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(71) Applicant *(for all designated States except US)*: **MASSACHUSETTS EYE & EAR INFIRMARY** [US/US]; 243 Charles Street, Boston, Massachusetts 02114 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **GLIKLICH, Richard, E.** [US/US]; 10 Nobscot Road, Weston, Massachusetts 02493 (US). **WHITE, William, Matthew** [US/US]; 756 East 3rd Street, Apt. 1, South Boston, Massachusetts 02127 (US).

(74) Agents: **OCCHIUTI, Frank, R.** et al.; Fish & Richardson PC, PO Box 1022, Minneapolis, MN 55440-1022 (US).

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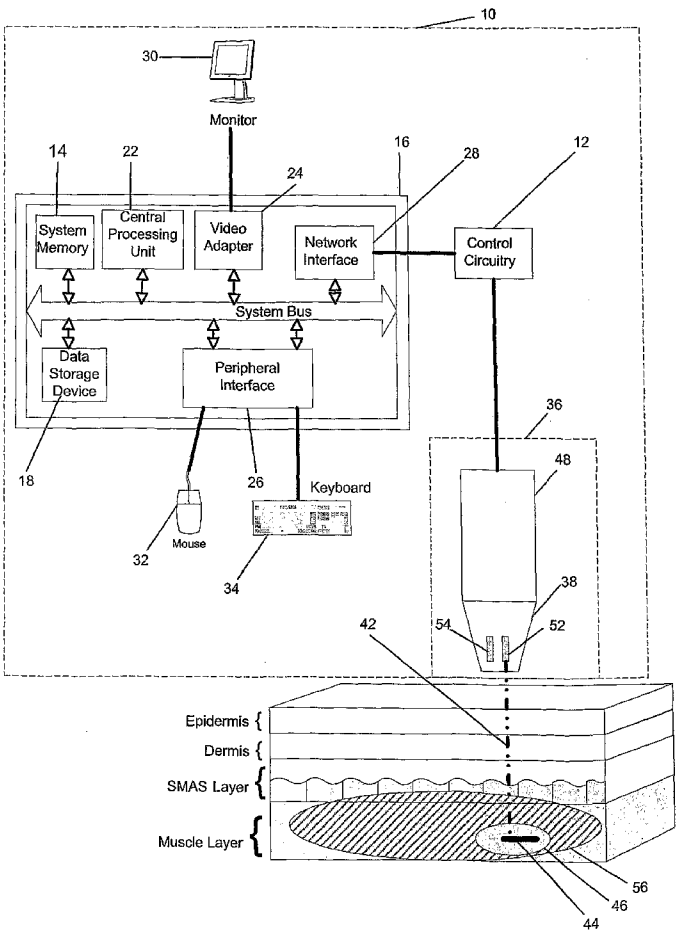
(54) Title: TARGETED MUSCLE ABLATION FOR REDUCING SIGNS OF AGING



(57) Abstract: A method and system for delivering energy to affect the signs of aging is described. Energy is delivered to a target volume of a muscle such that the energy creates a lesion in the target volume. A characteristic of the lesion is controlled to affect movement of the muscle.

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TARGETED MUSCLE ABLATION FOR REDUCING SIGNS OF AGING

TECHNICAL FIELD

This invention relates to medical applications of ultrasound, and more particularly to using ultrasound to reduce wrinkles and sagging skin.

CROSS-RELATED APPLICATION

Under 35 U.S.C. 119(e)(1), this application claims the benefit of provision application serial number, 60/705,030, filed August 3, 2005, and entitled, "Transcutaneous Delivery of Ultrasound for Reducing Signs of Aging."

BACKGROUND

As a person ages, the skin, underlying connective tissue, and muscle undergo changes that result in wrinkles and sagging skin. These changes occur all over the body but are often most noticeable in the face.

Current methods for reducing wrinkles and tightening sagging skin include surgical procedures, such as rhytidectomy (i.e., a face lift), brow lifts, and blepharoplasty (i.e., eyelid surgery), botulinum toxin injection, and skin resurfacing techniques (e.g., chemical peels).

Surgical procedures for tightening sagging skin usually involve making an incision in the skin and underlying layers, elevating the skin and soft tissue, and stretching the underlying muscle and membrane layers to a desired level of tightness. The amount by which sagging skin may be tightened is often limited by the underlying elasticity of the muscle and membrane layers and the degree to which these layers relax after surgery.

Surgical procedures for reducing wrinkles involve selectively destroying muscles, or parts of muscles that primarily contribute to the formation of wrinkles. Selective muscle destruction may be performed openly or endoscopically; however, both techniques require direct visualization of the muscle groups and employ invasive procedures, such as avulsion, incision, and direct cautery for removing portions of

muscle. Because of their invasive nature, surgical procedures often require prolonged recovery time, and put patients at risk for potential complications, such as hematoma.

Botulinum toxin injection reduces wrinkles by temporarily paralyzing muscles whose movement causes skin to wrinkle. Patients may have variable responses to an injection of the same dosage depending on patient factors that are not determinable prior to injection. Because the effects of an injection are temporary, repeated injections are typically needed every four to six months to maintain a desired result. Furthermore, when the toxin is applied to the forehead and brow, the resulting muscle paralysis may cause brow ptosis and/or a noticeable loss of facial animation.

Skin resurfacing techniques include delivery of energy to layers of the skin including the epidermis and dermis using lasers, chemical agents, and radiofrequency delivery devices. These techniques often have limited penetration depth and therefore are limited to treating superficial layers of the skin. Some skin resurfacing techniques may cause uneven pigmentation in the skin. Although these techniques may improve the texture of the skin, they often do little to tighten sagging skin and to reduce wrinkles.

SUMMARY

The invention provides methods and systems for reducing signs of aging.

In one aspect, the invention features a method that includes producing a map of a muscle; locating a target volume of the muscle using the map; and delivering energy to the target volume such that the energy creates a lesion in the target volume, the lesion having a characteristic selected for affecting movement of the muscle.

In another aspect, the invention features a method that includes producing a map of SMAS tissue; locate a target volume of the SMAS tissue using the map; and delivering energy to the target volume such that the energy creates a lesion in the target volume, the lesion having a characteristic selected for affecting movement of the SMAS tissue.

In a further aspect, the invention features a method that includes producing a map of target tissue including muscle and SMAS tissue; locating a target volume of the target tissue using the map; delivering energy to the target volume such that the energy creates a pattern of lesions in the target volume; and selecting the pattern to impact the degree and direction of movement of the target tissue.

In another aspect, the invention features a system that includes an ablating transducer configured to deliver ablative radiation (e.g., ultrasound) at a power sufficient to ablate muscle tissue; and control circuitry in communication with the ablating transducer. The control circuitry is configured to receive lesion pattern specifications (e.g., size and depth specifications of the lesions of a pattern) and stimulate the ablating transducer to produce a pattern of lesions within the target volume. The pattern is produced in accordance with the lesion pattern specifications and selected to impact a degree of paralysis of a muscle.

Embodiments may include one or more of the following. The characteristic may be one of a size, a shape, an orientation, a depth below an epidermal surface, and a location relative to another lesion. The characteristic may be selected to reduce movement of the muscle and/or produce a contraction of the muscle. The characteristic may be selected to induce contraction of the SMAS tissue in a desired direction. For example, the characteristic may be selected to release the SMAS tissue from muscle tissue causing skin attached to the SMAS tissue to be pulled in a desired direction.

The pattern of lesions may be selected to impact the degree and direction of movement of SMAS tissue. For examples, the pattern of lesions may be one of: a square, triangle, polygon, grid, criss-cross pattern, circle, oval, and coil. The pattern may also be a matrix of lesions (e.g., each approximately $1mm^3$ in volume) spaced approximately equidistant from each other (e.g., such that the spacings between the lesions are approximately 1mm). The density of the lesions of the pattern may be selected to achieve a desired degree of contraction of the SMAS tissue within the target volume. Furthermore, the spacings between the lesions of a pattern may be selected to achieve a desired degree of paralysis of the muscle tissue within the target volume.

The delivered energy may be ultrasound or radio frequency electromagnetic energy. For example, the energy may be ultrasound having a frequency within a range of 4 to 8 MHz and a power within a range of 60 to 80W. A map of a target tissue may be obtained by acquiring an echo image from echoes generated by reflections of ultrasound pulses directed towards the target tissue.

The imaging transducer may be configured to deliver ultrasound radiation at a power sufficient to produce an echo image of a target volume of tissue without damaging tissue within the target volume.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described below. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety. In case of conflict, the present specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

Other features and advantages of the invention will be apparent from the following detailed description, and from the claims, in which

DESCRIPTION OF DRAWINGS

FIG. 1 shows a block diagram of a system for ablating tissue using ultrasound;

FIG. 2 is a flow chart of a process for ablating tissue using the system shown in **FIG. 1**;

FIG. 3 shows exemplary lesion placements and orientations;

FIG. 4 shows an image of lesions produced on a temporalis muscle; and

FIG. 5 shows an image of lesions produced on a porcine muscle.

DETAILED DESCRIPTION

FIG. 1 shows a block diagram of an ultrasound delivery system **10** for ablating a target volume **44** of muscle tissue within a muscle **56**. In some embodiments, the muscle **56** is located in the face. Examples of the muscle **56** include the corrugator, procerus, and frontalis muscles of the brow and forehead. The muscle **56** is located beneath a connective tissue layer called the superficial musculo-aponeurotic system (SMAS) layer. The SMAS layer envelopes underlying muscles (e.g., platysma muscle in the neck and frontalis muscle in the forehead), including the muscle **56**, and is tethered to the overlying

dermis and epidermis layers of the skin. The SMAS layer includes a portion of muscle **56**. When the muscle **56** contracts, the resultant pull of the SMAS layer on the skin produces visible facial expressions and causes the skin to wrinkle. Repeated contraction of the muscle **56** produces wrinkles in the skin. Over time, gravity causes the SMAS layer to loosen and this leads to more pronounced wrinkles and sagging skin. In some embodiments, ultrasound delivery system **10** ablates a target volume **44** of connective tissue located within the SMAS layer, rather than a target volume **44** of muscle **56**, causing the SMAS tissue to contract in a desired direction.

The ultrasound delivery system **10** includes an ultrasound applicator **36** for imaging the muscle **56** and for delivering ablating ultrasound radiation **42** ("ablating radiation") to the target volume **44**. The ablating radiation **42** heats the tissue in the target volume **44** until a finite volume of that tissue coagulates and forms a lesion **46**. The ultrasound delivery system **10** also includes control circuitry **12** for controlling the ablating radiation **42** emitted from the ultrasound applicator **36**, a computer **16** that transmits control commands to and receives data from the ultrasound applicator **36** via the control circuitry **12**, a monitor **30** for displaying images of the muscle **56**, and a mouse **32** and keyboard **34** for entering commands into the computer **16**.

The computer **16** includes a data storage device **18**, such as a hard drive, for storing images of the muscle **56**, system memory **14**, such as random-access memory (RAM), for loading software programs that perform image processing and ablation control functions, and a central processing unit **22** for executing software instructions stored in the system memory **14**. The computer **16** also includes a video adapter **24** that interfaces the monitor **30**, a peripheral control interface **26** for receiving signals from the mouse **32** and the keyboard **34**, and a network interface **28** for transmitting signals between the computer **16** and the control circuitry **12**. In some embodiments the network interface **28** is a serial port, a parallel port, a universal-bus (USB) interface, or a peripheral component interface (PCI). In other embodiments, the control circuitry **12** is integrated within the computer **16**.

The ultrasound applicator **36** includes a handle **48** and a probe tip **38** that is removably attached to the applicator handle **48**. The probe tip **38** includes an ablating transducer **52** and an imaging transducer **54**. The ablating transducer **52** emits high-

power ultrasound radiation (i.e., ablating radiation **42**) for ablating muscle tissue. The imaging transducer **54** emits low-power ultrasound radiation (hereinafter referred to as "imaging radiation") for producing an echo image of the muscle **56** without damaging any tissue. The imaging transducer **54** detects the echoes of the imaging radiation after it bounces off the muscle **56**. During ablation, the control circuitry **12** receives a control signal from the computer **16** and produces an electrical signal as a response. The electrical signal in turn stimulates the ablating transducer **52** to produce ablating radiation **42**. The ablating radiation **42** is then emitted from the probe tip **38** with a fixed frequency and power. In some embodiments, the applicator **36** is configured to lay down a pattern of multiple lesions simultaneously or sequentially. An example of such a pattern is a line of five $1mm^3$ lesions spaced 1mm apart from each other.

The probe tip **38** is selected from a set of interchangeable probe tips having different frequency and power output specifications. The frequency of the ablative radiation **42** limits how deep within the tissue a lesion **46** can be formed; and the power of the ablative radiation **42** affects the size of the lesion **46**. The frequency and power output specifications of the probe tip **38** are selected to produce a lesion **46** of a determined size and depth. If the size and depth specifications of the lesion **46** change such that the frequency and power specifications of the probe tip **38** are no longer sufficient to produce lesions with the new size and depth specifications, the probe tip **38** is replaced with another probe tip **38** that has sufficient power and frequency specifications. In some embodiments, some of the interchangeable probe tips produce different patterns of lesions. Examples of lesion patterns include squares, triangles, polygons, grids, and criss-cross patterns. Examples of grid patterns (also referred to as "matrix patterns") include a two- or three-dimensional grid of approximately equally spaced lesions in which the spacings between lesions is approximately equal to a dimension of the lesion. In one such grid pattern, the volumes of the lesions are approximately $1mm^3$ and the spacings between lesions are approximately 1mm. In another grid pattern the spacings between lesions are approximately1.5 to 2.0 mm. In further grid patterns the volumes of lesions may be greater than or less than $1mm^3$ and the spacings between the lesions may be greater than or less than 1mm. The pattern specifications (e.g., lesion sizes and spacings) are selected such that distinct lesions

separated by a sufficient amount of living tissue can be produced. The patterns of lesions affect the degree to which the movement and tone of the muscle **56** is reduced.

In other embodiments, the applicator **36** is used only for ablating tissue, and a separate imaging device (not shown) is provided for imaging the muscle **56**. In these embodiments, the separate imaging device, rather than the applicator **36**, includes an imaging transducer **54**. In further embodiments, the power and frequency of the ultrasound radiation produced by the ablating transducer **52** may be electronically adjusted by varying the electrical signal produced by the control circuitry **12**. Thereby enabling ablating transducer **52** to alternately transmit ablating radiation **42** and imaging radiation. Furthermore, if a lesion pattern is specified at the computer **16**, the computer **16** sends the lesion pattern specifications to the control circuitry **12**, which in turn stimulates the transducers in the applicator **36** to direct the ablating radiation **42** such that the specified pattern of lesions is produced. In these embodiments, the probe tip **38** need not be interchanged with other probe tips when the frequency, power output, and / or pattern specifications change.

FIG. 2 shows a process **60** for ablating muscle tissue using the ultrasound delivery system **10**. An operator places the ultrasound applicator **36** in direct contact with the epidermis of the patient and positions the applicator **36** above the muscle **56**. For example, if the muscle **56** is the corrugator muscle, the applicator **36** is placed in contact with the patient's forehead. An echo image of the muscle **56** is produced using ultrasound echo imaging (step **62**). During imaging, the applicator **36** directs imaging radiation (e.g., ultrasound pulses) to the muscle **56** at a power level that avoids damage to tissue. The muscle **56** reflects these pulses, thereby causing echoes. The imaging transducer **54** receives the echoes and translates them into an electrical signal. The applicator **36** then sends this signal to the computer **16** for analysis. The central processing unit **22** analyzes the echo data carried by the signal, constructs an echo image of the muscle **56**, and displays that echo image on the monitor **30**. From the echo image, the operator identifies a target volume **44** in which to produce a lesion **46** (step **64**). The operator also identifies tissue surrounding the target volume **44**, such as nerves, that the ablating radiation **42** should avoid. The echo image includes a marker that represents the coordinates of the tissue being viewed in the image. The operator determines the location

of the target volume **44** shown in the image by placing the marker over or near the image of the target volume **44** (step **66**). Based on the coordinates of the target volume **44**, the operator determines the depth of the target volume **44** below the surface of the skin. This depth may vary depending on the thickness of the tissue and where it is located. For facial treatments, the target volume **44** is between approximately 2 mm and 12 mm below the surface of the skin. In some embodiments, a target volume **44** of muscle tissue in the forehead is between approximately 8 mm and 10 mm below the epidermal surface and a target volume **44** of muscle tissue around the eyes is between approximately (2 mm and 5 mm, although variable from person to person) below the epidermal surface. In other embodiments, such as for suspensory ligaments, muscle insertions, periosteal areas and others, the target volume **44** is as much as 2 cm below the epidermal surface.

The extent to which ultrasound radiation **42** can penetrate below the epidermal surface and still retain just enough power to ablate tissue (referred to as penetration depth) depends in part on the frequency of the ablative radiation **42**. Lower-frequency ultrasound generally penetrates more deeply than higher-frequency ultrasound. In some embodiments, higher frequency (e.g. 10 MHz) ultrasound is used for dermal treatment and lower frequency ultrasound (e.g. 4-8 MHz) is used for treating layers beneath the dermal layer. The frequency of the ultrasound is selected such that the penetration depth is greater than or equal to the depth of the target volume **44** below the epidermal surface.

In addition to the power, how long one ablates the target volume **44** affects the size of the lesion **46** produced within the target volume **44**. The probe tip **38** applies ablative radiation **42** as a series of pulses. The duration of each pulse in a series of applied pulses is referred to as "application time" and the time between pulses is referred to as "off time." In some embodiments, the off time is selected to be between150 and 200 ms to provide the target tissue sufficient time to cool between each pulse. Increasing the power and /or the application time increases the volume of the lesion **46**. The tissue density of the target volume **44** also affects how much power and application time is needed to produce a lesion **46** of a desired volume. In general, higher power and longer application times are needed to produce a lesion **46** of a given volume in denser tissues.

The power output, frequency, and application time of the ultrasound radiation **42** are selected based the depth of the target volume **44** below the epidermal surface and on

the density of the tissue within it (step **68**). In some embodiments, lesions between approximately $1mm^3$ and $5mm^3$ are produced by setting the frequency within a range of 4 to 8MHz, the power within a range of 10 to 100W, and the application time within a range of 5 to 1000ms. In some embodiments, the power of the ablative radiation **42** is selected to be within a range of 60 to 80W. When producing a grid pattern of lesions, the power, frequency, and application time of the ablative radiation 42 are selected to form distinct, non-overlapping, and non-contiguous lesions.

The power output, frequency, and application time may be determined from data acquired in human cadaver, animal, and clinical studies. Examples of a human cadaver and animal studies are described below in the Examples section. The data from various studies may be used to produce a table that stores optimal frequency, power, and application time settings for producing different combinations of lesion depths and volumes for various target muscles (e.g., corrugator and frontalis muscles). In some embodiments, a mathematical model, rather than a table, is used to determine an optimal set of frequency, power, and application time specifications given input values of lesion depth and volume for a given target muscle. The mathematical model may be based wholly or in part on human cadaver, animal, and clinical studies.

The operator selects a probe tip **38** that meets the selected frequency and power output specifications and that can produce lesions arranged in the selected pattern. Examples of three probe tips (P1, P2, and P3) and their specifications are shown below in Table 1.

Table 1

Probe tip	Frequency	Focus	Power	Application time	Total Energy
P1	7.5 MHz	3.0 mm	25-40 W	25-50 ms	0.5-1.2 J
P2	7.5 MHz	4.5 mm	25-50 W	25-50 ms	0.5-1.5 J
P3	4.4 MHz	4.5 mm	25-60 W	25-60 ms	0.5-2.0 J

The position of the marker specifies where a lesion will be placed on the tissue shown in the image. The computer **16** determines whether the operator has entered a command to begin ablation (step **70**). Upon receiving a command to begin ablation, the computer sends an ablation control signal to the control circuitry **12**, which in turn

stimulates the ablation transducer **54** in applicator **36** to ablate the target volume **44** for the specified application period (step **72**). The ultrasound radiation **42** is sufficient to produce a lesion of a desired volume within the target tissue volume **44** without damaging any surrounding tissue. The result of the ablation is an appropriately-sized lesion produced at the coordinates represented by the marker. In some embodiments, the result is a pattern of appropriately-sized lesions produced at the coordinates represented by the marker.

In some embodiments, in which the power and frequency of the ultrasound radiation **42** is adjusted electronically, the operator uses the same probe tip **38** even when the power and frequency specification changes. To change the power and frequency of the ultrasound radiation **42**, the computer **16** sends the power and frequency specifications to the control circuitry **12**, which in turn stimulates the transducers in the applicator **36** to produce ultrasonic radiation **42** having the specified power and frequency. In some embodiments, if a lesion pattern is specified at the computer **16**, the computer **16** sends the pattern specifications to the control circuitry **12**, which in turn stimulates multiple ablation transducers in the applicator **36** to direct the ultrasound radiation **42** such that the specified pattern of lesions is produced.

The ablation process **60** shown in **FIG. 2** can also be used to ablate target volumes of SMAS tissue. Lesions produced in the SMAS layer induce shrinkage of the fibrous layers within the affected SMAS tissue. As the fibrous layers shrink, the skin attached to the SMAS layer is pulled tighter. The patterns and /or orientation of the lesions may be varied to impact the direction and amount by which the skin is pulled. In some embodiments, the pulling action induced by a particular pattern is affected by characteristics of the skin and underlying tissue layers. Examples of these characteristics include thickness and elasticity. The lesion patterns that are best suited to produce a desired pulling affect given a particular skin characteristic are determined from cadaver and clinical studies. Based on these results, an optimal lesion pattern is selected. Examples of lesion patterns include squares, triangles, polygons, grids, criss-cross patterns, and other patterns of straight lines. In some embodiments, the lesions patterns include circles, ovals, coils, and other patterns of curved lines.

Lesions produced in SMAS or other connective tissues (e.g., periosteum) may be positioned to cause the connective tissues to release from the muscle tissue to which they are attached. For example, a non-invasive browlift could be performed by releasing SMAS or periosteum from muscles that pull the eyebrows downward. Releasing the SMAS or periosteum causes eyebrows to move upward because the frontalis muscles that pull the eyebrows upward are no longer opposed by the downward pulling muscles.

The ablation process **60** could also be used to reduce or remove unwanted fat from the face and other areas of the body.

FIG. 3 shows exemplary orientations of lesions **90a**, **90b**, **90c**, **90d**, and **90e** with respect to relaxed skin tension lines (RSTLs) **94a**, **94b**, **94c**, and **94d**. RSTLs **94a**, **94b**, **94c**, and **94d** are the natural skin lines and creases of the face and neck along which wrinkles and sagged skin tend to form. To tighten sagging skin and wrinkles, especially those formed along RSTLs **94a**, **94b**, **94c**, and **94d**, the lesions **90a**, **90b**, **90c**, **90d**, and **90e** are produced in the SMAS and muscle tissues. The lesions **90a**, **90b**, **90c**, **90d**, and **90e** are oriented approximately perpendicular to lines **92a**, **92b**, **92c**, **92d**, and **92e** that are tangential to the points on the RSTLs **94a**, **94b**, **94c**, **94d** at which lesions are to be produced.

EXAMPLES

The feasibility and performance of the tissue ablation process (**FIG. 2**) using the ultrasound-delivery system (**FIG. 1**) were tested using experiments on porcine and human cadaver tissues. In the human cadaver studies, energy was varied over a given set of source conditions to see which energy levels would produce selective muscle heating.

FIG. 4 shows a an image **100** of lesions produced on a temporalis (forehead) muscle of a human cadaver using ultrasound having a frequency of 4.4 MHz, a focal distance of 4.5 mm, a power of 80W. The ultrasound was applied as a series of pulses, each applied over a duration of approximately 60ms. In the image **100**, the locations of the lesions are marked with black arrows. The volumes of the lesions were measured to be approximately $1mm^3$. The depths of the lesions from the surface of the skin ranged between approximately 5 to 6mm. In the human studies that produced lesions within the

dermis, the energy of the applied ultrasound ranged between approximately 0.5 to 2 Joules. In some of the studies, an energy of 1.2 J was optimal for producing lesions having a desired volume of $1mm^3$.

FIG. 5 shows an image **110** of lesions produced on a cross-section of porcine muscle. The depths of the lesions beneath the surface of the skin are approximately 4mm. The lesions shown in image **110** are arranged as three dimensional grid of approximately equally spaced lesions, referred to as "matrix pattern." The volumes of the lesions are approximately $1mm^3$ and the spacings between lesions are approximately 1mm. The matrix pattern was formed by laying down successive rows of five lesions using an ultrasound applicator having focal distances of 4.5 and 7.5mm. The lesions of each row were produced simultaneously. The density of the lesions shown in image **110** is approximately 125 lesions per cm^3.

The pattern of lesions was shown to affect (1) the degree and direction of pull in SMAS tissue and (2) the degree of paralysis in muscle tissue. Delivering a larger number of lesions per given surface area allow a "volumetric effect" and was shown to induce a greater collagen contraction in SMAS tissue. When placed a sufficient distance apart, the lesions contract toward each other. Lesions between approximately $1\text{-}2mm^3$ and spaced approximately $1\text{-}2mm^3$ away from each other in a matrix pattern provided a desired effect of SMAS tissue shrinkage and muscle paralysis. The experiments suggest that a matrix pattern of lesions delivered to the facial musculature would produce a greater paralysis of the muscles than other types of patters. The experiments also suggest that increasing the density of lesions within a volume increases the amount of tissue contraction within that volume.

The experiments described above demonstrate the feasibility of transcutaneously targeting and subsequently ablating muscle tissue without damaging the overlying skin tissue. Unlike some conventional methods that direct energy at the skin, the tissue ablation process (**FIG. 2**) enables energy to be focused at a depth selectively in tissue to induce a desired effect (e.g., SMAS tissue shrinkage and/or muscle paralysis).

A number of embodiments of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. For example, the ultrasound delivery system **10** can be

modified to deliver ablating radiation **42** and imaging radiation in the form of electromagnetic energy, e.g., radiofrequency (RF) energy, rather than ultrasound.

In some embodiments, a needle is used to deliver the ablative energy percutaneously to the target volume **44**. The ablative energy may be in the form of electromagnetic radiation (e.g., radiofrequency) or ultrasound radiation or other modalities such as electrical current or laser energy. The needle is guided to the target volume **44** using ultrasound echo imaging as described above. The needle then delivers the ablative energy to the target volume **44** until a finite volume of tissue within the target volume coagulates and forms a lesion. In some embodiments, an array of needles carrying electricity is inserted through the skin and positioned within the target volume **44** of muscle. As current flows between needles, ohmic heating cauterizes the target volume **44** of muscle.

A needle, rather than ultrasound echo imaging, may be used to map the position of the target volume **44**. In some embodiments, a needle inserted into the muscle **56** carries current to nearby muscle that is either touching the needle or located close (i.e., within approximately 1 to 2mm depending on the amount of energy delivered) to the needle. The current stimulates activity in the muscle and nerve tissue. The computer **16** analyzes the activity in the muscle and nerve tissue and determines where the location of the needle relative to muscle and nerve tissue. As the needle moves, the computer **16** analyzes the muscle and nerve tissue activity and produces a map of the region that is traversed by the needle. The operator identifies the target volume **44** in the map and guides the needle to the target volume **44**.

Accordingly, these and other embodiments are within the scope of the following claims.

WHAT IS CLAIMED IS:

1. A method for reducing signs of aging, the method comprising:

producing a map of a muscle (56);

using the map, locating a target volume (44) of the muscle (56); and

delivering energy (42) to the target volume (44) such that the energy (42) creates a lesion (46) in the target volume (44), the lesion (46) having a characteristic selected for affecting movement of the muscle (56).

2. The method of claim **1**, further comprising selecting the characteristic to reduce movement of the muscle (56).

3. The method of claim **1**, further comprising selecting the characteristic to produce a contraction of the muscle (56).

4. The method of claims **1**, **2**, or **3**, wherein the characteristic comprises at least one of: a size, a shape, a depth below an epidermal surface, and a location relative to another lesion.

5. The method of claim **1**, wherein delivering energy (42) comprises selecting the energy (42) to be ultrasound.

6. The method of claim **1**, wherein delivering energy (42) comprises selecting the energy (42) to be radio frequency electromagnetic energy.

7. The method of claim **5**, further comprising:

selecting a frequency of the ultrasound to be a value within a range of 4 to 8 MHz; and

selecting a power of the ultrasound to be a value within a range of 60 to 80W.

8. The method of claim **1**, wherein producing a map of a muscle (56) comprises acquiring an echo image of the muscle (56) from echoes generated by reflections of ultrasound pulses directed towards the muscle (56).

9. A method for reducing signs of aging, the method comprising:

producing a map of SMAS tissue;

using the map, locate a target volume (44) of the SMAS tissue; and

delivering energy (42) to the target volume (44) such that the energy (42) creates a lesion (46) in the target volume (44), the lesion (46) having a characteristic selected for affecting movement of the SMAS tissue.

10. The method of claim **9**, further comprising selecting the characteristic to induce contraction of the SMAS tissue in a desired direction.

11. The method of claim **9**, further comprising selecting the characteristic to release the SMAS tissue from muscle tissue causing skin attached to the SMAS tissue to be pulled in a desired direction.

12. The method of claims **9**, **10**, or **11**, wherein the characteristic comprises at least one of: a size, a shape, an orientation, a depth below an epidermal surface, and a location relative to another lesion.

13. The method of claim **9**, wherein delivering energy (42) comprises selecting the energy (42) to be ultrasound.

14. The method of claim **9**, wherein delivering energy (42) comprises selecting the energy (42) to be radio frequency electromagnetic energy.

15. The method of claim **13**, further comprising:

selecting a frequency of the ultrasound to be a value within a range of 4 to 8 MHz; and

selecting a power of the ultrasound to be a value within a range of 60 to 80W.

16. The method of claim **9**, wherein producing a map of SMAS tissue comprises acquiring an echo image of the SMAS tissue from echoes generated by reflections of ultrasound pulses (42) directed towards the SMAS tissue.

17. A method for reducing signs of aging, the method comprising:

producing a map of target tissue including muscle (56) and SMAS tissue;

using the map, locating a target volume (44) of the target tissue;

delivering energy (42) to the target volume (44) such that the energy creates a pattern of lesions in the target volume (44); and

selecting the pattern to impact the degree and direction of movement of the target tissue.

18. The method of claim **17**, further comprising selecting the pattern to be one of: a square, triangle, polygon, grid, criss-cross pattern, circle, oval, and coil.

19. The method of claim **17**, further comprising selecting the pattern to be a matrix of lesions spaced approximately equidistant from each other.

20. The method of claim **19**, further comprising:

selecting the lesions to be approximately $1mm^3$ in volume; and

selecting spacings between the lesions to be approximately 1mm.

21. The method of claim **17**, wherein delivering energy (42) comprises selecting the energy (42) to be ultrasound.

22. The method of claim **17**, wherein delivering energy (42) comprises selecting the energy (42) to be radiofrequency electromagnetic energy.

23. The method of claims **17**, **18**, or **19**, wherein selecting the pattern to impact the degree and direction of movement of the target tissue comprises selecting a density of the lesions to achieve a desired degree of contraction of the SMAS tissue within the target volume (44).

24. The method of claim **17**, **18**, or **19**, wherein selecting the pattern to impact the degree and direction of movement of the target tissue comprises selecting spacings between the lesions to achieve a desired degree of paralysis of the muscle tissue (56) within the target volume (44).

25. A system (10) for delivering energy (42) to affect the signs of aging, the system (10) comprising:

an ablating transducer (52) configured to deliver ablative radiation (42) at a power sufficient to ablate muscle tissue of a muscle (56);

control circuitry (12) in communication with the ablating transducer (52), the control circuitry (12) configured to receive lesion pattern specifications and stimulate the ablating transducer (52) to produce a pattern of lesions within a target volume (44) of the muscle (56), the pattern being in accordance with the lesion pattern specifications and selected to impact a degree of paralysis of the muscle (56).

26. The system (10) of claim **25**, further comprising an imaging transducer (54) configured to deliver ultrasound radiation at a power sufficient to produce an echo image of the target volume (44) without damaging tissue within the target volume (44).

27. The system (10) of claim **25**, wherein the ablative radiation (52) is ultrasound radiation.

28. The system (10) of claim **25**, wherein the lesion pattern specifications include size and depth specifications of the lesions of the pattern.

120 **29.** The system (10) of claim **25**, wherein the pattern comprises lesions of
121 approximately $1mm^3$ in size and spaced approximately 1 mm apart from each other.
122
123 **30.** The system (10) of claim **25**, wherein the target volume (44) includes SMAS
124 tissue and the pattern is further selected to impact the degree and direction of movement
125 of SMAS tissue.

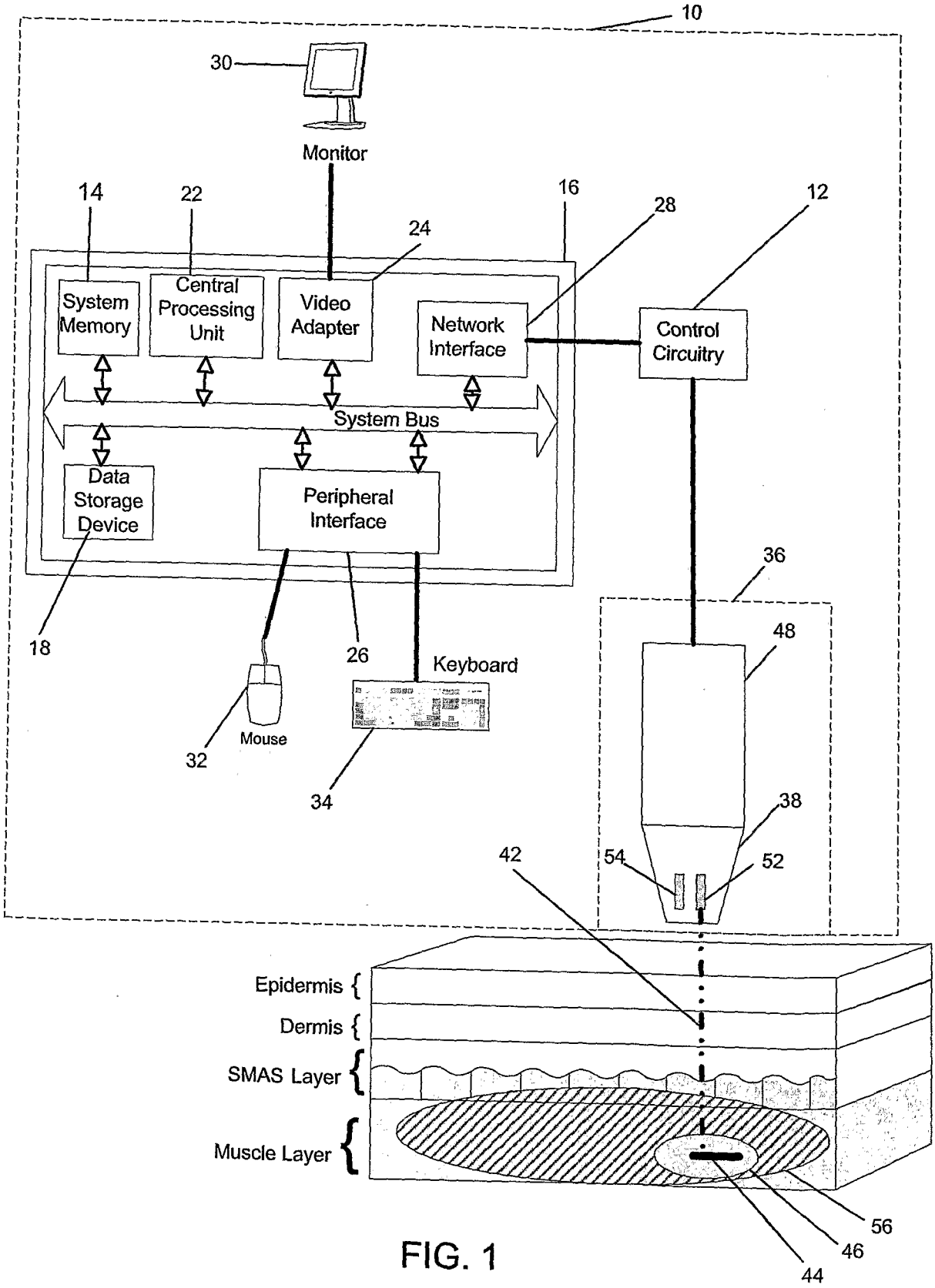
10
30
Monitor
14
22
16
28
12
24
System Memory
Central Processing Unit
Video Adapter
Network Interface
Control Circuitry
System Bus
Data Storage Device
Peripheral Interface
36
18
26
Keyboard
48
Mouse
32
34
38
42
54
52
Epidermis
Dermis
SMAS Layer
Muscle Layer
56
46
44

FIG. 1

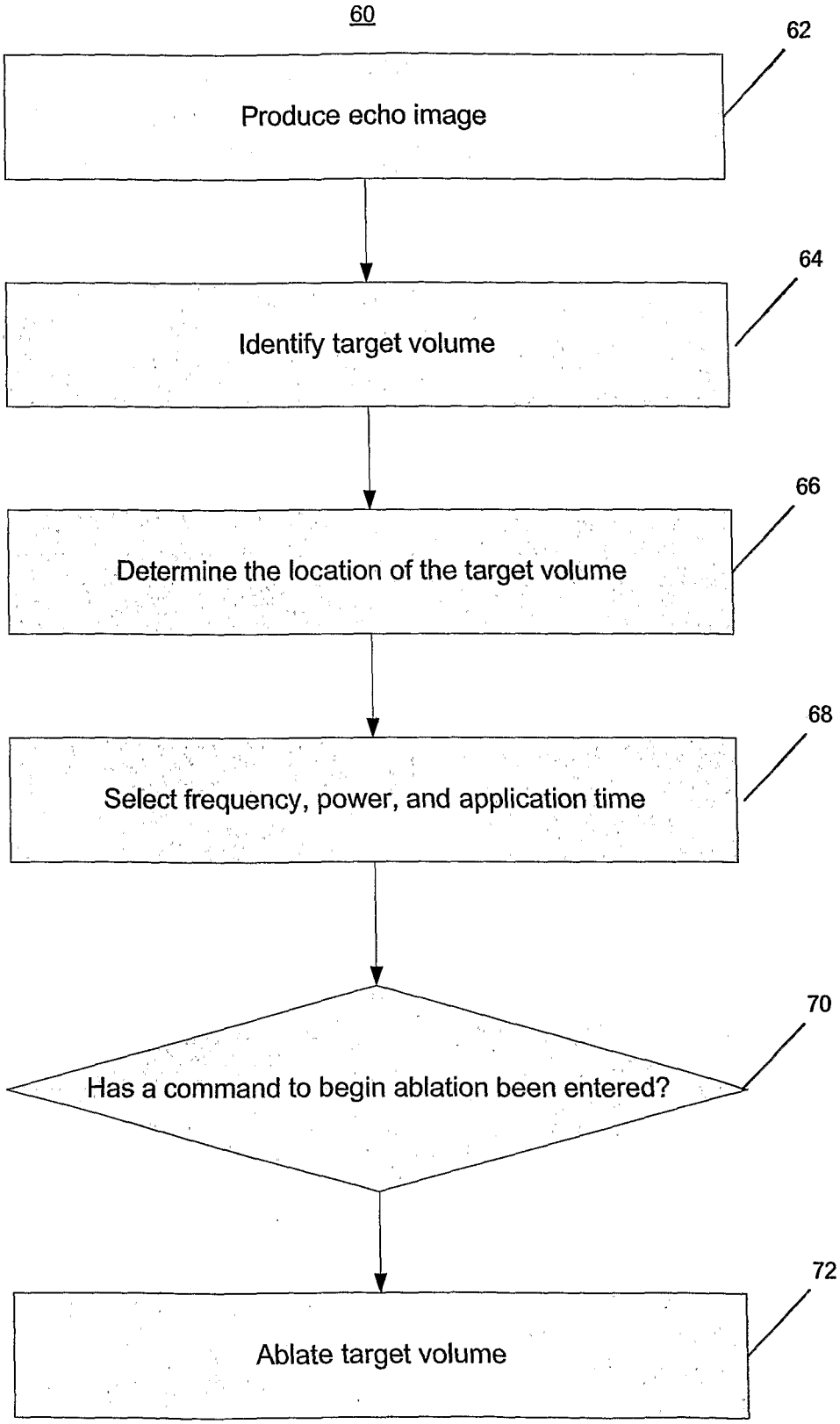
60
62
Produce echo image
64
Identify target volume
66
Determine the location of the target volume
68
Select frequency, power, and application time
70
Has a command to begin ablation been entered?
72
Ablate target volume

FIG. 2

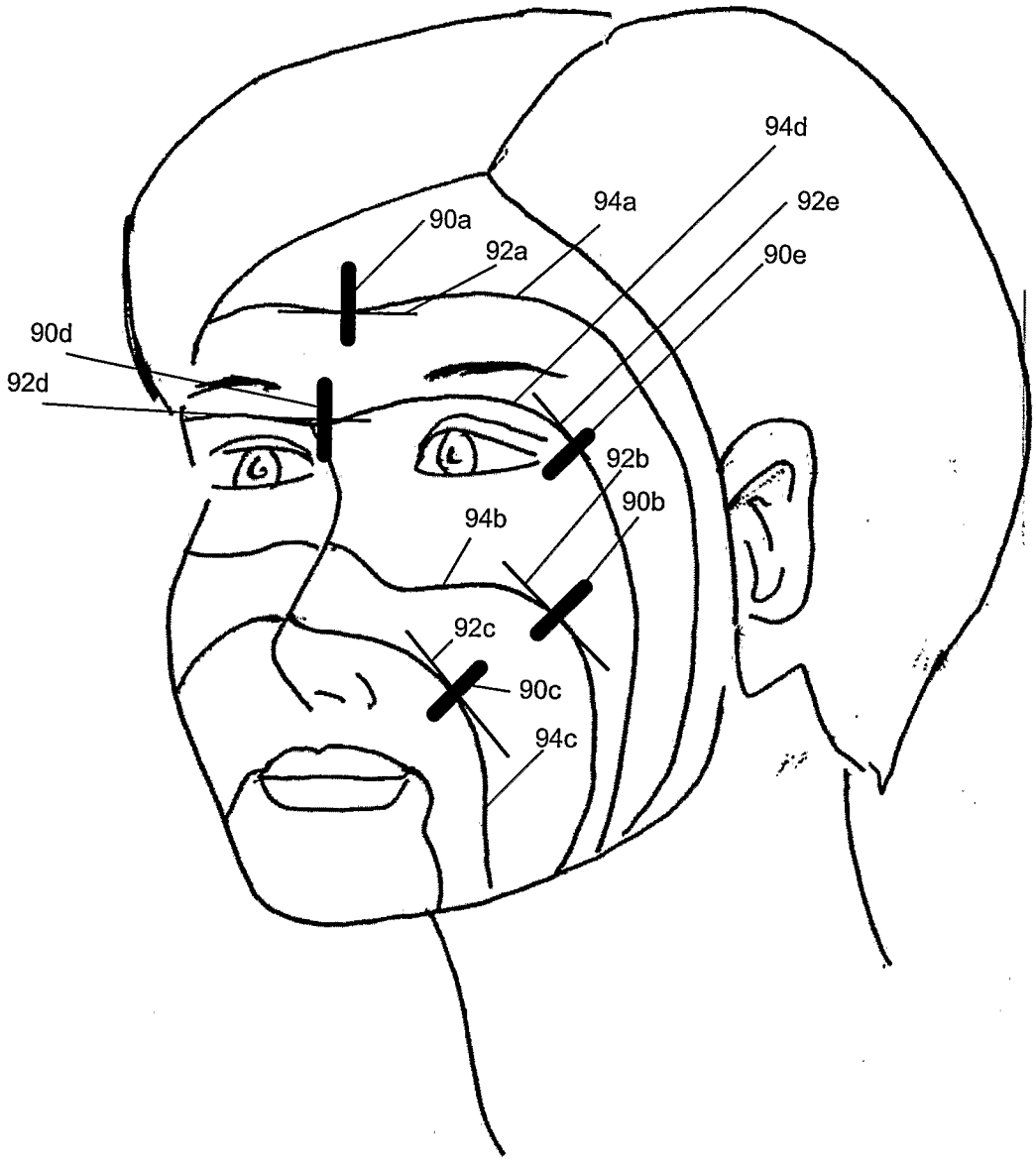

FIG. 3

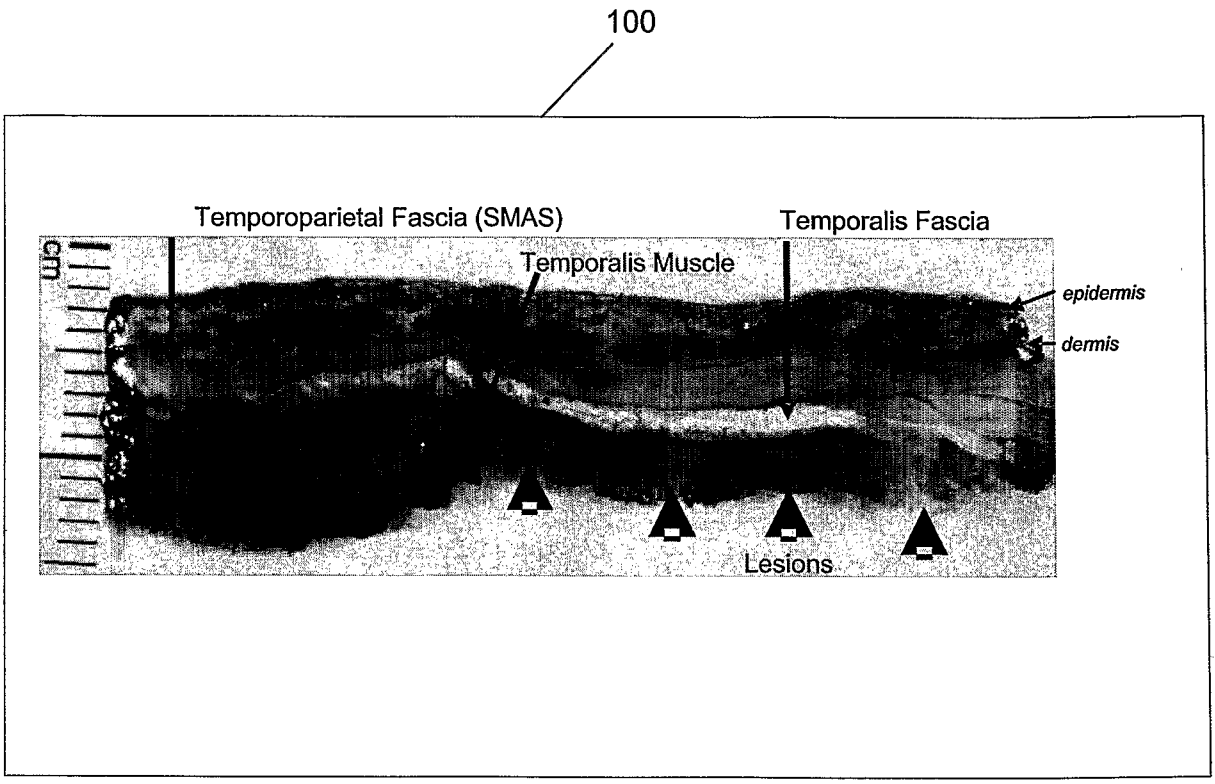
100
Temporoparietal Fascia (SMAS)
Temporalis Fascia
Temporalis Muscle
epidermis
dermis
Lesions

FIG. 4

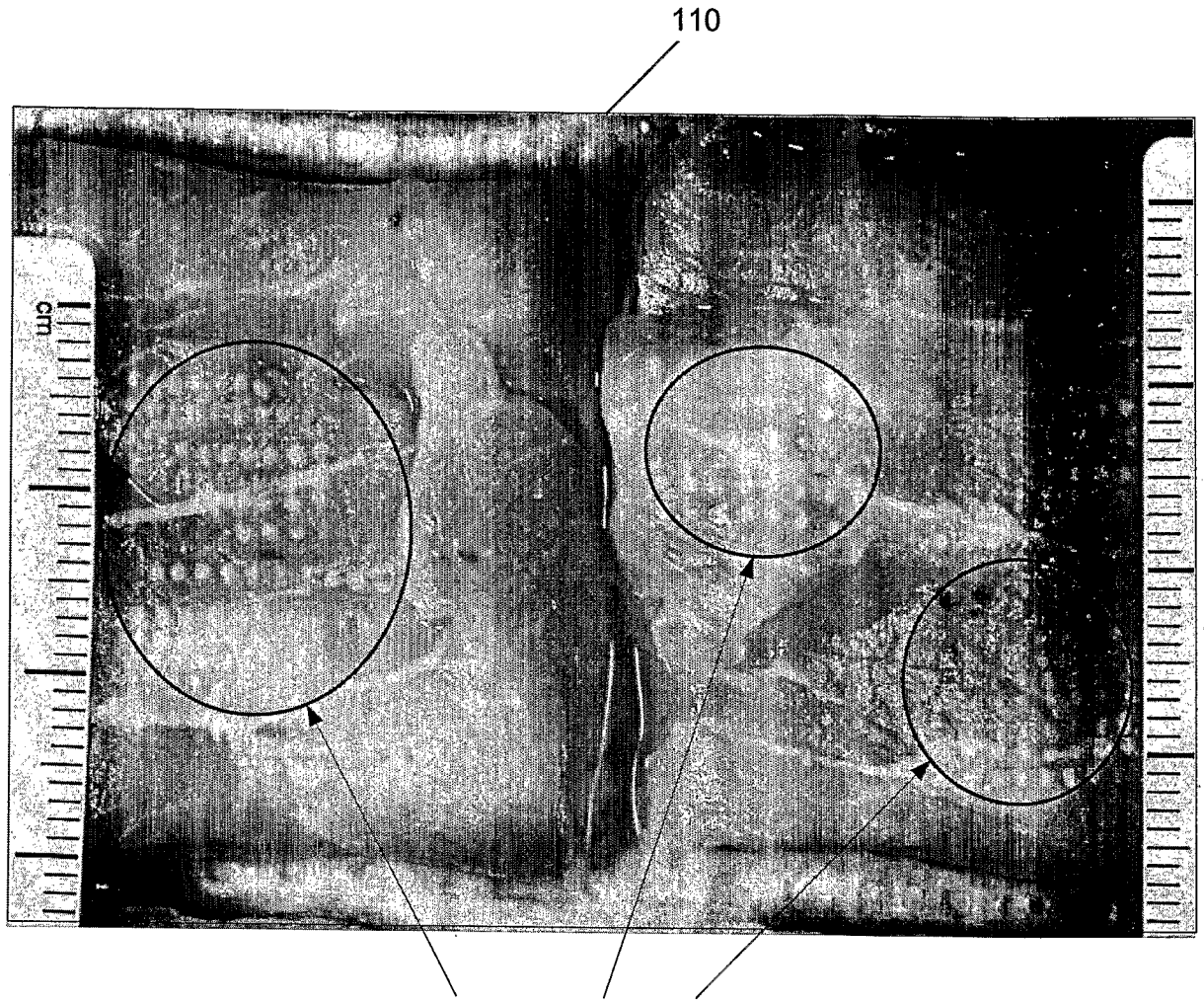

FIG. 5