A DEVICE, A TOOL MEANS, A KIT AND A METHOD FOR ANASTOMOSIS

(10) International Publication Number
WO 2012/161627 A1

(51) International Patent Classification:
A61B 17/11 (2006.01)

(21) International Application Number:
PCT/SE2012/050640

(22) International Filing Date:
23 May 2011 (23.05.2011)

(25) Filing Language:
English

(26) Publication Language:
English


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(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

(54) Title: A DEVICE, A TOOL MEANS, A KIT AND A METHOD FOR ANASTOMOSIS

(57) Abstract: The invention relates to an anastomosis device for anastomosing two vessel parts together. The device includes a male attachment unit (100) and a female attachment unit (200). The units are (100, 200) attachable to a respective vessel part and connectable to each other by connection means (107, 108, 109, 208, 209). The connection means (107, 108, 109) of the male unit (100) includes a plurality of projections (107) having at least one shoulder (108) with a male abutment surface (109) facing in the rearward direction, and the female unit (200) includes an outer circumferential surface. According to the invention the projections (107) and the outer surface (204) are arranged to cooperate such that the radial insides of the projections (107) face the outer surface (204) when the units (100, 200) are connected. The female unit (200) includes at least one female abutment surface (209) facing in the rearward direction. At male abutment surface (109) of each projection (107) and a female abutment surface (209) are arranged to abut each other when the units (100, 200) are connected to each other. The invention also relates to tool means for manipulating the units and to a method for anastomosis.
A DEVICE, A TOOL MEANS, A KIT AND A METHOD FOR ANASTOMOSIS

Field of invention

The present invention in a first aspect relates to an anastomosis device for
anastomising two vessel parts or other tubular organs together, the device
including a male attachment unit and a female attachment unit, which units are
attachable to a respective vessel part and connectable to each other by
connection means on each unit, each attachment unit having a through-hole
defining a longitudinal axis of the attachment unit, each unit defining a front
direction toward the other unit when the units are connected to each other and
defining a rear direction in the opposite direction, and each unit has a vessel
receiving surface, whereby the connection means of the male unit includes a
plurality of projections extending in the front direction of the male unit, each
projection being flexible in the radial direction and having at least one shoulder
with a male abutment surface facing in the rearward direction, and the female unit
includes an outer circumferential surface.

In a second aspect the invention relates to an anastomosis tool means for
manipulating an anastomosis device according to the invention, and to a kit
including the invented anastomosis device and the invented anastomosis tool
means.

In a third aspect the invention relates to a method for anastomosing two
vessel parts or other tubular organs together including the steps of
- providing a male attachment unit with a connection means having
  a plurality of axially extending projections,
- providing a female attachment unit having an outer
  circumferential surface,
- attaching a vessel receiving surface of each unit to a respective
  vessel part, and
- connecting the units together.

The through-hole of each attachment unit thus defines a longitudinal axis.
The through-holes are normally, but not necessarily, circular, whereby the
longitudinal axis is the centre axis of the circle. In the present application all terms
like axial, radial, tangential, angular and circumferential relate to this axis of not
otherwise explicitly expressed. This relates also to the tool means when holding
the attachment units. By front side of an attachment unit is in this application meant the side thereof that faces the other attachment unit when they are connected, and the front direction is defined accordingly. By rear side and rear direction of an attachment unit is meant the opposite side and direction, respectively.

It is to be understood that the expression "other tubular organs" also includes body organs that are massive but has a tubular encapsulation such as the epineurium of a nerve. The invented devices and method thus are applicable also for nerve repair.

Background of invention

Anastomosis is the surgical joining biological tissue to create an internal communication between them. Vascular surgery often involves creating an anastomosis between blood vessels to create or restore blood flow to essential tissues. At present, the majority of all vascular anastomosis procedures are performed by conventional hand suturing. Suturing an anastomosis is time consuming and difficult. It is important that each anastomosis provide a smooth and open flow path and the attachment must be leak free under relatively high pressures. A completely leak free anastomosis is not always achieved on the first try. Consequently, there is a frequent need to re-suture the anastomosis to close any leaks or remove any flow interruptions that are detected.

Attempts has been made to provide devices and methods that allow more reliable anastomosis and which require shorter operation time. Thus there exists various devices for anastomosis where an attachment unit is attached to a respective vessel and then the two units are coupled together. It is important that the connection of the two units to each other can be made rapid, easily and safe. One solution for this is to provide one of the units with projections and the other unit with openings, whereby the units are connected by inserting the projections into the openings and allow the projections to snap into a locking relationship.

Examples of this kind of connection are disclosed in US 5250058, WO 2006009503 and WO 2007081 247.

This kind of connection has shown to meet the above mentioned demands to a large extent. However, such a connection can be further improved. It is also
desirable to achieve a simple way for the manipulation of the attachment units when bringing them together.

**Summary of invention**

The object of the present invention is to overcome the drawbacks related to the prior art in this field and thus to achieve an anastomosis device of the kind in question which is very simple to manufacture and assemble.

This object is according to the first aspect of the invention achieved in that an anastomosis device of the kind specified in the introduction above includes the specific features that the projections and the outer surface are arranged to cooperate such that the radial insides of the projections face the outer surface when the units are connected and in that the connection means of the female unit includes at least one female abutment surface facing in the rearward direction of the female unit, whereby at least one male abutment surface of each projection and at least one female abutment surface are arranged to abut each other when the units are connected to each other.

Since the projections do not need to be inserted in special openings in the female attachment unit, the positioning of the two attachment units when they are to be connected is simplified. The matching of the projections to the female attachment unit thus does not require any precise angular adaption as is the case when the projections are received in openings. For some types of anastomosis devices within the scope of the present invention, an angular adaption is required with respect to the construction used for the attachment of the respective vessel. The invented device in this case simplifies the connection since only this latter mentioned aspect of the angular adaption has to be carefully attained to. In other types of anastomosis devices within the scope of the present invention, the construction used for the attachment of the respective vessel does not require any angular adjustment. In this case the invented device makes angular adaption very easy or even superfluous, leading to a very simple manipulation for the connection. In addition, the invented device will be more simple to manufacture because they need not to be provided with openings for receiving the projections.

According to a preferred embodiment of the invented anastomosis device, the at least one female abutment surface includes a plurality of axially distributed female abutment surfaces.
This offers a freedom to connect the two attachment units in more than one axial position relative to each other. To assure a safe and firm anastomosis, the surgeon has to achieve a proper tight anastomosis not to have necrosis of the tissue but provide a safe, connection between the vessels. By the having a plurality of female abutment surfaces the surgeon can control the tightness of the anastomosis. Thus, by varying the force when interconnecting the units, the surgeon can control the tightness of the anastomosis by controlling on which female abutment surface the projections abut. In this way a safe, tight, leakage free, easy and quick anastomosis can be made. Furthermore, in case each projection also has a plurality of abutment surfaces the connection can be safer due to the plurality of locking engagements that can be established thereby.

According to a further preferred embodiment, at least one female abutment surface is on the rear side of the female attachment unit.

This embodiment further contributes to simplify the device, since this abutment surface is formed by a surface that anyhow has to be present.

According to a further preferred embodiment, the outer circumferential surface of the female attachment unit is provided with at least one circumferentially extending rim and each rim has a rear side forming a female abutment surface.

Applying such rims is from a manufacturing point of view a simple way to create the abutment surfaces.

According to a further preferred embodiment, there is a plurality of rims at different axial positions.

Thereby a plurality of axially distributed abutment surfaces is formed in a simple way.

According to a further preferred embodiment, each rim extends completely around the female attachment unit.

In this way the need for angular adaption of the two attachment units is not only reduced but completely eliminated with regards to the connection aspect.

According to a further preferred embodiment, each abutment surface is perpendicular to the longitudinal axis.

The perpendicular orientation of these surfaces results in maximal strength and safety in comparison with inclined orientation.
According to a further preferred embodiment, the female attachment unit has a manipulation portion at its rear end, which portion has a non-circular contour.

This portion simplifies handling the female attachment unit during the operation when using a tool for that. It is thereby avoided that the tool might damage rims with abutment surfaces on the outer circumferential surface. The non-circular outer contour of that portion contributes to a controlled and precise gripping of the attachment unit by a tool, which simplifies the connection.

According to a further preferred embodiment, the male attachment unit has an outer contour that is non-circular at at least a part of its axial extension.

In a similar way this contributes to a controlled and precise gripping of the male attachment unit by a tool.

According to a further preferred embodiment, at least one of the non-circular contours on the female and male attachment unit, respectively, consists of a base contour with at least two depressions.

Forming the non-circular contour in this way is simple. Furthermore such a contour is particularly suitable for cooperation with a tool. Although two such depressions are sufficient to establish a good cooperation with a tool, it is preferred that the number of depressions is larger than two. Thereby the accuracy when gripping the respective attachment unit with a tool will be further increased. A plurality of depressions also allows a tool to be applied at different angular positions relative to the attachment unit. Particularly preferred is that the contour on the male attachment unit has three such depressions and the contour on the female attachment unit six.

According to a further preferred embodiment, at least one of the attachment units is composed of two separate elements fitted together, namely a radially outer element and a radially inner element, which outer element is provided with said projections or said outer circumferential surface, respectively, and has a central recess on its front side, and which inner element has said vessel receiving surface and is housed in said recess.

Manufacturing of the part of the attachment unit that has the vessel receiving surface thereby can be made separate from the manufacture of the outer element. This simplifies the manufacturing of the vessel receiving surface with an optimized design. In particular this simplifies manufacturing of the male attachment
unit, since the projections thereof makes it complicated to provide the spikes when it is in one piece.

According to a further preferred embodiment, the inner element is non-rotatable housed in the recess.

Thereby the angular position between the two elements is properly locked and well defined, such that relative twisting of the anastomosed vessel parts is avoided.

According to a further preferred embodiment, the recess and the inner element has matching circumferential contour, which contour is non-circular.

This is a very simple and reliable way of avoiding relative rotation of the inner and outer elements.

According to a further preferred embodiment, the vessel receiving surface of each unit is facing in the front direction and includes a plurality of circumferentially distributed spikes and a plurality of circumferentially distributed depressions, each spike having a length in the range of 0.5 to 3 mm.

Providing the vessel receiving surface at the front side results in a secure attachment of the vessel part thereto, and the spikes that penetrate the wall of the vessel part further contributes to make the attachment secure. The spikes will be able to be received by and housed in the depressions of the other attachment unit, whereby there will be no interspace between the vessel parts attached to the vessel receiving surfaces of the two attachment units. This results in a tight, compact and safe connection.

According to a further preferred embodiment, each depression is arc shaped and has extension in the circumferential direction that is at least 1.5 times the maximum diameter of a spike of the other attachment unit.

By this arc shape, precise angular alignment of the spikes in one of the attachment units and the depressions of the other attachment unit is not necessary. This makes the connection of the two attachment units to each other less complicated. The angular extension of each depression is limited with respect to the number of spikes that are provided, since the depressions have to be located circumferentially between the spikes.

According to a further preferred embodiment, the vessel receiving surface of each attachment unit is facing in the front direction and includes at least one
area having a large number of sharp projections arranged to partly penetrate the wall of the received vessel part.

Since these projections do not completely reach through the wall they will not reach the inside of the attached vessel and there will thus be no openings facing the interior of the vessel that could cause infection or the like. With a large number of such small projections the attachment will be sufficiently strong although each projection reaches only partly through the wall. In order to penetrate only partly through the wall the height of the projections should be between 0,05 and 1,00 mm, in most cases between 0,1 and 0,5 mm. By a large number is meant between 50 and 10 000. The surface thus has a function similar to that of a Velcron ™ tape.

In the second aspect of the invention, the object is achieved in that a tool means of the kind mentioned in the introduction has the specific features that the tool means includes a male unit tool adapted to hold the male attachment unit and a female unit tool adapted to hold the female attachment unit, whereby each tool has an oblong handle provided with an adjustable jaw at an end of the handle for holding the respective attachment unit, the axis of the attachment unit as hold by the tool defining a jaw axis, and which jaw has a support portion with an axially facing wall arranged to prevent the attachment unit to axially pass the support portion when the attachment unit is held in the jaw.

The use of such tool means considerably simplifies the manipulation of the attachment units when connecting them together, and also reduces the risk for mistakes during the operation. The adjustable jaw allows gripping and holding the attachment units, and by the support portion the attachment unit is held in a well defined axial position relative to the respective tool which results in a high accuracy at the manipulation. Thereby these support portions transmit the necessary axial force when bringing the projections of the male attachment unit into engagement with the female attachment unit. Without these supports the necessary axial force would have to be established by friction between the jaw and the circumferential of the respective attachment unit, entailing the risk of axial sliding of the attachment unit in the jaw and also risk that the jaw might deform the attachment unit.

According to a preferred embodiment of the tool means, each tool has a first component and a second component, each component forming a part of the
handle and a part of the jaw, which components are displaceable in relation to each other in a plane perpendicular to the axis.

The adjustability of the jaw thereby is established in a very simple way, since the gap of the jaw is adjusted simply by displacing the components relative to each other. This is easy performed since both components form parts of the handle.

According to a further preferred embodiment, each tool includes a locking element arranged to lock the relative position of the components.

When one of the tools has gripped the corresponding attachment unit, the relative position between the components can be locked in the position when there is a safe grip. During the subsequent manipulation, the surgeon thereby does not need to pay any attention to apply the force necessary for safely holding the attachment unit.

According to a further preferred embodiment, the locking device includes an end portion of one of the components, which end portion is connected to the rest of the component by a weak connection piece and has a hook-like locking part arranged to be able to snap into contact against the end of the other component. Thereby the locking is achieved in a very simple way that does not require any separate components.

According to a further preferred embodiment, the jaw of each tool has a contour as seen in a plane that is perpendicular to said axis, which contour has a base profile and at least two projections extending from the base profile towards said axis.

By these projections, if cooperating with matching indentations on the outer circumferential of the respective attachment unit, angular movement of the attachment unit by means of the tool is safe and accurate. Without this contour there would exist a risk for angular sliding of the jaw around the attachment unit when turning it around the axis. Normally the base profile is a circle.

According to a further preferred embodiment, the jaw of each tool has a contour as seen in a plane perpendicular to said axis, which contour has a base profile, and the female tool has at least two projections extending from the base profile in an outward direction with respect to the axis.
This embodiment offers a simple way of allowing the projections of the male attachment unit to pass outside the circumference of the female attachment unit. The female tool thereby will not constitute an obstacle against that.

According to a further preferred embodiment, the tool means has a guiding device arranged to establish a relative position between the male unit tool and the female unit tool in which the respective tool axes are aligned to each other and in which the tools are in a predetermined angular position relative to each other.

By the guiding device it is easy for the surgeon to manipulate the two attachments unit to a relative position in which they are ready for connection to each other.

According to a further preferred embodiment, the guiding device is arranged to guide movement of the tools towards each other.

The guiding device thereby further simplifies the connection of the attachment units. From the proper position established by the guiding device the surgeon merely needs to move the tools towards each other, and the attachment means will be correctly connected.

According to a further preferred embodiment, the guiding device includes two axially extending pins attached to the handle of one of the tools and two holes in handle of the other tool, which are arranged to receive the pins when the jaw axes of the tools are aligned and the tools are in the predetermined angular position relative to each other.

Such a construction of the guiding device is very simple in its construction and makes it very easy to bring the attachment unit together. Alternatively, each tool has one pin and one hole cooperating with one hole and one pin in the other tool. This alternative is substantially equivalent.

The invention also relates to a kit that includes an anastomosis device according to the present invention, in particular to any of the preferred embodiments thereof, which kit further includes an anastomosis tool means according to the present invention, in particular to any of the preferred embodiments thereof.

By providing such a kit, an anastomosis operation can be made quick and safe with very low risk for mistakes. The advantages mentioned above for the anastomosis device and the anastomosis tool means will be still further enhanced
with a kit, in which the components are especially tailored to cooperate with each
other.

The object of the invention is according to the third aspect thereof
achieved in that a method of the kind mentioned in the introduction of the present
application includes the specific steps of

- moving the attachment units towards each other such that
  the projections of the male unit move on the outside of the outer
  surface of the female unit until an axial rearward directed male
  abutment surface on the inside of each projection reaches an
  axial rearward directed female abutment surface on the female
  unit,
- allowing each projection of the male unit to snap radially inwards
  such that each male abutment surface comes into contact with
  the female abutment surface,

whereby a through-hole in each unit defines a longitudinal axis to which
the terms radial, axial and circumferential relate, and the rearward direction of an
attachment unit is defined as the direction facing away from the other unit when
they are in position for attachment to each other.

According to preferred embodiments, the method is performed by using an
anastomosis device according to the present invention, in particular to any of the
preferred embodiments thereof.

According to further preferred embodiments, the method is performed by
using an anastomosis tool means according to the present invention, in particular
to any of the preferred embodiments thereof.

Preferably the method is performed by a kit according to the present
invention.

The invented method and the preferred embodiments thereof have
advantages of the same kind as the invented anastomosis device and the invented
anastomosis tool means, and the respective preferred embodiments of these, and
which advantages have been described above.

The above described preferred embodiments of the invention are specified
in the dependent claims. It is to be understood that further preferred embodiments
of course can be constituted by any possible combination of the preferred
embodiments above and by any possible combination of these and features mentioned in the description of examples below.

The invention will be further explained through the following detailed description of examples thereof and with reference to the accompanying drawings.

**Short description of the drawings**

Fig. 1 is a perspective view of an example according to the invention of the two attachment units when not connected to each other.

Fig. 2 is a perspective view of the attachment units in fig. 1 when connected to each other.

Fig. 3 is a perspective view of a first element of the male attachment unit in fig. 1.

Fig. 4 is an end view of the element in fig. 3 as seen from its front side.

Fig. 5 is a perspective view of a second element of the male attachment unit in fig. 1.

Fig. 6 is a side view of the element in fig. 4.

Fig. 7 is a perspective view of the female attachment unit in fig. 1.

Fig. 8 is a side view of the female attachment unit in fig. 7.

Fig 9 is a perspective view of the second element of the male attachment unit according to an alternative example.

Fig 10 is a perspective view of a part of one of the attachment units according to a further alternative example.

Fig. 11 is a side view of fig. 10.

Fig. 12 is a perspective view of an example of a male unit tool according to the invention.

Fig. 13 is a side view in enlarged scale of a detail of the male unit tool in fig. 12.

Fig. 14 is a perspective view of an example of a female unit tool according to the invention.

Fig. 15 is a side view in enlarged scale of a detail of the female unit tool in fig. 14.

Fig. 16 is a perspective view of a further example of a male unit tool according to the invention.
Description of examples

The two attachment units 100, 200 of the anastomosis device depicted in fig. 1 to 8 are adapted to be attached to a respective vessel part and then connected to each other with their front sides facing toward each other. The two tools 300, 400 of the tool means depicted in fig. 12 to 15 are adapted to hold a respective attachment unit during the operation, i.e. when attaching the attachment units to the vessel and when connecting the attachment units to each other.

Fig 1 illustrates the two attachment units 100, 200 ready to be connected to each other.

The male attachment unit 100 is in fig. 1 shown in perspective from its front side. It has a central through hole 101 that in this example is circular, and a substantially circular outside 104 that is coaxial with the through hole 101. The through hole 101 is arranged to receive a vessel part (not shown) introduced from the rear side 102. A number of flexible projections 107, in this example three, extend axially in the front direction out from the attachment unit 100. Each projection has an inwardly directed shoulder 108 with an abutment surface 109 facing in the rearward direction. The projections 107 are arranged to cooperate with the female attachment unit.

On the front side 103 there is a plurality of spikes 105 extending axially in the front direction, in this example the number of spikes is six. Between the spikes 105 there are depressions 106 having circular shape. The spikes 105 are for the purpose of attaching the vessel part to the attachment unit 100. The vessel part is drawn up through the through hole 101 so that it reaches above the front side 103. Thereafter the end of the vessel part is wrapped radially outwards against the front side 103, whereby the spikes 105 will penetrate the vessel wall such that the end of the vessel part will be securely attached.

The female attachment unit is in fig. 1 seen from its rear side 202, and with its front side 203 facing towards the male attachment unit 100. The female attachment unit has a through hole 201 through which another vessel part (not shown) is to be inserted so that it reaches beyond the its front side 203 and attached thereto in the same manner as described above in relation to the male attachment unit 100.
On the outer circumferential surface 204 the female attachment unit 200 has a plurality of circumferential rims 208. Each rim has a rear side forming an abutment surface 209 (see fig. 8). The rims 208 are to cooperate with the shoulders 108 of the male attachment unit 100.

For connecting the attachment units 100, 200, they are moved toward each other from the position in fig. 1 such that the projections 107 slide on the outer circumferential surface 204 of the female attachment unit 200. The projections 107 has a flexibility sufficient to allow them to be pressed outward when sliding on the surface 204, and then by spring action each shoulder 108 snaps in behind one of the rims 208, whereby the abutment surfaces 109,209 will contact each other and lock the attachment units from being separated.

Fig. 2 illustrates the device when the attachment units 100, 200 are connected. In principle only one rim 208 should be sufficient for the connection. With a plurality of rims 208 as in the figure there will be a possibility to select an appropriate tightness of the connection. It is also possible to use the rear side 202 of the female attachment unit to cooperate with the abutment surface 109 of each projection 107. It is also possible to provide a plurality of axially spaced shoulders 108 on each projection 107 in order to achieve the adjustability mentioned above even if there is only one rim 208. A further alternative is to have both a plurality of rims 208 and a plurality of shoulders 108.

In the illustrated example the male attachment unit 100 is composed by two separate elements, an outer element 100a and an inner element 100b. The projections 107 for connection to the female attachment unit are attached to the outer element 100a, and the spikes 105 for attachment of the vessel part are on the inner element. The inner element 100b is located in a recess 111 (see fig. 3) in the outer element 100a. In this example the shape of the inner element 100b and the recess is hexagonal with rounded corners.

It is, however, to be understood that the male attachment unit 100 as an alternative can be made in one single piece. The female attachment unit in this example is made in one single piece, but correspondingly this unit also could be composed of two units similar to the male attachment unit.

The outer element 100a is separately illustrated in fig. 3 and 4, and the inner element is separately illustrated in fig. 5 and 6. As can be seen in fig. 1, 3 and 5, the recess 111 and the inner element have matching contours. In this
example the contour is hexagonal, but it is to be understood that the contour could have any other shape, including a circular shape.

The outer contour of the male attachment unit 100 has a number of depressions 110, in this example three, in order to facilitate the manipulation thereof by a tool. At the rear end of the female attachment unit 200 there is a manipulation part 211, which also has a number of depressions 210, in this example six, for a corresponding purpose.

As best can be seen in fig. 6 and 8 the spikes are substantially cone shaped with a rounded profile when adjoining the front surface 103. The radius of the rounded profile is 0.25 mm.

In the alternative example illustrated in fig. 9, the depressions 106' in the inner element 100b' of the male attachment unit have an arc shape extending in the circumferential direction between the spikes. The circular extension of the arcs in this example is about 15°. When there are fewer spikes the extension of the arcs can be considerably longer, e.g. 45° and with a larger number of spikes they have to be shorter, e.g. 5°. Also the depressions on the female attachment unit may be correspondingly arc shaped.

A further alternative is illustrated in fig. 10 and 11, where fig. 10 schematically represents the vessel receiving surface on the front side of one of the attachment units. The spikes are here replaced by a rough surface 111 having a large number of short and sharp projections. In fig. 11 these projections 105" are enlarged illustrated. The length of these projections is such that they only partly penetrate the vessel wall.

A further example is illustrated in fig. 10 and 11, where fig. 10 schematically represents the vessel receiving surface on the front side of the attachment units. A rough surface 111 is formed by a large number of short and sharp projections 105". The length of these projections is such that they only partly penetrate the vessel wall.

The material of the attachment units should be some kind of biocompatible polymer, for example polyether ether ketone. For the spikes 105, 205 it is preferred to use a titan based material in order to manufacture them as sharp as possible.

A tool means for manipulating the attachment units is depicted in fig. 12 to 15. The tool means consists of a male unit tool 300 (fig. 12) and a female unit tool
400 (fig 14). The male unit tool has a handle 301 with a jaw 302 at its right end for gripping and holding the male attachment unit 100. The tool consists of two main components 303, 304 that are coupled to each other in such a way that they can move relative to each other in the longitudinal direction, e.g. by means of dovetail joint. Thereby the width of the jaw 302 can be varied. The relative position of the components 303, 304 can be locked, e.g. by a screw in the upper component 303 that can be brought into friction engagement with the lower component 304. The head 306 of such a screw is shown in the figure.

The upper element has two holes 305 extending in parallel with the axis of the jaw 302, the function of which will be described later.

In fig. 13 the jaw 302 of the male unit tool 300 is illustrated more in detail. The jaw has an inner profile that is substantially circular when the jaw is in its maximum closed position and with a diameter corresponding to the external diameter of the male attachment unit 100. At one of the axial ends of the jaw there is provided a flange 309, 310 on each of the components 303, 302, which flanges extend inwards in the radial direction. The flanges 309, 310 together form a support portion for the rear side 102 of the male attachment unit 100.

The flanges do not necessarily have to extend completely along the jaw as in the illustrated example. They may have shorter extension. In further alternatives they may be replaced by a plurality of small flanges or even by a plurality of short pins. The only important aspect is that a support for the attachment unit in the axial direction is attained.

The jaw 302 further is provided with two projections 307, 308 extending radially inwards from the generally circular contour. One projection 307 is on the component 303 and the other projection 308 is on the other component 304. These projections are adapted to fit in the depressions on the outer surface 104 of the male attachment unit 100, when it is hold by the tool.

The female unit tool 400 in fig. 14 has basically a similar construction as the male unit tool. It thus consists of two components 403, 404 that are slidable in relation to each other and lockable by means of the screw 406. In stead of holes, the female unit tool has two pins 405. These pins are dimensioned and positioned to match the holes 305 of the male unit tool 300.

As can be seen in fig. 15 the jaw 402 of the female unit tool 400 also has a support portion 409, 410 formed by flanges in the respective component 403, 404,
against which the rear side 202 of the female attachment unit 200 is supported when gripped by the tool.

The projections 407, 408 are adapted to fit into two of the depressions 210 of the manipulation part 211 at the rear end of the female attachment unit 200. The projections 407, 408 therefore have only a short axial extension corresponding to the depth of the depressions 210 of the manipulation portion 211.

The jaw 402 of the female unit tool further has two depressions 411, 412, which extend radially outwards from the basically circular contour. These depressions have the purpose of allowing entrance of the projections 107 of the male attachment unit 100 when connecting the two attachment units.

When an anastomosis operation is to be made, the surgeon puts the male attachment unit 100 in the jaw 302 of the male unit tool 300. At this initial stage, the component 304 is somewhat retracted in relation to the other component 303 such that the width of the jaw 302 is somewhat larger than the external diameter of the male attachment unit 100. Thereby the male attachment unit 100 can easily be put in place from above as seen in fig. 13. The width of the jaw 302, however is sufficient tight for the support portion 309, 310 to prevent the male attachment unit 100 to pass beyond it.

Next the surgeon displaces element 304 towards tightening of the jaw gap until a grip is established on the male attachment unit 100 and with the projections 307, 308 fitted into two of the depressions 110.

When holding the male attachment unit 100 in this safe grip, the end of the first vessel part is inserted from the rear end 102 through the hole 101. The wall of the end of the vessel is then wrapped radially outwards and will be penetrated by the spikes 105 for attachment.

The use of the female unit tool 400 and the attachment of the female attachment unit 200 to the other vessel part are made in a similar way.

At this stage both the attachment tools 100, 200 are secured to its respective vessel part and hold by its respective tool 300, 400. The next moment is to connect the attachment units 100, 200 to each other. Also this is made by the aid of the tool means, by moving them axially together with the axes of the respective attachment unit 100, 200 aligned. For performing this movement, the pins 405 of the female unit tool are entered into the holes 305 of the male unit tool 300. The pins 405 and the holes then guide a correct connection of the attachment
units ass the tools are moved together. Thereby two of the projections 107 of the male attachment unit 100 enter into the depressions 411, 412 of the female unit tool 400. The third projection 107 is located in the open part of the jaw 402. During the axial movement the projections slide on the outside 204 of the female attachment unit 200. When the movement is finished, the shoulders 108 of the projections snap into engagement with the female attachment unit 200 behind one of the rims 208 thereof.

In the example of the device where spikes 105, 205 are provided, these spikes during the final part of the movement enter the depressions 206, 106 on the other attachment unit.

Then the anastomosis is completed and the tools are loosened from their respective attachment units.

Fig. 16 illustrates a slightly modified construction of the tool means described with reference to the male unit tool 301", but it is to be understood that the female unit tool may be correspondingly modified. The modification is that the locking screw 306 of the tool shown in fig. 12 is replaced by a locking arrangement at the end of the component 303" that is opposite to that holding the attachment unit 100. The locking arrangement is achieved in that the component 303" has a groove 311" close to this end, separating the end portion 306" from the rest of component 303", The two portions of the component 303" thereby are connected by only a weak piece 313" forming a flexible connection between the two portions.

The outer end of the end portion 306" has a hook-like locking part 312" for abutting the end of the other component 304". When gripping and holding the attachment unit 100 the component 304" is brought to slide along the component 303" while being connected thereto by the dovetail connection on the surfaces of the components that face each other. However, the end portion 306" has no dovetail connection, whereby the locking part 312" is allowed to slide on the (not visible) side surface of component 304". The movement continues until being stopped by the attachment unit in the jaw 302". At this position the locking part 312" has reached a position outside the end of the component 304" and will due to the spring force of the piece 313" snap into abutment against the end of the component 304". Thereby the two components 303", 304" will be locked against relative movement by the attachment unit 100 in one direction and by the locking part 312" in the other direction.
CLAIMS

1. An anastomosis device for anastomising two vessel parts or other tubular organs together, the device including a male attachment unit (100) and a female attachment unit (200), which attachment units are (100, 200) attachable to a respective vessel part and connectable to each other by connection means (107, 108, 109, 208, 209) on each attachment unit (100, 200), each attachment unit (100, 200) having a through-hole (101, 201) defining an axis of the attachment unit, each attachment unit (100, 200) defining a front direction toward the other attachment unit (200, 100) when the attachment units (100, 200) are connected to each other and defining a rear direction in the opposite direction, and each attachment unit (100, 200) has a vessel receiving surface, whereby the connection means (107, 108, 109) of the male attachment unit (100) includes a plurality of projections (107) extending in the front direction of the male attachment unit (100), each projection (107) being flexible in the radial direction and having at least one shoulder (108) with a male abutment surface (109) facing in the rearward direction, and the female attachment unit (200) includes an outer circumferential surface (204), characterized in that said projections (107) and said outer surface (204) are arranged to cooperate such that the radial insides of the projections (107) face the outer surface (204) when the attachment units (100, 200) are connected and in that the connection means (208, 209) of the female attachment unit (200) includes at least one female abutment surface (209) facing in the rearward direction of the female attachment unit (200), whereby at least one male abutment surface (109) of each projection (107) and at least one female abutment surface (209) are arranged to abut each other when the attachment units (100, 200) are connected to each other.

2. An anastomosis device according to claim 1, characterized in that said at least one female abutment surface (209) includes a plurality of axially distributed female abutment surfaces (209).
3. An anastomosis device according to claim 1 or 2, characterized in that
said at least one female abutment surface (209) includes a female
abutment surface on the rear side (202) of the female attachment unit
(200).

4. An anastomosis device according to any of claims 1-3, characterized in
that the outer circumferential surface (204) of the female attachment unit
(200) is provided with at least one circumferentially extending rim (208) and
that each rim (208) has a rear side forming a female abutment surface
(209).

5. An anastomosis device according to claim 4, characterized in that there is
a plurality of rims (208) located at different axial positions.

6. An anastomosis device according to claim 4 or 5, characterized in that
each rim (208) extends completely around the female attachment unit
(200).

7. An anastomosis device according to any of claims 1-6, characterized in
that each abutment surface (109, 209) is perpendicular to the axis.

8. An anastomosis device, according to any of claims 1-7, characterized in
that the female attachment unit (200) has a manipulation portion (21 1) at its
rear end, which manipulation portion (21 1) has a non-circular outer
contour.

9. An anastomosis device according to any of claims 1-8, characterized in
that the male attachment unit (100) has an outer contour that is non-circular
at at least a part of its axial extension.

10. An anastomosis device according to claim 8 or 9, characterized in that at
least one of said non-circular contours consists of a circular base contour
with at least two depressions (110, 210).

11. An anastomosis device according to any of claims 1-10, characterized in
that at least one (100) of the attachment units (100, 200) is composed of
two separate elements (100a, 100b) fitted together, namely a radially outer
element (100a) and a radially inner element (100b), which outer element
(100a) is provided with said projections (107) or said outer circumferential
surface (204), respectively, and has a central recess (111) on its front side,
and which inner element (100b) has said vessel receiving surface and is
housed in said recess (111).
12. An anastomosis device according to claim 11, characterized in that the inner element (100b) is non-rotatable housed in the recess (111).

13. An anastomosis device according to claim 12, characterized in that the recess (111) and the inner element (100b) has matching circumferential contour, which contour is non-circular.

14. An anastomosis device according to any of claims 1-13, characterized in that the vessel receiving surface of each attachment unit (100, 200) is facing in the front direction and includes a plurality of circumferentially distributed spikes (105, 205) and a plurality of circumferentially distributed depressions (106, 106', 206), each spike (105, 205) having a length in the range of 0.5 to 3 mm.

15. An anastomosis device according to claim 14, characterized that each depression (106') is arc shaped and has extension in the circumferential direction that is at least 1.5 times as long as the maximum diameter of a spike (105, 205) of the other attachment unit.

16. An anastomosis device according to any of claims 1-13, characterized in that the vessel receiving surface of each attachment unit is facing in the front direction and includes at least one area (111) having a large number of small sharp projections (105") arranged to partly penetrate the wall of the received vessel part.

17. An anastomosis tool means for manipulating an anastomosis device according to any of claims 1-16 at operation, characterized in that the tool means includes a male unit tool (300) adapted to hold the male attachment unit (100) and a female unit tool (400) adapted to hold the female attachment unit (200), whereby each tool (300, 400) has an oblong handle provided with an adjustable jaw (302, 402) at an end of the handle for holding the respective attachment unit (100, 200), the axis of the attachment unit (100, 200) as hold by the tool (300, 400) defining a jaw axis, and which jaw (302, 402) has a support portion (309, 310, 409, 410) with an axially facing wall arranged to prevent the attachment unit (100, 200) to axially pass the support portion (309, 310, 409, 410) when the attachment unit (100, 200) is held in the jaw (302, 402).

18. An anastomosis tool means according to claim 17, characterized in that each tool (300, 400) has a first component (303, 403) and second
component (304, 404), each component forming a part of the handle and a
part of the jaw, which components (303, 304, 403, 404) are displaceable in
relation to each other in a plane perpendicular to said axis.

19. An anastomosis tool means according to claim 18, characterized in that
each tool (300, 400) includes a locking device (306, 306", 312", 406)
arranged to lock the relative position of said components (303, 304, 403,
404, 303", 304").

20. An anastomosis tool means according to claim 19, characterized in that
the locking device includes an end portion (306") of one of the components
(303"), which end portion (306") is connected to the rest of the component
(303") by a weak connection piece (313") and has a hook like locking part
(312") arranged to be able to snap into contact against the end of the other
component (304").

21. An anastomosis tool means according to any of claims 17-20,
characterized in that the jaw (302, 402) of each tool (300, 400) has a
contour as seen in a plane that is perpendicular to said axis, which contour
has a base profile and at least two projections (307, 308, 407, 408)
extending from the base profile towards said axis.

22. An anastomosis tool means according to any of claims 17-21,
characterized in that the jaw (302, 402) of each tool (300, 400) has a
contour as seen in a plane perpendicular to said axis, which contour has a
base profile, and the female unit tool (400) has at least two projections
(411, 412) extending from the base profile in an outward direction with
respect to the axis.

23. An anastomosis tool means according to any of claims 17-22,
characterized in that the tool means has a guiding device (305, 405)
arranged to establish a relative position between the male unit tool (300)
and the female unit tool (400) in which the respective tool axes are aligned
to each other and the tools (300, 400) are in a predetermined relative
angular position to each other.

24. An anastomosis tool means according to claim 23, characterized in that
the guiding device (305, 405) is arranged to guide axial movement of the
tools (300, 400) towards each other.
25. An anastomosis tool means according to claim 24, characterized in that the guiding device (305, 405) includes two axially extending pins (405) attached to the handle of one (400) of the tools and two holes (305) in the handle of the other tool (300), which are arranged to receive the pins (405) when the jaw axes of the tools (300, 400) are aligned and the tools are in said predetermined relative angular position.

26. An anastomosis kit, characterized in that the kit includes an anastomosis device (100, 200) according to any of claims 1-16 and an anastomosis tool means (300, 400) according to any of claims 17-25.

27. A method for anastomosing two vessel pars or other tubular organs together including the steps of

- providing a male attachment unit (100) with a connection means having a plurality of axially extending projections (107),
- providing a female attachment unit (200) having an outer circumferential surface (204),
- attaching a vessel receiving surface of each attachment unit (100, 200) to a respective vessel part,
- connecting the attachment units (100, 200) together, characterized by

- moving the attachment units (100, 200) towards each other such that the projections (107) of the male attachment unit (100) move on the outside of the outer surface (204) of the female attachment unit (200) until an axial rearward directed male abutment surface (109) on the inside of each projection (107) reaches an axial rearward directed female abutment surface (209) on the female attachment unit (200),
- allowing each projection (107) of the male attachment unit (100) to snap radially inwards such that each male abutment surface (109) comes into contact with the female abutment surface (209), whereby a through-hole (101, 201) in each attachment unit (100, 200) defines a longitudinal axis to which the terms radial, axial and circumferential relate, and the rearward direction of an attachment unit (100, 200) is defined as the direction facing away from the other attachment unit (200, 100) when they are in position for attachment to each other.
28. A method according to claim 27, characterized by using an anastomosis device (100, 200) according to any of claims 1-16 when performing the method.

29. A method according to claim 28, characterized by using an anastomosis tool means (300, 400) according to any of claims 17-24 when performing the method.
INTERNATIONAL SEARCH REPORT

PCT/SE2011/050640

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: A61 B

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>WO 2007122220 A2 (CARPONOVUM AB ET AL), 1 November 2007 (2007-1 1-01 ); page 8, line 25 - page 9, line 14; figures 3A,3B,4A,4B</td>
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Date of the actual completion of the international search: 17-01-2012

Date of mailing of the international search report: 03-02-2012

Name and mailing address of the ISA/SE

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Form PCT/ISA/210 (second sheet) (July 2009)
## DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>KR 10 1026933 B 1 (METABIOMED CO LTD), 4 April 2011 (201-04-04); figures 1-7</td>
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This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. **Claims Nos.: 27-29**
   - because they relate to subject matter not required to be searched by this Authority, namely:
     - Claims 27-29 relates to a method for treatment of the human or animal body by ...

2. **Claims Nos.:**
   - because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. **Claims Nos.:**
   - because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

This International Searching Authority found multiple inventions in this international application, as follows:

1. **As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.**

2. **As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.**

3. **As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:**

4. **No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:**

**Remark on Protest**
- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.
Continuation of: Box No. II

surgery or by therapy, as well as diagnostic methods, see PCT rule 39.1 (iv). Nevertheless, a search has been made for these claims. The search has been directed to the technical content of the claims.
Continuation of: second sheet
International Patent Classification (IPC)
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Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-7822885).

Cited literature, if any, will be enclosed in paper form.
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