

Fiber-optic Cannula

A fluid cannula is an assembly of a metal tube and a fluid tube receptacle, used for administering fluids when metal tube is inserted into the body. A venous cannula is inserted into a vein to obtain blood samples or to deliver medicines. The body of a cannula has a form that easily connects to or disconnects from the plastic tubing. The plastic tubing can be disconnected while the cannula remains attached to the body surface with the hollow needle (tube) inserted into the body for the later use. Similar to those fluid cannulas, biomedical and optogenetics applications need fiber-optic cannulas to introduce the laser or LED light into the body tissue. As an example, illuminating the neurons within the mouse brain with the blue or orange light has become an essential tool for studying the processes within genetically modified photosensitive neurons. In early days of optogenetics, researchers used a fluid cannula to insert the optical fibers into the brain tissue, where the metal tube guides the fiber to the neurons. After the experiment, the optical fiber is removed from the cannula only to be reinserted later. The optical fiber removal and re-entry could lead to infections and clogging of the fluid cannula.

The fiber-optic cannula is used without the metal tube of the fluid cannula. It consists of a fiber-optic ferrule with some sort of fiber-optic connector receptacle on one side and the implantable fiber protruding from the other side. When the fiber-optic cannula is fixed to the body with the fiber implanted it can deliver the light to the tissue and capture the fluorescence or scatter from the tissue. It is imperative in these experiments, that the connection between the delivery fiber and the cannula be light, small and simple to connect and disconnect. For a mono fiber delivery, the connection between the ferrules of the light delivery fiber patch cord and the fiber-optic cannula is achieved, in its simplest form, via fiber-optic sleeve. The connector type connection is preferred but it is not always applicable. In some optogenetics experiments it is necessary to introduce two or more implantable fibers within a small, precise distance. Those applications call for the dual or multiple fiber-optic cannula that is easily connected to the matching delivery fiber.

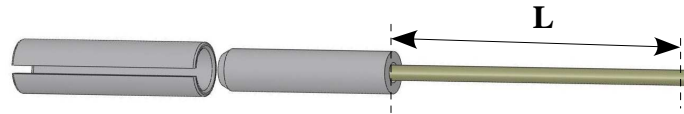
The concept of fiber-optic cannulas with different receptacle types and fiber terminations is bound to be further fragmented. So far we have *Mono fiber cannulas*, *Dual fiber cannulas* and *Two ferrules cannulas* as the latest addition to the product family. In effect, we are contemplating different hybrid cannulas that transmit combination of light, liquid and electrical signals.

Mono Fiber-optic Cannula

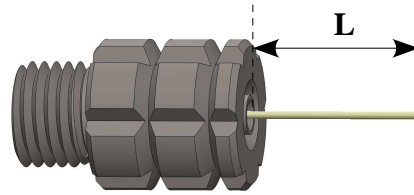
The mono fiber-optic cannula is an assembly of a bare optical fiber, a fiber ferrule and a receptacle or a sleeve. One side of the ferrule is polished while the implantable part of the fiber protrudes from the opposite end of the ferrule. The ferrule is placed within receptacle or sleeve to allow connecting to the fiber-optic patch cord. The protruding fiber can be implanted into the body while the ferrule or the receptacle is attached to the skin. When the cannula is connected with the patch cord, it is possible to send the light signals to and from the tissue close to fiber tip. It is imperative for in-vivo optogenetics applications that the fiber-optic cannula allows for efficient, plug and play type connection with the fiber-optic patch cord.

A receptacle is a mechanical holder that defines the positions of the fiber tip and guides the connecting ferrule to the optical coupling position. For mono fiber-optic cannulas we offer Zirconia sleeves as the simplest form of receptacle, mini sma (or "sma") receptacles, M3 receptacles and magnetic receptacles in cylindrical or rectangular shape. On Fig.x those receptacles are depicted in the same order.

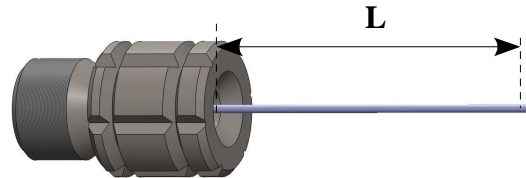
For more information on receptacles, refer to receptacle section. N.B. Zirconia sleeves are ordered separately.



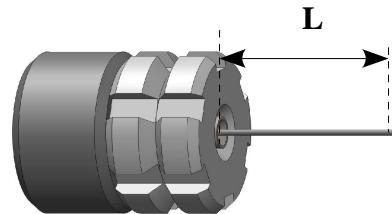
Mono Fiber-optic Cannula with Zirconia sleeve



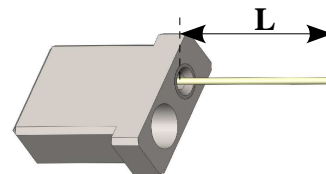
Mono Fiber-optic Cannula with sma receptacle



Mono Fiber-optic Cannula with M3 receptacle



Mono Fiber-optic Cannula with cylindrical magnetic receptacle



Mono Fiber-optic Cannula with rectangle magnetic receptacle

Drawing 1: Available types of mono fiber-optic cannulas

All our mono fiber-optic cannulas have a typical transmission higher than 80%.

ORDERING CODE : MFC_□□□/□□□-□□□_□□□_□□□_□□□

Fiber core diameter (μm)

50, 62.5, 100, 200

Fiber buffer diameter (μm)

70, 125, 260

Numerical Aperture

0.22, 0.27, 0.37, 0.48

Length "L" (mm)

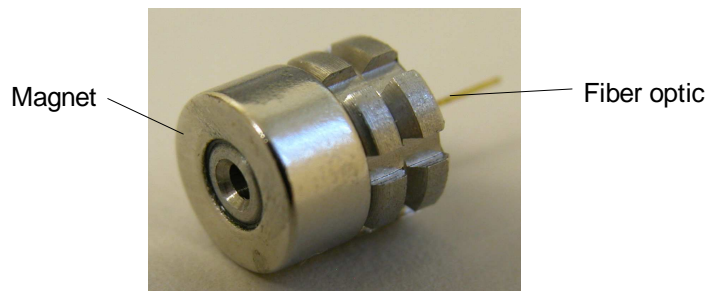
See convention on figure on previous page

Receptacle code:

(see table 3 for available codes)

Fiber Termination code:

(see table 4 for available codes)



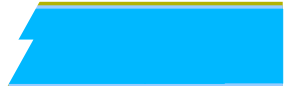
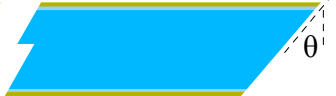
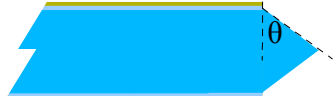
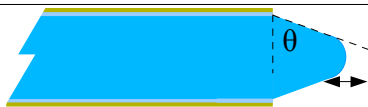

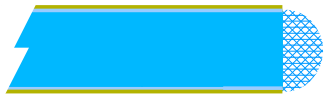
Example of cylindrical magnetic cannula

Table 3: Receptacle codes for mono fiber cannula

Termination code	Description
ZF1.25	Zirconia ferrule OD 1.25mm
MF1.25	Metal ferrule OD 1.25mm
ZF2.5	Zirconia ferrule OD 2.5mm
MF2.5	Metal ferrule OD 2.5mm
sma	Mini sma receptacle
RM3	Receptacle with M3 thread
CMR	Cylindrical Magnetic Receptacle
RMR	Rectangular Magnetic Receptacle

See receptacle section for details on mass and dimensions.

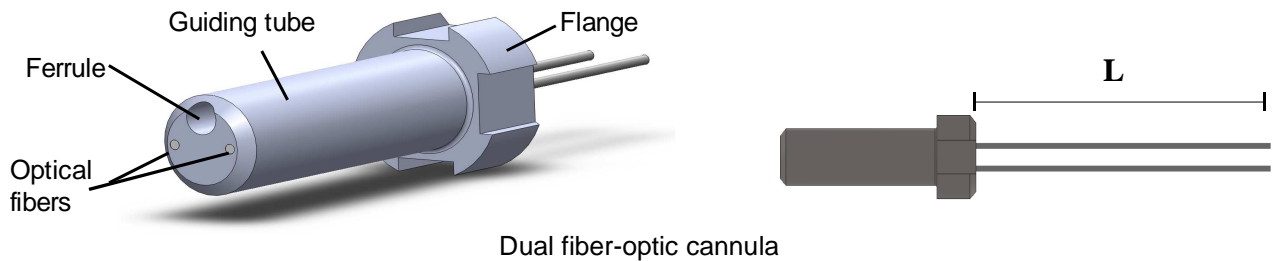
Table 4: Fiber-optic termination codes for mono fiber cannula

Termination code	Description	Drawing	Comments
FLT	Flat tip		
Axx	Angled tip		
Bxx	Bi prism tip		
Cxx	Conical tip		Rounded tip thickness: ~ 0.1x to 0.2x core diameter
Rxx	Round tip		Round tip thickness: ~ 0.5x core diameter
DFL	Diffuser layer		

Dual Fiber-optic Cannula

A dual fiber-optic cannula provides two implantable fibers at precise distance within single ferrule. The difference in length of each fiber protrusion is less than 0.1 mm. These cannulas are perfectly suited for the applications where two brain centers close to each other are simultaneously optically stimulated or controlled. The positioning of one mono fiber cannula at the time with the stereotaxic equipment has greater likelihood of 3D positioning errors (lateral and depth). Additionally, the diameter of the ferrules limits the minimum distance between the fiber tips. With dual fiber-optic cannula the insertion of the fiber is faster (single shot), the distance between the fiber tips is predefined and equal protrusion depth is assured. The cannula includes a guiding hole to insure precise alignment when connecting to a dual fiber-optic connector (equipped with a guiding pin). The dual fiber cannula can be made for any distance in 0.7 to 2 mm range. If larger distances between the brain centers need to be covered, please refer to *Two Ferrules Cannulas*.

Our dual fiber-optic cannula have a typical transmission higher than 75% for each fiber.



ORDERING CODE : DFC_□□□/□□□-□□□_□□□_□□□_□□□

Fiber core diameter (μm)

50, 62.5, 100, 200

Fiber buffer diameter (μm)

70, 125, 260

Numerical Aperture

0.22, 0.27, 0.37, 0.48

Length "L"(mm)

See convention on figure above

Receptacle code:

(see table 5 for available codes)

Fiber Termination code:

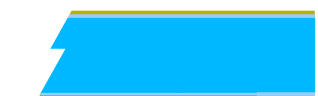
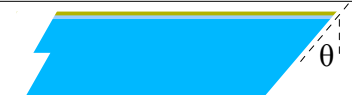




(see table 6 for available codes)

NOTE : Currently all dual fiber ferrules are made of Titanium.

Table 5: Receptacle codes for dual fiber cannula

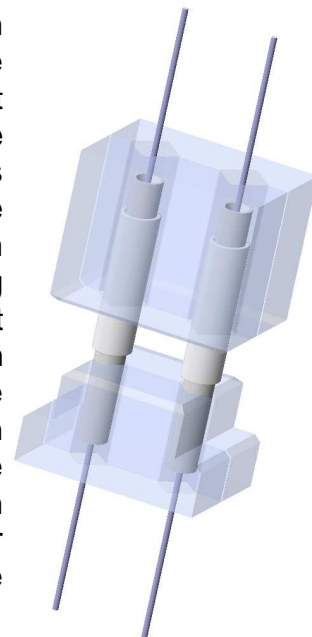
Receptacle code	Distance between the fibers (mm)
DF0.7	0,7
DF1.0	1.0mm
DF1.5	1.5mm
DF2.0	2.0mm
DFx	Select distance (x) in 0.7 mm – 2 mm range

Table 6: Fiber-optic termination codes for dual fiber cannula

Termination code	Description	Drawing	Comments
FLT	Flat tip		
Axx	Angled tip		
Bxx	Bi prism tip		
Cxx	Conical tip		Rounded tip thickness: ~ 0.1x to 0.2x core diameter
Rxx	Round tip		Round tip thickness: ~ 0.5x core diameter
DFL	Diffuser layer		

Two Ferrules Cannula

The two ferrules cannula provides two implantable fibers, each within its own ferrule, at precise distance exceeding 2 mm. The cannula consists of precision engineered sandwiched V-grooves that house zirconia ferrules and determine the spacing between the ferrules centers. The difference in length of each fiber protrusion is less than 0.1 mm. These cannulas are perfectly suited for the applications where two brain centers at distance larger than 2 mm from each other are optically stimulated or controlled. The positioning of one mono fiber cannula at the time with the stereotaxic equipment has greater likelihood of 3D positioning errors (lateral and depth). With two ferrules cannula the insertion of the fiber is faster (single shot), the distance between the fiber tips is predefined and equal protrusion depth is assured. This cannula is connected to matching dual ferrule connector or two individual ferrules with zirconia sleeves as shown on Drawing 2. The two ferrules cannula can be made for distances larger than 2 mm. For shorter distances between the brain centers, please refer to *Dual fiber-optic Cannulas*.



Drawing 2: Two ferrule cannula with connector

ORDERING CODE : TFC_□□□/□□□-□□□_□□□_□□□_□□□

Fiber core diameter (μm)

50, 62.5, 100, 200

Fiber buffer diameter (μm)

70, 125, 260

Numerical Aperture

0.22, 0.27, 0.37, 0.48

Length of fiber “L”(mm)

See convention on figure above

Receptacle code:

(see table 7 for available codes, use same code for patch cord termination)

Fiber Termination code:

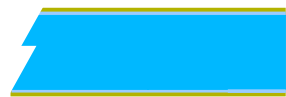
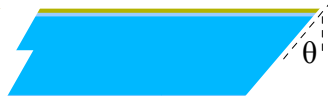
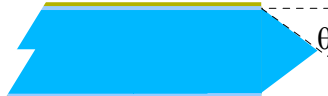
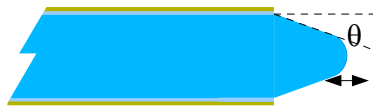
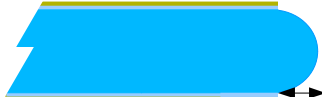
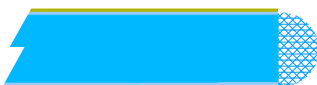
(see table 8 for available codes)

NOTE : Currently we use fused silica v-grooves and Zirconia ferrules.

Table 7: Termination codes for two ferrules cannula

Termination code	Center-to-center distance between ferrules (mm)	W(mm)xH(mm)
TF 3	3mm	5x4
TF4	4mm	6x4
TFx	Select center-to-center distance (x)	(x+2) x 4

Table 8: Fiber-optic termination codes for two ferrules cannula

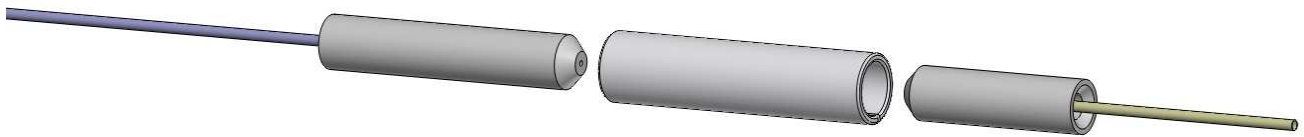
Termination code	Description	Drawing	Comments
FLT	Flat tip		
Axx	Angled tip		
Bxx	Bi prism tip		
Cxx	Conical tip		Rounded tip thickness: ~ 0.1x to 0.2x core diameter
Rxx	Round tip		Round tip thickness: ~ 0.5x core diameter
DFL	Diffuser layer		

Receptacles for optogenetics

Connecting a fiber-optic cannula and a fiber-optic patch cord requires matching the receptacle on the cannula side and connector on the patch cord end. The receptacle is the female part of the fiber-optic connection that contains centered fiber tip, guides connecting ferrule to the optical coupling positions and fastens it in place. In fiber optics, there are many different types of receptacles. However, here we show only those specific to our optogenetics products like Zirconia sleeve, mini sma, M3 and magnetic receptacles. Other receptacle types like SMA, FC/PC are too big to be used for fiber-optic cannulas.

Zirconia sleeve as receptacle

The simplest form of receptacle consists of an implantable fiber glued in a Zirconia or metal ferrule inserted in a Zirconia sleeve. The matching ferrule from the patch cord side is simply inserted in the sleeve.



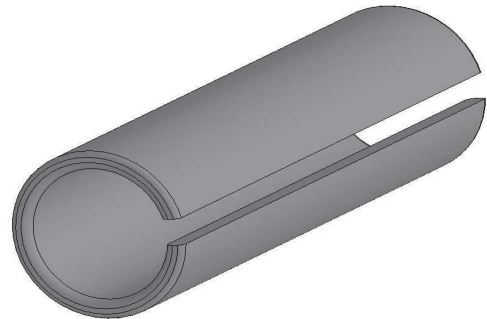
Connecting 1.25mm ferrules with Zirconia sleeve



Connecting dual ferrules with Zirconia sleeve

Two versions of Zirconia sleeve receptacles are available:

Inner diameter	Outer diameter	Length
1.25 mm	1.6 mm	6.8 mm
2.5 mm	3.2 mm	11.4 mm



Zirconia sleeve

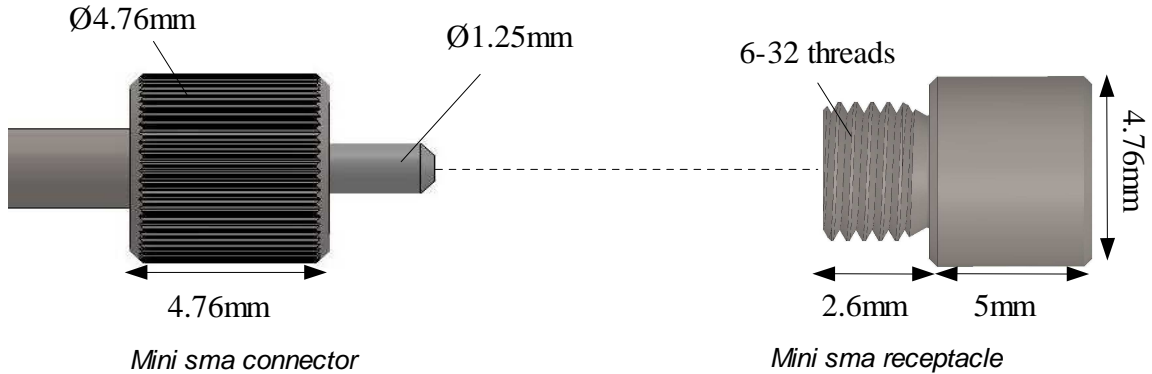
ORDERING CODE : SLEEVE_ZR_□□□

Inner diameter(mm) _____ ↑
1.25, 2.50

Mini sma receptacle

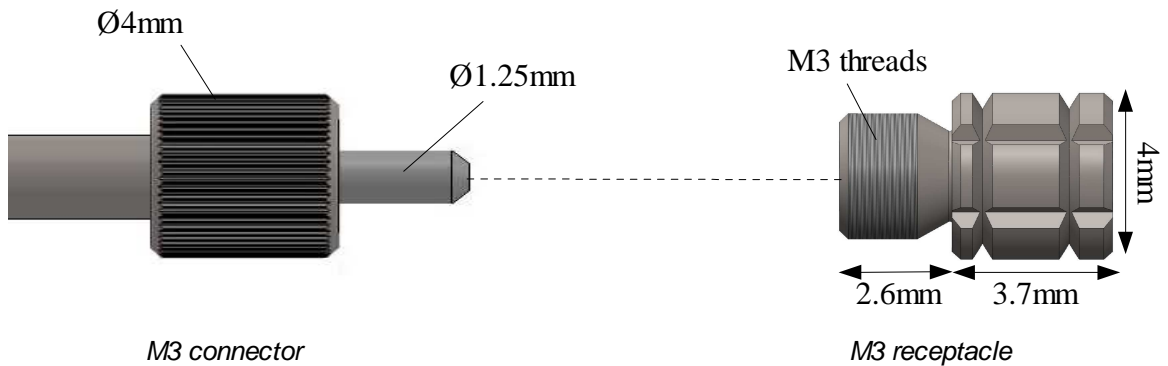
This type of receptacle is designed to secure the connection between the mono fiber-optic cannula and sma connector on the patch cord side using minimal practical size. The implantable fiber is glued in a mini sma receptacle, thus compatible with patch cord equipped with a mini sma connector.

We include a plastic cap to cover the mini sma receptacle when not connected to a cable.

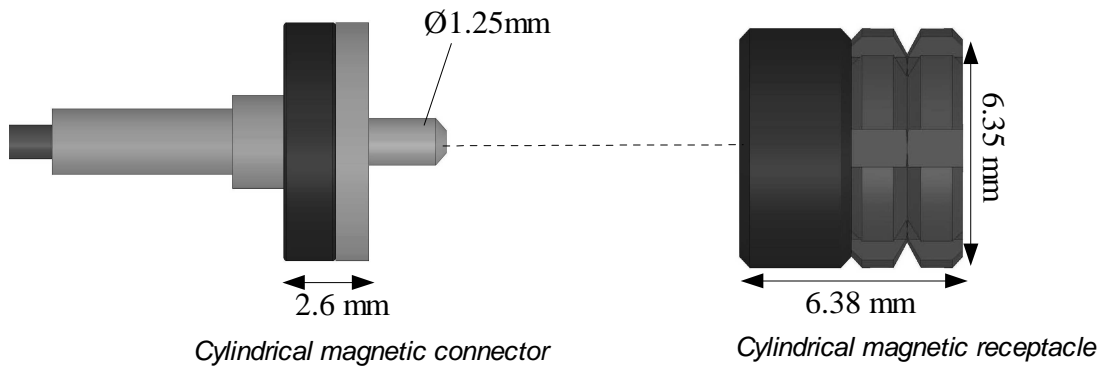


M3 receptacle

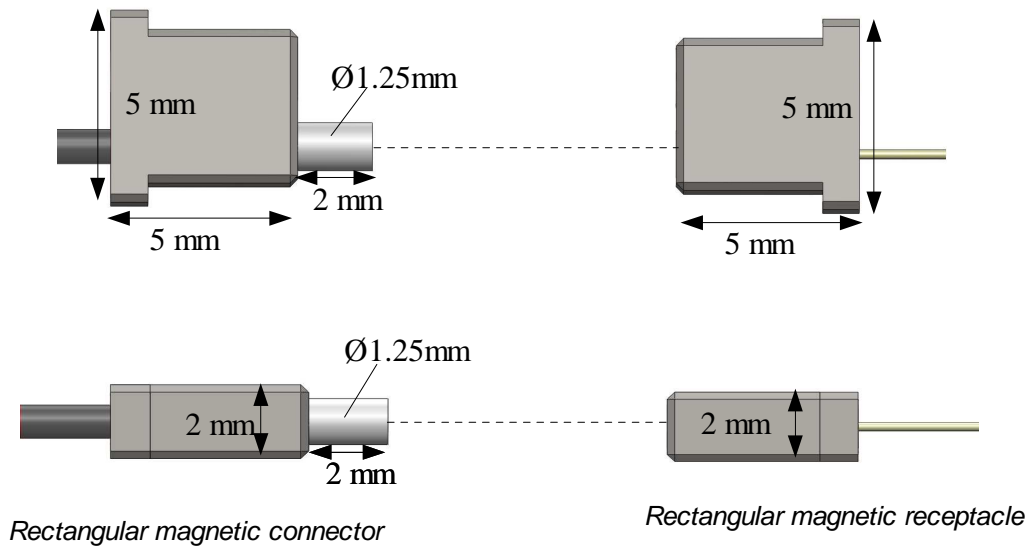
When our customers pressed for smaller receptor than mini sma, our engineers responded with M3 connector and receptacle.



Cylindrical Magnetic Receptacle



Rectangular Magnetic Receptacle



Fiber-optic cannula specifications

Part	Mass [g]	Max OD [mm]	Length [mm]
1.25mm ferrules			
Zirconia ferrule 1.25mm	0.05	1.25	6.5
Zirconia ferrule with MU flange	0.12	2.5	12
Metal ferrule 1.25mm	0.05	1.25	6.5
2.5mm ferrules			
Zirconia ferrule 2.5mm	0.35	2.5	10.5
Zirconia ferrule 2.5mm with FC flange	Not measured yet	4.5	16
Metal ferrule 2.5mm	0.40	2.5	10 or 12.5
Dual ferrule 2.5mm	Not measured yet	4.0	10 + 1.5 (pin)
Sleeves			
Zirconia sleeve ID=1.25mm	0.02	1.6	6
Zirconia sleeve ID=2.5mm	0.08	3.2	12
Mini sma connection			
Mini sma receptacle - titane	0.40	4.76	7.6
Mini sma receptacle - peek	0.10	4.76	7.6
Mini sma screw - titane	0.18	4.76	4.5
Mini sma screw - peek	0.05	4.76	4.5
Mini sma protective cap	0.05	4.76	5
Magnetic connection			
Magnetic receptacle	1.35	6.35	6.38
Magnetic connector	Not measured yet	6.35	12
Cannula assemblies			
1.25mm Zirconia ferrules (x2) + sleeve 1.25mm	0.12	1.6	13
1.25mm metal ferrules (x2) + sleeve 1.25mm	0.12	1.6	13
2.5mm Zirconia ferrule (x2) + sleeve 2.5mm	0.78	3.2	21
2.5mm metal ferrules (x2) + sleeve 2.5mm	0.88	3.2	21
Dual ferrule (x2) + sleeve 2.5mm		4.5	20
Mini sma receptacle + mini sma screw + Zirconia ferrule with MU flange - titane	0.7	4.76	15
Mini sma receptacle + mini sma screw + Zirconia ferrule with MU flange - peek	0.3	4.76	15
Magnetic receptacle + magnetic connector	Not measured yet	6.35	18.4