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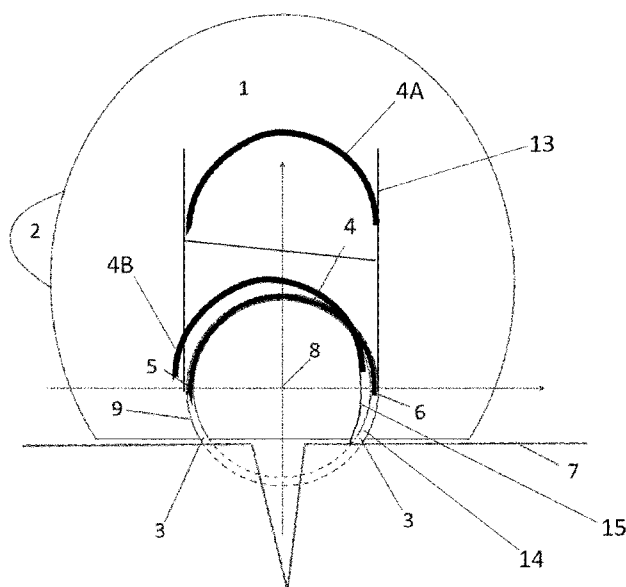


Fig. 5

(57) Abstract: The present invention relates to a device for suturing a tissue comprising a handle, activation means (2), a curved needle (4), a drive mechanism for the curved needle, a number of locking means (10) adapted to secure one end of a suture relative to another end of said suture, and a needle carrying cartridge (13) with a plurality of curved needles.

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Handheld suturing device

Technical field of the invention

The present invention relates to a semi-automatic device for suturing a tissue comprising a curved needle located within an internal circular needle track of the device.

Background of the invention

Traditional manual suturing methods are slow; each hand-made stitch takes about 30-45 seconds, and often multiple stitches are needed. Moreover, it takes time to prepare for the suturing, particularly because every object used during suturing must be kept sterile or at least very clean. To enhance speed of wound closure, surgeons and veterinarians opt for staplers, which require about 3-5 seconds per staple. Of all competing wound closure products, the most relevant competitor to the traditional needle and suture is the conventional surgical metal skin stapler, since seals, glues, and adhesive bandages are not suitable for open wounds.

Although 6-15 times faster than traditional suturing, metal staples increase risk of infection by a factor of 4, requiring more post-operative visits and increased costs due to wound complications. Skin staples also leave unsightly railroad scarring due to the thickness and rigidity of stainless-steel staples. Surgical stapling ultimately presents a 14 times greater risk of wound morbidity at discharge compared to suture closure. The only advantage of stapling is the speed of wound closure.

US 2018/000475 disclose a hand-held and hand-operable stitching device capable of securely placing a single interrupted suture through a wound using sterile suturing material with a single squeeze of the device's arms. Using the stitching device provides substantially faster operation than a surgeon, the stitching device has a center assembly capable of closing a wound with

traditional suturing material secured by anchors that remain on either side of the wound. The stitching device employs needle-suture units stored in a center assembly and deployed individually when the device is actuated. When actuated, an epicyclic gear train within a center assembly causes a needle-suture unit to move through part of a circular path through the tissue, bringing the edges of separated tissue together. The suture thread is then secured in its position with anchors and the needle is then disjointed from the suture thread with a blade.

EP 2563238 relates to an automatic suturing apparatus to be used with heart valve replacement surgery. Heart valve replacement surgery may take approximately 4 hours or longer. Historically, in a valve replacement operation the patient is placed on cardiopulmonary bypass with the heart arrested and the patient is under anesthesia for a prolonged period. A heart valve replacement surgery normally involves the following steps: 1) expose the valve, 2) resect the valve leaflet tissue, 3) place sutures through the annulus of the native tissue, 4) size the prosthesis, 5) place each individual stitch (10-20 pairs) through the sewing ring of the prosthesis, 6) lower the prosthesis and ring into the patient, 7) tie each pair of sutures, and 8) cut each pair of sutures. The number of sutures may range from 12 to over 25 and each is individually tied. A surgeon must be careful to not apply too much or too little tension on the sutures. EP 2563238 discloses an automatic suturing apparatus wherein triggers activate suturing and securing of the tissue of a patient and wherein triggers activate suturing and securing of a valve to tissue of a patient.

The device according to the present invention provides a series of stitches by use of a curved needle, the device provides a complete suture i.e. no knot needs to be tied when the suture ends are joined. The device ensures safe operation as the needle is covered up between stitches and the device is intuitively operable and may therefore be operated by people with no or little medical education.

Summary of the invention

The device of the present invention ensures a faster sewing procedure/closing of wounds and allows other healthcare professionals than doctors to take on the job. The device will therefore be very useful in rural environments where medical help is limited, and experienced doctors have more complicated tasks to deal with.

A first aspect relates to a device for suturing a tissue comprising a handle, activation means, a curved needle, and a drive mechanism for the curved needle, wherein the curved needle is adapted to transport a suture; wherein the device further comprises a number of locking means adapted to secure one end of a suture relative to another end of said suture.

Preferably, the device further comprises a needle carrying cartridge with a plurality of curved needles, preferably arranged in line.

A second aspect relates to a device for suturing a tissue comprising a handle, activation means, a curved needle, and a drive mechanism for the curved needle, wherein the curved needle is adapted to transport a suture; wherein the device further comprises a number of locking means adapted to secure one end of a suture relative to another end of said suture; wherein the device further comprises a needle carrying cartridge with a plurality of curved needles, preferably arranged in line.

A third aspect relates to a device for suturing a tissue comprising a handle, activation means, a curved needle, and a drive mechanism for the curved needle, the curved needle can move along a circular track and transport a suture in the circular track, the curved needle extends over more than half the length of the circular track, the device also comprises a number of locking means comprising at least one through-going opening which locking means can secure one end of a suture relative to another end of the suture; wherein the curved

needle is moved repeatedly along the circular track and when moved along the circular track, the curved needle may pass through at least one through-going opening of the locking means.

- 5 In one or more embodiments, the device further comprises a needle carrying cartridge with a plurality of curved needles, preferably arranged in line.

10 In the present context the term “suture” is used to define a thread used for preparing stitches through skin, and the word “suture” is also used to define a complete stitch. Occasionally, the words “thread”, “string” and “stitch” may also be used.

15 “Relative to the other end of the suture” means that the two ends of a suture are either directly in contact and fixed to each other or the two ends of a suture are both fixed to a single locking means or the two ends of a suture are fixed to each their locking means which two locking means are then fixed to each other.

20 “Another end of the suture” is often the opposite end of the suture, but in general it may be any position of the suture in a distance from the one end which has passed through the edges of a wound and afterwards is positioned above the skin surface.

“Repeatedly” means that a curved needle moves more than once along the circular track.

25 A “through-going opening” may be shaped as a pocket or a hollow in the surface of the locking means, i.e. the opening is partly surrounded by material of the locking means, or it may be shaped as a hole through the locking means, i.e. the opening is surrounded with material of the locking means.

30 The circular track is not necessarily defined by walls and may simply be the space in which the curved needle is moving, e.g. controlled by a needle leading

guide and optionally also a needle capture guide as e.g. disclosed in EP2563238, hereby incorporated by reference. The circular track may also be a spiral track, i.e. the needle does not necessarily move in a circle or semicircle within the same plane. A part of the circular track may also change during the operation of the needle. The upper part of the circular track may comprise two interchangeable paths/tracks that can each switch into and out of the circular track by a switching means. Hence, in one part of the operation the first interchangeable paths/track leads from a needle carrying cartridge with a plurality of curved needles, preferably arranged in line, thereby allowing a new needle to enter the circular track. In another part of the operation, the track changes to the second interchangeable paths/track leading to a storage chamber adapted for receiving a used needle. The track then again changes to the first interchangeable paths/track, allowing a new needle to be loaded, and the cycle repeats itself.

The curved needle must exit the outer casing of the device through an opening and re-enter the outer casing through an opening.

In one or more embodiments, the device further comprises a storage chamber adapted for receiving a used needle. This embodiment secures that a user will not come into contact with a used needle. The drive mechanism for the curved needle may be configured to forward the curved needle to the storage chamber after the needle tip reenters the outer casing. The storage chamber may e.g. be positioned in the upper part of the circular track that the needle passes through.

A needle release mechanism may be incorporated within the storage chamber. A separate drive mechanism may alternatively be present that is adapted for transporting a used needle from the circular track and into said storage chamber.

In one or more embodiments, a pusher element is slidably mounted within the cartridge and adapted for ejecting a single curved needle directly or indirectly

into the circular track, preferably into a needle carrying cartridge with a plurality of curved needles, preferably arranged in line.

5 In one or more embodiments, each curved needle is fed through the same circular track one at the time by a drive mechanism.

According to some embodiments of the present invention, the device may comprise a thread cutting means configured to cut the suture after a stitch, when the suture is constituted by a continuous thread or suture.

10 According to some embodiments of the present invention, the device may comprise one or more pre-cut thread(s) or suture(s) where the length of each pre-cut thread or suture is adapted to fit a single stitch. E.g. each pre-cut thread or suture may be configured to be threaded to a curved needle during use or
15 each pre-cut thread or suture may be pre-fixed to each their curved needle before use. E.g. the length of a pre-cut thread or suture may be adapted to a series of stitches e.g. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more stitches.

20 According to some embodiments of the present invention, the curved needle may move in one direction through the circular track, i.e. the drive mechanism may exclusively drive the curved needle around the circular track in one direction.

25 According to some embodiments of the present invention, the curved needle is configured to move in two directions through the circular track i.e. both forward and backward, and one or more drive mechanisms drives the curved needle around the circular track between one or more stationary position(s).

30 According to some embodiments of the present invention, the through-going opening of locking means may be reduced in size or deformed to such an extent that a suture positioned in the through-going opening is fixed or secured within

the through-going opening.

E.g. the thread or suture is cut at the same time or by same action as is used when deforming the locking means.

5 According to some embodiments of the present invention, the locking means may be constructed of a plastic material such as a metal or a polymer allowing the material constituting the locking means to be deformed by squeezing and thereby reducing the size of the through-going opening. In the context of the present application a "plastic material" is a flexible material which can be
10 deformed and after deformation maintain its new shape, e.g. aluminum is a plastic material. This is contrary to an elastic material as an elastic material after deformation - at least partly - returns to its original shape.

15 According to some embodiments of the present invention, the locking means may be constructed of a meltable material such as thermo-plastic polymer allowing the material to be deformed by heating and thereby reducing the size of the through-going opening.

20 According to some embodiments of the present invention, the device may comprise an outer casing defining both an outer barrier holding and protecting the functional parts such as the curved needle, the drive mechanism, the thread to be used for suture, locking means etc., and a handle. The handle may be positioned on the side of the outer casing. One end of the outer casing may be provided with an opening through which opening a pointy end of the curved
25 needle exits the outer casing and re-enters into the outer casing. In some embodiments, the outer casing is provided with a second opening through which the curved needle may re-enter said outer casing.

30 According to some embodiments of the present invention, the outer casing may shield and/or cover more than 50 percent, normally more than 60 percent, of a

circle partly constituting the circular path travelled by the curved needle.

According to some embodiments of the present invention, the outer casing may be provided with colored markings indicating where the curved needle exits and re-enters the outer casing.

According to some embodiments of the present invention, the device may be a single-use or disposable device. I.e. the device is delivered with an outer shield or cover providing a sterile inner environment where at least the curved needle, the suture(s), and the locking means are kept sterile and ready for use. The outer shield or cover may be partly constituted of the outer casing.

It should be noted that embodiments and features described in the context of one of the aspects of the present invention also apply to the other aspects of the invention.

As used in the specification and the appended claims, the singular forms "a", "an", and "the" include plural referents unless the context clearly dictates otherwise. Ranges may be expressed herein as from "about" or "approximately" one particular value and/or to "about" or "approximately" another particular value. When such a range is expressed, another embodiment includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent "about", it will be understood that the particular value forms another embodiment.

Brief description of the figures

Figure 1 shows an outer casing of a device according to the invention;

Figure 2 illustrates the position of two curved needles, one within a circular needle track and the other within a needle carrying cartridge in a cut-through

view of the device when positioned on a patient's skin;

Figure 3 shows a series of sutures provided by an embodiment of a device according to the invention;

5

Figure 4 shows an embodiment of a curved needle which may be applied in a device according to the invention;

10

Figure 5 illustrates the position of three curved needles, one within a circular needle track, a second within a needle carrying cartridge, and a third within a storage chamber, in a cut-through view of the device when positioned on a patient's skin; and

15

Figure 6 illustrates the position of the curved needle and circular needle track in a cut-through view of the device when positioned on a patient's skin.

Detailed description of the invention

20

The invention relates to a hand-held semi-automatic suture device (Figure 1). The device comprises a curved needle 4, a handle which may be constituted of an outer casing 1, and first activation means 2 used to activate a drive mechanism to force the curved needle 4 forward. The drive mechanism (not shown in figures) forces the curved needle 4 out of an opening 3 in the outer protective casing 1, through the patient's skin and back into the outer protective casing 1 through an opening 3 at a second position. Figure 1 shows an embodiment of an outer casing 1, which may be used in a device according to the invention. The outer casing 1 has a cut ellipsoid shape in one dimension and in a second dimension it has a constant width forming a side-portion. First activation means 2 in form of a button are positioned on the side-portion, so it is possible to grip the device with one hand and push the button with one or more fingers.

30

Figure 2 shows a cut-through view of a device in accordance with various embodiments of the invention and positioned on a patient's skin 7. A curved needle 4 is shown moving along a circular track 9 having a center 8. A second needle 4A is shown positioned in a needle carrying cartridge 13, ready for being lowered or dropped into the circular track 9 after the present needle 4 has been removed therefrom after use. A suture (Not shown, see Figure 4) is attached to the curved needle 4 and the suture 11 will be moved along the circular track 9 together with the curved needle 4. The curved needle 4 extends over more than half the length of the circular track 9 to assure that part of the curved needle 4 is always positioned within the housing to allow driving forces to be transferred to the needle and controlling the position of the curved needle.

Normally, releasing the first activation means 2 will force the complete length of the curved needle 4 out of the outer casing 1 at a first position and the complete length of the curved needle 4 back into the outer casing 1 at a second position. During a manual stitch, the surgeon/doctor will need to tie a knot securing the two ends of a suture to each other. Instead of a knot, the device of the present invention uses a locking mechanism ensuring a perfectly closed suture. The locking mechanism comprises or is constituted of a unit having at least one through-going opening, e.g. the locking mechanism may be constituted of a small "pearl" of plastic, metal or the like where the through-going opening first forms a closed or semi-closed circle around the suture, and when one or both ends of the suture is/are positioned inside the through-going opening, the walls of the through-going opening may be deformed and closed around the suture thereby fixating the suture to the locking means, e.g. by activating a second activation means which may squeeze or heat the locking means causing the locking means to deform and fix or secure the suture. Normally, the second activation means may comprise a second button extending from the outer casing of the device, and the second activation means may be activated by pressing the button.

The device also comprises a number of locking means 10 (not shown positioned within the device, see Figure 3). Each locking means 10 comprises at least one through-going opening, and each locking means 10 can secure or lock at least one end of a suture 11, e.g. both ends of a suture 11, at a position where edges of a wound are forced together. The dimension of the at least one through-going opening is large enough to allow at least one suture, possibly two sutures, to be placed within the opening, if the curved needle 4 positions the suture within the through-going opening by dragging the suture through the opening, then the dimension of the through-going opening is large enough to allow a curved needle 4 to pass through the through-going opening. Normally, the device comprises or includes one or two locking means 10 for each stitch the device is designed to provide. The device may comprise more than one locking means, e.g. more than 5 locking means, and e.g. between 10-20 locking means. In general, the device will comprise enough locking means to be able to provide 5-20 stitches.

Figure 3 shows a series of sutures 11 made by a device according to the present invention. The sutures are unconnected and closed by a locking means 10 in form of a pearl-like structure with one or more through-going openings.

The device may comprise an internal cutting mechanism that releases the curved needle 4 from a first suture.

The device as shown in Figure 2 is provided with more than one curved needle 4 where each needle is threaded with a suture e.g. as shown in Figure 4 and placed inside the outer casing before use of the device. Figure 4 shows a curved needle 4, which may be used in an embodiment of a device according to the invention. In this embodiment a suture string is attached to the tail end 6 of the curved needle 4 and the length of the curved needle 4 is provided with at least two notches 12 comprising a surface which may be used when the drive mechanism forces the needle forward. The drive mechanism pushes against the

surface and at least one notch 12 should always be present inside the outer casing of the device.

Generally, the device according to the present invention may be made of a see-through material making it easier to visualize where the needle will emerge when having passed through the patient's skin. E.g. the outer casing may be provided with colored markings, e.g. in red as red indicates risk or danger, indicating where the needle will emerge and exit.

A ruler may be indicated on the side of the device and help the healthcare professional to assess where the next suture should go.

The device can make single sutures thereby giving the best treatment for emergency patients. The device may be suitable for all hand sizes, and the shaping of the outer casing can be shaped to provide a firm grip providing a more comfortable sewing experience. The device can be scaled to carry different needle sizes, i.e. both the internal diameter or width of the circular track may be adapted defining a different diameter or thickness of the needle. Also, the diameter of the circular track may be adapted defining different length of a curved needle.

Figure 5 illustrates the position of three curved needles 4, 4A, 4B. The first needle 4 is positioned within a circular needle track 9, as also shown in Figure 2. The second needle 4A is also as shown in Figure 2 positioned within a needle carrying cartridge 13. The third needle is positioned within a storage chamber, which is the destination for a needle after use. The upper part of the circular track is shown comprising two interchangeable paths/tracks 14, 14 that can each switch into and out of the circular track 9 by a switching means (not shown). Hence, in one part of the operation the first interchangeable paths/track 14 leads from the needle carrying cartridge 13, thereby allowing a new needle 4A to enter the circular track 9. In another part of the operation, the track changes to the second interchangeable paths/track 15 leading to a storage chamber adapted for receiving a used needle. The track then again changes to the first

interchangeable paths/track 14, allowing a new needle to be loaded, and the cycle repeats itself.

In figure 6, a different device compared to the ones in Figure 2 and 5 is shown.

5 Here, the curved needle 4 is shown moving along a circular track 9 having a center 8, and normally the curved needle will be able to complete a full circle inside the circular track 9. A suture 11 is attached to the curved needle 4 and the suture 11 will be moved along the circular track 9 together with the curved
10 needle 4. Normally, the curved needle 4 will extend over more than half the length of the circular track 9, even over more than 60% of the circular track 9, this feature assures that part of the curved needle 4 always is positioned within the housing allowing driving forces to be transferred to the needle and controlling the position of the curved needle.

The curved needle 4 can be moved repeatedly along the same circular track 9.

15 The curved needle 4 may pass through at least one through-going opening of the locking means 10 when moving along a part of the circular track. If a locking means comprises more than one through-going opening the curved needle may pass through one opening in one direction and a second opening – or the same opening – in a second direction.

20 During use, the curved needle 4 is located within the internal circular track 9 of the device i.e. the curved needle 4 is completely hidden by the outer casing 1 and process providing a stitch starts by activating the first activation means 2 which may comprise pressing a button or similar.

25 The device may comprise an internal cutting mechanism that releases the curved needle 4 from a first suture. The curved needle 4 may then be rethreaded before being ready to perform a new stitch. Alternatively, the suture may be provided in pre-cut lengths which need not be cut after each stitch.

Rethreading of a curved needle may be automatically and take place inside the outer casing before each stitch, or alternatively the device is provided with more
30 than one curved needle 4 where each needle is threaded with a suture e.g. as shown in Figure 4 and placed inside the outer casing before use of the device.

Alternatively, more stitches may be provided with one thread, the device should then be pre-set to a maximum number of stitches for a single operation or use, e.g. if the wound is 3 cm a five-stitch device is chosen, or if the wound is 10 cm a fifteen-stitches device is chosen, etc..

5 The device may be used with only one hand and can withstand both warm and cold environments.

The device according to the present invention will preferably be disposable.

Normally, the complete device is delivered with sterile parts for use in connection with a wound, i.e. at least the curved needle 4 and the suture 11 are sterile. The
10 locking means 11 may also be sterile, whereas the remaining parts of the device e.g. the outer casing 1 may just be clean when delivered to the user. The complete device may be provided with an outer cover constituting a sterile limit, such cover is then removed before use, exposing the exit and re-enter openings 3 for the curved needle 4 in the outer casing 1. E.g. the outer casing 1 may
15 constitute part of the sterile limit.

The suture may be placed within the outer casing 1, either as a continuous thread, which need to be cut between stitches, or as pre-cut thread parts, which e.g. may be attached to a locking means prior to stitching. The locking means 10
are normally also placed within the outer casing before use.

20 The device will ensure the speed of a stapling machine, but the preciseness and effectiveness of suturing as sutures do not need a special device for removing them.

Figure 6 shows a cut-through view of an embodiment of a device according to
25 the invention. The embodiment comprises an outer casing 1 of similar shape as the device of Figure 1. Inside the outer casing 1 is shown the position of a circular track 9 having a center 8 in which circular track 9 a curve needle 4 is positioned. The curved needle 4 has a pointy end 5 – which in Figure 6 points to the left – and a tail end 6.

30 During operation the curved needle 4 will exit the outer casing 1 with the pointy end 5 forward through a first opening 3, cut-through the patient's skin which is

indicated with reference number 7 and re-enter the outer casing 3 through a second opening 3, the first and the second openings 3 may be constituted by a single opening. The dotted lines indicate the curved needle's path when the curved needle travels outside the outer casing 1. According to this embodiment the curved needle 4 extends over approximately 55% of the length of the circular track 9, and a curved needle 4 must always be longer than the length of the track defined by the distance between the exit opening 3 and the re-enter opening 3 for the curved needle 4 in the outer casing. The curved needle 4 may travel either clockwise or counter clockwise through the circular path 9, however, it is advantageous that the curved needle 4 exits the outer casing in proximity of the first activation means 2 (in the embodiment of Figure 6 the curved needle would travel counter clockwise), preferably below the first activation means 2 or at least in the same side or half as the first activation means 2.

References

- | | | |
|----|----|------------------------------------|
| | 1 | Outer casing |
| | 2 | First activation means |
| | 3 | Opening for curved needle |
| 5 | 4 | Curved needle |
| | 5 | Pointy end of curved needle |
| | 6 | Tail end of curved needle |
| | 7 | Patients skin |
| | 8 | Center of circular track |
| 10 | 9 | Circular track |
| | 10 | Locking means |
| | 11 | Suture |
| | 12 | Notch |
| | 13 | Needle carrying cartridge |
| 15 | 14 | First interchangeable paths/track |
| | 15 | Second interchangeable paths/track |

Claims

1. A device for suturing a tissue comprising a handle, activation means (2), a curved needle (4), and a drive mechanism for the curved needle, wherein the curved needle (4) is adapted to transport a suture (11); wherein the device
5 further comprises a number of locking means (10) adapted to secure one end of a suture relative to another end of said suture;

characterized in that the device further comprises a needle carrying cartridge (13) with a plurality of curved needles, preferably arranged in line.

10 2. A device for suturing according to claim 1, further comprising a storage chamber adapted for receiving a used needle.

15 3. A device for suturing according to claim 2, further comprising drive mechanism adapted for transporting a used needle from the circular track and into said storage chamber.

20 4. A device for suturing according to any one of the claims 1-3, wherein a pusher element is slidably mounted within the needle carrying cartridge and adapted for ejecting a single curved needle directly or indirectly into the circular track.

5. A device for suturing according to any one of the claims 1-4, wherein each curved needle is fed through the same circular track one at the time by a drive mechanism.

25 6. A device for suturing according to any one of the claims 1-5, wherein the curved needle may pass through at least one through-going opening of the locking means (10).

30 7. A device for suturing according to any one of the claims 1-5, wherein the curved needle (4) is moved repeatedly along the circular track (9) and when

moved along the circular track, the curved needle may pass through at least one through-going opening of the locking means (10).

8. A device for suturing according to any one of the claims 1-7, wherein the device further comprises thread cutting means configured to cut the suture after a stitch, thereby separating the needle from the thread.

9. A device for suturing according to any one of the claims 1-8, wherein the curved needle (4) moves in one direction through the circular track, i.e. the drive mechanism exclusively drives the curved needle (4) around the circular track in one direction.

10. A device for suturing according to any one of the claims 1-8, wherein the curved needle (4) may move in two directions through the circular track i.e. both forward and backward, and one or more drive mechanisms drives the curved needle (4) around the circular track between one or more stationary position(s).

11. A device for suturing according to any one of the claims 1-10, wherein the through-going opening of locking means (10) may be reduced in size to such an extent that a suture positioned in the through-going opening is fixed or secured within the through-going opening.

12. A device for suturing according to claim 11, wherein the locking means (10) is constructed of a plastic material such as a metal or a polymer allowing the material to be deformed by squeezing and thereby reducing the size of the through-going opening.

13. A device for suturing according to claim 11, wherein the locking means (10) is constructed of a meltable material such as thermo-plastic polymer allowing the material to be deformed by heating and thereby reducing the size of the through-going opening.

14. A device for suturing according to any one of the claims 1-13, wherein the device comprises an outer casing (1) defining both an outer barrier holding and protecting the functional parts such as the curved needle (4), the drive
5 mechanism, string to be used for suture, locking means (10) etc., and a handle; wherein at one end the outer casing is provided with an opening (3) through which opening a pointy end (5) of the curved needle (4) may exit the outer casing and re-enter into the outer casing, possibly a second opening (3) through which the curved needle (4) may re-enter into the outer casing.

10 15. A device for suturing according to according to claim 14, wherein the outer casing (1) shields or covers more than 50 percent, normally more than 60 percent, of a circle partly constituting the circular path travelled by the curved needle (4).

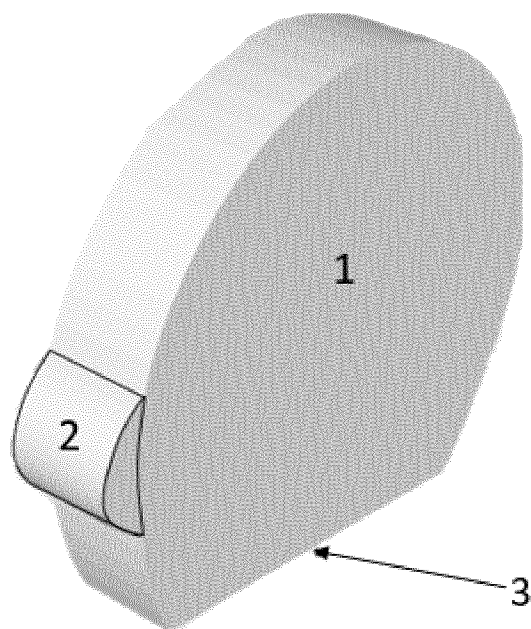


Fig. 1

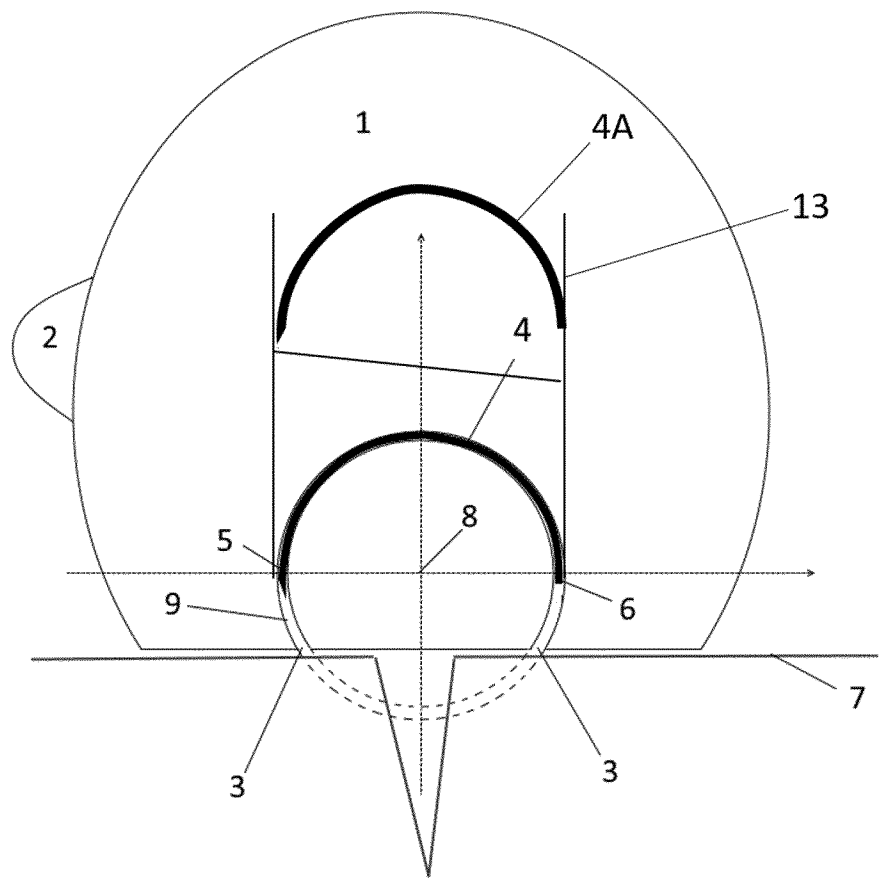


Fig. 2

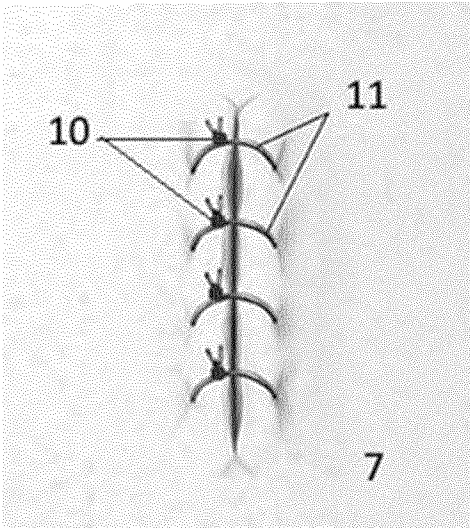


Fig. 3

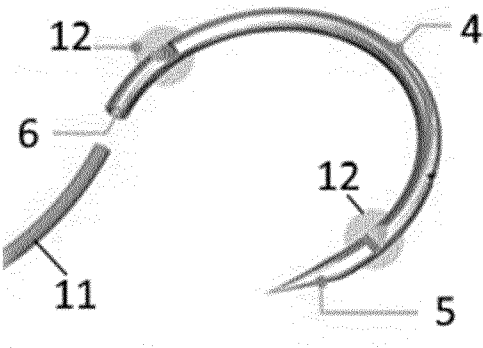


Fig. 4

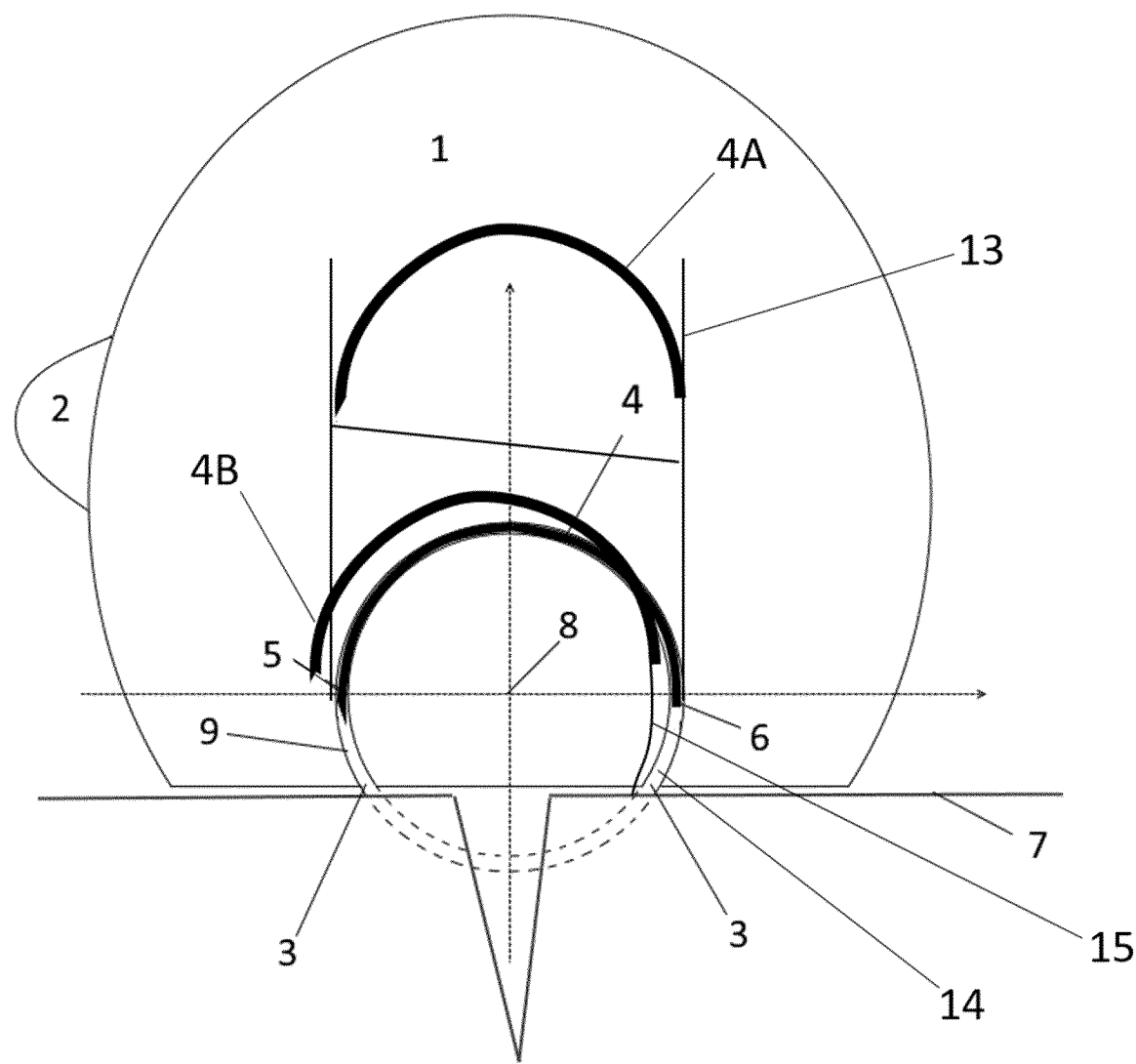


Fig. 5

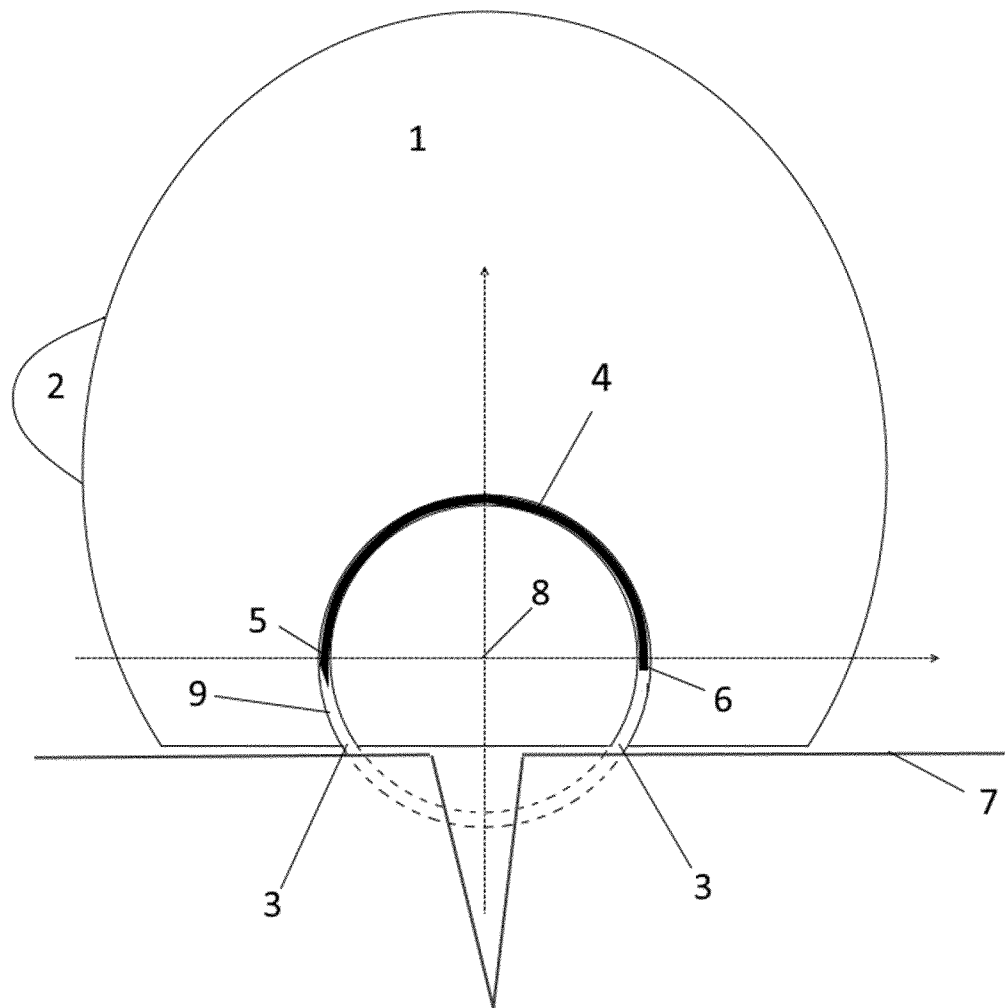


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/066929

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/04 A61B17/062 A61B17/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 563 238 A1 (BADHWAR VINAY [US]) 6 March 2013 (2013-03-06) cited in the application figures 1,2,3,5-10 paragraph [0039] - paragraph [0041] paragraph [0051] paragraph [0053]	1,2,6-9, 11,12, 14,15
X	US 2014/163584 A1 (ROHL JAMES [US] ET AL) 12 June 2014 (2014-06-12) figures 14-18 paragraph [0104] paragraph [0106] paragraph [0107] - paragraph [0108]	1,2,10, 14,15



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

28 August 2019

Date of mailing of the international search report

17/09/2019

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/066929

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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