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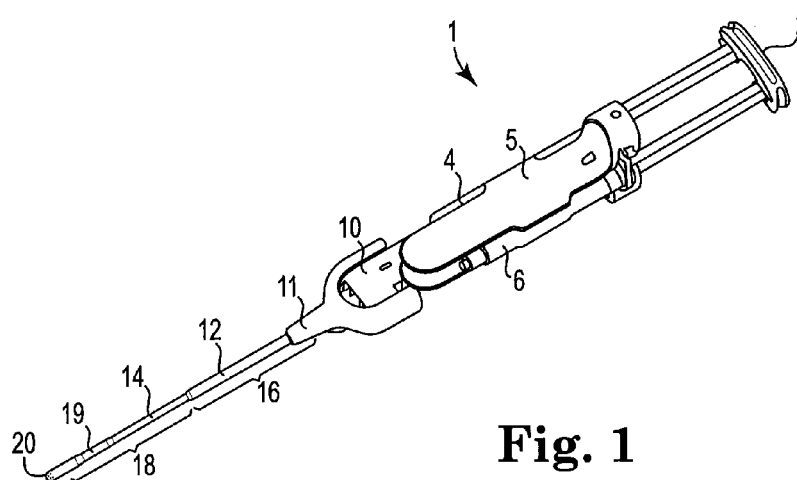
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[Continued on next page]

(54) Title: MULTI-SECTIONED CANNULA WITH AT LEAST ONE LUMEN



**Fig. 1**

(57) Abstract: A malleable cannula having multiple lumens, constrained at the proximal end portion to provide rigidity and malleable at the distal end portion. The cannula has a combination of flexibility and stiffness that assists in accessing body passageways without kinking.



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## MULTI-SECTIONED CANNULA WITH MULTIPLE LUMENS

### Cross-Reference to Related Application

[0001] This application claims priority from U.S. Patent Application Serial No.  
5 13/284,387 filed October 28, 2011, the disclosure of which is incorporated herein by reference.

### Technical Field

[0002] This invention relates to a medical cannula used to deliver fluids.

10

### Background

[0003] Sinusitis is an inflammation of the mucosal tissue lining of the sinus walls which may lead to nasal passageway blockage, mucous stagnation and bacterial or fungal sinus cavity infection. Typical treatments begin with antibiotics. However, when antibiotics cannot relieve sinusitis, sinus surgery (which involves opening the sinus  
15 cavities and removing mucosal tissue) may be an alternative. Post-operative care for such surgery requires temporary and uncomfortable sinus packing or gauze which supports the reopened sinus passage and absorbs excess fluid while the tissues heal. After several days or at the discretion of the physician, the gauze packing is removed. Doing so is painful.

[0004] Sinus sealants and other biological materials have emerged as a promising  
20 technique to temporarily seal or otherwise protect the post-operative passageways with less intrusion and pain than that caused by traditional packing techniques.

[0004A] Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in  
25 the field relevant to the present disclosure as it existed before the priority date of each claim of this application.

### Summary of the Invention

[0005] Biomaterials have been used in ear, nose, and throat (ENT) procedures for  
30 surgical repair and drug delivery. The chemical nature of some biomaterials requires that they be provided in a multi-component form with the components being separated prior to

use. The components are mixed together shortly before or during delivery, and the mixture rapidly forms a gel or solid.

[0006] There are, however, potential difficulties when using highly-reactive multi-component biomaterial systems. If the components react too rapidly, the resulting mixture may exhibit poor or erratic performance. Rapid reaction may however be desired for other reasons, such as a need for the biomaterial system to be spray-applied yet quickly form a gel or solid at a desired application site. An operator also desirably should be able to dispense the biomaterial using a single gloved hand.

[0007] Other concerns encountered using tissue sealants such as sinus sealants include navigating the sealant delivery system within a patient's anatomic structures. For example, sealants may be delivered through a cannula having one or more lumens through which fluids can flow. The cannula requires flexibility for insertion through various pathways that may twist and turn, sometimes abruptly at acute angles. At the same time, the cannula should be able to resist kinking or closing off of the lumen and permit uninterrupted fluid flow.

[0008] The invention provides, in one aspect, a multi-sectioned cannula comprising:

- a) a malleable member having a proximal portion and a distal portion;
- b) at least one lumen within and extending between the proximal and distal portion; the at least one lumen in fluid communication with a fluid supply; and;
- c) a reinforcement member extending along the length of the at least one lumen; the cannula having a durometer such that the cannula does not kink when bent greater than 45 degrees.

[0009] The invention provides, in another aspect, a method of dispensing fluids to a target site, the method comprising:

A) providing a spray delivery system comprising:

- (i) at least one fluid supply; and
- (ii) a cannula, the cannula comprising:
  - a) a malleable member having a proximal portion and a distal portion;
  - b) at least one lumen within and extending between the proximal and distal portion; the at least one lumen in fluid communication with a fluid supply; and;

c) a reinforcement member extending along the length of the at least one lumen; the cannula having a durometer such that the cannula does not kink when bent greater than 45 degrees; and

(iii) a spray head through which the at least one fluid supply exits;

5 B) dispensing fluid from the fluid supply into the at least one such lumen and through the spray head.

**[0009A]** The invention provides, in yet another aspect, a cannula comprising:

a) a rigid proximal portion connected to a malleable distal portion;

10 b) a first polymeric lumen and at least a second polymeric lumen within and extending between the rigid proximal portion and malleable distal portion;

c) the first polymeric lumen having a malleable reinforcement member within and extending along the length of the malleable distal portion ; and

d) the at least second polymeric lumen being in fluid communication with a fluid supply; wherein the connected malleable distal portion and rigid proximal portion  
15 can be inserted and maneuvered into a human nasal cavity, the rigid proximal portion prevents or discourages cannula bending if maneuvering in such cavity, the malleable distal portion has a durometer such that the malleable distal portion does not kink when bent greater than 45 degrees, and the malleable reinforcement member is sufficiently stiff so that the malleable distal portion will retain its shape until bent into a new shape.

20 **[0009B]** The invention also provides, in another aspect, a method of dispensing fluids to a body cavity target site, the method comprising:

A) providing a spray delivery system comprising:

(i) at least one fluid supply; and

(ii) a cannula, the cannula comprising:

25 a) a rigid proximal portion connected to a malleable distal portion;

b) a first polymeric lumen and at least a second polymeric lumen within and extending between the rigid proximal portion and malleable distal portion;

30 c) the first polymeric lumen having a malleable reinforcement member within and extending along the length of the malleable distal portion; and

- d) the at least second polymeric lumen being in fluid communication with a fluid supply;

wherein the connected malleable distal portion and rigid proximal portion can be inserted and maneuvered into a human nasal cavity, the rigid proximal portion prevents or discourages cannula bending if maneuvering in such cavity, the malleable distal portion has a durometer such that the cannula does not kink when bent greater than 45 degrees, and the malleable reinforcement member is sufficiently stiff so that the malleable distal portion will retain its shape until bent into a new shape; and

- iii) a spray head through which the at least one fluid supply exits; and  
B) dispensing fluid from the fluid supply into the at least second polymeric lumen and through the spray head.

[0009C] Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

[0010] The disclosed apparatus and method have particular use for accessing various anatomical locations such as sinus cavities and for applying tissue sealants at these anatomical locations.

#### Brief Description of the Drawing

[0011] **Fig. 1** is a perspective view of a partially assembled spray delivery system including an exemplary cannula;

[0012] **Fig. 2** is a perspective, exploded view of the cannula of **Fig. 1**;

[0013] **Fig. 3A** is a perspective view of a shroud and support member;

[0014] **Fig. 3B** is a perspective view, partially in cross-section of the **Fig. 3A** shroud;

[0015] **Fig. 4A** is a perspective view of a distal portion of the cannula;

[0016] **Fig. 4B** is a perspective, exploded view of components in the **Fig. 4A** cannula;

[0017] **Figs. 5A-B** are perspective views, partially in phantom, of the **Fig. 4A** and **4B** cannula.

[0018] **Fig. 6** is a perspective view of an embodiment of a distal portion of the cannula.

[0019] Like reference symbols in the various figures of the drawing indicate like elements. The elements in the drawing are not to scale.

5

### Detailed Description

[0020] The recitation of a numerical range using endpoints includes all numbers subsumed within that range (e.g., 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4, 5, etc.).

[0021] The present invention provides, in one aspect, a malleable, kink-resistant cannula and, in other aspects, a method of delivering tissue sealants using such cannula.

10 The cannula can be bent to desirable configurations that are maintained during use and without the cannula or its lumen(s) kinking or closing off and thereby provide uninterrupted fluid delivery through the lumen(s). This kink-resistant feature permits the cannula to be shaped and reshaped during a sealant delivery process while fluid is flowing through the cannula.



[0022] The cannula may be assembled to a delivery system and spray head that may be used to apply multi-component fluid compositions. Such delivery systems and spray heads, for example, include those described in U.S. Patent Application Ser. No.

13/284,600 and Attorney Docket No. 151-P-41646.WO04 and U.S. Patent Application  
5 Ser. No. 13/284,421 and Attorney Docket No. 151-P-41646.WO02, respectively, filed even date herewith and each of which is incorporated herein by reference in its entirety.

[0023] The apparatus and method may be used to apply compositions containing multiple agents, such as a multiple component tissue sealant (e.g. two components) to a variety of bodily passageways or cavities including nasal cavities and sinus cavities (e.g.  
10 maxillary, frontal or sphenoid sinuses). Exemplary multi-component tissue sealants may include reactive polysaccharides, for example, chitosan and starch. Other exemplary multi-component tissue sealants are provided in U.S. patent application Ser. No.12/429,141, now published as U.S. Patent Application Publication No. 2009/0270346A1 and U.S. Patent Application Ser. No.12/429,150, now published as U.S.  
15 Patent Application Publication No. 2009/0291912 A1.

[0024] FIG. 1, which shows a partially assembled spray delivery system 1, includes an actuating member 2, and a body 5 capable of receiving and capturing syringes 4, 6. The actuating member 2 operates upon syringes 4, 6 to provide simultaneous delivery of fluids housed in syringes 4, 6. The spray delivery system 1, as shown in FIG. 1, further includes  
20 cannula 14 and spray head 20.

[0025] Cannula 14 may be a flexible or malleable member that may be assembled to include a rigid proximal end portion 16 and a malleable distal end portion 18. The rigid proximal end portion 16 may be constrained at the proximal end by support shaft 12 and shroud 11, which prevents or discourages cannula bending. The rigid proximal end  
25 portion 16 also includes the portion of cannula 14 surrounded by support shaft 12. Cannula 14 may be bent at the malleable distal end portion 18, which extends from the end of the support shaft 12 up to the proximal portion of the spray head 20.

[0026] Cannula 14 and spray head 20 are connected to body 5 through manifold 10. Manifold 10 may be surrounded by a shroud 11 with support shaft 12 constraining the  
30 proximal end of cannula 14. Manifold 10 may be configured to receive portions of syringes 4, 6 without requiring threaded or rotating engagement of the syringe to manifold 10 to provide a liquid tight connection. Spray head 20 is connected to malleable distal end

portion **18**. Covering the interface between the malleable distal end portion **18** and spray head **20** is a sheath **19** which provides a smooth transitional interface at the joint between cannula **14** and spray head **20**.

**[0027]** When used to deliver a tissue sealant to a sinus cavity, cannula **14** preferably has an overall length of about 10 cm to 15 cm, more preferably about 12 to 13 cm. The rigid proximal end portion **16** may have a length in the range from about 4 cm to 8 cm, preferably about 5 cm to 7 cm, and the malleable distal end portion **18** may have a length, for example, in the range from about 4 cm to 8 cm, preferably about 5 cm to 7 cm. The outer diameter of cannula **14** may be from about 0.1 cm to 1.0 cm, preferably about 0.3 cm to 0.4 cm. The ratio of the rigid proximal end portion **16** to the malleable distal end portion **18** may be in a ratio of about 2:1 or about 1:2, and preferably about 1:1.

**[0028]** Depending on the specific cannula use, other dimensions are also acceptable. For example, cannula **14** may be used in laparoscopic anatomical or gynecological surgery, neural surgery, pulmonary surgery or the like.

**[0029]** The cannula **14** may be formed of a material acceptable for use inside the human body and of a selected durometer (hardness). The selected durometer aids in preventing the cannula from kinking when bent greater than 45 degrees, greater than 90 degrees, or greater than 180 degrees with respect to a straight, unbent configuration. The selected material may include for example, thermoplastic or thermoset polymers such as polyolefins, silicones, polyvinyl chlorides, polyurethanes, polyesters and the like. To attain a desired durometer, fillers or plasticizers may be used. The amount and type of filler or plasticizer is determined by the selected thermoplastic or thermoset polymers used. Cannula **14** may have a durometer (Shore A) in the range, for example, from 60 to 95, preferably from about 85 to 95.

**[0030]** Referring to **FIG. 2**, support member **12** may be in the form of a cylindrical metal or plastic tube surrounding cannula **14** and molded within or otherwise connected to the distal end portion of shroud **11**, for example, by adhesive or welding. The support member **12** preferably is made of stainless steel. Other exemplary materials include, for example, metals such aluminum and plastics such as thermoplastic or thermoset polymers. The support member **12** desirably has a thickness and length such that it minimizes physical obstruction during anatomic insertion and resists sideways deflection of proximal end portion **16** so as to provide improved control when maneuvering and navigating

cannula **14** through bodily passageways. The support member **12** may, for example, have a thickness of about 0.01 cm to about 0.1 cm, preferably from about 0.02 cm to 0.03 cm; and a length, for example, of about 3 cm to 10 cm, preferably from about 4.5 cm to 5.5 cm.

5   **[0031]**     As illustrated in **FIGS. 2** and **3A-B**, shroud or casing **11** surrounds outer portions of manifold **10**. The shroud **11** also engages the support member **12**, and when assembled to cannula **14**, provides additional proximal rigidity to the cannula **14**. Shroud **11** may be permanently attached to the manifold **10**, for example, by adhesives, welding or injection molding or may be optionally removable.

10   **[0032]**     As illustrated in **FIGS. 4A-B**, sheath **19** may, for example, surround the proximal portion of spray head **20** and the distal end portion **18** producing a smooth interface between the spray head **20** and cannula **14**. Sheath **19** also helps keep spray head **20** firmly attached to cannula **14** when withdrawing spray head **20** from a confined location.

15   **[0033]**     Desirable lengths of sheath **19** may for example, range from about 10 mm to 50 mm, preferably from about 20 mm to 25 mm. A thickness for sheath **19** desirably may be selected such that it minimizes interference with anatomical features during cannula insertion. The sheath thickness may, for example, range from to 0.001 cm to 0.010 cm, preferably 0.001 cm to 0.003 cm. The sheath **19** may be a heat shrink tube, a  
20   mechanically expanded tube, or an extruded plastic tube, and may be made from a variety of materials, for example, polyester, polyolefin, and fluoropolymers.

**[0034]**     As shown in **FIGS. 5A-B**, an exemplary cannula **14** may enclose multiple lumens that extend the entire cannula length, from the rigid proximal end portion **16** to the malleable distal end portion **18** and maintains the separation of each lumen. The  
25   individual lumen diameters are dependent on a number of factors, including the spray head opening diameters, the desired pressure and flow rate. The lumens may, for example, all be of the same diameter and cross sectional shape. The lumen shape may be, for example, circular, oval, square or D-shaped in cross-section, with the flat portions of neighboring D-shapes being adjacent to one another.

30   **[0035]**     As illustrated in **FIG. 5A**, at least one of the lumens may include a reinforcement member **22** to allow selective bending of the cannula **14** to fit different orientations. The reinforcement member **22** may, for example, be in the form of a wire

located within and extending along the length of a lumen. The reinforcement member **22** may, but need not be centrally located in the multi-lumen cannula **14**. In such embodiments, the cannula **14** may be formed with at least two lumens, one of which will become occupied by the reinforcement member **22**. The cannula **14** may also be formed  
5 by extruding or molding it over the reinforcement member **22** and by providing at least one lumen through which fluid may flow.

**[0036]** The reinforcement member **22** may be made of, for example, metal or a metal alloy such as stainless steel, copper, aluminum or the like. In other examples, reinforcement member **22** may be made of a shape memory metal such as Nitinol. The  
10 diameter of the reinforcement member **22**, may, for example, range from 0.001 cm to 0.10 cm, preferably 0.03 cm to 0.05 cm. The shape of the reinforcement member **22** may be, for example, circular, oval, square or D-shaped in cross-section. The stiffness of the reinforcement member **22** may be full hard, half hard, quarter hard, annealed, soft or any other desired stiffness depending on the desired application.

**[0037]** The cannula **14**, illustrated in **FIGS. 5A-B**, includes four lumens, one of which is occupied by reinforcement member **22**. Remaining lumens **24**, **26**, **28** are in fluid communication with one or more fluid supplies such as syringes **4**, **6** and a source of pressurized air (not shown) that may be introduced into lumen **28** via port **30**, which is shown in **FIG. 2**.

**[0038]** In some aspects, the cannula **14**, illustrated in **FIG. 6** shows at least a portion of the distal tip of cannula **14** as a beveled or tapered distal end **32**. The beveled end **32** is positioned to be centered with respect to the four lumens, three lumens, two lumens or one lumen. The bevel end **32** may, for example, extend through all the lumens, four lumens, three lumens, two lumens or one lumen. As illustrated in **FIG. 6**, bevel **32** extends over  
25 three lumens. As shown in **FIG. 6**, the distal tip of the cannula **14** that does not include bevel **32** has the longest lumen. In some embodiments, the longest lumen is occupied by reinforcement member **22**. As seen in **FIG. 6**, lumens **34**, **36** and **38** are part of the tapering. In some embodiments, the shortest lumen **38** allows air passage and lumens **34** and **36** allow fluid passage. In such an arrangement (as depicted in **FIG. 6**), exiting of air  
30 before fluids results in better mixing of the lumen contents as it enters spray head **20**. As will be appreciated, variations on the lumen arrangement and reinforcement member may be envisioned. The bevel angle may, for example, range from about 35 degrees to about

75 degrees. In other embodiments, the bevel angle may range from about 40 degrees to 45 degrees. Bevel 32 may be formed at any desired angle that allows insertion into a spray head and results in better homogeneous mixing of the lumen contents as it moves into spray head 20.

5    **[0039]**     In one exemplary assembly process for the disclosed device, an operator first inserts the actuating member 2 into body 5. Alternatively, actuating member 2 may be preassembled with body 5. Syringes 4, 6 are positioned against body 5 and actuating member 2 so that body 5 and actuating member 2 can receive and capture syringes 4, 6. In this manner, syringes 4, 6 are held substantially parallel in body 5.

10   **[0040]**     Once the syringes are received and captured by body 5, cannula 14 and spray head 20 are assembled to body 5 through manifold 10. Cannula 14 and spray head 20 may if desired be preassembled to manifold 10 during manufacturing.

15   **[0041]**     The operator then connects manifold 10 to syringe outlets to provide an unthreaded, liquid-tight connection such that the syringe contents in syringe barrels are in fluid communication with cannula 14 through manifold 10.

20   **[0042]**     When the delivery device 1 is fully assembled, the operator shapes the cannula 14 to a desired shape. Cannula 14 desirably is sufficiently stiff so that it will retain its shape until bent into a new shape. The shaped cannula 14 and spray head 20 are then maneuvered or navigated into a desired treatment site within the patient's body, for example, a nasal or sinus cavity or other opening, recess or passageway. Once satisfactorily positioned, an operator may, for example, depress actuating member 2 to move the plunger of syringe 4, 6 toward the syringe outlets, advancing the fluid syringe contents substantially at the same time through the separate syringe barrels and out into respective fluid channels in manifold 10 which maintain the fluid separation. Continued  
25   force will advance the fluids through the multi-lumen cannula 14 and into a region within spray head 20 where they mix before the mixed fluids exit spray head 20. If compressed gas is used, it may be supplied through a gas inlet (not shown). The gas stream passes through a lumen of multi-lumen cannula 14 into the mixing region of spray head 20. The gas stream helps atomize the mixed syringe contents resulting in much smaller droplets.  
30   In some embodiments, a beveled cannula may be used. Overall, a smoother manipulation and easier control of the device through passageways is provided.

**[0043]**     The invention is further illustrated in the following non-limiting examples.

**Example 1**

- 5 [0044] Delivery device 1 was clamped into a suitable fixture and evaluated using an air flow rate meter to determine rate of air flow through cannula 14 at different user configurations. The air flow rate was measured at least 14 times for each user configuration.

| Test   | Average Air Flow Rate (L/min) | STDEV |
|--|-------------------------------|-------|
| Air Flow Rate (Straight Cannula)               | 10.02                         | 0.47  |
| Air Flow Rate (90° Bent Cannula)               | 10.05                         | 0.43  |
| Air Flow Rate (180° Bent cannula)              | 10.29                         | 0.88  |
| Air Flow Rate (Greater than 180° Bent Cannula) | 9.89                          | 0.30  |

10

**Example 2**

- [0045] Delivery device 1 was clamped into a suitable fixture and evaluated using a calibrated force gauge to determine the force in Lbf units to bend the cannula 90 degrees. The required force was measured at least 14 times with the cannula bent at 90 degrees.

| Test                        | Average (Lbf) | STDEV |
|-----------------------------|---------------|-------|
| Cannula Bend<br>Force (90°) | 1.53          | 0.11  |

We claim:

1. A cannula comprising:
    - 5 a) a rigid proximal portion connected to a malleable distal portion;
    - b) a first polymeric lumen and at least a second polymeric lumen within and extending between the rigid proximal portion and malleable distal portion;
    - c) the first polymeric lumen having a malleable reinforcement member within and extending along the length of the malleable distal portion ; and
    - 10 d) the at least second polymeric lumen being in fluid communication with a fluid supply;

wherein the connected malleable distal portion and rigid proximal portion can be inserted and maneuvered into a human nasal cavity, the rigid proximal portion prevents or discourages cannula bending if maneuvering in such cavity,

  - 15 the malleable distal portion has a durometer such that the malleable distal portion does not kink when bent greater than 45 degrees, and the malleable reinforcement member is sufficiently stiff so that the malleable distal portion will retain its shape until bent into a new shape.
2. The cannula of claim 1 wherein the malleable distal portion does not kink when  
20 bent 90 degrees.
  3. The cannula of claim 1 wherein the malleable distal portion does not kink when bent 180 degrees.
  4. The cannula of claim 1 wherein the malleable distal portion durometer is about 60-95 Shore A.
  - 25 5. The cannula of any one of the preceding claims wherein the malleable distal portion comprises polyvinyl chloride.

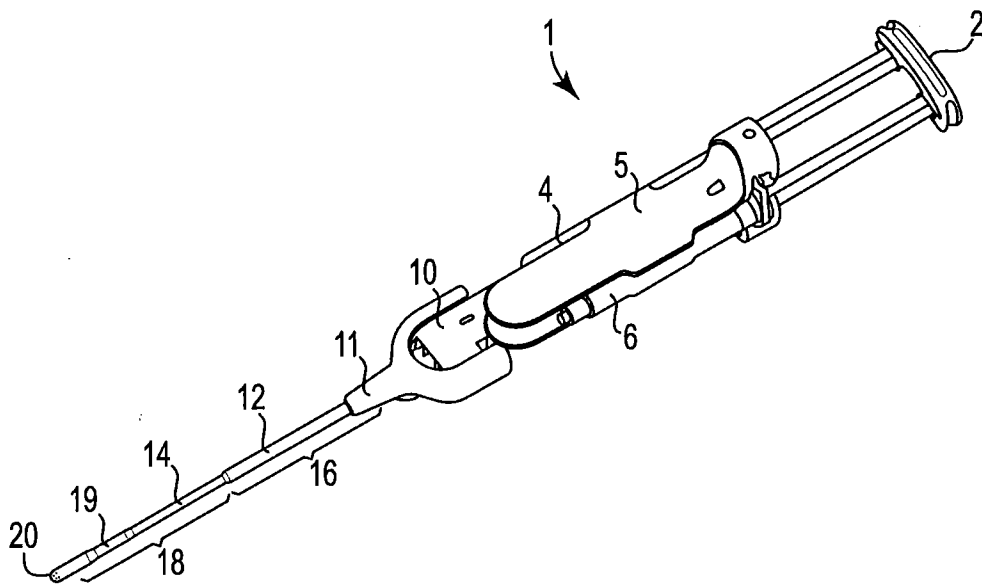


6. The cannula of any one of the preceding claims wherein the rigid proximal portion includes a rigid support member comprising a cylindrical metal or plastic tube.
7. The cannula of claim 6 wherein the support member comprises stainless steel.
8. The cannula of any one of the preceding claims wherein the malleable distal portion is connected to a spray head.
9. The cannula of claim 8 further comprising a sheath that provides a smooth transitional interface between the cannula and spray head.
10. The cannula of any one of the preceding claims wherein the cannula is dimensioned for use in a sinus cavity, the rigid proximal portion and the malleable distal portion each have a length, and the rigid proximal portion length and the malleable distal portion length are in a ratio of about 1:2 to about 2:1.
11. The cannula of any one of the preceding claims wherein the cannula includes four lumens.
12. The cannula of any one of claims 1 to 10 wherein the cannula includes at least two lumens configured to be in fluid communication with separate fluid supplies.
13. The cannula of any one of the preceding claims wherein the reinforcement member comprises a stainless steel wire.
14. The cannula of any one of the preceding claims wherein the cannula, the rigid proximal portion and the malleable distal portion have an overall length of about 10 cm to 15 cm.
15. A method of dispensing fluids to a body cavity target site, the method comprising:
  - A) providing a spray delivery system comprising:
    - (i) at least one fluid supply; and
    - (ii) a cannula, the cannula comprising:
      - a) a rigid proximal portion connected to a malleable distal portion;

- 5                   b) a first polymeric lumen and at least a second polymeric lumen  
                      within and extending between the rigid proximal portion and the  
                      malleable distal portion;
- c) the first polymeric lumen having a malleable reinforcement  
                      member within and extending along the length of the malleable  
                      distal portion; and
- d) the at least second polymeric lumen being in fluid  
                      communication with a fluid supply;
- 10               wherein the connected malleable distal portion and rigid proximal portion can be  
                      inserted and maneuvered into a human nasal cavity, the rigid proximal portion  
                      prevents or discourages cannula bending if maneuvering in such cavity, the  
                      malleable distal portion has a durometer such that the cannula does not kink when  
                      bent greater than 45 degrees, and the malleable reinforcement member is  
                      sufficiently stiff so that the malleable distal portion will retain its shape until bent  
15               into a new shape; and
- iii) a spray head through which the at least one fluid supply exits; and
- B) dispensing fluid from the fluid supply into the at least second polymeric  
                      lumen and through the spray head.
16.           The method of claim 15 wherein the cannula has a durometer (Shore A) from 60-  
20           95.
17.           The method of claim 15 or claim 16 wherein the cannula does not kink when bent  
                      90 degrees.
18.           The method of claim 15 or 16 wherein the cannula does not kink when bent 180  
                      degrees.
- 25           19.    The method of any one of claims 15 to 18 comprising dispensing a tissue sealant.

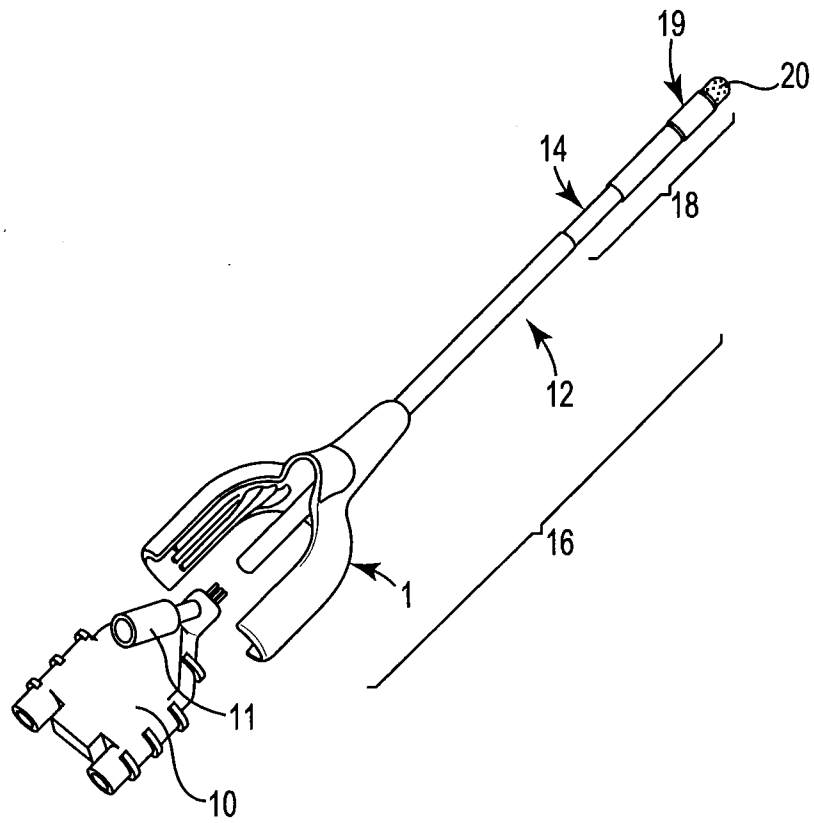
20. The method of any one of claims 15 to 19 comprising dispensing a mixture of chitosan and starch.

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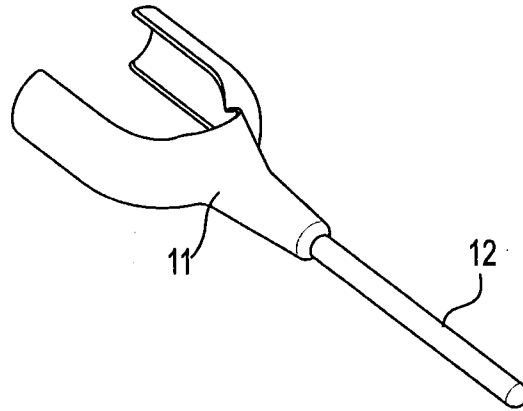
**Fig. 1**

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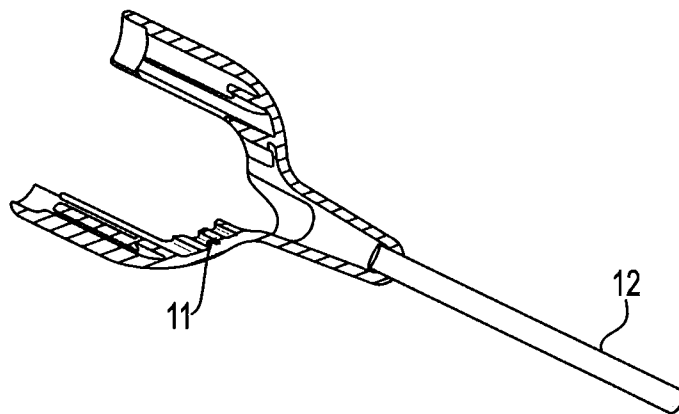


**Fig. 2**

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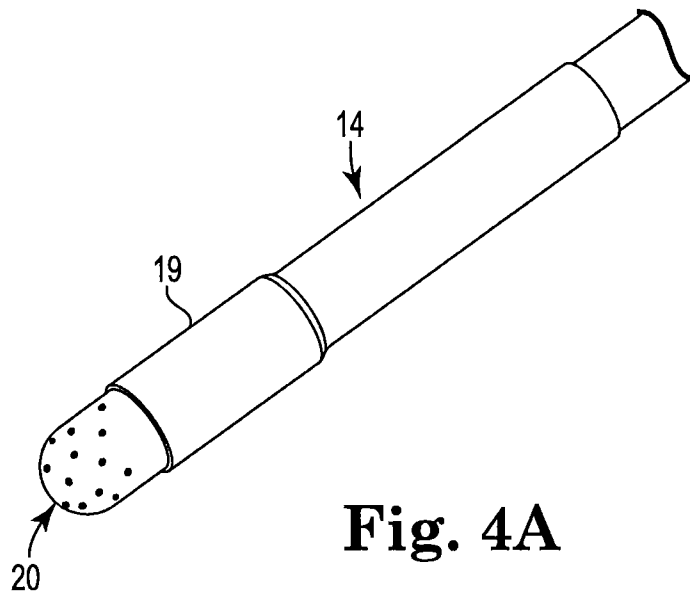


**Fig. 3A**

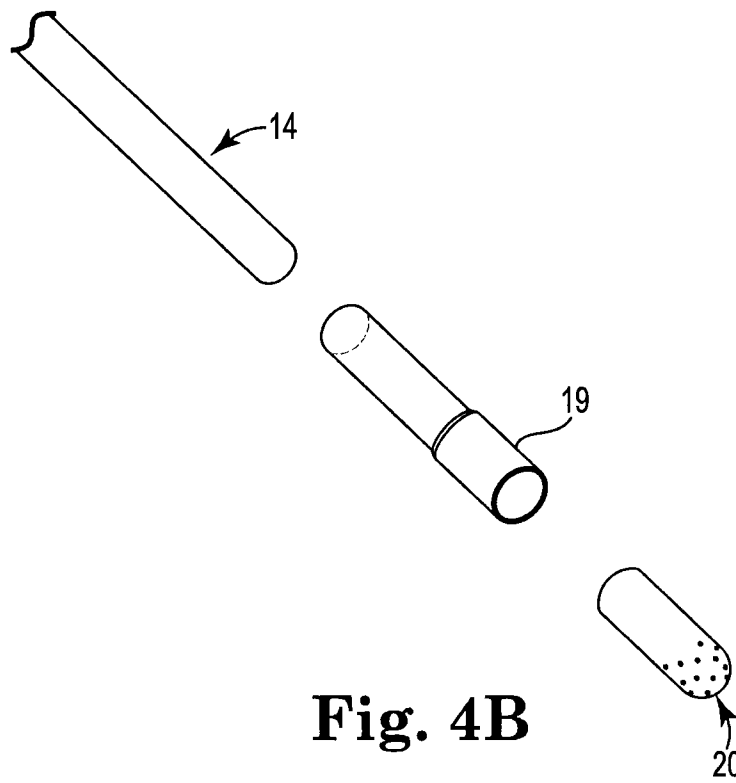


**Fig. 3B**

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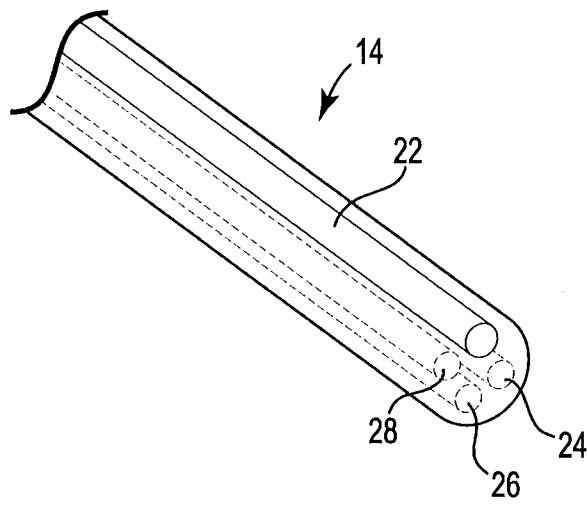


**Fig. 4A**

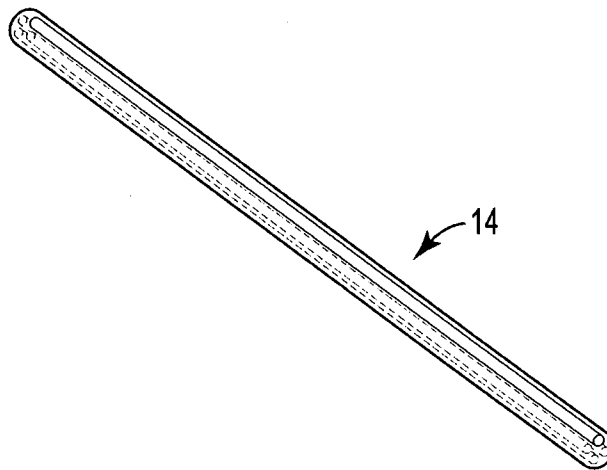


**Fig. 4B**

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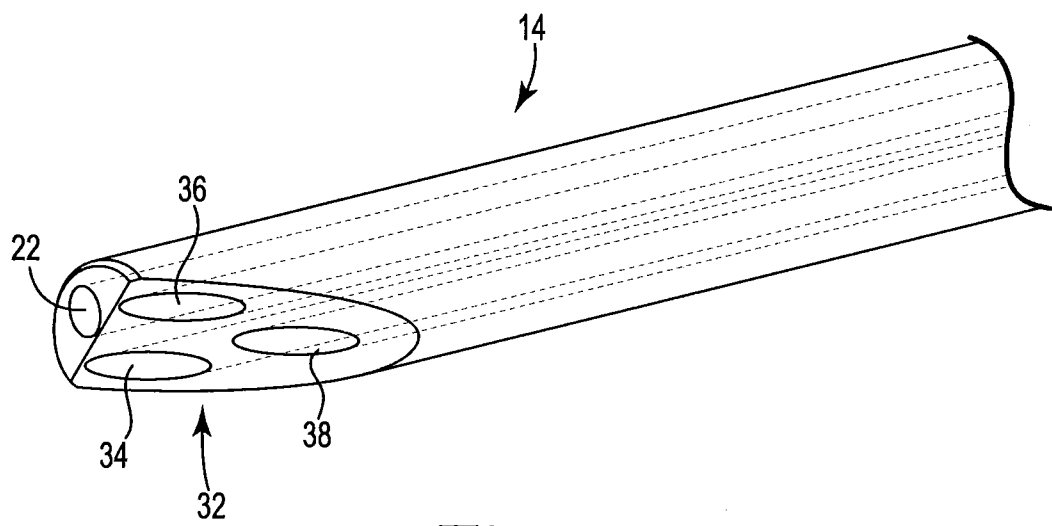
**Fig. 5A**



**Fig. 5B**



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**Fig. 6**