



A cannula for improved dental root canal cleaning

Lenau, Torben; Wandall, Allan Patrick; Schwab Rolver, Josefine; Steinfurth, Josefine; Hemmingsen, Mia; Kæseler, Ib

Publication date:
2024

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Lenau, T., Wandall, A. P., Schwab Rolver, J., Steinfurth, J., Hemmingsen, M., & Kæseler, I. (2024). A cannula for improved dental root canal cleaning. (Patent No. *WO2024002905*).

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



(51) International Patent Classification:

A61C 17/024 (2006.01) A61C 5/40 (2017.01)

(21) International Application Number:

PCT/EP2023/067175

(22) International Filing Date:

23 June 2023 (23.06.2023)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

22182647.2 01 July 2022 (01.07.2022) EP
PA202200899 03 October 2022 (03.10.2022) DK

(71) Applicant: **DANMARKS TEKNISKE UNIVERSITET** [DK/DK]; Anker Engelunds Vej 101, 2800 Kongens Lyngby (DK).

(72) Inventors: **LENAU, Torben**; c/o DTU, Anker Engelunds Vej 101, 2800 Kongens Lyngby (DK). **WANDALL, Allan Patrick**; c/o DTU, Anker Engelunds Vej 101, 2800 Kongens Lyngby (DK). **SCHWAB ROLVER, Josefine**; c/o DTU, Anker Engelunds Vej 101, 2800 Kongens Lyngby (DK). **STEINFURTH, Josefine**; c/o DTU, Anker Engelunds Vej 101, 2800 Kongens Lyngby (DK). **HEMMINGSEN, Mia**; c/o DTU, Anker Engelunds Vej 101,

2800 Kongens Lyngby (DK). **KÆSELER, Ib**; Idrætsvej 71, 2650 Hvidovre (DK).

(74) Agent: **INSPICOS P/S**; Agerm Alle 24, 2970 Horsholm (DK).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,

(54) Title: A CANNULA FOR IMPROVED DENTAL ROOT CANAL CLEANING

(57) Abstract: The invention relates to a cannula for a dental irrigation system comprising a body extending in an axial direction between a proximal end and a distal end, and comprising at least two separate conduits extending in the axial direction between at least one proximal opening and at least two distal openings. Each of the at least two separate conduits terminate at a separate opening of the at least two distal openings. The invention further relates to a cannula comprising a body with a non-circular cross section, to a dental irrigation system, to a method of irrigating a root canal, to a method of manufacturing a cannula, and to a dental irrigation system for use in endodontic therapy.

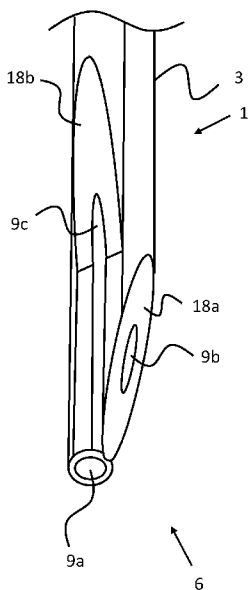


Fig. 6a



WO 2024/002905 A1

SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report (Art. 21(3))*
- *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

A CANNULA FOR IMPROVED DENTAL ROOT CANAL CLEANING

INTRODUCTION

The disclosure relates to a cannula for a dental irrigation system and to a method for flushing a liquid into a root canal.

5 BACKGROUND

Endodontic therapy sometimes includes flushing a rinsing or therapeutic liquid into a root canal for rinsing or treating the root canal. This process requires a very thin and flexible cannula.

10 When a cannula is inserted into the root canal to flush the canal, one problem which may occur is that the root canal may become partially or fully clogged from debris loosened during the flushing.

Another problem is that the flushing may accidentally cause bacterial contaminants to flow into the soft tissue rather than flushing it out of the canal. The risk of this undesirable outcome may be increased by the clogging of the root canal which inevitably increases
15 pressure at the soft tissue at the bottom of the canal at which the tip of the cannula is typically located during endodontic therapy procedures.

A further problem is that the cannula itself may become clogged. This may for example occur during insertion of the cannula into the root canal, upon which debris may be caught in an opening of the cannula. Resultingly, the desired flow of the rinsing or therapeutic liquid may
20 not be delivered in the root canal.

SUMMARY

It is an object of the present disclosure to improve flushing of root canals and particularly to allow better back-flushing of debris, to reduce excessive pressures in the root canal during flushing, and to allow better manoeuvrability and thereby reachability into the bottom of
25 curved root canals.

A first aspect of the invention relates to a cannula for a dental irrigation system comprising a body extending in an axial direction between a proximal end and a distal end, and comprising at least two separate conduits extending in the axial direction between at least one proximal opening and at least two distal openings such that each of the at least two separate conduits terminate at a separate opening of the at least two distal openings, where the distal openings are displaced relative to each other in the axial direction.

The provision of separate conduits with separate openings may ensure an improved distribution of pressure and liquid flow within the root canal. If a region of a root canal becomes partially or fully clogged, then the separate conduits may advantageously facilitate a redistribution of the pressure, thereby potentially reducing the risk of bacterial contaminants. This facilitation may for example be implemented by a manifold at the proximal end of the cannula fluidly coupling the different conduits. Alternatively, a subgroup of the conduits provides the rinsing or therapeutic liquid, while another subgroup of the conduits is configured to accommodate backflow of the rinsing or therapeutic liquid. Thereby, even if the root canal becomes fully clogged, liquid can advantageously flow out of the canal. Alternatively, backflow can be facilitated by the provision of a non-circular cross section of the body, for example via one or more outer indentations extending in the axial direction of the body.

In contrast to conventional cannulas with several openings, but only one conduit fluidly coupled to these openings, separate conduits terminating at separate openings may provide an improved control of the actual pressure provided at each opening.

Moreover, separate conduits terminating at separate openings of the distal end of a cannula may ensure that even if one of the conduits is partially or fully blocked by debris, flushing may still be performed via another conduit.

The provision of separate conduits may further ensure that even if manufacturing defects or damage should impair one conduit, another conduit is available.

In the context of the present invention, a cannula for a dental irrigation system is typically made with a thickness and a material which permits insertion into curvy and thin dental root canals. A cannula may for example be flexible in the sense that it has a flexural rigidity, at least within one bending plane, which enables straightforward insertion into a root canal. Further, a cannula may preferably have a threshold of plastic deformation which lies beyond the typical requirements for insertion in a root canal. These requirements may typically be obtained by using glass or a polymer material as a material of the cannula.

A cannula according to embodiments of the invention may alternatively be referred to as a dental cannula.

Typical outer diameters of cannulas may lie in the range of 0.1 mm to 1.5 mm, for example in the range of 0.1 mm to 1.0 mm, for example in the range of 0.3 mm to 0.6 mm. Typical wall thickness of the body and the individual conduits lie in the range of 0.05 mm to 0.2 mm. And typical inner diameters of the separate conduits lie in the range of 0.05 mm to 0.8 mm.

In other embodiments, the outer diameter varies along the axial direction, for example such that a proximal outer diameter of the proximal end is greater than a distal outer diameter in the distal end.

10 The at least two distal openings are typically located near the distal end of the body, although they are typically axially offset relatively to each other. For example, one distal opening can be located at the outermost part of the distal end of the body, whereas another opening is located at an axial distance of 2 mm from that outermost part. Thereby, the distal openings are not necessarily all located at the outer tip of the distal end but may be
15 distributed axially in the region of the distal end, although it is typically preferred that all of the distal openings are located in the root canal when the cannula is fully inserted into the root canal when performing endodontic therapy.

The conduits may be considered as separate in the sense that in a cross section of the cannula, the fluid canals that each of the conduits host are separate, i.e. separated by walls
20 of the cannula. Generally, the cross section of the body is perpendicular to the axial direction in which the body extends. A conduit typically has an at least partially empty volume extending in the axial direction for facilitating fluid flow within the cannula.

In some embodiments, the distal openings are axially offset relatively to each other. Resultingly, not all of the conduits extend all the way to the outermost part of the distal end
25 of the body. In such embodiments, a cross section near the distal end may only show one conduit. Nevertheless, a cross section between the proximal end and the at least two distal openings generally displays each separate conduit.

In embodiments of the invention, the cannula comprises at most one distal opening for each separate conduit.

30 The provision of a distal opening for each separate conduit may improve control of the pressure at each of the distal openings.

In embodiments of the invention, the distal openings are displaced relative to each other in the axial direction.

In embodiments of the invention, the cannula comprises no axially aligned distal openings.

5 In embodiments of the invention, one of the at least two distal openings is at the distal end of the body and another one of the at least two distal openings is remote from the distal end.

10 The provision of distal openings displaced relatively to each other in the axial direction, i.e., axially offset distal openings, may ensure that negative effects of clogging of the root canal are reduced. For example, if the root canal is clogged between two axially offset distal openings, the separate conduits may separately flush the regions of the root canal separated by the clogging.

Further, in embodiments in which separate subgroups of conduits facilitate separate flow directions, an axial thoroughly administered performed along the axial extend between the distal openings.

15 In embodiments of the invention, the body defines a tapered section comprising at least one tapered surface being non-perpendicular to the axial direction, and at least one of the distal openings is located in the at least one tapered surface.

20 In embodiments of the invention, the tapered section comprises at least two tapered surfaces being non-perpendicular to the axial direction, and at least one of the at least two distal openings is located in each of the at least two tapered surfaces. In other words, at each separate surface of the at least two tapered surfaces, a separate opening of the at least two distal openings is located.

The provision of one or more tapered sections may advantageously facilitate that distal openings of axially aligned conduits can be located remotely from the outermost distal end. Thereby, the manufacturing of the cannula may advantageously become easier.

25 Further, distal openings may thereby be partially radially oriented, in contrast to being fully axially oriented, thereby providing improved facilitation of radial fluid flow which can be desirable when flushing a root canal.

Additionally, the provision of one or more tapered sections may ease insertion of the cannula into the root canal.

Moreover, a tapered section may increase the effective area of a distal opening, potentially reducing the risk of clogging. If a distal opening is located partially or fully on a tapered surface, the risk of blocking that opening by contact with, e.g., the bottom of the root canal is also reduced.

- 5 Optionally, more than one distal opening is partially or fully located in a tapered surface, for example a first distal opening is partially located in the tapered surface, and a second distal opening is fully located in the tapered surface.

In embodiments of the invention, the distal end defines a plane transverse to the axial direction.

- 10 One of the distal openings may be located at such a transverse plane, for example the opening of a main conduit having the largest relative cross-sectional opening of all of the conduits.

- 15 Thereby, flushing of the bottommost part of the root canal may advantageously be prioritized by the dimensions of the cannula, while alternative flow routes are present via other conduits and other distal openings.

In embodiments of the invention, the conduits have different cross sections.

In embodiments of the invention, at least two of the at least two conduits have different cross-sectional size and shape.

- 20 Examples of different cross sections are thus different cross-sectional size and different cross-sectional shape. Such different cross sections may inherently ensure that the relative magnitudes of flow in the conduits differ, thereby, for example, ensuring that different volumes of fluid are provided to different regions in the root canal. Further, having different cross sections may ensure easier manufacturing of the cannula.

- 25 In embodiments of the invention, a main conduit of the at least two conduits has a larger internal cross-sectional size than another conduit of the at least two conduits, wherein the main conduit terminates at a distal opening of the at least two distal openings closest to a distal termination of the distal end.

The distal termination of the distal end may also be understood as the outermost part of the cannula at the distal end. That is, the location of termination of the end of the cannula intended for insertion into the root canal.

5 The provision of a main conduit terminating at a distal opening closest to the proximal end and with a larger internal cross-sectional size than another conduit may advantageously ensure that fluid flow is primarily provided to the distal end.

In embodiments of the invention, at least one of the at least two conduits have a circular cross-sectional shape, and another of the at least two conduits have a non-circular cross-sectional shape.

10 For example, in an embodiment, the main conduit has a circular cross-sectional shape, and another conduit has a non-circular cross-sectional shape. Such a choice of shapes may enable straightforward manufacturing of cannulas which are to host, e.g., both a main conduit as well as one or more secondary/auxiliary conduits.

15 In embodiments of the invention, the proximal end forms a connector for connection to a source of fluid. The connector could e.g. include a threaded screw connection, e.g. Luer Lock, or the connector may include a sharp pointed proximal termination suitable for penetrating a puncture. The connector may particularly serve to connect the cannula to a syringe which may be used for flushing liquid through the canula into the root canal. The connector may particularly encircle all proximal openings to thereby allow simultaneous connection of all
20 conduits to the same source of fluid.

Alternatively, the proximal end is in fixed connection with a source of fluid, e.g. with a syringe. In that case, the fixedly joined source of fluid may be in fluid communication with all proximal openings for simultaneous flushing of liquid into all separate conduits.

In embodiments of the invention, the body is, at least partly, of a flexible material.

25 This flexible material may alternatively be referred to as a main body material.

In embodiments of the invention, the flexible material is glass or a polymer material, such as polypropylene or polycarbonate. Preferably, the body is primarily formed of the flexible material, i.e., the flexible material forms more than 50 % of the volume of the body, for example more than 60 %, for example more than 70 %, such as more than 80 %. Here, the
30 volume of the body does not include the empty parts of the body such as those provided by the conduits.

Glass or polymer materials may advantageously provide the desired properties of the cannula, particularly regarding flexibility.

In embodiments of the invention, the body further comprises a rigid material deposited in the flexible material as elongated strands extending in the axial direction.

- 5 In embodiments of the invention, the rigid material comprises a glycol-modified polyethylene terephthalate (PETG), a polycarbonate, or a cyclic olefin copolymer.

In embodiments of the invention, the elongated strands are deposited around each of the at least two separate conduits.

- 10 By combining a flexible material with a rigid material deposited in the flexible material as elongated strands extending in the axial direction, a cannula having the correct balance of flexibility and stiffness may be obtained.

- 15 In particular, polypropylene is very flexible and permits a large degree of bending, i.e. a relatively small bend radius of the cannula. Even if the material is plastically deformed, it tends to deflect back towards its original shape. By further depositing a rigid material, a desired bend radius may be provided, while not making the cannula too soft. Thereby, the cannula may easily and efficiently be inserted into a root canal.

- 20 In embodiments of the invention, the cannula has a first flexural rigidity in a first bending direction perpendicular to the axial direction and a second flexural rigidity in a second bending direction perpendicular to the axial direction and the first bending direction, wherein the first flexural rigidity and the second flexural rigidity are different.

The flexural rigidity may be understood as a resistance offered by a structure such as a beam, while undergoing bending. In the context of bending and flexibility, the cannula, typically having a long and thin body, may be modelled as a beam or a rod.

- 25 The first flexural rigidity may, for example, be at least 5 % larger than the second flexural rigidity, for example at least 10 % larger, for example at least 20 % larger, such as at least 30 % larger.

By having different flexural rigidities in different bending directions, a preferred bending plane is established. This bending plane could be spanned by the axial direction and the bending direction associated with the lower flexural rigidity, for example the second flexural

rigidity. Thereby, the cannula may be easier the flexibly insert into a root canal. Further, in some embodiment, a preferred bending plane may also ensure that the cannula has a particular orientation inside the root canal, which may be preferable in some situations.

5 In embodiments of the invention, the body defines a non-circular section having a non-circular cross section.

The provision of a non-circular cross section may facilitate backflow, for example via outer indentations extending in the axial direction of the body. Thereby, the risk of clogging is strongly reduced. In this respect, a non-circular cross section is particularly useful, since the cross section of the root canal itself is typically circular since it is typically drilled by a
10 rotating drill. Hence, a non-circular cross-section may ensure that backflow is possible, despite variations in root canal diameters.

In embodiments of the invention, the non-circular section extends at least from the distal end and at least 50 percent, for example 100 percent, of the distance between the proximal end and the distal end.

15 In other words, cannulas according to the invention are not necessarily non-circular along their entire extend in the axial direction, but may just be non-circular along part of their extend, such as along 50 percent of their extend. By having both a non-circular and a circular section, the advantages of a non-circular section may be provided, for example facilitation of backflow in the root canal, while also maintaining the advantages of a circular section, for
20 example easy attachment to a connector.

In embodiments of the invention, the non-circular cross section has a roundness of at most 0.9, for example at most 0.8, for example at most 0.7, for example at most 0.6, such as at most 0.5.

The ISO definition of roundness is the ratio of the radii of the inscribed circle and the
25 circumscribed circle, i.e. the maximum and minimum sizes for circles that are just sufficient to fit inside and to enclose the shape. In this context, the shape is the outer perimeter of the (non-circular) cross section.

An alternative criterium for a cross-section being non-circular is that the circularity, which is defined as $4\pi \times \text{Area} / \text{Perimeter}^2$, has a certain value. That is, in embodiments of the
30 invention, the non-circular cross section has a circularity of at most 0.9, for example at most 0.8, for example at most 0.7, for example at most 0.6, such as at most 0.5. Again, the

relevant shape from which the circularity is to be evaluated is the outer perimeter and the area which it encloses.

In embodiments of the invention, the non-circular cross section comprises one or more outer indentations extending in the axial direction in the non-circular section, the one or more
5 outer indentations having a radial depth of at least 5 % of a maximal cross-sectional diameter of the cannula in the non-circular section, for example at least 10 %, for example at least 15 %, for example at least 20 %, such as at least 25 % of the maximal cross-sectional diameter.

10 For a given cross section, the maximal cross-sectional diameter is the largest diameter of that cross section. Since cross sections may be non-circular, a cross section may have several different diameters depending on the angle and position of measurements. Between all the diameters measured via all possible angles and positions of measurements, the maximal cross-sectional diameter may be understood as the largest of these.

15 In embodiments of the invention, the non-circular cross section has an outer cross-sectional flow area between a cross-sectional perimeter of the non-circular cross section and a circumscribed circle of the non-circular cross section, wherein the non-circular cross-section has an inner cross-sectional flow area defined by the at least two separate conduits, wherein the outer cross-sectional flow area is larger than the inner cross-sectional flow area.

20 Here, the circumscribed circle may be understood as the minimum sized circle which is just sufficient to enclose the non-circular cross section. In embodiments of the invention, such a circumscribed circle leaves one or more gaps relatively to the body (and its non-circular section having a non-circular cross section). These gaps correspond to the area through which fluid may flow backwardly in endodontic therapy, and hence, these gaps define an outer cross-sectional flow area. The conduits, namely the inner cross-sectional areas thereof,
25 define the inner cross-sectional flow area.

The provision of an outer cross-sectional flow area which is larger than the inner cross-sectional flow area may ensure that sufficient area for backflow is always provided, thereby avoiding undesirably large pressures at the bottom of the root canal.

30 In embodiments of the invention, the non-circular section has a cross section defining a plurality of sectors of a circle, e.g. such that the circumference extends continuously in one sector but discontinuously between two sectors.

In embodiments of the invention, the sectors of a circle have different radial size.

In embodiments of the invention, the cannula comprises one conduit for each sector of a circle.

Each sector of the plurality of sectors of a circle may, for example, host a separate conduit of the at least two conduits. The provision of a cross section defining a plurality of sectors of a circle, may serve as a simple approach of realizing separate conduits. In particular,
5 manufacturing may be simple. Further, circular sectors may ensure that the outer perimeter of the body is provided with outer indentations, for example between these sectors. Different radially sized sectors of a circle may advantageously facilitate conduits having different properties or functions, for example different flow rates.

10 In embodiments of the invention, the cannula has an outer diameter from 0.2 mm to 1.5 mm, for example from 0.2 mm to 0.8 mm, for example from 0.3 mm to 0.6 mm, such as from 0.35 mm to 0.5 mm.

In embodiments of the invention, the outer diameter gradually changes from a proximal outer diameter at the proximal end to a distal outer diameter at the distal end, wherein the
15 proximal outer diameter is greater than the distal outer diameter.

A gradually changing outer diameter at the proximal end to the distal end may ensure that the flexibility of the cannula varies along the axial direction. In particular, the proximal end of the cannula which is typically not inserted into the root canal does not require the same
20 flexibility as the distal end which is typically located at the bottom of the root canal during use. Since the outer diameter gradually changes, mechanical weaknesses of the cannula may potentially be avoided.

The proximal outer diameter can for example be at least 0.9 mm, for example at least 1.0 mm, such as at least 1.1 mm. The distal outer diameter can for example be at most 0.9 mm, for example at most 0.8 mm, such as at most 0.7 mm.

25 In some embodiments, a gradually changing outer diameter is present in sections of the cannula not comprising a tapered surface or a circumferentially tapered shape.

In embodiments of the invention, the at least two conduits are at least four conduits and the at least two distal openings are at least four distal openings, wherein each of the at least four conduits terminate at a separate opening of the at least four distal openings.

30 Additional conduits may increase adaptability of the cannula, for example regarding clogging or blocking of a conduit.

In embodiments of the invention, the at least four conduits comprise a central conduit and at least three circumferential conduits, wherein the central conduit is circumferentially surrounded by the at least three circumferential conduits.

5 A central conduit circumferentially surrounded by circumferential conduits may advantageously constitute an approximately symmetrical shape which in turn can simplify manufacturing of the cannula.

In embodiments of the invention, each of the at least three circumferential conduits forms a respective protruding structure extending in the axial direction an protruding from the central conduit transverse to the axial direction.

10 The provision of protruding structures formed by the circumferential conduit may in turn facilitate the formation of one or more outer indentation, for example to provide a non-circular cross section of the cannula.

In embodiments of the invention, distances separating the at least three circumferential conduits from the central conduit are different.

15 Such different distances may also be referred to as different transversal distances.

Different distances can ensure that the openings of the relevant conduits have different axial locations. For example, if the openings are located at a tapered surface or a circumferentially tapered shape of the cannula, the different distances between the conduits can enable different axial locations of the openings of these conduits.

20 In embodiments of the invention, at least one distance separating the at least three circumferential conduits from the central conduit is greater than an outer wall thickness of the at least three circumferential conduits by a factor of at least two.

25 A certain distance between a circumferential conduit and the central conduit may in turn ensure a certain axial distance between the opening of the central conduit and the opening of the relevant circumferential conduit, for example if one of these openings are located at a tapered surface or a tapered face of a circumferentially tapered shape.

In embodiments of the invention, the central conduit terminates at the distal end of the body and at least some of the at least three circumferential conduits terminate remote from the distal end.

In embodiments of the invention, the distal end has a circumferentially tapered shape having a narrowed end at the termination of the distal end. A circumferentially tapered shape may typically define a conical section.

The circumferentially tapered shape may ease insertion of the cannula into a root canal.

5 Further, it may facilitate different axial locations of openings of different conduits.

Moreover, a circumferentially tapered shape having a narrowed end at the termination of the distal end may be simpler to manufacture, for example in comparison with a non-circumferentially tapered shape.

10 In embodiments of the invention, the central conduit terminates at the narrowed end of the circumferentially tapered shape and each of the at least three circumferential conduits terminate in a tapered face of the circumferentially tapered shape.

This ensures different axial locations of the central conduit and the circumferential conduits.

15 In embodiments of the invention, the body has a length of at least 10 mm in the axial direction, for example at least 12 mm, for example at least 14 mm, for example at least 16 mm, for example at least 18 mm, such as at least 20 mm.

In embodiments of the invention, the body has an outer diameter transverse to the axial direction of at most 1.50 mm, for example at most 1.40 mm, for example at most 1.30 mm, for example at most 1.20 mm, such as at most 1.10 mm.

20 In embodiments of the invention, wherein the body has a length of at least 10 mm in the axial direction and an outer diameter transverse to the axial direction of at most 1.50 mm for insertion of the dental cannula into a root canal of a human permanent tooth.

In embodiments of the invention, the length of the body is at most 60 mm, for example at most 50 mm, for example at most 40 mm, such as at most 30 mm.

25 In embodiments of the invention, a distal portion of the dental cannula has a bending moment of at most 12 mNmm, for example at most 9.0 mNmm, for example at most 6.0 mNmm, such as at most 4.0 mNmm. In embodiments of the invention, the distal portion of the dental cannula is the portion of the body starting from the distal end and extending 7.0 mm in the axial direction towards the proximal end.

In embodiments of the invention, the body has a conical section terminating at the distal end such that the outer diameter of the body decreases along the axial direction towards the distal end. In case the body also has a spherically rounded tip at the distal end, this spherically rounded tip may be considered as a part of the conical section.

- 5 In embodiments of the invention, the outer diameter at the distal end is at most 0.60 mm, for example at most 0.50 mm, for example at most 0.40 mm, such as at most 0.30 mm.

- In embodiments of the invention, the length of the conical section in the axial direction is at least 1.0 mm, for example at least 2.0 mm, for example at least 5.0 mm, for example at least 10 mm, such as at least 15 mm. In embodiments of the invention, the length of the
10 conical section in the axial direction is at most 35 mm, for example at most 30 mm, for example at most 25 mm, such as at most 20 mm, such as at most 15 mm.

- In embodiments of the invention, the body has a cylindrical section extending in the axial direction from the proximal end and terminating at the conical section. In embodiments of the invention, the outer diameter along the cylindrical section is at least 0.70 mm, for
15 example at least 0.80 mm, for example at least 0.90 mm, such as at least 1.0 mm.

In embodiments of the invention, the outer diameter is constant along the cylindrical section. In embodiments of the invention, the cross-section of the body transverse to the axial direction is constant along the cylindrical section.

- The cross-section of the body in the cylindrical section is not necessarily circular, but in
20 contrast to along the conical section, the outer diameter or the cross-section may be constant along the cylindrical section.

- In embodiments of the invention, the body has a spherically rounded tip at the distal end. In
embodiments of the invention, the spherically rounded tip has a radius of at most 0.40 mm,
for example at most 0.35 mm, for example at most 0.30 mm, for example at most 0.25 mm,
25 for example at most 0.20 mm, such as at most 0.15 mm, such as at most 0.10 mm.

In embodiments of the invention, the body is, at least partly, of a flexible material, the flexible material having an elastic modulus of at most 20 GPa, for example at most 15 GPa, for example at most 10 GPa, such as at most 5 GPa.

- In embodiments of the invention, the at least two conduits are at least four conduits and the
30 at least two distal openings are at least four distal openings, wherein each of the at least four conduits terminate at a separate opening of the at least four distal openings, wherein the at

least four conduits comprise a central conduit and at least three circumferential conduits, wherein the central conduit is circumferentially surrounded by the at least three circumferential conduits, wherein the central conduit terminates at the distal end of the body and at least some of the at least three circumferential conduits terminate along the conical section and are displaced along the axial direction from the distal opening of the central conduit at the distal end.

A second aspect of the invention relates to a method of irrigating a root canal comprising inserting a cannula according to this disclosure into the root canal and exchanging a flushing liquid between the proximal opening and the root canal via at least one of the at least two separate conduits.

By using at least one of at least two separate conduits of a cannula to flush a root canal, the distribution of pressure and liquid flow within the root canal may be improved, for example in relation to clogging of the root canal and/or of a proximal opening of the cannula.

In embodiments of the invention, the liquid is flushed from the proximal end to the distal end and into the root canal via one of the at least two conduits and flushed from the root canal to the proximal end via another of the at least two conduits.

In embodiments of the invention, the at least two separate conduits and the at least two distal openings are applied for establishing different pressure at two axially offset locations in the root canal.

In embodiments of the invention, one of the at least two separate conduits is used for continuing irrigation while another of the at least two separate conduits is clogged.

A third aspect of the invention relates to a dental irrigation system comprising a cannula according to this disclosure, and a connector attached to the proximal end of the cannula and configured to fluidly couple the cannula to a source of fluid.

A fourth aspect of the invention relates to a method of manufacturing a cannula for a dental irrigation system, such as the cannula according to the first aspect or the fifth aspect, the method comprising the steps of:

producing a cannula preform extending in an axial direction;

pulling the cannula preform in said axial direction to elongate a length of the cannula preform in the axial direction and to shrink a diameter of the cannula preform perpendicularly to the axial direction, thereby producing a cannula fibre having an outer diameter of at least 0.20 mm, for example at least 0.25 mm, such as at least 0.30 mm, for example at least 0.70 mm, 5 for example at least 0.80 mm, for example at least 0.90 mm, such as at least 1.0 mm; and

cutting the cannula fibre perpendicularly to the axial direction to provide the cannula with a cannula length in the axial direction of at most 30 mm, for example at most 25 mm, such as at most 20 mm.

10 By adopting a methodology of producing a preform and pulling the preform to produce a fibre which is then cut to the cannula, a large number of cannulas with a complex geometry and composition of materials may be efficiently manufactured.

Very long, uniform objects may previously have been produced e.g. by pulling a preform which e.g. via a so-called draw tower, in which an end of the preform is heated, allowing the object to be pulled from the preform. This process is until now carried out in an entirely 15 different field, typically for producing very long industrial products having a circular, cylindrical shape.

On the contrary, the present invention provides a method of making very short cannulas for dental irrigation systems, particularly cannulas with complex geometry as disclosed herein, and particularly short cannulas having a non-circular cross-section and typically with an outer 20 diameter which is relatively large compared to typical pultruded objects.

In embodiments of the invention, the cannula preform is produced by additive manufacturing.

Alternatively, the cannula preform may be produced via moulding such as injection moulding, casting, milling, extrusion, or pultrusion. However, additive manufacturing, e.g., 3D printing, 25 is preferable, since it permits a large degree of control of geometry and potentially distribution of separate materials.

Generally, additive manufacturing is counterintuitive to adopt in manufacturing, since it is a relatively slow method of shaping an object in comparison with, e.g., moulding. However, since the production of a single preform may potentially result in many thousands of 30 cannulas, additive manufacturing surprisingly becomes viable.

Further, it is counterintuitive to combine additive manufacturing with fibre pulling, since optical fibres require near-perfect geometry, which is difficult to obtain by conventional additive manufacturing. However, cannulas for dental irrigation systems have lower requirements to geometry than optical fibres, and hence it is viable to employ additive
5 manufacturing.

A cannula preform may for example have an outer diameter of 25 mm to 100 mm before being pulled.

In embodiments of the invention, the cannula preform is produced with a cannula preform body of a flexible material and a rigid material deposited in the flexible material as elongated
10 strands extending in the axial direction.

Additive manufacturing may, for example, be adopted to provide the separate materials.

In embodiments of the invention, the step of pulling the cannula preform is performed using a draw tower, such as a draw tower for drawing optical fibres.

In embodiments of the invention, the method comprises a step of slantly removing material
15 at a distal end of the cannula to establish at least one tapered surface being non-perpendicular to the axial direction, wherein at least one distal opening of a separate conduit of the cannula is located at the at least one tapered surface.

In embodiments of the invention, the method comprises a step of slantly removing material
20 at a distal end of the cannula to establish a circumferentially tapered shape having a narrowed end at the termination of the distal end,

Material may for example be slantly removed by performing a slant cut, or by grinding at a slant/oblique angle.

In embodiments of the invention, the circumferentially tapered shape defines a conical section of the dental cannula, the conical section terminating at the distal end such that the
25 outer diameter of the body decreases along the axial direction towards the distal end.

In embodiments of the invention, the method comprises a step of slantly removing material at a distal end of the cannula to establish a spherically rounded tip.

A spherically rounded tip may for example be established by grinding using an appropriate tool.

In embodiments of the invention, the cannula comprises a body extending in the axial direction between a proximal end and a distal end, and comprising at least one separate
5 conduit extending in the axial direction between at least one proximal opening and at least one distal opening such that each of the at least one separate opening terminates at a separate opening of the at least one distal opening.

As a part of manufacturing the cannula, the cannula may further be attached to a connector. The cannula may be attached by adhesion to the connector, or by insert moulding of the
10 connector

A fifth aspect of the invention relates to a cannula for a dental irrigation system and comprising a body, at least one conduit extending between a proximal opening and a distal opening of the body, where the body has a non-circular cross section.

Preferably, the conduit extends in an axial direction between the proximal opening and the
15 distal opening. Preferably, the body has a non-circular cross section transverse to the axial direction. Generally, a non-circular cross section may refer to an outer contour, which may, e.g., consist of two or more circular arcs joined at end points to form outer indentations at the end points.

Thus, embodiments may have a non-circular cross-section without necessarily having
20 separate conduits terminating at separate openings.

Such cannulas comprising a body having a non-circular cross section may thereby improve backflow, or at least reduce the risk of clogging the root canal, during endodontic therapy.

In such embodiments, the body may define a non-circular section having the non-circular cross section. The non-circular section may extend at least from the distal end and at least
25 50 percent, for example 100 percent, of the distance between the proximal end and the distal end. The non-circular cross section may have a roundness of at most 0.9, for example at most 0.8, for example at most 0.7, for example at most 0.6, such as at most 0.5. The non-circular cross section may have a circularity of at most 0.9, for example at most 0.8, for example at most 0.7, for example at most 0.6, such as at most 0.5. The non-circular cross
30 section may optionally comprise one or more outer indentations extending in the axial direction in the non-circular section, these one or more outer indentations having a radial depth of at least 0.05 of a maximal cross-sectional diameter of the cannula in the non-

circular section, for example at least 0.1, for example at least 0.15, for example at least 0.2, such as at least 0.25 of the maximal cross-sectional diameter.

The aspect of having a cannula with a non-circular cross section shares a common concept with the aspect of having a cannula with separate conduits terminating at separate openings.

5 Namely, both a non-circular cross section and separate conduits may be used to facilitate backflow.

A sixth aspect of the invention relates to a dental irrigation system for use in endodontic therapy, the dental irrigation system comprising a cannula according to the first aspect or the fifth aspect, a connector attached to the proximal end of the cannula, and a source of fluid
10 fluidly coupled to the cannula via the connector.

Thereby, the dental irrigation system may provide an active agent or ingredient in the form of a flushing liquid from the source of fluid. The flushing fluid may for example be a chemically active irrigant. The flushing fluid may be at least partly consumed when using the system. The dental irrigation system may provide improved chemical treatment of a root
15 canal, for example due to improved flushing of the fluid, pressure of the fluid, distribution of the fluid, or any combination thereof.

Cannulas according to the present disclosure are small and thereby difficult to sterilize. Yet, they may also be relatively cheap to mass-produce. Thereby, a dental irrigation system may advantageously be sterilized by disposing a contaminated cannula, i.e., a first cannula, and
20 simply attaching a new cannula, i.e., a second cannula, to the dental irrigation system. Sterilization of the dental irrigation system may further involve steps directed at sterilizing other parts of the dental irrigation system, but at least the cannula is sterilized by replacement.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Embodiments of the invention will now be further described by reference to the accompanying drawings, in which:

Fig. 1a-b illustrate a cannula according to an embodiment of the invention with separate conduits;

30 Fig. 2a-b illustrate a cannula according to another embodiment of the invention where the body of the cannula has a non-circular cross section;

Fig. 3 illustrates a dental irrigation system according to an embodiment of the invention;

Fig. 4 illustrates an example of a cannula according to an embodiment inserted into a root canal;

5 Fig. 5 illustrates an example of another cannula according to an embodiment inserted into a root canal;

Fig. 6a-b illustrate an embodiment of the invention comprising three conduits and its non-circular cross section;

Fig. 7 illustrates a cross section of an embodiment with a rigid material deposited in flexible material as elongated strands extending in the axial direction,

10 Fig. 8 illustrates a flow chart of method steps of irrigating a root canal according to an embodiment of the invention;

Fig. 9 illustrates a flow chart of method steps of manufacturing a cannula for a dental irrigation system according to an embodiment of the invention,

Fig. 10 illustrates an additional embodiment of the invention,

15 Fig. 11a-b illustrate another embodiment of the invention comprising a central conduit and circumferential conduits terminating at a tapered face of a circumferentially tapered shape,

Fig. 12 illustrates a cross section of another embodiment with a central conduit and circumferential conduits,

20 Fig. 13 schematically illustrates dimensions of a cannula according to embodiments of the invention, and

Fig. 14a-d illustrate two exemplary cannulas attached to connectors.

DETAILED DESCRIPTION

Fig. 1a-b illustrate a cannula 1 according to an embodiment of the invention with separate conduits 7a-b. Fig. 1a illustrates a perspective view and Fig. 1b illustrates a cross-sectional

view of the cannula 3. In the perspective view of Fig. 1a, a cross-sectional plane is drawn with reference to Fig. 1b, indicating the plane of the cross-section illustrated in Fig. 1b.

The cannula 1 comprises a body 3 of a flexible material, namely a polymer material, which provides the cannula 1 with the elastic flexibility required for unproblematic insertion into a
5 root canal of a tooth.

As illustrated in Fig. 1a, the body 3 of the cannula 1 extends in an axial direction 4, the axial direction 4 being indicated by an arrow in the figure. The axial direction 4 lies between the two outer ends of the cannula 1, referred to as the proximal end 5 and the distal end 6.

As illustrated in other figures of other embodiments, the body 3 of the cannula 1 can curve
10 slightly. The cannula 1 may be manufactured with such a curvature, or the curvature may arise from elastically bending the cannula, for example due to insertion of the cannula into a root canal. Typically, the axial direction 4 may be substantially the same as a flow direction within the cannula 1.

The distal end 6 is intended to be inserted into a root canal, whereas the proximal end 5 is
15 intended to be connected to a connector. This connector may then facilitate a fluid connection between a source of fluid and the cannula 1 and its conduits 7a-b.

The cannula 1 comprises two separate conduits 7a-b which each extend in the axial direction within the body 3 of the cannula. They have a collective proximal opening 8 at the proximal
20 end 5 of the body 3, and separate distal openings 9a-b at the distal end 6 of the body. Each of the two separate conduits 7a-b terminate at a separate opening of the two separate distal openings 9a-b. In other words, a first conduit 7a terminate at a first distal opening 9a and a second conduit 7b terminate at a second distal opening 9b.

The distal openings 9a-b are displaced in the axial direction relatively to each other. The first
25 distal opening 9a is located at the outermost end of the body 3 and outermost end of the distal end 6, i.e., located where the body 3 and the distal end 6 terminate in the axial direction 4 away from the proximal end 5. The second distal opening 9b is displaced in the axial direction 4 relatively to the first distal opening 9a.

In this embodiment, the cross section of the cannula 1 between the proximal end 5 and the
30 two distal openings 9a-b has an outer circular shape as illustrated in Fig. 1b. This outer circular shape is internally segmented into two internal regions 15a-b of substantially similar size and shape by an internal wall 16. This internal wall corresponds to a diameter line of the

outer circular shape. The two internal regions 15a-b of the cross section correspond to cross-sectional cutouts of the two respective separate conduits 7a-b.

In this embodiment, a thickness of the inner wall and the outer circular shape of the body 3 is 0.1 mm and an outer diameter of the cannula is 0.6 mm. The cannula has a length of 20 mm, and the distal openings are displaced relative to each other in the axial direction by 2 mm.

This embodiment can thereby provide improved distribution of pressure and liquid within the root canal of a tooth during endodontic therapy.

Fig. 2a-b illustrate a cannula 1 according to another embodiment of the invention where the body 3 of the cannula 1 has a non-circular cross section. Fig. 2a illustrates a perspective view and Fig. 2b illustrates a cross-sectional view of the cannula 3. Again, in the perspective view of Fig. 2a, a cross-sectional plane is drawn, now with reference to Fig. 2b, indicating the plane of the cross-section illustrated in Fig. 2b.

In contrast to the cannula illustrated in Fig. 1a-b, the cannula illustrated in Fig. 2a-b has a single conduit 7a extending between a proximal opening 5 and a distal opening 9a of the body 3.

In this embodiment, the body 3 is shaped such that the cross section of the body 3 consists of two circular arcs which are joined at the end points of the circular arcs. Each of the circular arcs correspond to approximately 270 degrees of a full circle. As a result, the body 3 forms two outer indentations 17a-b extending in the axial direction 4 along the intersections of the circular arcs. These outer indentations 17a-b have a radial depth of approximately 0.1 of the cross-sectional diameter of the cannula 1 along its greatest width within the relevant cross-section (horizontal direction in the illustration of Fig. 2b).

The non-circular cross section defined by the body further has a roundness below 0.9 and a circularity below 0.9.

As a result of the non-circular cross section, pathways for backflow of fluid when the cannula is inserted in a root canal are provided via the outer indentations 17a-b.

Fig. 3 illustrates a dental irrigation system 2 according to an embodiment of the invention. The dental irrigation system 2 comprises a cannula according to the embodiment illustrated in Fig. 1a-b. However, dental irrigation systems according to the invention are not restricted

to cannulas as the one illustrated in Fig. 1a-b, and may, for example, have a cannula as the one illustrated in Fig. 2a-b.

The dental irrigation 2 system comprises a connector 10 attached to the proximal end of the cannula 1 and configured to fluidly couple the cannula 1 to a source of fluid 11. In this embodiment, the conduits are collectively fluidly coupled via a single proximal opening at the proximal end to the source of fluid 11 via the connector 10. In other embodiments, separate subgroups of conduits are separately connected to a source of fluid configured to supply different fluid pressures to the separate subgroups. For example, a source of fluid may provide a first pressure to a first conduit, and a second pressure to a second conduit. Or a source of fluid may provide a first pressure to a first conduit, and no pressure to a second conduit, for example to permit backflow via the second conduit. In embodiments where the same fluid pressure is not applied to separate subgroups of conduits, the connector 10 may also have separate fluid paths for separately coupling the separate conduits to the source of fluid 11.

Fig. 4 illustrates an example of a cannula 1 according to an embodiment inserted into a root canal. The figure shows a cross-sectional side view along the axial direction of the body 3 (in contrast to the cross-sectional views of Fig. 1b and 2b, which are perpendicular to the axial direction). The cannula 3 corresponds to the embodiment illustrated in Fig. 1a-b. Water flow in the cannula 1 is indicated by dashed arrows.

The figure illustrates the outer tooth dentin 12 which outlines the inner root canal in which the cannula 3 is at least partly inserted, for example to conduct endodontic therapy. Towards the bottom of the root canal, the tooth dentin 12 narrows in a tooth apex 14, thereby defining the bottom of the root canal.

In this illustration, the root canal has become clogged by debris 13 loosened during the endodontic therapy. In such a situation, use of a conventional cannula 3 with only a single distal opening to flush liquid would result a high risk of apical extrusion, in which liquid is forced out through the apex into the underlying bone, potentially transferring harmful bacteria thereto.

However, by having separate conduits 7a-b terminating at separate openings 9a-b displaced relative to each other in the axial direction as provided in the illustrated embodiment, one distal opening 9b is located on the other side of the debris 13 clogging the root canal. Since fluid cannot leave the region between the debris 13 and the tooth apex 14, the water pressure at the distal opening 9a located in this region will increase slightly, causing the water flow injected at a proximal opening of the cannula 3 to be redistributed among the

conduits 7a-b. As a result, the fluid flow at the distal opening 9a located between the debris 13 and the tooth apex 14 is reduced, whereas fluid flow at the other distal opening 9b is increased. This redistribution of water flow reduces the risk of apical extrusion in comparison with scenarios in which conventional cannulas 1 are used.

5 Fig. 5 illustrates an example of another cannula 1 according to an embodiment inserted into a root canal. As for Fig. 4, the figure shows a cross-sectional side view along the axial direction of the body 3 and water flow in the cannula is indicated by arrows.

In contrast to the scenario illustrated in Fig. 4, two distal openings 9a-b of separate conduits 7a-b are located between the debris 13 and the tooth apex 14. Further, inward fluid flow is only provided via one of the conduits 7a, and hence, the other conduit 7b may facilitate outward backflow of fluid. Accordingly, the risk of apical extrusion in comparison with scenarios in which conventional cannulas 1 are used.

To rinse the region above the debris 13, the cannula can be moved slightly upwards, such that the conduit providing fluid flow is able to rinse this region. Optionally, the illustrated embodiment may comprise a third separate conduit terminating at a distal opening displaced relatively to the two distal openings 9a-b, such that the distal opening of this third conduit is located above the debris. Fluid flow can then be provided via both this third conduit as well as one of the two conduits 7a-b having a distal opening 9a-b between the debris 13 and the apex 14.

20 Figs. 6a-b illustrate an embodiment of the invention comprising three conduits and its non-circular cross section. Fig. 6a illustrates an angled view of the distal end of the cannula 1, and Fig. 6b illustrates a cross-sectional view of a part of the body 3 of the cannula 1 between the distal end 6 and the proximal end. In addition, the non-circular cross section of the body 3 is illustrated relatively to a circular canal 19.

25 The embodiment illustrated in Fig. 6a-b features three separate conduits individually terminating at three separate distal openings 9a-c. One conduit is a main conduit which has a larger internal cross-sectional size than the other two conduits. The main conduit terminates at the distal opening 9a located the outermost part of the distal end, i.e. the distal termination of the distal end. Thereby, fluid flow through the cannula 1 is primarily provided to the bottommost part of the root canal when using this cannula 1 in endodontic therapy.

Beside the main conduit terminating at a first distal opening 9a, the embodiment further comprises a second conduit terminating at a second distal opening 9b and a third conduit

terminating at a third distal opening 9c. All three distal openings 9a-c are displaced relatively to each other in the axial direction.

In this embodiment, the body defines a tapered section comprising two tapered surfaces 18a-b, such that the second distal opening 9b is located at a first tapered surface 18a and the third distal opening 9c is located at a second tapered surface 18b. Generally, the tapered section provides a thinner tip permitting easier insertion of the cannula 1 into a root canal. Moreover, the tapered openings 9b-c provided by the tapered surfaces 18a-b may provide some radial directionality to fluid flow therefrom.

Further, implementation of tapered surfaces 18a-b to host distal openings 9b-c simplify manufacturing. In particular, as an intermediate manufacturing step, a tentative precursor cannula without tapered surfaces, i.e. with a substantially non-changing cross section extending throughout the distal end. Then, by cutting the tapered surfaces, the distal openings are displaced relatively to each other in the axial direction, thereby providing the final cannula as illustrated.

Due to the tapered surfaces 18a-b, some of the distal openings 18a-b are elongated in the axial direction. In some embodiments, distal openings may even overlap in the axial direction. Distal openings may be considered as being displaced relative to each other if the centres of the distal openings are displaced. Or alternatively, distal openings may be considered as being displaced relative to each other if the distal openings begin or terminate at different points in the axial direction.

In the cross-sectional view in Fig. 6b, the non-circular cross section of the body 3 is displayed. Further, three internal regions 15a-c are shown, corresponding to the three conduits terminating at the three distal openings 9a-c shown in Fig. 6a.

The cross-sectional view displays that, in this embodiment, the non-circular cross section has a cross section defining a plurality of sectors of a circle. Namely, the non-circular cross section corresponds to three sectors of a circle, or in other words, three circular sectors, each hosting one of the three internal regions 15a-c, corresponding to one of the three conduits of the cannula 1. That the non-circular cross-section has a cross section defining a plurality of sectors of a circle is particularly evident by the outer cross-sectional shape which outlines three circular arcs.

Note that one internal region 15a is larger, corresponding to the main conduit.

Further, the non-circular cross section is illustrated relatively to a circular canal 19, representing, for example, the cross section of a root canal. The body 3 is provided with three outer indentations 17a-c, which each provide a potential backflow channel relatively to the circular canal 19.

- 5 In this embodiment, each outer indentation 17a-c is located at an azimuthal angle between two of the conduits, the azimuthal angle being evaluated from a central axis in the axial direction. This provides an improved utilization of the limited space available in a root canal.

The circular canal 19 approximately corresponds to a circumscribed circle of the non-circular cross section. Thereby, Fig. 6b further illustrates that the outer cross-sectional flow area is
10 larger than the inner cross-sectional flow area in this embodiment.

Fig. 7 illustrates a cross section of an embodiment with a rigid material deposited in flexible material as elongated strands 20 extending in the axial direction.

The shape of the body 3 of the illustrated embodiment is substantially similar to the embodiment illustrated in Fig. 6a-b. In comparison, the embodiment of Fig. 7 is additionally
15 characterised by a strands 20 being embedded in the flexible material of the body 3.

The flexible material of the body 3 is primarily composed of polypropylene. Within this body 3, a plurality of flexible strands 20 of rigid material is deposited. Each of the strands 20 extend in the same axial direction as the body 3. The material of the strands are based on glycol-modified polyethylene terephthalate, also referred to as "PETG".

20 The strands 20 are arranged such that each of the separate conduits (and the internal regions 15a-c thereof) is encircled by strands 20, which ensures the desired properties of the cannula with regards to flexibility and bending. In other words, the elongated strands 20 are deposited around each of the three separate conduits.

Fig. 8 illustrates a flow chart of method steps of irrigating a root canal according to an
25 embodiment of the invention.

In a first step S11 of the method, a cannula according to this disclosure is inserted into a root canal. This may, for example, be a cannula with separate conduits terminating at separate distal openings, or a cannula with a non-circular cross section.

In a next step S12, a flushing liquid is exchanged between the proximal opening of the cannula and the root canal via a conduit of the cannula. Optionally, if the cannula comprises separate conduits, the flushing liquid is flushed from the proximal end to the distal end of cannula and into the root canal via one conduit and flushed from the root canal to the proximal end via another conduit. Or the cannula, including the two separate conduits and the two distal openings may be applied for establishing different pressure at two axially offset locations in the root canal, for example establishing a first pressure at a first opening of the two openings, and a second pressure a second opening of the two openings.

5

10

Fig. 9 illustrates a flow chart of method steps of manufacturing a cannula for a dental irrigation system according to an embodiment of the invention.

In a first step S21 of the method, a cannula preform is produced. The cannula preform extends in an axial direction. The preform may optionally be produced with a cannula preform body of a flexible material and a rigid material deposited in the flexible material as elongated strands extending in the axial direction.

15

20

In a next step S22, the cannula preform is pulled in the axial direction to elongate a length of the cannula preform in the axial direction, and to shrink a diameter of the cannula preform perpendicularly to the axial direction. Thereby, a cannula fibre having an outer diameter of at least 0.2 mm is produced. In this example, the pulling is performed via draw tower also suitable for drawing optical fibres. Thereby, well-known technology is utilized in a new context, i.e., in manufacturing cannulas for a dental irrigation system.

25

In a next step S23, the cannula fibre is cut perpendicularly to the axial direction to provide the cannula for a dental irrigation system. The cannula fibre is cut such that the cannula length of the cannula in the axial direction of the cannula is at most 30 mm. Thereby, a cannula, such as a cannula according to this disclosure, is manufactured. The axial direction of the cannula preform is adopted by the cannula.

Typically, thousands of cannulas are cut from the same cannula prepreg, although the invention is not restricted to a particular number of cannulas being cut from the same cannula preform.

30

Optionally, the manufacturing method may comprise an additional step (not shown) of slantly removing material at a distal end of the cannula to establish at least one tapered surface being non-perpendicular to the axial direction. The material is removed such that at least one distal opening of a separate conduit of the cannula is located at the at least one tapered surface. An example of a cannula with such a tapered surface is illustrated in Fig. 6a.

Fig. 10 illustrates an additional embodiment of the invention.

In comparison with the embodiment illustrated in Fig. 6a-b, the embodiment illustrated in Fig. 10 has other relative cross-sectional sizes of the separate conduits, and hence also other (relative) sizes of the distal openings 9a-c.

- 5 Moreover, the embodiment illustrated in Fig. 10 has a tapered surface 18a on which two distal openings 9a-b are located. This reduces the risk that the cannula, particularly the bottommost distal opening 9a, is clogged or blocked by contact with the bottom of the root canal.

- 10 Fig. 11a-b illustrate another embodiment of the invention comprising a central conduit 21 and circumferential conduits 22 terminating at a tapered face 25 of a circumferentially tapered shape 24. In particular, Fig. 11a illustrates an angled view of the distal end 6 of the cannula 1, and Fig. 11b illustrates a cross-sectional view of a part of the body 3.

- 15 The embodiment illustrated in Fig. 6a-b has six conduits, namely a central conduit 21 circumferentially surrounded by five circumferential conduits 22. Correspondingly, the embodiment has six distal openings 9, such that each of the conduits 21,22 terminates at a separate distal opening 9.

- 20 Referring to the cross-sectional view of Fig. 11b, the central conduit 21 is centrally located in the body 3, whereas the circumferential conduits 22 surrounds or encircles the central conduit 21. Each of the circumferential conduits 22 forms a respective protruding structure 23 extending in an axial direction and protruding transversely from the central conduit 21 transverse to the axial direction of the body 3. Accordingly, a circumferential conduit 22 is located inside each protruding structure 23. The gaps between the protruding structures 23 constitute outer indentations 17 which may facilitate backflow of liquid. In this particular embodiment, each protruding structures 23 has an outer annular shape.

- 25 Fig. 11b further exhibits an exemplary distance 27 separating a circumferential conduit 22 from the central conduit 21. In comparison with an outer wall thickness 26 of a circumferential conduit 22, the distance 27 separating a circumferential conduit 22 from the central conduit 21 is at least twice as great. The outer wall thickness may for example be evaluated is a thickness of the outermost wall of the circumferential conduit, for example
30 evaluated in a direction transverse to the axial direction.

Referring now to Fig. 11a, the embodiment is manufactured such that a distal end 6 of the cannula 1 has a circumferentially tapered shape 24 having a narrowed end 28 at the

termination of the distal end. In this specific embodiment, the circumferentially tapered shape 24 is a conical shape, more specifically a conical frustum shape. In other embodiments, the circumferentially tapered shape is a pyramidal frustum with a polygon base.

- 5 The central conduit 21 terminates at the narrowed end 28 of the circumferentially tapered shape 24 and each of the circumferential conduits 22 terminate at a tapered face 25 of the circumferentially tapered shape 24. Accordingly, the conduits 21,22 are axially displaced relative to each other.

10 The cross-sectional view of Fig. 11b is from a part of the cannula 1 which is not a part of the circumferentially tapered shape.

Fig. 12 illustrates a cross section of another embodiment with a central conduit 21 and circumferential conduits 22. In comparison with the cross-sectional view provided in Fig. 11b, the embodiment of Fig. 12 has a different cross-sectional shape, different cross-sectional area sizes and shapes of the conduits 21,22, and different distance separating circumferential conduit 22 from the central conduit 21. In this embodiment, each of the protruding structures 15 23 has a pointed shape.

Fig. 13 schematically illustrates dimensions of a cannula 1 according to embodiments of the invention.

20 The cannula 1 comprises a body 3 extending in an axial direction 4 between a proximal end 5 and a distal end 6. It may comprise one conduit and a non-circular cross section, or it may comprise several conduits.

The body 3 has a length 32 along the axial direction 4 from the proximal end 5 to the distal end 6. In this example, the length 32 is 35 mm.

25 The body 3 further has an outer diameter 33 transverse to the axial direction 4. This outer diameter 33 is not constant along the axial direction 4. Even though the outer diameter 33 varies, it does not exceed 1.20 mm at any point along the axial direction. Accordingly, the outer diameter transverse to the axial direction is at most 1.20 mm. Given these dimensions, the cannula is suitable for insertion into a root canal of a human permanent tooth in relation to endodontic therapy.

30 Along the axial direction 4, the body 3 has a cylindrical section 30 and a conical section 29. The cylindrical section 30 extends along the axial direction 4 from the proximal end 5 to the

conical section 29, and the conical section 29 extends along the axial direction 4 from the cylindrical section 30 to the distal end 6.

In the cylindrical section 30, the body 3 has a constant cross-section transverse to the axial direction 4. That is, the cross-section transverse to the axial direction 4 at one point is the same as the cross-section transverse to the axial direction 4 at another point.

In the conical section 29, the outer diameter 33 decreases towards the distal end 6. The conical section 29 has a length along the axial direction of 20 mm.

At the distal end 6, the cannula has a spherically rounded tip 31. This tip 31 has a radius 34 of 0.3 mm. Since this spherically rounded tip 31 has an extension which is at less than a third of the length of the conical section 29 along the axial direction 4, the spherically rounded tip 31 can duly be considered as part of the conical section 29. In some examples, the spherically rounded tip 31 has an extension which is less than a fourth, for example less than a fifth, such as less than a sixth of the length of the conical section along the axial direction. The extension of the spherically rounded tip 31 starts where the linear decrease in outer diameter 33 of the conical section terminates (which is indicated by a horizontal dashed line within the body 3 near the distal end 6) and ends at the outermost part of the distal end 6.

In case a cannula has a non-circular cross-section, the outer diameter may be measured based on a smallest enclosing circle containing all parts of the cannula, and then using the diameter of this circle.

Fig. 14a-d illustrate two exemplary cannulas 1 attached to connectors 10. Fig. 14a-b illustrate a first exemplary cannula 1 as a halftone image and a schematic drawing, and Fig. 14c-d illustrate a second exemplary cannula 1 as a halftone image and a schematic drawing. The first exemplary cannula 1 is attached to the connector 10 by insert moulding. The cannula 1 bends within the connector 10. The second exemplary cannula 1 is attached to the connector 10 by use of an adhesive.

In this disclosure, various versions and elements of the invention have been exemplified for the purpose of clarification rather than limitation. Well-known details of methods and systems have been omitted to not obscure the content of the disclosure with redundancy. Various elements and features of the invention and this disclosure may be combined in any way possible within the scope of the claims.

List of figure references

	1	cannula
	2	dental irrigation system
	3	body
5	4	axial direction
	5	proximal end
	6	distal end
	7a-c	conduit
	8	proximal opening
10	9a-c	distal opening
	10	connector
	11	source of fluid
	12	tooth dentin
	13	debris
15	14	tooth apex
	15, 15a-c	internal region
	16	internal wall
	17, 17a-c	outer indentation
	18a-b	tapered surface
20	19	circular canal
	20	elongated strand of rigid material
	21	central conduit
	22	circumferential conduit
	23	protruding structure
25	24	circumferentially tapered shape
	25	tapered face
	26	outer wall thickness
	27	distance separating circumferential conduit from central conduit
	28	narrowed end
30	29	conical section
	30	cylindrical section
	31	spherically rounded tip
	32	length
	33	outer diameter
35	34	radius
	S11-S23	method steps

LIST OF NUMBERED EMBODIMENTS

1. A cannula for a dental irrigation system comprising a body extending in an axial direction between a proximal end and a distal end, and comprising at least two separate conduits extending in the axial direction between at least one proximal opening and at least two distal openings such that each of the at least two separate conduits terminate(s) at a separate opening of the at least two distal openings.
5
2. The cannula according to embodiment 1, comprising at most one distal opening for each separate conduit.
3. The cannula according to embodiment 1 or 2, wherein the distal openings are displaced relative to each other in the axial direction.
10
4. The cannula according to any of the preceding embodiments, comprising no axially aligned distal openings.
5. The cannula according to any of the preceding embodiments, wherein one of the at least two distal openings is at the distal end of the body and another one of the at least two distal openings is remote from the distal end.
15
6. The cannula according to any of the preceding embodiments, wherein the body defines a tapered section comprising at least one tapered surface being non-perpendicular to the axial direction, and at least one of the distal openings is located in the at least one tapered surface.
7. The cannula according to embodiment 6, wherein the tapered section comprises at least two tapered surfaces being non-perpendicular to the axial direction, and at least one of the at least two distal openings is located in each of the at least two tapered surfaces.
20
8. The cannula according to any of the preceding embodiments, wherein the distal end defines a plane transverse to the axial direction.
9. The cannula according to any of the preceding embodiments, wherein the conduits have different cross sections.
25
10. The cannula according to embodiment 9, wherein at least two of the at least two conduits have different cross-sectional size and shape.

11. The cannula according to any of the preceding embodiments, wherein a main conduit of the at least two conduits has a larger internal cross-sectional size than another conduit of the at least two conduits, wherein the main conduit terminates at a distal opening of the at least two distal openings closest to a distal termination of the distal end.

5 12. The cannula according to any of the preceding embodiments, wherein at least one of the at least two conduits have a circular cross-sectional shape, and another of the at least two conduits have a non-circular cross-sectional shape.

13. The cannula according to any of the preceding embodiments, wherein the proximal end forms a connector for connection to a source of fluid.

10 14. The cannula according to any of the preceding embodiments, wherein the body is, at least partly, of a flexible material.

15. The cannula according to embodiment 14, wherein the flexible material is glass or a polymer material, such as polypropylene.

15 16. The cannula according to embodiment 14 or 15, wherein the body further comprises a rigid material deposited in the flexible material as elongated strands extending in the axial direction.

17. The cannula according to embodiment 16, wherein the rigid material comprises a glycol-modified polyethylene terephthalate (PETG), a polycarbonate, or a cyclic olefin copolymer.

20 18. The cannula according to embodiment 16 or 17, wherein the elongated strands are deposited around each of the at least two separate conduits.

25 19. The cannula according to any of the preceding embodiments, wherein the cannula has a first flexural rigidity in a first bending direction perpendicular to the axial direction and a second flexural rigidity in a second bending direction perpendicular to the axial direction and the first bending direction, wherein the first flexural rigidity and the second flexural rigidity are different.

20. The cannula according to any of the preceding embodiments, wherein the body defines a non-circular section having a non-circular cross section.

21. The cannula according to embodiment 20, wherein the non-circular section extends at least from the distal end and at least 50 percent, for example 100 percent, of the distance between the proximal end and the distal end.

5 22. The cannula according to embodiment 20 or 21, wherein the non-circular cross section has a roundness of at most 0.9, for example at most 0.8, for example at most 0.7, for example at most 0.6, such as at most 0.5.

10 23. The cannula according to any of embodiments 20 to 22, wherein the non-circular cross section comprises one or more outer indentations extending in the axial direction in the non-circular section, the one or more outer indentations having a radial depth of at least 0.05 of a maximal cross-sectional diameter of the cannula in the non-circular section, for example at least 0.1, for example at least 0.15, for example at least 0.2, such as at least 0.25 of the maximal cross-sectional diameter.

15 24. The cannula according to any of embodiments 20 to 23, wherein the non-circular cross section has an outer cross-sectional flow area between a cross-sectional perimeter of the non-circular cross section and a circumscribed circle of the non-circular cross section, wherein the non-circular cross-section has an inner cross-sectional flow area defined by the at least two separate conduits, wherein the outer cross-sectional flow area is larger than the inner cross-sectional flow area.

20 25. The cannula according to any of embodiments 20 to 24, wherein the non-circular section has a cross section defining a plurality of sectors of a circle.

26. The cannula according to embodiment 25, wherein the sectors of a circle have different radial size.

27. The cannula according to embodiment 25 or 26, comprising one conduit for each sector of a circle.

25 28. The cannula according to any of the preceding embodiments, wherein the cannula has an outer diameter from 0.2 mm to 1.5 mm, for example from 0.2 mm to 0.8 mm, for example from 0.3 mm to 0.6 mm, such as from 0.35 mm to 0.5 mm.

30 29. The cannula according to any of the preceding embodiments, wherein the outer diameter gradually changes from a proximal outer diameter at the proximal end to a distal outer diameter at the distal end, wherein the proximal outer diameter is greater than the distal outer diameter.

30. The cannula according to any of the preceding embodiments, wherein the at least two conduits are at least four conduits and the at least two distal openings are at least four distal openings, wherein each of the at least four conduits terminate at a separate opening of the at least four distal openings.

5 31. The cannula according to embodiment 30, wherein the at least four conduits comprise a central conduit and at least three circumferential conduits, wherein the central conduit is circumferentially surrounded by the at least three circumferential conduits.

10 32. The cannula according to embodiment 31, wherein each of the at least three circumferential conduits forms a respective protruding structure extending in the axial direction an protruding from the central conduit transverse to the axial direction.

33. The cannula according to any of embodiments 31 to 32, wherein distances separating the at least three circumferential conduits from the central conduit are different.

15 34. The cannula according to any of embodiments 31 to 33, wherein at least one distance separating the at least three circumferential conduits from the central conduit is greater than an outer wall thickness of the at least three circumferential conduits by a factor of at least two.

35. The cannula according to any of embodiments 31 to 34, wherein the central conduit terminates at the distal end of the body and at least some of the at least three circumferential conduits terminate remote from the distal end.

20 36. The cannula according to any of embodiments 31 to 35, wherein the distal end has a circumferentially tapered shape having a narrowed end at the termination of the distal end.

37. The cannula according to embodiment 36, wherein the central conduit terminates at the narrowed end of the circumferentially tapered shape and each of the at least three circumferential conduits terminate in a tapered face of the circumferentially tapered shape.

25 38. The cannula according to any of the preceding embodiments, wherein the body has a length of at least 10 mm in the axial direction, for example at least 12 mm, for example at least 14 mm, for example at least 16 mm, for example at least 18 mm, such as at least 20 mm.

39. The cannula according to any of the preceding embodiments, wherein the body has an outer diameter transverse to the axial direction of at most 1.50 mm, for example at most 1.40 mm, for example at most 1.30 mm, for example at most 1.20 mm, such as at most 1.10 mm.

5 40. The cannula according to any of the preceding embodiments, wherein the body has a length of at least 10 mm in the axial direction and an outer diameter transverse to the axial direction of at most 1.50 mm for insertion of the dental cannula into a root canal of a human permanent tooth.

10 41. The cannula according to any of embodiments 38-40, wherein the length of the body is at most 60 mm, for example at most 50 mm, for example at most 40 mm, such as at most 30 mm.

42. The cannula according to any of the preceding embodiments, wherein a distal portion of the dental cannula has a bending moment of at most 12 mNmm, for example at most 9.0 mNmm, for example at most 6.0 mNmm, such as at most 4.0 mNmm.

15 43. The cannula according to embodiment 42, wherein the distal portion of the dental cannula is the portion of the body starting from the distal end and extending 7.0 mm in the axial direction towards the proximal end.

20 44. The cannula according to any of embodiments 38-43, wherein the body has a conical section terminating at the distal end such that the outer diameter of the body decreases along the axial direction towards the distal end.

45. The cannula according to any of embodiments 38-44, wherein the outer diameter at the distal end is at most 0.60 mm, for example at most 0.50 mm, for example at most 0.40 mm, such as at most 0.30 mm.

25 46. The cannula according to any of embodiments 44-45, wherein the length of the conical section in the axial direction is at least 1.0 mm, for example at least 2.0 mm, for example at least 5.0 mm, for example at least 10 mm, such as at least 15 mm.

47. The cannula according to any of embodiments 44-46, wherein the length of the conical section in the axial direction is at most 35 mm, for example at most 30 mm, for example at most 25 mm, such as at most 20 mm, such as at most 15 mm.

48. The cannula according to any of embodiments 44-47, wherein the body has a cylindrical section extending in the axial direction from the proximal end and terminating at the conical section.

5 49. The cannula according to embodiment 48, wherein the outer diameter along the cylindrical section is at least 0.70 mm, for example at least 0.80 mm, for example at least 0.90 mm, such as at least 1.0 mm.

50. The cannula according to any of embodiments 48-49, wherein the outer diameter is constant along the cylindrical section.

10 51. The cannula according to any of embodiments 48-50, wherein the cross-section of the body transverse to the axial direction is constant along the cylindrical section.

52. The cannula according to any of the preceding embodiments, wherein the body has a spherically rounded tip at the distal end.

15 53. The cannula according to embodiment 52, wherein the spherically rounded tip has a radius of at most 0.40 mm, for example at most 0.35 mm, for example at most 0.30 mm, for example at most 0.25 mm, for example at most 0.20 mm, such as at most 0.15 mm, such as at most 0.10 mm.

54. The cannula according to any of the preceding embodiments, wherein the body is, at least partly, of a flexible material, the flexible material having an elastic modulus of at most 20 GPa, for example at most 15 GPa, for example at most 10 GPa, such as at most 5 GPa.

20 55. The cannula according to any of the preceding embodiments, wherein the at least two conduits are at least four conduits and the at least two distal openings are at least four distal openings, wherein each of the at least four conduits terminate at a separate opening of the at least four distal openings, wherein the at least four conduits comprise a central conduit and at least three circumferential conduits, wherein the central conduit is circumferentially
25 surrounded by the at least three circumferential conduits, wherein the central conduit terminates at the distal end of the body and at least some of the at least three circumferential conduits terminate along the conical section and are displaced along the axial direction from the distal opening of the central conduit at the distal end.

30 56. A method of irrigating a root canal comprising inserting a cannula according to any of the preceding embodiments into the root canal and exchanging a flushing liquid between the proximal opening and the root canal via at least one of the at least two separate conduits.

57. The method according to embodiment 56, wherein the liquid is flushed from the proximal end to the distal end and into the root canal via one of the at least two conduits and flushed from the root canal to the proximal end via another of the at least two conduits.

58. The method according to embodiment 56 or 57, wherein the at least two separate
5 conduits and the at least two distal openings are applied for establishing different pressure at two axially offset locations in the root canal.

59. The method according to any of embodiments 56-58, wherein one of the at least two separate conduits is used for continuing irrigation while another of the at least two separate conduits is clogged.

10 60. A dental irrigation system comprising a cannula according to any of the embodiments 1-55 or any of embodiments 71-89, and a connector attached to the proximal end of the cannula and configured to fluidly couple the cannula to a source of fluid.

15 61. A method of manufacturing a cannula for a dental irrigation system, such as the cannula according to any of embodiments 1-55 or any of embodiments 71-89, the method comprising the steps of:

producing a cannula preform extending in an axial direction;

20 pulling the cannula preform in said axial direction to elongate a length of the cannula preform in the axial direction and to shrink a diameter of the cannula preform perpendicularly to the axial direction, thereby producing a cannula fibre having an outer diameter of at least 0.20 mm, for example at least 0.25 mm, such as at least 0.30 mm; and

25 cutting the cannula fibre perpendicularly to the axial direction to provide the cannula with a cannula length in the axial direction of at most 40 mm, for example at most 35 mm, for example at most 30 mm, for example at most 25 mm, such as at most 20 mm.

62. A method according to embodiment 61, wherein the outer diameter of the cannula fibre produced by the step of pulling the cannula preform is at least 0.70 mm, for example at least 0.80 mm, for example at least 0.90 mm, such as at least 1.0 mm.

63. A method according to embodiment 61 or 62, wherein the cannula preform is produced by additive manufacturing.

64. A method according to any of embodiments 61-63, wherein the cannula preform is produced with a cannula preform body of a flexible material and a rigid material deposited in the flexible material as elongated strands extending in the axial direction.

65. A method according to any of embodiments 61-64, wherein the step of pulling the cannula preform is performed using a draw tower, such as a draw tower for drawing optical fibres.

66. A method according to any of embodiments 61-65, wherein the method comprises a step of slantly removing material at a distal end of the cannula to establish at least one tapered surface being non-perpendicular to the axial direction, wherein at least one distal opening of a separate conduit of the cannula is located at the at least one tapered surface.

67. A method according to any of embodiments 61-66, wherein the method comprises a step of slantly removing material at a distal end of the cannula to establish a circumferentially tapered shape having a narrowed end at the termination of the distal end.

68. A method according to any of embodiments 61-67, wherein the circumferentially tapered shape defines a conical section of the dental cannula, the conical section terminating at the distal end such that the outer diameter of the body decreases along the axial direction towards the distal end.

69. A method according to any of embodiments 61-68, wherein the method comprises a step of slantly removing material at a distal end of the cannula to establish a spherically rounded tip.

70. A method according to any of embodiments 61-69, wherein the cannula comprises a body extending in the axial direction between a proximal end and a distal end, and comprising at least one separate conduit extending in the axial direction between at least one proximal opening and at least one distal opening such that each of the at least one separate opening terminates at a separate opening of the at least one distal opening.

71. A cannula for a dental irrigation system and comprising a body, at least one conduit extending between a proximal opening and a distal opening of the body, wherein the body has a non-circular cross section.

72. The cannula according to embodiment 71, wherein the non-circular cross section has a roundness of at most 0.9, for example at most 0.8, for example at most 0.7, for example at most 0.6, such as at most 0.5.

5 73. The cannula according to any of embodiments 71-72, wherein the non-circular cross section comprises one or more outer indentations extending in the axial direction in the non-circular section, the one or more outer indentations having a radial depth of at least 0.05 of a maximal cross-sectional diameter of the cannula in the non-circular section, for example at least 0.1, for example at least 0.15, for example at least 0.2, such as at least 0.25 of the maximal cross-sectional diameter.

10 74. The cannula according to any of embodiments 71-73, wherein the body has a length of at least 10 mm in the axial direction, for example at least 12 mm, for example at least 14 mm, for example at least 16 mm, for example at least 18 mm, such as at least 20 mm.

15 75. The cannula according to any of embodiments 71-74, wherein the body has an outer diameter transverse to the axial direction of at most 1.50 mm, for example at most 1.40 mm, for example at most 1.30 mm, for example at most 1.20 mm, such as at most 1.10 mm.

20 76. The cannula according to any of embodiments 71-75, wherein the body has a length of at least 10 mm in the axial direction and an outer diameter transverse to the axial direction of at most 1.50 mm for insertion of the dental cannula into a root canal of a human permanent tooth.

77. The cannula according to any of embodiments 71-76, the length of the body is at most 60 mm, for example at most 50 mm, for example at most 40 mm, such as at most 30 mm.

25 78. The cannula according to any of embodiments 71-77, wherein a distal portion of the dental cannula has a bending moment of at most 12 mNmm, for example at most 9.0 mNmm, for example at most 6.0 mNmm, such as at most 4.0 mNmm.

79. The cannula according to embodiment 78, wherein the distal portion of the dental cannula is the portion of the body starting from the distal end and extending 7.0 mm in the axial direction towards the proximal end.

30 80. The cannula according to any of embodiments 71-79, wherein the body has a conical section terminating at the distal end such that the outer diameter of the body decreases along the axial direction towards the distal end.

81. The cannula according to any of embodiments 71-80, wherein the outer diameter at the distal end is at most 0.60 mm, for example at most 0.50 mm, for example at most 0.40 mm, such as at most 0.30 mm.

5 82. The cannula according to any of embodiments 80-81, wherein the length of the conical section in the axial direction is at least 1.0 mm, for example at least 2.0 mm, for example at least 5.0 mm, for example at least 10 mm, such as at least 15 mm.

83. The cannula according to any of embodiments 80-82, wherein the length of the conical section in the axial direction is at most 35 mm, for example at most 30 mm, for example at most 25 mm, such as at most 20 mm, such as at most 15 mm.

10 84. The cannula according to any of embodiments 80-83, wherein the body has a cylindrical section extending in the axial direction from the proximal end and terminating at the conical section.

15 85. The cannula according to embodiment 84, wherein the outer diameter along the cylindrical section is at least 0.70 mm, for example at least 0.80 mm, for example at least 0.90 mm, such as at least 1.0 mm.

86. The cannula according to any of embodiments 84-85, wherein the outer diameter is constant along the cylindrical section.

87. The cannula according to any of embodiments 84-86, wherein the cross-section of the body transverse to the axial direction is constant along the cylindrical section.

20 88. The cannula according to any of embodiments 71-87, wherein the body has a spherically rounded tip at the distal end.

25 89. The cannula according to embodiment 88, wherein the spherically rounded tip has a radius of at most 0.40 mm, for example at most 0.35 mm, for example at most 0.30 mm, for example at most 0.25 mm, for example at most 0.20 mm, such as at most 0.15 mm, such as at most 0.10 mm.

90. A dental irrigation system for use in endodontic therapy, the dental irrigation system comprising a cannula according to any of embodiments 1-55 or any of embodiments 71-89, a connector attached to the proximal end of the cannula, and a source of fluid fluidly coupled to the cannula via the connector.

CLAIMS

1. A cannula for a dental irrigation system comprising a body extending in an axial direction between a proximal end and a distal end, and comprising at least two separate conduits extending in the axial direction between at least one proximal opening and at least two distal openings such that each of the at least two separate conduits terminate at a separate opening of the at least two distal openings, wherein the body has a length of at least 10 mm in the axial direction and an outer diameter transverse to the axial direction of at most 1.50 mm for insertion of the dental cannula into a root canal of a human permanent tooth.
5
2. The cannula according to claim 1, wherein a distal portion of the dental cannula has a bending moment of at most 12 mNmm, for example at most 9.0 mNmm, for example at most 6.0 mNmm, such as at most 4.0 mNmm;
10
wherein the distal portion of the dental cannula is the portion of the body starting from the distal end and extending 7.0 mm in the axial direction towards the proximal end.
3. The cannula according to any of the preceding claims, wherein the body has a conical section terminating at the distal end such that the outer diameter of the body decreases along the axial direction towards the distal end.
15
4. The cannula according to any of the preceding claims, wherein the outer diameter at the distal end is at most 0.60 mm, for example at most 0.50 mm, for example at most 0.40 mm, such as at most 0.30 mm.
- 20 5. The cannula according to any of the preceding claims, comprising at most one distal opening for each separate conduit.
6. The cannula according to any of the preceding claim, wherein the distal openings are displaced relative to each other in the axial direction.
7. The cannula according to any of the preceding claims, wherein one of the at least two distal openings is at the distal end of the body and another one of the at least two distal openings is remote from the distal end.
25
8. The cannula according to any of the preceding claims, wherein the body defines a tapered section comprising at least one tapered surface being non-perpendicular to the axial

direction, and at least one of the distal openings is located in the at least one tapered surface.

9. The cannula according to claim 8, wherein the tapered section comprises at least two tapered surfaces being non-perpendicular to the axial direction, and at least one of the at
5 least two distal openings is located in each of the at least two tapered surfaces.

10. The cannula according to any of the preceding claims, wherein the conduits have different cross sections.

11. The cannula according to claim 10, wherein at least two of the at least two conduits have different cross-sectional size and shape.

10 12. The cannula according to any of the preceding claims, wherein a main conduit of the at least two conduits has a larger internal cross-sectional size than another conduit of the at least two conduits, wherein the main conduit terminates at a distal opening of the at least two distal openings closest to a distal termination of the distal end.

15 13. The cannula according to any of the preceding claims, wherein the body is, at least partly, of a flexible material, the flexible material having an elastic modulus of at most 20 GPa, for example at most 15 GPa, for example at most 10 GPa, such as at most 5 GPa.

14. The cannula according to claim 13, wherein the flexible material is glass or a polymer material, such as polypropylene.

20 15. The cannula according to any of the preceding claims, wherein the at least two conduits are at least four conduits and the at least two distal openings are at least four distal openings, wherein each of the at least four conduits terminate at a separate opening of the at least four distal openings, wherein the at least four conduits comprise a central conduit and at least three circumferential conduits, wherein the central conduit is circumferentially surrounded by the at least three circumferential conduits, wherein the central conduit
25 terminates at the distal end of the body and at least some of the at least three circumferential conduits terminate along the conical section and are displaced along the axial direction from the distal opening of the central conduit at the distal end.

30 16. A method of irrigating a root canal comprising inserting a cannula according to any of the preceding claims into the root canal and exchanging a flushing liquid between the proximal opening and the root canal via at least one of the at least two separate conduits.

17. A dental irrigation system comprising a cannula according to any of claims 1-15, and a connector attached to the proximal end of the cannula and configured to fluidly couple the cannula to a source of fluid.

5 18. The dental irrigation system according to claim 17, comprising a syringe configured to expel fluid from an outlet and wherein the connector provides a releasable or fixed coupling between the cannula and the outlet such that all proximal openings are within the outlet.

19. A method of manufacturing a cannula for a dental irrigation system, such as the cannula according to any of claims 1-15, the method comprising the steps of:

producing a cannula preform extending in an axial direction;

10 pulling the cannula preform in said axial direction to elongate a length of the cannula preform in the axial direction and to shrink a diameter of the cannula preform perpendicularly to the axial direction, thereby producing a cannula fibre having an outer diameter of at least 0.70 mm, for example at least 0.80 mm, for example at least 0.90 mm, such as at least 1.0 mm; and

15 cutting the cannula fibre perpendicularly to the axial direction to provide the cannula with a cannula length in the axial direction of at most 30 mm, for example at most 25 mm, such as at most 20 mm.

20 20. The method according to claim 19, wherein the method comprises a step of slantly removing material at a distal end of the cannula to establish a conical section terminating at the distal end of the cannula, such that the outer diameter of the body of the cannula decreases along the axial direction towards the distal end.

21. A dental irrigation system for use in endodontic therapy, the dental irrigation system comprising a cannula according to any of claims 1-15, a connector attached to the proximal end of the cannula, and a source of fluid fluidly coupled to the cannula via the connector.

25 22. A cannula for a dental irrigation system and comprising a body, at least one conduit extending in an axial direction between a proximal opening and a distal opening of the body, wherein the body has a non-circular cross section, wherein the body has a length of at least 10 mm in the axial direction and an outer diameter transverse to the axial direction of at most 1.50 mm for insertion of the dental cannula into a root canal of a human permanent
30 tooth.

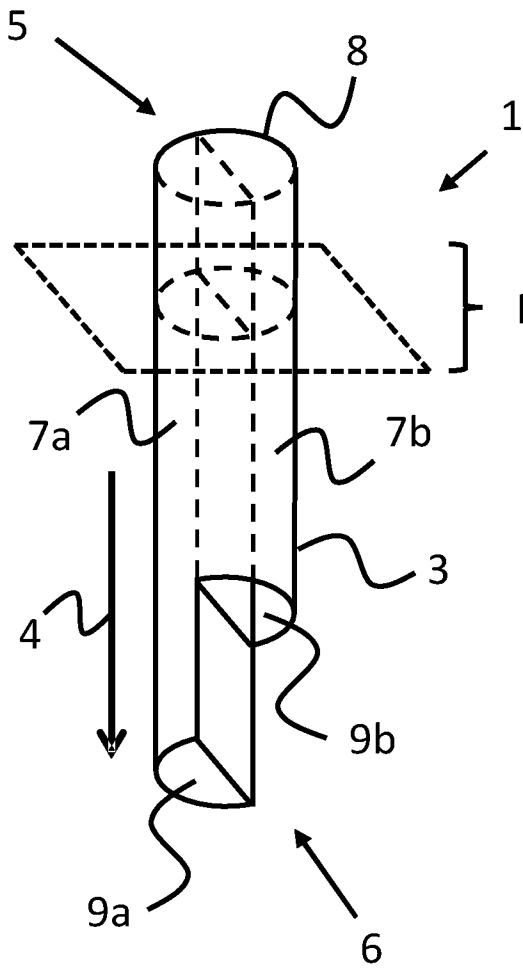


Fig. 1a

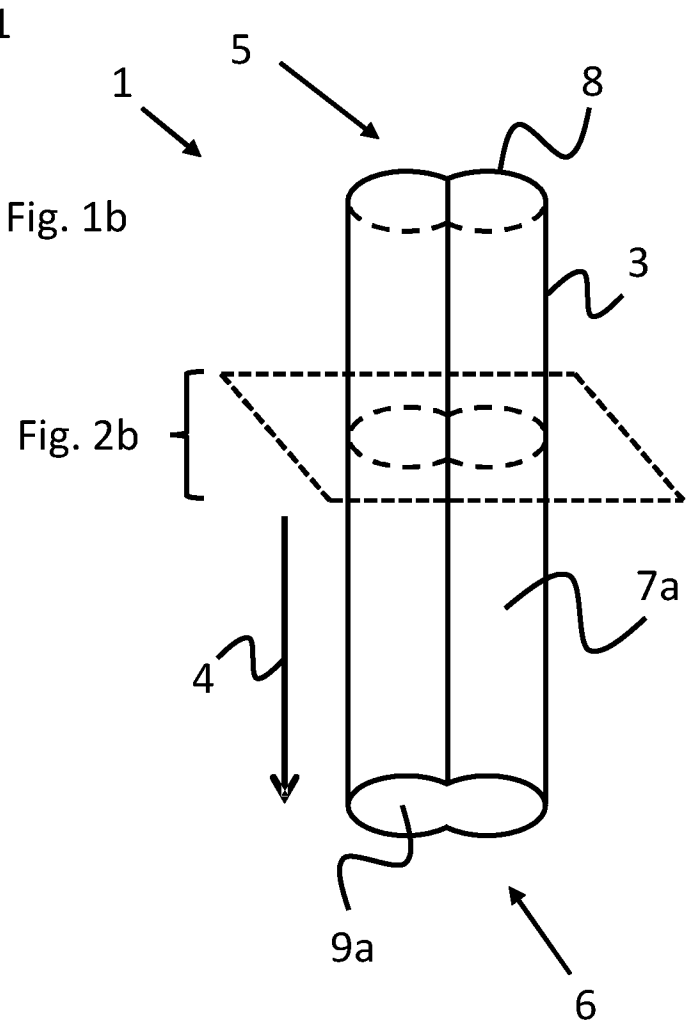


Fig. 2a

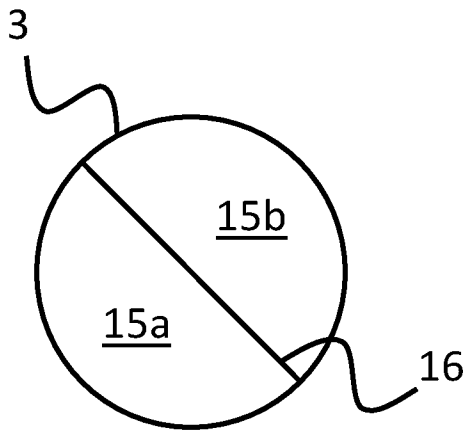


Fig. 1b

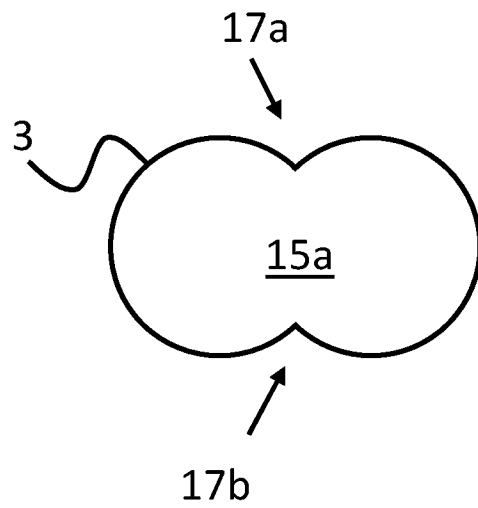


Fig. 2b

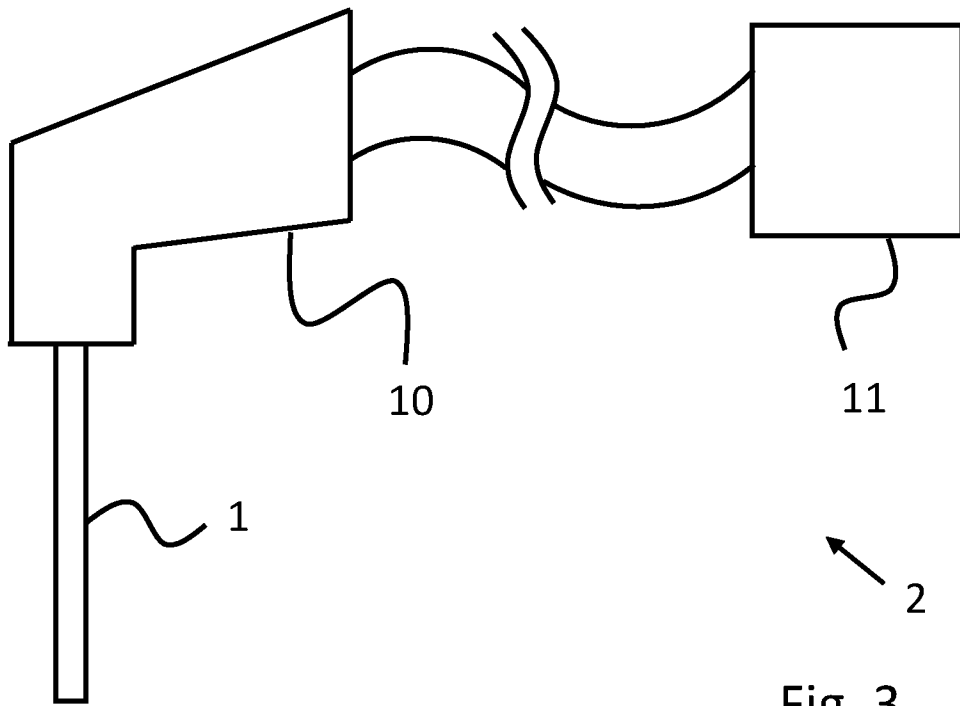


Fig. 3

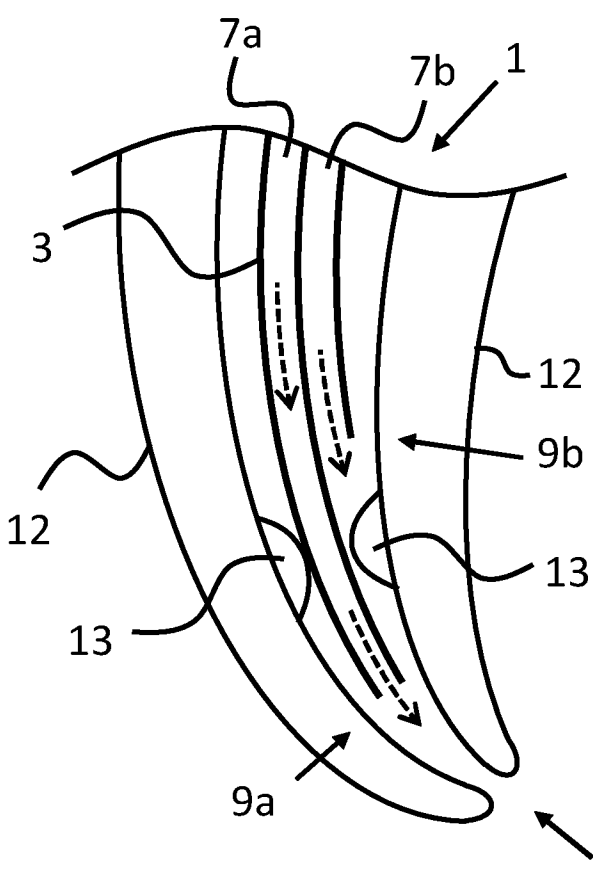


Fig. 4

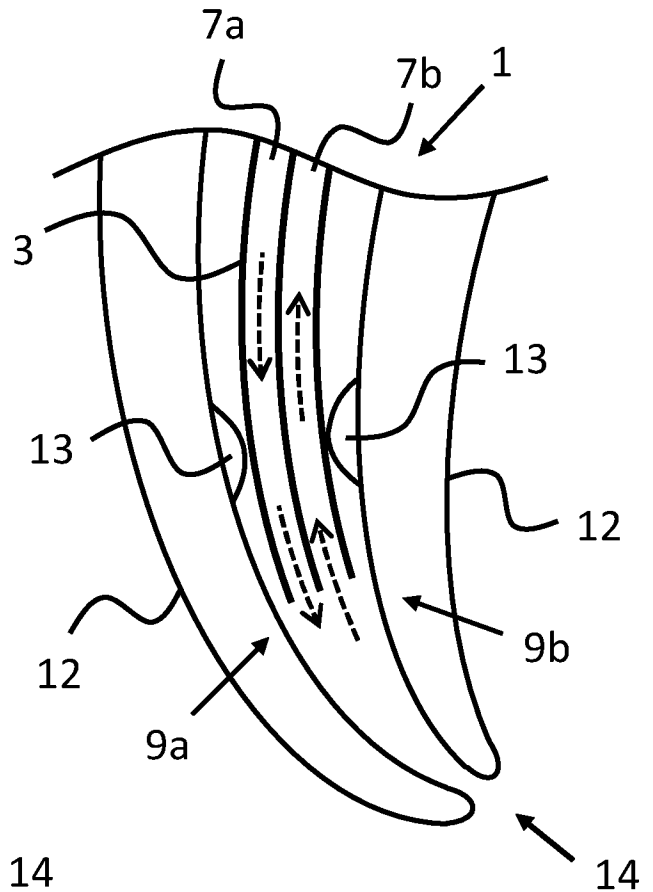


Fig. 5

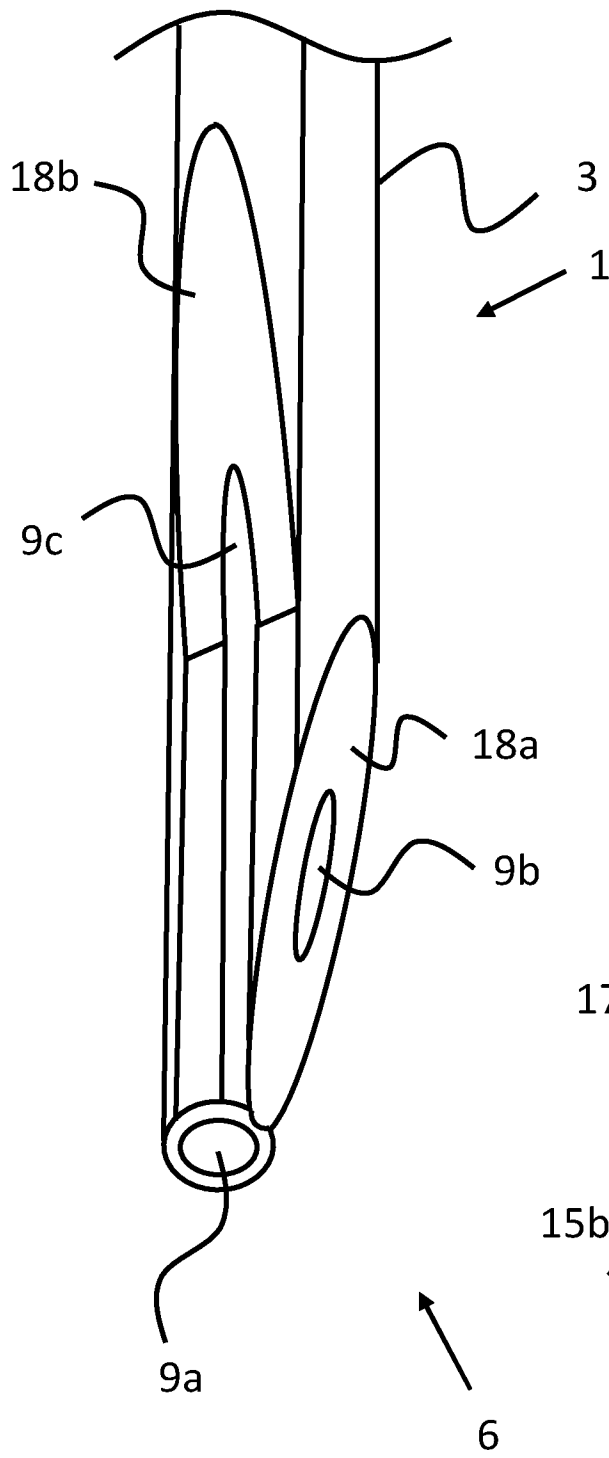


Fig. 6a

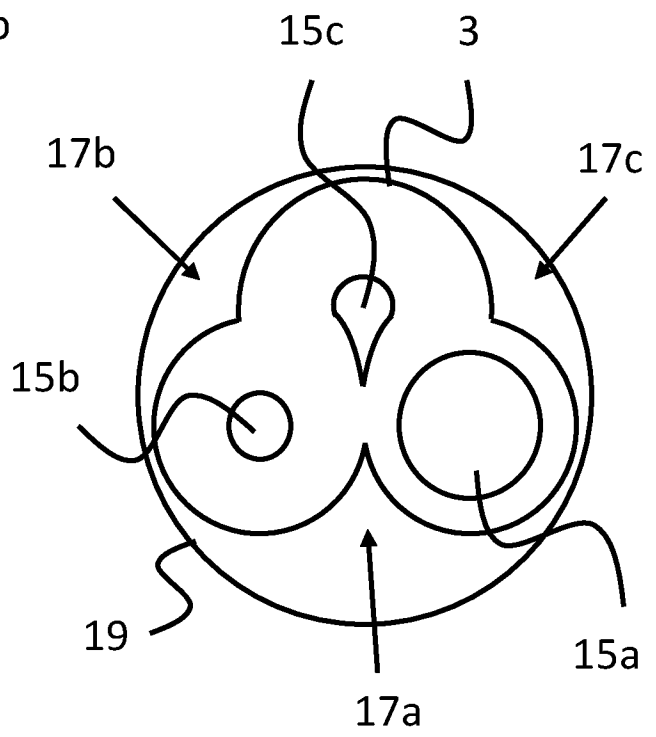


Fig. 6b

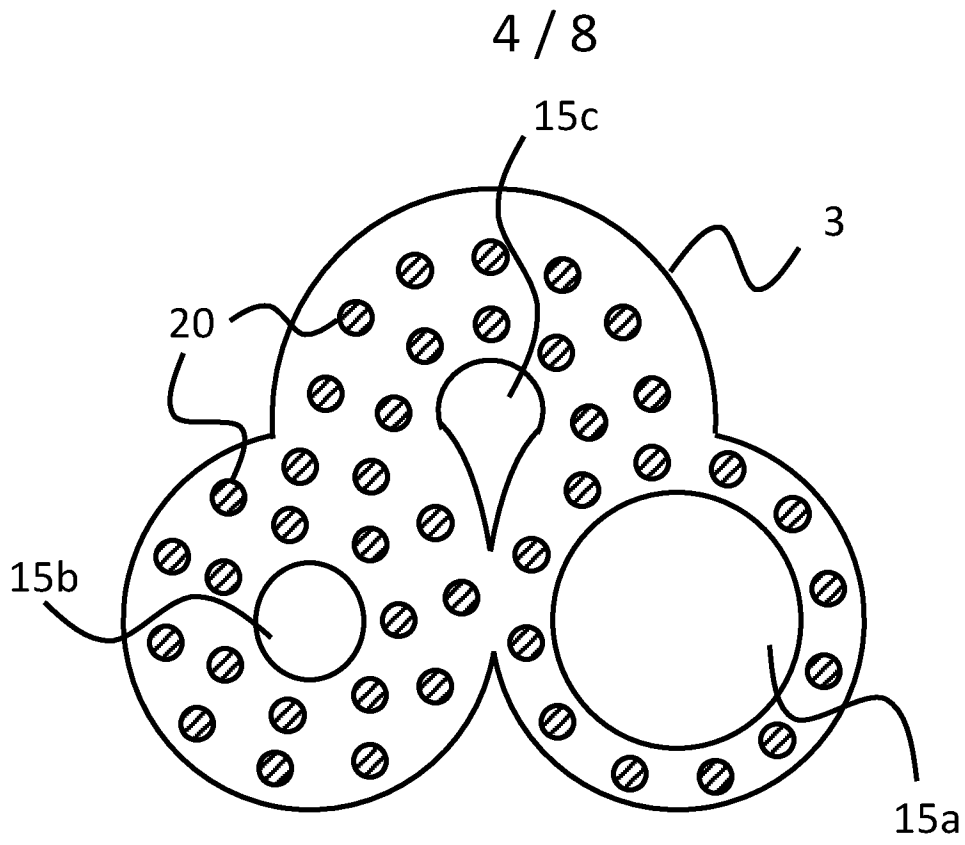


Fig. 7

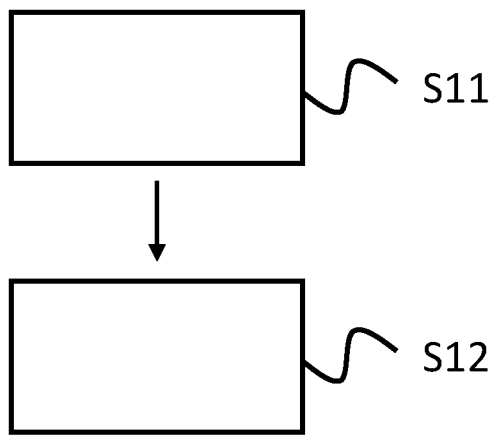


Fig. 8

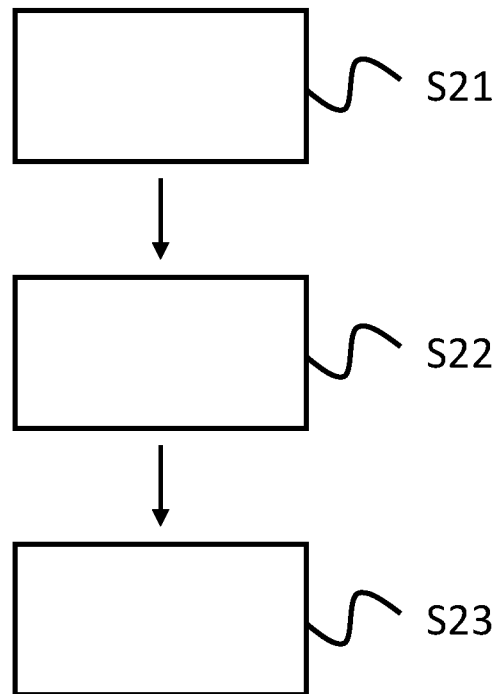


Fig. 9

5 / 8

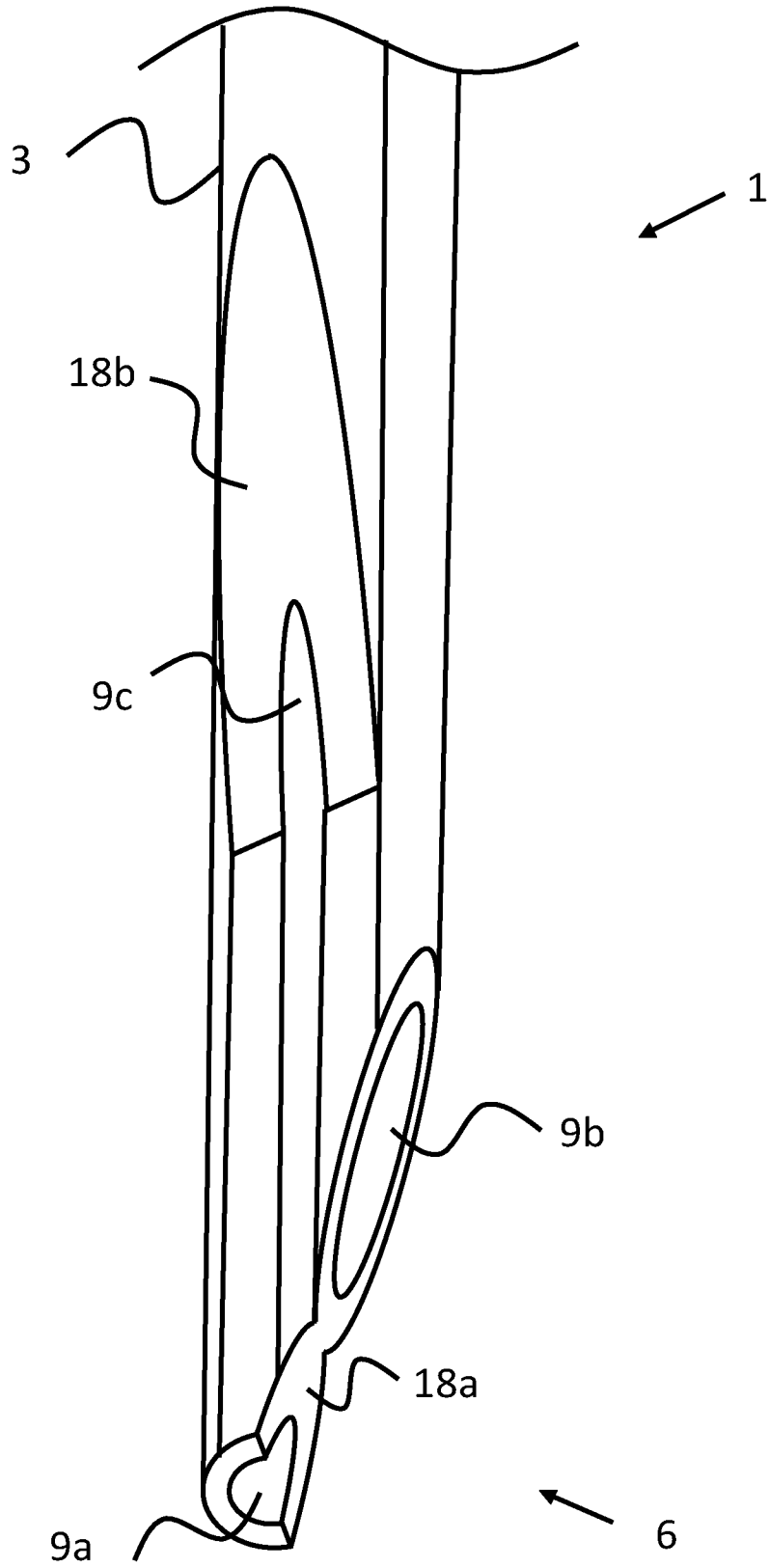


Fig. 10

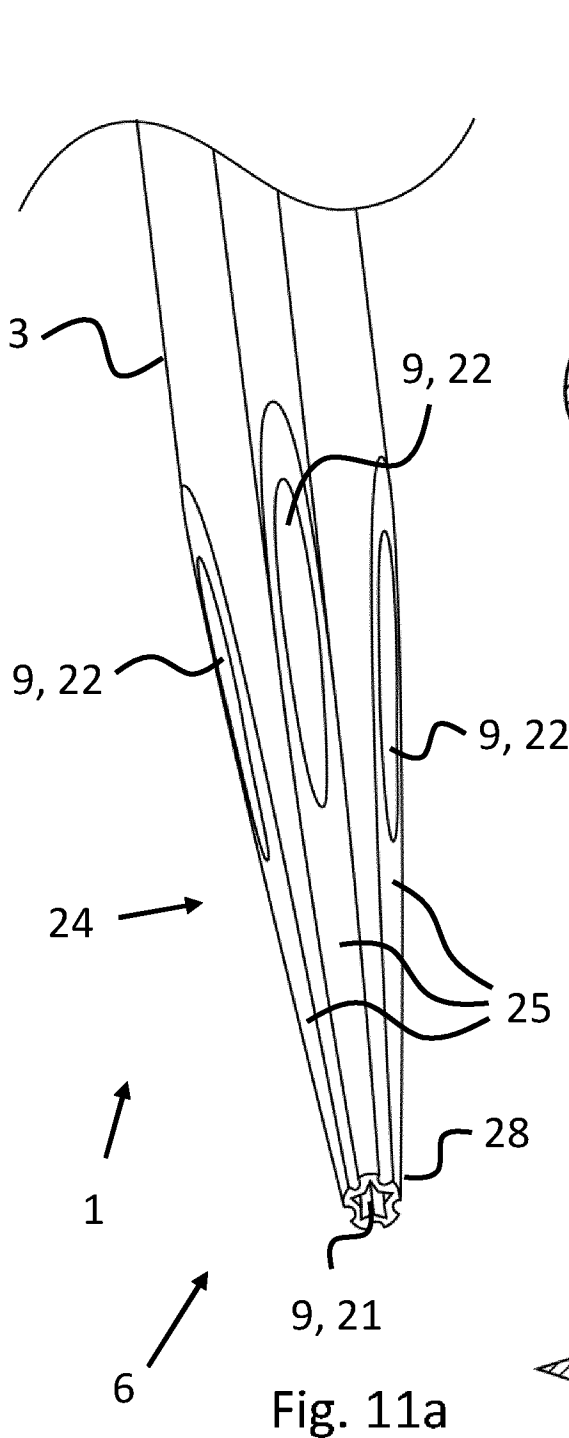


Fig. 11a

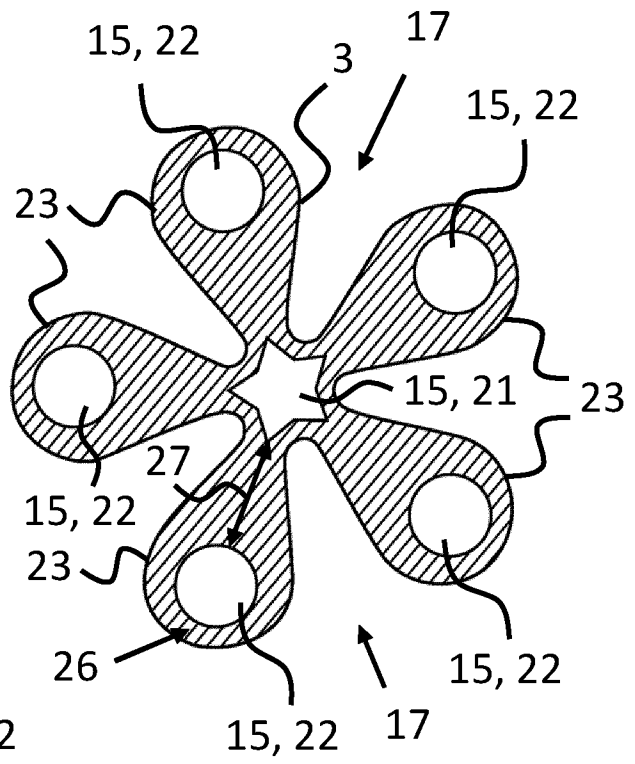


Fig. 11b

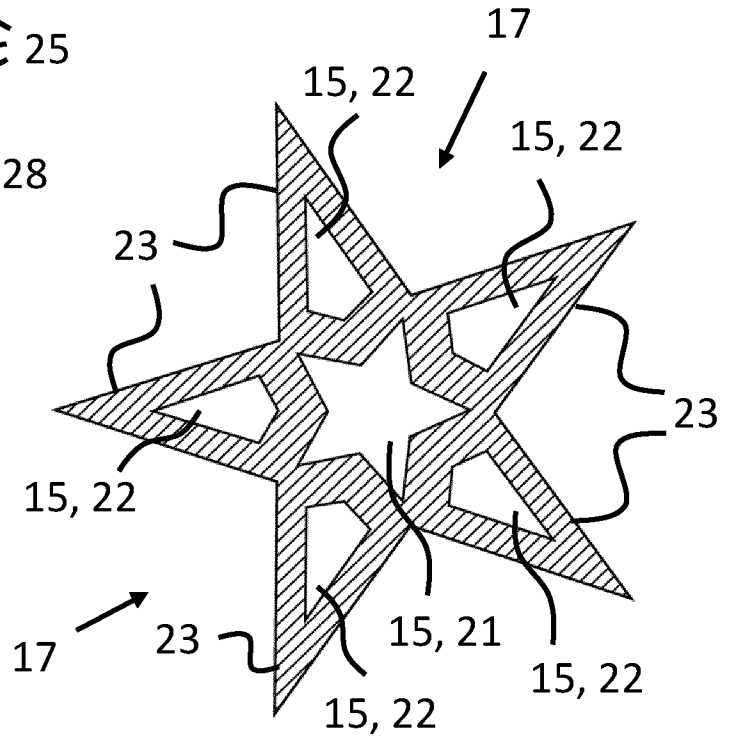


Fig. 12

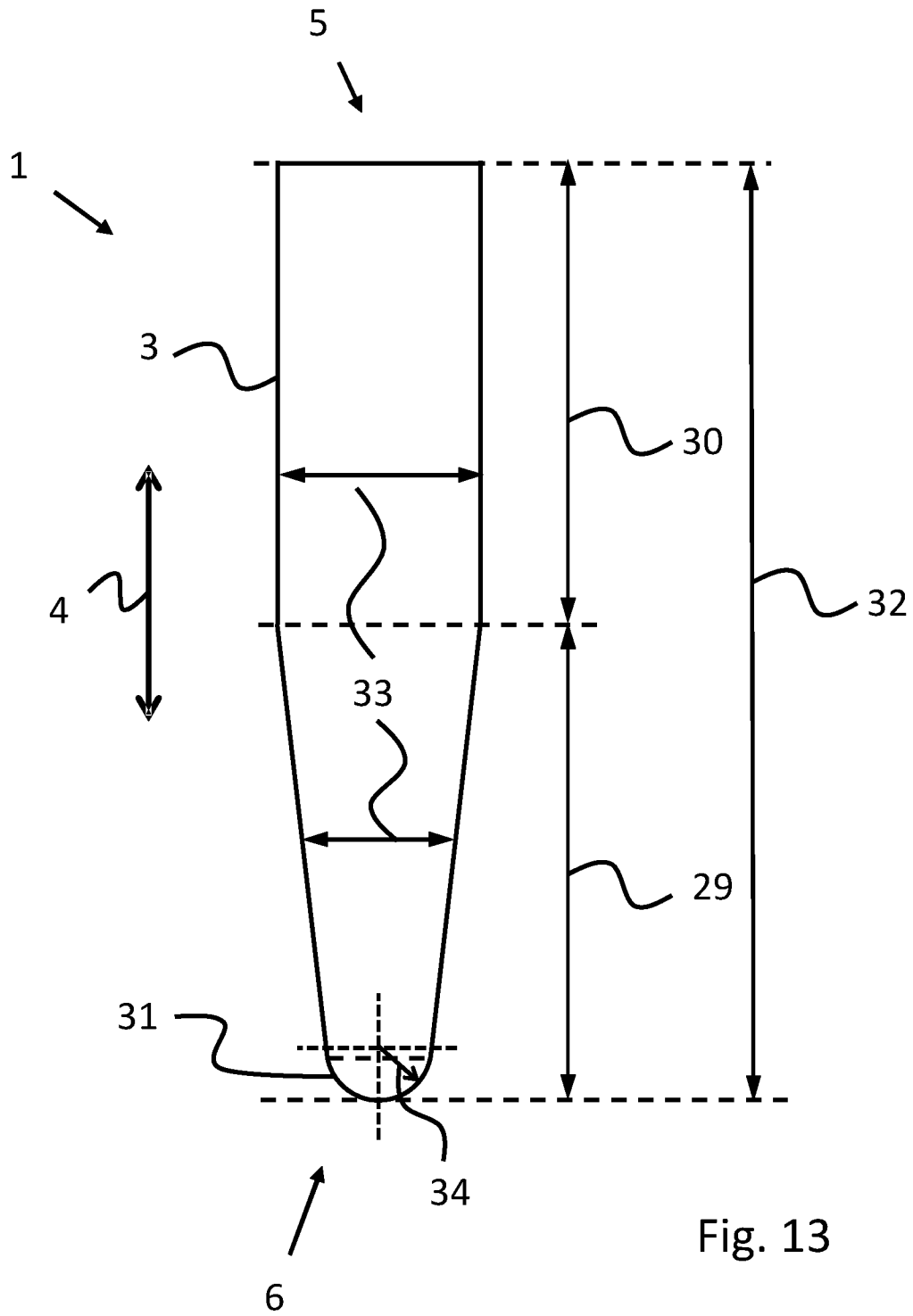


Fig. 13

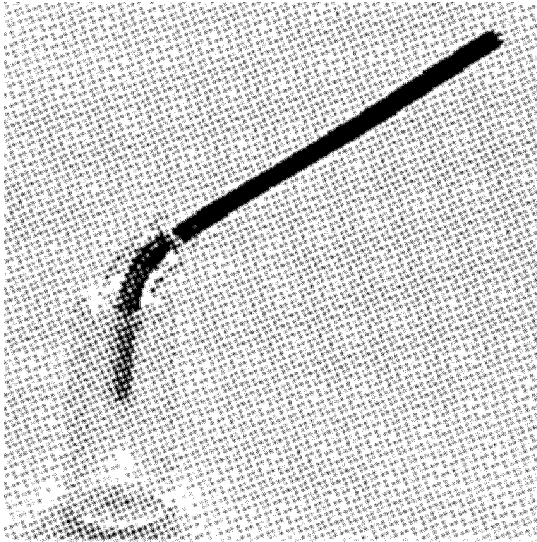


Fig. 14a

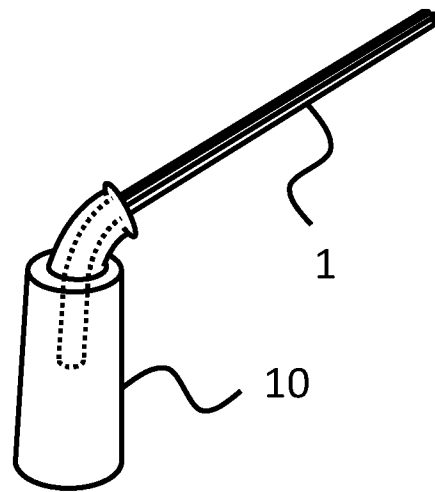


Fig. 14b

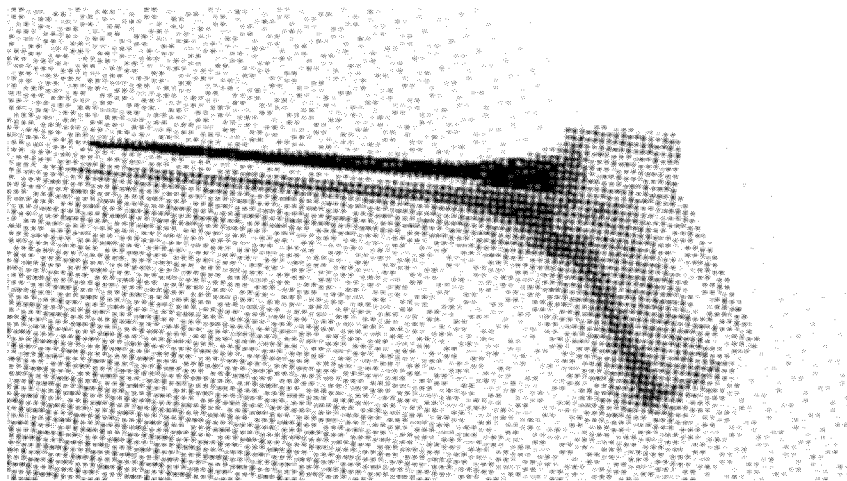


Fig. 14c

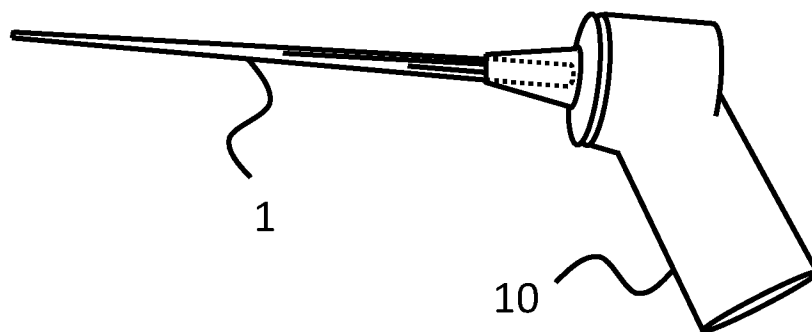


Fig. 14d

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/067175

A. CLASSIFICATION OF SUBJECT MATTER INV. A61C17/024 A61C5/40 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) A61C		
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.
Y	US 2014/080090 A1 (LAUFER ZOHAR [US]) 20 March 2014 (2014-03-20) paragraph [0034]; claim 25; figure 11 -----	1-21
X	WO 2018/081180 A2 (DENTSPLY SIRONA INC [US]) 3 May 2018 (2018-05-03)	22
Y	paragraphs [2315], [0017]; figures 5, 6 -----	1-21
<input type="checkbox"/> Further documents are listed in the continuation of Box C.		
<input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 8 August 2023	Date of mailing of the international search report 17/08/2023	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Haller, E	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2023/067175

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014080090	A1	20-03-2014	NONE

WO 2018081180	A2	03-05-2018	CA 3041655 A1 03-05-2018
		CN 110891517 A	17-03-2020
		EP 3528739 A2	28-08-2019
		ES 2885835 T3	15-12-2021
		PT 3528739 T	27-08-2021
		US 2019290397 A1	26-09-2019
		WO 2018081180 A2	03-05-2018
