTero intra-oral imaging systems), three-dimensional surface imaging (e.g. 3M's True Definition unit), and other digital imaging systems known and yet to be discovered. U.S. Pat. No. 7,787,132 to Korner et al., U.S. Pat. No. 7,819,591 to Rohaly et al., U.S. Pat. No. 7,990,548 to Babayoff et al., U.S. Pat. No. 8,310,683 to Babayoff et al., and U.S. Pat. No. 8,363,228 to Babayoff et al. disclose exemplary imaging systems or technology related to imaging systems that may be used in this impressions and scanning of the pre-surgical phase **80**. These references are hereby incorporated by reference in their entirety. For purposes of this disclosure, these systems may be considered to be part of the scanning technology **86**. These systems may be used instead of or in conjunction with the previously discussed scanning technology (e.g. the CBCT technology).

Using digital imaging systems to take digital impressions may include using a digital "wand" that is inserted into the patient's mouth and the surfaces directly scanned. Alternatively, digital imaging systems may be used to take digital impressions **84** using conventional plaster impressions (plaster models) that are digitally scanned. Dedicated laboratory scanning systems to scan plaster models use yet other technologies such as video or laser-based scanning.

(3) Assembling a TBA Surgical Kit **88**

The pre-surgical phase **80** of the TBA procedure **70** includes assembling a TBA surgical kit **88**. This step of assembling a TBA surgical kit **88** preferably includes computing pre-determined settings **105** and manufacturing or fabricating the stent **110** based on tooth bud size and position data **86'** obtained from the scanning technology **86**. The process of computing pre-determined settings **105** may be controlled by a process (that may be implemented by software or a program). The process of manufacturing or fabricating the stent **110** may also be controlled by a process (that may be implemented by software or a program).

After the impressions **84** are processed and/or scanned and the tooth bud size and position data **86'** is obtained, the process of manufacturing or fabricating the stent **110** may be carried out using direct-digital manufacturing or fabricating techniques similar to the processes used for manufacturing or fabricating implant surgical stents directly from CBCT scans (e.g. the processes used for fabricating SurgiGuide™ and other implant surgical guides) and the process used for manufacturing or fabricating orthodontic aligners (e.g. orthodontic aligners made by Align Technology or ClearCorrect). The direct-digital manufacturing or fabricating techniques, however, use the tooth bud size and position data **86'** to position and angle the surgical guides **112** on the distal aspects of the surgical stents **110** and use the erupted first molars as the primary landmark for positioning. Although manufacturing or fabricating will usually be done remotely in a laboratory and/or factory, it is possible that larger clinics will have the ability to manufacture or fabricate surgical stents **110** in their own in-house laboratory and/or factory.

Direct-digital manufacturing or fabricating techniques can be defined as any manufacturing or fabricating process that creates physical parts directly from data (e.g. three-dimensional CAD files) using manufacturing or fabricating techniques including, but not limited to, surgical stent manufacturing or fabricating technologies, rapid turn-around fabrication technologies, computer aided manufacturing (CAM), technologies using computer aided design (CAD), computer numerical control (CNC) milling, "additive" manufacturing, direct-digital laser stereolithography fabrication, "three-dimensional printing," or any other manufacturing or fabricating means known or yet to be discovered that is capable of using the results generated by scanning to manufacture or fabricate the custom surgical stents. Because of the possibility for the integrated use of direct-digital volume scanning of impressions, low manufacturing costs, and rapid turn around times, use of direct-digital manufacturing or fabricating techniques is one preferred manufacturing or fabricating technique, but more traditional manufacturing or fabricating techniques that require more labor intensive manual laboratory processing could also be used.

At least one process that may be implemented as software or as at least one program (e.g. custom software enhancements in the CBCT software) will preferably assist in the direct-digital manufacturing or fabricating of the surgical stents **110** and define (and/or compute or calculate) the pre-determined settings **105**. This process would include defining (and/or computing or calculating) positioning and entry angle data required for placement of the ablation probe tip's effective center of ablation **130***a* into the middle of the targeted tooth bud **120**. Additionally, tooth bud volumes are preferably computed (possibly using the scanning technology) and then the tooth bud volumes are used to determine the pre-determined settings **105** necessary to effect therapeutic ablation. Tooth bud volumes will generally range from 4.0 mm to 12.0 mm in diameter at ages 6-12. The ablation means **104'** and treatment times are preferably considered in the calculations. Companies that make CBCT imaging equipment promote the development of procedure-specific software in order to gain end-user acceptance of their imaging systems in the market place. The process may use calculations and/or look-up charts (e.g. based on experimental data) for determining the necessary settings.

FIG. **12** is a flowchart showing the steps of a process (that may be implemented as one or more software programs or subprograms if the shown steps are divided) for manufacturing or fabricating custom surgical stents **110** and/or determining the pre-determined parameter settings **105***a* and/or treatment time settings **105***b*. As shown, the process begins with receiving pre-operative measurements of the precise three-dimensional location and volume of each third molar tooth bud and information regarding the ablation probe unit including its ablation means capabilities **200**. To make the stents **110**, the process would preferably include the following steps: determining an entry point for an ablation probe tip **210**; computing the angle and depth of the path (including the three-dimensional path of insertion) between the entry point and the middle of a tooth bud **212**; taking into consideration the depth of the path, creating or selecting an ablation probe tip having the proper distance between its mechanical stop and its center of ablation so that the ablation probe tip will be inserted so that its center of ablation will be in the middle of the tooth bud **214**; taking into consideration the angle and depth of the path and the thickness of the surgical stent, computing the surgical guide pathway (including the three-dimensional path of insertion) through which the ablation probe tip will be inserted so that its center of ablation will be in the middle of the tooth bud **216**; and providing the surgical guide pathway as output for the creation of a surgical stent with surgical guides **218**. To calculate the pre-determined parameter settings **105***a* and/or treatment time settings **105***b*, the process would preferably include the following steps: taking into consideration the information regarding the ablation probe unit including its ablation means capabilities, determining the proper power settings **220**; taking into consideration the information regarding the ablation probe unit including its ablation means capabilities, determining the proper time settings **222**; and providing the proper power and time settings as output for use in programming the ablation probe unit or generator **224**.

As described above, in addition to the surgical stent(s) **110** and the pre-determined settings **105**, the TBA surgical kit may include at least one ablation probe tip **108**, **148** labeled for its respective surgical site, at least one tissue trocar **146** (if necessary), and patient and operator identification.

The TBA surgical kit is provided to the operator.

(4) Surgical Phase **90**

FIGS. **6-10** show graphically, and FIG. **11** shows as a flow chart, the surgical phase **90** of the TBA procedure. The surgical phase **90** may be performed by a dental operator (dental practitioner) in his office (e.g. a pediatric and/or general dental office) under normal office conditions. At this point, the generator **104** has been programmed with the pre-determined settings **105** and normal surgical procedures have been followed. The generator **104** is preferably tuned so that the ablation means **104'** is set to ablate the small, substantially spherical ablation volumes of third molar tooth buds **120** in order to minimize (or possibly eliminate) collateral osseous and soft tissue damage, especially damage to adjacent second molars that are likely not yet erupted. Further, the surgical phase **90** uses single-use and disposable delivery systems that use components designed for intra-oral use.

Summarily, as shown in FIG. **11**, the first step is physically seating a surgical stent **160** in a patient's mouth. Next, the operator makes an access path at the at least one tooth bud surgical site **162**. The operator also places the ablation probe tip so that the center of ablation is in the middle of a tooth bud at the at least one tooth bud surgical site (using the custom surgical stent to guide the placement) **164**. It should be noted that if the ablation probe tip is "self-introducing," the step of making an access path and the step of placing the ablation probe tip may occur simultaneously. Then, the at least one tooth bud is at least partially ablated **166** and the ablation probe tip is removed from the tooth bud **168**. These and other exemplary steps are detailed in the following paragraphs.

The operator preferably starts the surgical phase **90** by placing the surgical stent **110** into place onto the patient's teeth prior to administering local anesthetic to the surgical site. The local anesthetic will then be administered through the surgical stent **110** and guides **112** that are in close approximation with the gingival tissue **122**, thus reducing the amount of anesthetic necessary because of the precise placement of anesthetic agent. Achieving local anesthesia in this procedure will be easier than anesthetizing lower permanent molar teeth for routine fillings since only soft tissues, which will be 8.0 mm to 15.0 mm deep, are involved.

The step of physically seating a surgical stent **110** may also include physically seating the surgical stent in a patient's mouth, physically seating the surgical stent on a patient's erupted teeth, physically seating the surgical stent on at least one tooth in a patient's mouth, physically seating the surgical stent on a patient's soft tissue, physically seating the surgical stent on a patient's bone, or a combination of the above steps (e.g. physically seating the surgical stent on a patient's teeth, soft tissue, and bone).

Once the custom surgical stent **110** is in place and the patient is fully anesthetized, the operator then mechanically gains access to the tooth bud **120** through the stent surgical guides **112** by creating (introducing) a small surgical access path opening through the gingival tissue **122** approximately 0.1 mm to 2.0 mm (and more particularly 0.5 mm to 1.0 mm) in diameter using tissue trocars. If the ablation probe tips **108**, **148** are designed to be strong enough and sharp enough to act as "self-introducing" probe tips, they can be used to introduce the surgical access path. On the other hand, if the ablation probe tip itself is not self-introducing, the surgical access path may be introduced using known techniques then there will be no need for separate tissue trocar **146**.

It should be noted that the surgical access path is preferably an incision, a puncture, or a hole through the gingival tissue **122**. If a self-introducing probe tip is used, the surgical access path has substantially the same diameter as the ablation probe tip **108**, **148**. If the probe tip is not self-introducing, the surgical access path may be a sutureless puncture (0.1 mm to 2.0 mm in diameter) or, more particularly, a sutureless puncture (0.5 mm to 1.0 mm in diameter). Alternatively, a trocar "punch" may be made through tough gingival tissue **122**. Regardless of the procedure used to introduce the surgical access path, using a surgical access path to gain access or allow placement of the ablation probe tips **108**, **148** to the tooth bud **120** does not kill, damage, or otherwise cause necrosis to the surrounding soft tissues (e.g. gingival tissues **122**). This can be compared to other processes such as coring, boring, cutting, electrosurge ablating, or other invasive procedures that kill, damage, and/or otherwise cause necrosis to the soft tissue to which the invasive procedure has been applied. Although the preferred procedures for introducing the surgical access path might kill individual cells, the soft tissue (the gingival tissue **122**) does not become necrosed because the tissue is a collection of cells that can heal itself.

As shown in FIGS. **6** and **7**, the next step in the surgical phase **90** is to insert the designated ablation probe tip **108**, **148** through the surgical stent **110** and into the tooth bud space until it is mechanically "stopped" in order to position the probe to the prescribed depth (which would be the pre-defined depth). The surgical stent **110** and/or its surgical guides **112** are used to control the angle (φ) and/or depth (x) of the ablation probe tip **108**, **148** so that the effective center of ablation **130***a* of the ablation probe tip is in the middle of the tooth bud **130***b*. It should be noted that the effective center of ablation **130***a* for any given ablation technology does not necessarily correspond with the tip of the ablation probe. For instance, microwave ablation probes have windows or slots that may be 0.5 mm to 2.0 mm from the tip depending on the frequency of the wavelength used. Cryoablation probes have their center of ablation roughly in the middle of the probe, depending on the design and refrigerant used. A mechanical stop structure **140** on the ablation probe tip **108** preferably seats firmly onto the mechanical stop structure **142** of the surgical stent guide **112** to prevent over extension of the ablation probe tip **108**. Alternatively, the mechanical stop structure **150** on the ablation probe tip **148** may be used to prevent over extension of the ablation probe tip **108**.

FIG. **8** shows embedded temperature sensors **144** (or other types of feedback control mechanisms) that may be used during the ablation process. An independent feedback process using the temperature sensors **144** is preferable for this clinical procedure. Use of temperature sensors **144** along with monitoring probe impedance characteristics and percentage of reflected energy in RF/MW circuits will provide "go/no go" output for the clinician. Control algorithms are preferably used to accelerate initial ablation means **104'** input followed by lower-level temperature maintenance for a defined period of time with independent confirmation that results in a fast process while simultaneously assuring complete tooth bud ablation.

FIG. **9** shows the actual ablation process. Activation of the ablation probe unit **102** to perform the ablation process is executed according to the pre-determined settings **105**. Activation of the ablation probe unit **102** causes the generator **104** to provide the ablation means **104'** that passes through the hand piece **106** and the ablation probe tip **108**, **148** and into the tooth bud **120**. This step of at least partially ablating the tooth bud is preferably accomplished without ablating any surrounding gingival tissue (although a minimal amount of surrounding gingival tissue may be ablated as an accidental byproduct of the step). This can also be thought of as the activation of the ablation probe unit **102** creating a zone of ablation that resides predominantly or completely within the tooth bud **120**. The temperature sensors **144** (feedback control mechanisms) assure successful delivery of adequate ablation means **104'** to ablate the tooth bud **120** while minimizing damage to adjacent osseous and soft tissues by, for example, eliminating over-heating. Given the small tissue volumes involved for pediatric patients, activation using an RF ablation means **104'** would have an ablation time that is preferably less than three (3) minutes and activation using an MW ablation means **104'** would have an ablation time that is preferably less than thirty (30) seconds.

FIGS. **10** and **34** show the ablation probe tips **108**, **148** being removed from the now ablated tooth bud **120'**. As shown in these figures, any access path created by the procedure rapidly closes.

(5) Post-Surgical Phase **98**:

After the surgical phase **90**, the patient may have follow-up including, but not limited to, post-surgical instructions and, if necessary follow-up care and screening.

Post-surgical instructions that may be given to parents include the following: kids can go out and play immediately unless they were sedated, no post-surgical pain medication is necessary, bleeding (if any) will be gone in minutes, and post-surgical X-ray screening may be necessary at patient's next routine 6-month hygiene cleaning appointment to verify full ablation.

Simulated TBA Procedure **70**

The following paragraphs, along with FIGS. **13-29**, detail an exemplary simulated TBA procedure **70** including routine screening and diagnosis **72**, the pre-surgical phase **80**, and the surgical phase **90**. (The structure of FIGS. **30-34** would be used in a similar manner making adjustments as suggested herein.) In several of these figures, a patient's mouth **124** (with gums **122** and teeth **126**) is shown that looks like a stone model, but it should be understood that unless otherwise specified the shown mouth **124** would be a live patient's mouth.

As shown in FIG. **4**, the TBA procedure begins with routine screening and diagnosis **72**. FIG. **13** is a panographic X-ray showing a patient whose third molar tooth buds **120** in the #17 & #32 positions are treatable by a TBA procedure **70**. FIG. **14** is a pre-operative cone beam computed tomography ("CBCT") scan (although other types of volume scanning could be used) of a patient. In a real procedure, the volume scan would be taken of the specific patient on which the TBA procedure **70** is being performed. This CBCT "reconstructed" panographic scan has a 1.0 mm scale along its bottom edge. FIG. **15** is a series of CBCT volume scan cross-sections showing successive 1.0 mm slices through both #17 and #32 in 1.0 mm increments. Each X-ray corresponds to 1.0 mm locations along the scale of FIG. **14**. The left-side scale is 1.0 mm vertically. The maximum tooth bud diameters are measured to be 8.0-9.0 mm.

For purposes of describing this exemplary simulated TBA procedure **70**, the use of a physical impression **84** is described in connection with FIGS. **16-19**. It should be noted that an alternative exemplary TBA procedure **70** could use a virtual impression **84**.

FIG. **16** shows a pre-operative physical upper-arch impression **84** being taken of the simulated patient's mouth **124** (shown as a stone model for clarity, but an impression **84** would be taken of the patient himself) using an impression tray **128**. It is assumed that all four tooth buds of the wisdom teeth are present in the simulated patient. FIG. **17** is a cross-sectional view of the physical upper-arch impression **84** being taken of a simulated patient. FIG. **18** shows the completed physical upper-arch impression **84**. A similar process would be performed to manufacture or fabricate a pre-operative physical lower-arch impression **84**. At this time the practitioner may send impressions **84** and volume scan data to a laboratory and/or factory for processing.

The laboratory and/or factory uses the physical impressions **84** (although digital impressions **84** could be used) and volume scan data (scanning technology file) to create (including calculating, manufacturing, fabricating, selecting, and/or assembling) components of the TBA system **100** (including the surgical stents **110** and the pre-determined settings **105**). The surgical stents **110** and the pre-determined settings **105** and other components are then assembled into the TBA surgical kit to be provided to the operator.

FIG. **19** shows the completed physical upper-arch impression **84**, along with a stone model **85** that will serve as a "positive" for manufacturing or fabricating a surgical stent **110** for that patient's upper-arch. Alternatively, when using stereolithography manufacturing to manufacture or fabricate surgical stents **110**, the physical impressions **84** can be computed tomography ("CT") scanned to digitize as an alternative to making physical intermediates. The CT volume scan file (scanning technology file) can then be emailed (or otherwise directly transmitted) for direct manufacturing or fabricating. Alternatively, the practitioner may handle the processing "in house."

FIG. **20** is a CBCT scan with notations showing the measurement of the perpendicular angle of entry into the tooth bud **120**. The measurement is based on the distal aspect of the molar and the occlusal bite plane of the teeth. FIG. **21** is a series of X-rays with notations showing the measurement of the lateral angle of entry. The measurement is determined relative to the vertical axis in order to avoid the jaw's boney interferences during surgical placement of the ablation probe unit **102**. FIG. **22** is a CBCT scan with highlights showing the computed volume of each tooth bud **120**. CBCT volume data is used to determine and/or calculate the pre-determined settings **105**.

FIG. **23** shows the resulting surgical stent **110** that will be placed in a patient's mouth **124**. The shown stent has two surgical guides **112** based upon the location of the patient's two tooth buds to be ablated.

The surgical stent(s) **110** and the pre-determined setting(s) **105** are provided to the operator along with the rest of the TBA surgical kit.

Prior to the surgical phase **90** of the TBA procedure **70**, the ablation probe unit **102** and/or the generator **104** should be set up so that at least one pre-determined setting **105** is correctly entered for at least one tooth bud **120** with safety interlocks carefully considered. (The pre-determined settings **105** may all be entered prior to the surgical phase **90** or they may be entered one at a time.) The surgical phase **90** of the TBA procedure **70** may then be performed.

FIG. **24** shows topical anesthetic **87** being applied to the base of the surgical guide **112** (FIG. **24**) prior to the surgical stents **110** being seated in a patient's mouth **124**.

FIG. **25** shows the surgical stent **110** being seated on the upper-arch of the simulated patient's mouth **124** (shown as a stone model for clarity). This process would be repeated on the lower arch of the simulated patient.

FIG. **26** shows a local anesthetic being injected **89** into each site through a surgical guide **112** of the stent **110**.

FIG. **27** shows a tissue trocar **146** being used to create an access path through the gingival tissue **122** to the base of each tooth bud **120**. The tissue trocar **146** is only necessary if self-introducing ablation probe tips **108** are not used.

FIG. **28** shows an ablation probe tip **108** with mechanical stop structure **140'** (shown as a shoulder) being inserted through the surgical guide **112**. This would be similar to the position of the ablation probe tip **108** in FIG. **6**. (Alternatively, if the alternative ablation probe tip **148** with mechanical stop structure **150** was inserted through the surgical guide **112**, the position would be similar to the position of the alternative ablation probe tip **148** in FIG. **30**.)

FIG. **29** shows the ablation probe tip **108** positioned through the surgical guide **112** and into the tooth bud **120** through the surgical guide **112** so that the ablation probe tip's effective center of ablation **130***a* is in the middle of each tooth bud **120**. This would be similar to the position of the ablation probe tip **108** in FIG. **7**. (Alternatively, if the alternative ablation probe tip **148** was used, the position would be similar to the position of the alternative ablation probe tip **148** in FIG. **31**.)

The ablation means **104'** is delivered in this position (FIG. **9**, or FIG. **33** for the alternative ablation probe tip **148**). The ablation means **104'** is delivered based on the pre-determined settings **105** (e.g. times, intensities, and other prescribed settings unique to each tooth bud).

The ablation probe tip **108** would then be removed and the process repeated at the site of each tooth bud **120**. Once the entire surgical phase **90** is complete, the surgical stents **110** are removed.

Finally, the dental practitioner or an assistant provides post-surgical instructions to the patient or a caregiver of the patient.

Alternative Scanning and Fabrication of Custom TBA Surgical Kits

An alternative to the pre-surgical phase **80** of the TBA procedure **70** described above includes simultaneous three-dimensional scanning of both hard tissues (bone and teeth) and soft tissues (tooth bud **120** and gingival tissue **122**). From the information obtained using this unique simultaneous three-dimensional scanning, a custom surgical stent **110** may be manufactured or fabricated. As discussed, the custom surgical stent **110** is used in the surgical phase **90** to help with the placement of the center of ablation **130***a* into a tooth bud **120** that results in tooth agenesis.

The simultaneous three-dimensional scanning uses a single scan to obtain both soft tissue and hard tissue information. Soft tissue information generally does not show on a scan, although progress in volume scanning is improving and this may be possible in the near future. Known and future technologies able to provide a scan image of soft tissue are included in the scope of this invention. A typical X-ray scan will only show the hard tissue. One way to obtain both soft and hard tissue information using simultaneous three-dimensional scanning, a physical dental impression **84** is used that can be viewed on an X-ray. The physical dental impression **84** is made of materials that are preferably "contrast optimized" for high resolution X-ray volume scanning. The ideal level of contrast agent in the range of 25% to 75% radiopacity (such as barium or iodine based compounds) is mixed into the dental impression materials so that the highest level of surface detail can be picked upon when volume scanning the physical dental impression **84**. The physical dental impression **84** is placed in the patient's mouth **124** during the X-ray volume scan. The resulting X-ray volume scan image would show the tooth distinguished (is visible) and the physical dental impression **84** distinguished (is visible) and the void therebetween would be the soft tissue and would therefore be "visible." The resulting X-ray volume scan with both hard and soft tissue information may then be used to formulate the custom stent **110** used in the surgical phase **90** described herein. In other words, an X-ray volume scan image is generated in which hard tissue (e.g. a tooth) is visible hard tissue and the physical dental impression **84** is a visible dental impression and soft tissue (e.g. gingival tissue **122**) is "visible" as the space between the visible hard tissue and the visible dental impression.

One separate preferred pre-surgical phase **80** of the TBA procedure **70** preferably includes using X-ray volume scans of physical or digital dental impressions **84** to manufacture or fabricate surgical stents **110**. The X-ray volume scan of the dental impression **84** is "super imposed" over the patient X-ray volume scan (e.g. CBCT scanning) using the dental hard tissues (the teeth) to "snap" the two volume scans together into an accurate overlay so that soft tissues of the mouth (which cannot be X-ray volume scanned or otherwise obtained directly) are accurately defined for the surgical stent manufacturing or fabricating (which must take into account the soft tissue and teeth) and probe positioning (which must take into account the tooth bud positioning from the patient's CBCT scan).

One separate preferred pre-surgical phase **80** of the TBA procedure **70** preferably includes using physical dental impression materials that are "contrast optimized" for high resolution X-ray volume scanning that is then used to manufacture or fabricate surgical stents **110**. The ideal level of contrast agent (such as barium or iodine based compounds) is mixed into the physical dental impression materials so that the highest level of surface detail can be picked upon when CT volume scanning the physical dental impression **84**.

Virtual Stent System

The at least one custom surgical stent **110** (a physical stent system or physical stent) could be replaced (or used in conjunction with) a virtual stent system (also referred to as a "virtual stent") in a TBA procedure or with a TBA system. As set forth in the Background, U.S. Pat. No. 8,221,121 to Berckmans, III et al., U.S. Pat. No. 8,013,853 to Douglas, et al., U.S. Pat. No. 7,812,815 to Banerjee, et al., U.S. Pat. No. 7,457,443 to Persky, U.S. Pat. No. 7,249,952 to Ranta, et al., U.S. Pat. No. 5,688,118 to Hayka et al., U.S. Patent Publication No. 20100316974 to Yau, et al., U.S. Patent Publication No. 20100311028 to Bell, et al., and U.S. Patent Publication No. 20090253095 to Salcedo, et al. are references that address aspects of virtual dentistry. These references are hereby incorporated by reference in their entirety. Although none of these references are used in a TBA procedure or with a TBA system, many of the details of the virtual stent system may be implemented using aspects described in these references.

As a broad concept, a virtual stent system uses the three-dimensional volume scans (computed tomography volume scans) created using scanning technologies (e.g. computed tomography volume scanning such as cone beam computed tomography (CBCT) scanning and MRI volume scanning) displayed on a display system (e.g. a computer screen). The three-dimensional volume scans are taken of a specific patient on which the TBA procedure is being performed. Calculations are made to determine or calculate the parameter settings, the treatment time settings, the pre-defined angle (φ), and/or the pre-defined depth (x). The calculations of the pre-defined angle (φ) and pre-defined depth (x) are used to define a three-dimensional path of insertion through which the ablation probe tip **108**, **148** accesses the gingival tissue **122** and the tooth bud **120** so that the center of ablation **130***a* substantially coincides with or overlaps the middle of the tooth bud **130***b*. Using sensors **230** on the ablation probe tip **232** and/or the hand piece **106** to transmit movement, a real-time representation of the ablation probe tip **232** and/or the hand piece **106** is overlaid on the displayed three-dimensional volume scans. Movement of the ablation probe tip **232** is displayed in real-time. (It should be noted that the sensors **230** may be the ablation probe tip itself, the hand piece itself, sensors such as those described in the references incorporated herein, and any known or yet to be discovered sensors that are sensible from within a patient's mouth and are safe for use in a patient's mouth. It should also be noted that the sensors **230** have associated sensing technology (not shown) for sensing the sensors **230** and communicating and/or interpreting the position of the ablation probe tip **232** and/or the hand piece **106** so that a representation of the ablation probe tip **232** and/or the hand piece **106** is displayed on the display **240**. This sensing technology may be any known or yet to be discovered sensing technology capable of sensing the sensors within a patient's mouth (and is safe to use for such a purpose) including sensing technology described in the references incorporated herein.) The operator is able to monitor in real time the relationship of the effective center of ablation **130***a* of the ablation probe tip **232** as compared to the middle of the tooth bud **130***b*.

FIG. **35** shows a horizontal hand piece **234** and ablation probe tip **232** with sensors **230** and a display **240** with a representation of the horizontal hand piece **234** and ablation probe tip **232** displayed thereon. FIG. **36** shows a vertical hand piece **234** and ablation probe tip **232** with sensors **230** and a display **240** with a representation of the vertical hand piece **234** and ablation probe tip **232** displayed thereon. The sensors **230** would pick up movement of the hand piece **234** and ablation probe tip **232** in real time and would display the movement of the sensored hand piece **234** and sensored ablation probe tip **232** as real-time representations of the hand piece **234** and ablation probe tip **232** on the display **240**.

FIGS. **37** and **38** show an exemplary patient X-ray volume scan shown on a display **240** with a representation of the hand piece **234** and/or ablation probe tip **232** displayed as well as exemplary indicators of position (position indicator **250**) and status (status indicator **252**) shown on the display **240** in real time. FIG. **37** shows the sensored ablation probe tip **232** just barely inserted into the tooth bud such that the center of ablation **130***a* is relatively far from the middle of the tooth bud **130***b*. The position indicator **250**, therefore, would show a large percentage (shown as 98% which is the percentage of the average diameter of the tooth bud at which the center of ablation **130***a* is located in this position). The status indicator **252** is shown as "inactive" because the system would not be activated (it is not delivering ablation means **104'**) so far from the middle of the tooth bud **130***b*. FIG. **38** shows the ablation probe tip **232** in a relatively optimal position for ablation within the tooth bud. In other words, the center of ablation **130***a* is relatively close to the middle of the tooth bud **130***b*. The position indicator **250**, therefore, would show a small percentage (shown as 8% which is the percentage of the average diameter of the tooth bud at which the center of ablation **130***a* is located in this position). The status indicator **252** is shown as "active" because the system might be activated (delivering ablation means **104'**) this close to the middle of the tooth bud **130***b*.

FIG. **39** is an enlarged view of the display **240** showing virtual surgical guide angle markings **260**, a virtual stop marking **262**, and virtual target markings **264**. The virtual surgical guide angle markings **260** are based on the three-dimensional path of insertion (defined by the pre-defined angle (φ) and pre-defined depth (x)). Although these markings may be shown using an enlarging setting for the display **240**, they may also be present on the regular (non-enlarged) display **240**. In preferred embodiments, the system would not be able to be activated if the center of ablation **130***a* was not in proper relationship to the middle of the tooth bud **130***b*.

The virtual surgical guide angle markings **260** function in a manner similar to the physical surgical guide **112** (providing angle guidance) as they show the representation of the ablation probe tip **232** in the proper pre-defined angle (φ) in which the operator can guide the ablation probe tip **232** so that its center of ablation **130***a* is placed into the middle of the tooth bud **130***b*. The guide angle markings **260** show the proper path so that the user would see the representation of the ablation probe tip **232** outside the path if the sensored ablation probe tip **232** is not on the proper path. Preferably the representation is three-dimensional so that the operator would see a three-dimensional representation of the ablation probe tip **232** and a three-dimensional representation of the path of insertion. Further, the operator may be alerted that the sensored ablation probe tip **232** is not at the proper pre-defined angle using, for example, visual indicators (e.g. two-dimensional or three-dimensional graphical representations, lights on the display **240**, warning messages on the display **240**, or lights on the hand piece **234** or ablation probe tip **232**), audible indicators (e.g. buzzing or an audible warning message), tactile indicators (e.g. the vibrating of the hand piece **234**), or a combination thereof.

At least one virtual stop marking **262** is displayable on the display **240** to provide stop information to limit the depth of said sensored ablation probe tip **232** to a pre-defined depth (x). The virtual stop marking **262** functions in a manner similar to the physical stops **140**, **150** (which would not technically be needed for the sensored ablation probe tip **232**) as the virtual stop marking **262** limits (or at least provides a visual indication of the proper limit for) the representation of the ablation probe tip **232** so that its center of ablation **130***a* is at the proper pre-defined depth (x) to be placed into the middle of the tooth bud **130***b*. The operator may be alerted that the center of ablation **130***a* is not at the proper pre-defined depth (x) using, for example, visual indicators (e.g. lights on the display **240**, warning messages on the display **240**, or lights on the hand piece **234** or ablation probe tip **232**), audible indicators (e.g. buzzing or an audible warning message), tactile indicators (e.g. the vibrating of the hand piece **234**), or a combination thereof. It should be noted that the virtual stop marking **262** may not be at the middle of the tooth bud **130***b*. The virtual stop marking **262** would take into consideration the ablation probe tip **232** and its center of ablation **130***a* and indicate the proper position for the ablation probe tip **232** such that its center of ablation **130***a* (which may not be at its ultimate tip) is positioned at the middle of the tooth bud **130***b*. The virtual stop marking **262** and/or the alerts (e.g. visual indicators, audible indicators, tactile indicators, or a combination thereof) are a type of "stop information," the ablation probe tip **108**, **148** being depth limited to the depth indicated by the stop information (which would be the depth at which the center of ablation **130***a* substantially coincides with or overlaps with the middle of the tooth bud **130***b*).

The virtual target markings **264** are an optional feature (in that they are not strictly necessary if there are virtual surgical guide angle markings **260** and a virtual stop marking **26**). Alternatively, the virtual target markings **264** could replace one or both of the virtual surgical guide angle markings **260** and a virtual stop marking **26**. The virtual target markings **264**, however, might represent the "middle" of the tooth bud **130***b* within, for example, approximately 50%, 25%, and 10% of the average diameter of the tooth bud **120**. This information could be helpful to the operator. The operator may be alerted that the ablation probe tip **232** is not at the proper position using, for example, visual indicators (e.g. lights on the display **240**, warning messages on the display **240**, or lights on the hand piece **234** or ablation probe tip **232**), audible indicators (e.g. buzzing or an audible warning message), tactile indicators (e.g. the vibrating of the hand piece **234**), or a combination thereof.

The sensored hand piece **234** and/or ablation probe tip **232** overlapped on the patient X-ray volume scan on the display **240** and the indicators **250**, **252** and/or markings **260**, **262**, **264** thereon are the major components of a preferred implementation of the virtual stent system in a TBA procedure or with the TBA system. Some versions of the virtual TBA system do not include any physical stent **110**, because the virtual stent system guides the sensored hand piece **234** and/or ablation probe tip **232** so that the center of ablation **130***a* is placed into the middle of the tooth bud **130***b*.

In a TBA procedure, the virtual stent system may be operated manually, automatically (e.g. computer controlled), or a combination thereof. The sensored hand piece **234** in an automatic system (or a combination system) may be part of a robotic system that physically manipulates the physical sensored hand piece **234** and/or ablation probe tip **232**. The automatic system (or a combination system) may also control the generator **104** as described herein. If the system is being operated manually, the system acts as a failsafe in that it may automatically control or have override control of the status (making the system inactive) of the virtual stent system such that if the center of ablation **130***a* is not in the middle of the tooth bud **130***b*, the system will not allow ablation or will cease ablation if the center of ablation **130***a* moves out of the middle of the tooth bud **130***b* (or if any other problem is sensed). On the other hand, if the system is being operated automatically, the operator acts as a failsafe in that he may manually control or have override control of the status (making the system inactive) of the virtual stent system such that if the center of ablation **130***a* is not in the middle of the tooth bud **130***b*, the system will not allow ablation or will cease ablation if the center of ablation **130***a* moves out of the middle of the tooth bud **130***b* (or if he sees any other problem).

For most of the specific steps set forth below, the operator may watch the step being performed on the display **240** as he manually (physically) manipulates the sensored ablation probe tip **232** to perform the step. In such a case, the system would monitor the progress and alert the operator if there was a problem (e.g. the ablation probe tip **232** is not at the proper pre-defined angle) using, for example, visual indicators, audible indicators, tactile indicators, or a combination thereof. As set forth, during manual operation the system may automatically override the status (making the system inactive) to prevent ablation or further ablation if there is any problem (e.g. if the center of ablation **130***a* moves out of the middle of the tooth bud **130***b*). On the other hand, the operator may monitor the step being performed on the display **240** as the automatically controlled sensored ablation probe tip **232** performs the step automatically (e.g. using a robotics system). As set forth, the operator may manually override the status (making the system inactive) to prevent ablation or further ablation if there is any problem (e.g. if the center of ablation **130***a* moves out of the middle of the tooth bud **130***b*).

As shown in FIG. **40**, the following steps are exemplary steps in a TBA procedure using the virtual stent system.

Parameter Setting Step **300**: The ablation probe properties (center of ablation, diameter, length, power output properties, etc.) are programmed into the virtual guide software along with the patient's specific ablation parameters (size of tooth bud, power setting, time to ablate, etc). These ablation probe properties are used in steps such as the guiding step and the ablating step. These properties may be obtained using a procedure similar to that shown in FIG. **12** and discussed herein. The major difference between the procedure of FIG. **12** and one used to calculate the parameters for the TBA procedure using the virtual stent system is that the virtual system would not necessarily require the production of a physical stent, but would instead need the calculation of the virtual surgical guide angle markings **260**, a virtual stop marking **262**, and/or virtual target markings **264** to be displayed on the display **240**.

Calibrating Step **302**: As set forth above, the sensored hand piece **234** and/or ablation probe tip **232** is represented overlapped on the patient X-ray volume scan on the display **240**. In a perfect world, this step would be optional. In the real world, however, an operator would want to verify that the representation of the sensored hand piece **234** and/or ablation probe tip **232** is in the proper position relative to the patient's mouth. This may be accomplished using visual checks such as the operator positioning the physical absolute tip of the ablation probe tip **232** in relation to a known physical point of the patient's mouth. This may be, for example, an easily recognizable point on one of the patient's erupted teeth. The operator then confirms that the virtual absolute tip of the ablation probe tip **232** is in the same relationship with the same point of the patient's mouth shown on the patient X-ray volume scan on the display **240**. If these do not match, appropriate adjustments may be made.

Anesthetizing Step **304**: The patient is anesthetized using the sensored ablation probe tip **232** or a sensored specialized anesthetic tip (similar to the one shown and discussed in relation to FIG. **26** and having sensors thereon). The virtual stent system may be used as the visual guide (e.g. virtual surgical guide angle markings **260**, a virtual stop marking **262**, and/or virtual target markings **264**) for separately inserting the anesthetic needle and recommending the placement of the needle in the middle of the tooth bud. The sensored anesthetic needle may be of a known length and may be displayed on the display **240** in order to place the sensored anesthetic needle in the middle of the tooth bud **130***b* so as to provide "virtual guided anesthesia" into the tooth bud **120**. When the system indicates that the anesthetic needle is properly placed, the anesthetic is administered manually or automatically. The monitoring and override safeguards are preferably used in this step, although damage caused by incorrect placement of the sensored anesthetic needle would be relatively minor.

Introducing Step **306**: In this step the sensored ablation probe tip **232** is introduced to the tooth bud **120**. The operator may watch the insertion process on the display **240** as he physically manipulates the sensored ablation probe tip **232**. Alternatively, the operator may monitor the insertion process on the display **240** as the sensored ablation probe tip **232** is inserted automatically (e.g. using a robotics system). The introducing step may be implemented as a single step if the sensored ablation probe tip **232** is self-introducing. Alternatively, the introducing step may be implemented in two steps if the sensored ablation probe tip **232** is not self-introducing. The two steps would gain access to the tooth bud **120** through the stent surgical guides **112** by creating (introducing) a small surgical access path opening through the gingival tissue **122** approximately 0.1 mm to 2.0 mm (and more particularly 0.5 mm to 1.0 mm) in diameter using sensored tissue trocars or other sharp tools. Then, there is the actual step of introducing the non-self-introducing sensored ablation probe tip **232**. The monitoring and override safeguards described herein are preferably used in this step.

Guiding Step **308**: In this step the sensored ablation probe tip **232** is guided by the virtual surgical guide angle markings **260** (FIG. **39**) and the virtual stop marking **262** (FIG. **39**) to a position in which the effective center of ablation **130***a* of the ablation probe tip is in the middle of the tooth bud **130***b*. The operator may watch the insertion process on the display **240** as he physically manipulates the sensored ablation probe tip **232**. The virtual target markings **264** (FIG. **39**) may also provide an indication that the sensored ablation probe tip **232** is within approximately 50%, 25%, and 10% of the average diameter of the tooth bud **120**. The position indicator **250** (FIGS. **37** and **38**) provide even more accurate data as to the positioning of the effective center of ablation **130***a* of the ablation probe tip relative to the middle of the tooth bud **130***b*. If the operator were manually manipulating the sensored ablation probe tip **232**, the system would monitor the progress and alert the operator that the ablation probe tip **232** is not at the proper position using, for example, visual indicators, audible indicators, tactile indicators, or a combination thereof. Alternatively, the operator may monitor the progress on the display **240** as the sensored ablation probe tip **232** is inserted automatically (e.g. using a robotics system). The monitoring and override safeguards described herein are preferably used in this step.

Readying Step: Visual indications on the display **240** (and possibly audible or tactile indications) are used to indicate that the effective center of ablation **130***a* of the ablation probe tip is properly positioned relative to the middle of the tooth bud **130***b*. Such visual indications may include the position indicator **250** reaching a proper number (this may be based on pre-determined tolerances that may be programmed into the system with the other parameters). Other visual indicators could be color changes, flashing, or text (e.g. "ready to ablate") on the visual display **240**. The operator may also have to provide a "ready input" indicating that he has independently verified the ready condition and is authorizing the ablation.

Ablating Step **312**: When both the operator and the system are "ready" the ablation may be triggered and ablation means **104'** is delivered through the properly positioned ablation probe tip **232** to middle of the tooth bud **130***b*. The monitoring and override safeguards described herein may be used and may allow either the system (automatic) or the operator (manual) to cease ablation for any reason. During ablation, a visual indicator (e.g. a countdown reading based upon the programmed parameters) or other indicators preferably provide constant feedback to the operator about the ablation progress. The system preferably delivers the correct ablation energy level for the size of the tooth bud by actively measuring the energy being input (a closed loop system) and continuously correcting the physical position of the effective center of ablation **130***a* of the ablation probe tip relative to the middle of the tooth bud **130***b*. The monitoring and override safeguards described herein are preferably used in this step.

Completing Step **314**: Based on constant monitoring and feedback pertaining to the tooth bud and surrounding tissues, the ablation process, the system itself, and/or the pre-determined parameter settings and/or treatment time settings, the operator or the system may cease the delivery of ablation means **104'** to the middle of the tooth bud **130***b*. The ablation probe tip **232** may then be removed. The monitoring and override safeguards described herein are preferably used in this step.

It should be noted that the order of these steps is meant to be exemplary and is not meant to be limiting. For example, the parameter setting step **300** may be performed before or after the calibrating step **302** and/or anesthetizing step **304**. Similarly, the calibrating step **302** may be performed before or after the anesthetizing step **304**. Also, some of the steps are optional or may be performed separate from the TBA procedure. For example, if the patient was anesthetized for another procedure, the anesthetizing step **304** would not be necessary.

Alternative Procedures and Systems

Separate preferred surgical procedures preferably include the ablation of "non-tooth" bud lesions or tumors of the maxilla or mandible. In such a situation, a custom stent would be manufactured or fabricated with guides to guide an ablation probe tip **108** to such a lesion or tumor located at least one lesion or tumor surgical site. The process could then be used to ablate such lesion or tumor.

Separate TBA surgical procedures preferably include the use of ultrasound scanning with combined ultra-high energy ultrasound ablation but without the use of a surgical stent for transgingival tooth bud ablation that results in tooth agenesis. This can be described as direct ultrasound scanning with ultra-high energy ultrasound built into the same scanning head.

Comparison to the Silvestri Study

As set forth in the Background section of this document, the article entitled "Selectively Preventing Development Of Third Molars In Rats Using Electrosurgical Energy" by Silvestri et al. describes a pilot study that tests the hypothesis that third molars can be selectively prevented from developing. The results of the Silvestri study were mixed at best, with only ten rats out of thirty-three showing the desired result of no intraoral or radiographic evidence of third molar development. One reason that the Silvestri process was not successful may have had to do with the fact that the Silvestri process was inexact. For example, the Silvestri process relied on molds taken from molds of the mouths of euthanized rat pups rather than using molds fabricated for the rat pup on which the procedure was to be performed. The present invention uses the patient's mouth on which the procedure is to be performed. Another way in which the Silvestri process was inexact was that the Silvestri process did not locate the forming tooth bud **120**. More specifically, the Silvestri process did not locate or determine the location of the forming tooth bud **120** pre-operatively relative to the landmarks that he used. Silvestri even states " . . . when electrosurgical energy is applied near the invisible tooth anlage in the tiny mouth of newborn rats, the effects of the electrosurgical energy cannot be nearly as local or precise. The embryonic tooth-forming tissues of the third molar [lay] fractions of a millimeter below the oral mucosa and cannot be seen. As a result, it was not possible to predictably protect and isolate the vulnerable developing bone from the energy and heat of the electrosurgical energy. The result was a relatively large, unpredictable area of tissue damage during treatment and a wide range of bony developmental effects seen after the rats were euthanized." The TBA procedure **70** described herein can be distinguished from the Silvestri procedure in several ways including for example, that (1) the TBA procedure **70** described herein is a minimally invasive procedure consisting of introducing a surgical access path at each tooth bud surgical site as opposed to the boring, killing, and damaging procedure described by Silvestri, (2) the TBA procedure **70** described herein is performed in such a manner that it can be described as exact (e.g. using the patient's mouth as the mold for manufacturing or fabricating the surgical stent **110**, taking exact measurements of the patient's mouth (including the position of the tooth bud **120**), and using calculated parameter and time settings **105***b*) as opposed to the Silvestri procedure that can be described as inexact, and (3) the TBA procedure **70** described herein can predictably ablate tooth buds **120** as opposed to the Silvestri procedure that was essentially unpredictable and could never, under any circumstances, be considered for treating human patients.

Flow Charts

FIGS. **4**, **11**, **12**, and **40** are flow charts illustrating processes, methods, and/or systems. It will be understood that at least some of the blocks of these flow charts, components of all or some of the blocks of these flow charts, and/or combinations of blocks in these flow charts, may be implemented by software (e.g. coding, computer program instructions, software programs, subprograms, or other series of computer-executable or processor-executable instructions), by hardware (e.g. processors, memory), by firmware, and/or a combination of these forms. As an example, in the case of software, computer program instructions (computer-readable program code) may be loaded onto a computer (or on a special purpose machine such as a volume scanner or scanning technology) to produce a machine, such that the instructions that execute on the computer create structures for implementing the functions specified in the flow chart block or blocks. These computer program instructions may also be stored in a memory that can direct a computer to function in a particular manner, such that the instructions stored in the memory produce an article of manufacture including instruction structures that implement the function specified in the flow chart block or blocks. The computer program instructions may also be loaded onto a computer (or on a special purpose machine such as a volume scanner or scanning technology) to cause a series of operational steps to be performed on or by the computer to produce a computer implemented process such that the instructions that execute on the computer provide steps for implementing the functions specified in the flow chart block or blocks. The term "loaded onto a computer" also includes being loaded into the memory of the computer or a memory associated with or accessible by the computer (or on a special purpose machine such as a volume scanner or scanning technology). The term "memory" is defined to include any type of computer (or other technology)-readable media including, but not limited to, attached storage media (e.g. hard disk drives, network disk drives, servers), internal storage media (e.g. RAM, ROM), removable storage media (e.g. CDs, DVDs, flash drives, memory cards, floppy disks), and/or other storage media known or yet to be discovered. The term "computer" is meant to include any type of processor, programmable logic device, or other type of programmable apparatus known or yet to be discovered. Accordingly, blocks of the flow charts support combinations of steps, structures, and/or modules for performing the 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 comprising a display and a virtual stent displayed thereon, said virtual stent for use in a tooth bud ablation procedure that results in tooth agenesis, said tooth bud having a middle, said virtual stent for use with 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, said system comprising:

(a) at least one volume scan being displayed on said display;

(b) a real-time representation of said movement sensored ablation probe tip being displayed on said display;

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

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

wherein said center of ablation substantially coincides with or overlaps with said middle of 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**, said pre-defined angle being a three-dimensional angle.

3. The system of claim **1**, said virtual stent for use with a movement sensored hand piece connectable to said connection end of said movement sensored ablation probe tip, a representation of said movement sensored hand piece being displayed on said display.

4. The system of claim **1**, a real time relationship between said center of ablation as compared to said middle of said tooth bud being displayed on said display.

5. The system of claim **1**, said stop information being provided by at least one indicator selected from the group consisting of:

(a) a visual indicator;

(b) a visual indicator and an audible indicator;

(c) a visual indicator and a tactile indicator; and

(d) a visual indicator, an audible indicator, and a tactile indicator.

6. The system of claim **1**, said pre-defined angle being based on information obtained from a volume scan image.

7. The system of claim **1**, said pre-defined depth being based on information obtained from a volume scan image.

8. The system of claim **1**, said real-time representation of said movement sensored ablation probe tip being overlaid on said at least one volume scan displayed on said display.

9. The system of claim **1**, said real-time representation of said movement sensored ablation probe tip and said at least one virtual surgical guide angle marking being overlaid on said at least one volume scan displayed on said display.

10. The system of claim **1**, said real-time representation of said movement sensored ablation probe tip and said at least one virtual stop marking being overlaid on said at least one volume scan displayed on said display.

11. The system of claim **1**, said real-time representation of said movement sensored ablation probe tip, said at least one virtual surgical guide angle marking, and said at least one virtual stop marking being overlaid on said at least one volume scan displayed on said display.

12. The system of claim **1** further comprising at least one virtual target marking being displayed on said display, said at least one virtual target marking providing an indication of the location of said middle of said tooth bud.

13. The system of claim **1**, at least one virtual target marking being displayed on said display, said at least one virtual target marking providing an indication of the location of said middle of said tooth bud, said at least one virtual target marking being overlaid on said at least one volume scan displayed on said display.

14. The system of claim **1**, said center of ablation being between said insertion end and said connection end.

15. The system of claim **1**, said at least one volume scan being at least one three-dimensional volume scan.

16. The system of claim **1**, said at least one volume scan being of a volume scan of a specific patient on which a procedure is being performed.

17. The system comprising a display and a virtual stent displayed thereon of claim **1**, said at least one volume scan being selected from the group of volume scans consisting of:

(a) at least one computed tomography volume scan;

(b) at least one computed tomography volume scan created using a scanning technology;

(c) at least one computed tomography volume scan created using computed tomography volume scanning; and

(d) at least one computed tomography volume scan created using MRI volume scanning.

18. A tooth bud ablation method for ablating a tooth bud using a virtual stent on a display, said tooth bud having a middle, 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, a representation of said movement sensored ablation probe tip being displayable on said display;

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

(c) providing at least one virtual surgical guide angle marking, displaying said at least one virtual surgical guide angle marking overlaying said at least one volume scan on said display, said at least one virtual surgical guide angle marking providing angle guidance to guide said movement sensored ablation probe tip at a pre-defined angle; and

(d) providing at least one virtual stop marking, displaying said at least one virtual stop marking overlaying said at least one volume scan on said display, said at least one virtual stop marking 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, the introduction being displayed in real time on said display as said representation of said movement sensored ablation probe tip overlaid on said at least one volume scan;

(f) using said at least one virtual surgical guide angle marking and said at least one virtual stop marking, guiding said movement sensored ablation probe tip towards the position where said center of ablation substantially coincides with or overlaps with said middle of said tooth bud, the guidance being displayed in real time on said display as said representation of said movement sensored ablation probe tip overlaid on said at least one volume scan; and

(g) using ablation means, ablating said tooth bud when said center of ablation substantially coincides with or overlaps with said middle of said tooth bud.

19. The method of claim **18**, wherein said step of ablating results in tooth agenesis.

20. The method of claim **18** further comprising the step of setting parameters to be used for guiding said movement sensored ablation probe tip and for ablating said tooth bud.

21. The method of claim **18** further comprising the step of calibrating said display and said movement sensored ablation probe tip so that said movement sensored ablation probe tip is properly represented on said display.

22. The method of claim **18** further comprising the steps of:

(a) introducing a sensored anesthetic needle to said tooth bud, the introduction being displayed in real time on said display;

(b) using said at least one virtual surgical guide angle marking and said at least one virtual stop marking, guiding said sensored anesthetic needle towards said middle of said tooth bud, the guidance being displayed in real time on said display; and

(c) anesthetizing said tooth bud when said sensored anesthetic needle reaches said middle of said tooth bud.

23. The method of claim **18** further comprising the step of providing visual indications on said display to indicate that center of ablation substantially coincides with or overlaps with said middle of said tooth bud.

24. The method of claim **18** further comprising the step of providing audible indications on said display to indicate that center of ablation substantially coincides with or overlaps with said middle of said tooth bud.

25. The method of claim **18** further comprising the step of providing tactile indications on said display to indicate that center of ablation substantially coincides with or overlaps with said middle of said tooth bud.

26. The method of claim **18**, during said step of ablating said tooth bud, monitoring progress of the ablating.

27. The method of claim **18**, during said step of ablating said tooth bud, monitoring progress of the ablating, and providing constant feedback pertaining to said progress.

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

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

30. The method of claim **18** further comprising the step of ceasing the delivery of ablation means.

31. The method of claim **18** further comprising the step of displaying at least one virtual target marking being displayed on said display, said at least one virtual target marking providing an indication of the location of said middle of said tooth bud.

32. The method of claim **18**, said step of providing at least one volume scan further comprising the step of taking at least one three-dimensional volume scan.

33. The method of claim **18**, said step of providing at least one volume scan further comprising the step of taking a volume scan of a specific patient on which a procedure is being performed.

34. The method of claim **18**, said step of providing at least one volume scan further comprising at least one step selected from the group of:

(a) taking at least one computed tomography volume scan;

(b) taking at least one computed tomography volume scan using a scanning technology;

(c) taking at least one computed tomography volume scan using computed tomography volume scanning; and

(d) taking at least one computed tomography volume scan using MRI volume scanning.

35. The method of claim **18** further comprising the step of preventing activation until said center of ablation substantially coincides with or overlaps with said middle of said tooth bud.

36. A system comprising a display and a virtual stent displayed thereon, said virtual stent for use in a tooth bud ablation procedure that results in tooth agenesis, said tooth bud having a middle, said virtual stent for use with 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, said system comprising:

(a) at least one volume scan being displayed on said display, said at least one volume scan being of a volume scan of a specific patient on which a procedure is being performed;

(b) a real-time representation of said movement sensored ablation probe tip being displayed on said display, said real-time representation of said movement sensored ablation probe tip being overlaid on said at least one volume scan displayed on said display;

(c) at least one virtual surgical guide angle marking being displayed on said display, said at least one virtual surgical guide angle marking providing angle guidance to guide said movement sensored ablation probe tip at a pre-defined angle, said at least one virtual surgical guide angle marking being overlaid on said at least one volume scan displayed on said display; and

(d) at least one virtual stop marking being displayed on said display, said at least one virtual stop marking providing stop information to limit the depth of said movement sensored ablation probe tip to a pre-defined depth, said at least one virtual stop marking being overlaid on said at least one volume scan displayed on said display;

wherein said center of ablation substantially coincides with or overlaps with said middle of said tooth bud when said movement sensored ablation probe tip is guided at said pre-defined angle to said pre-defined depth.

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