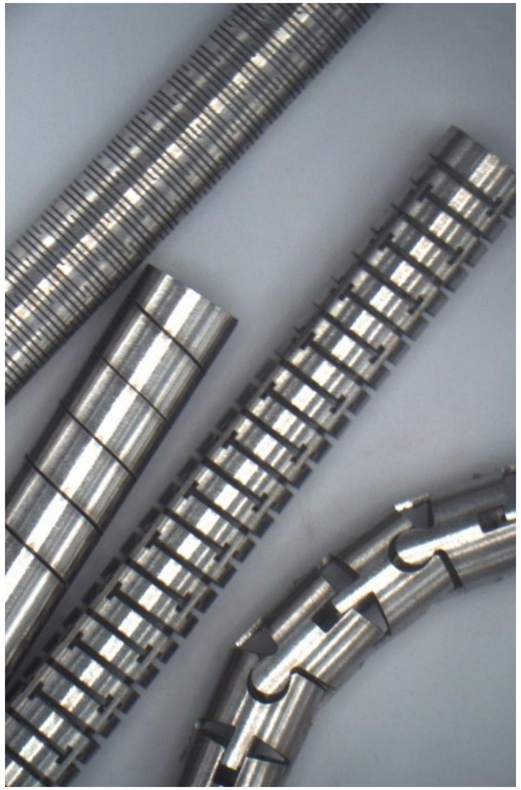
Blueacre TECHNOLOGY

Flexible Hypotubes

Flexible Tubes



As medicine advances, surgeons are always seeking to access further into the human body. Minimally invasive, or key-hole, surgery relies on the ability to reach different parts of the body, through small access points into the arteries.

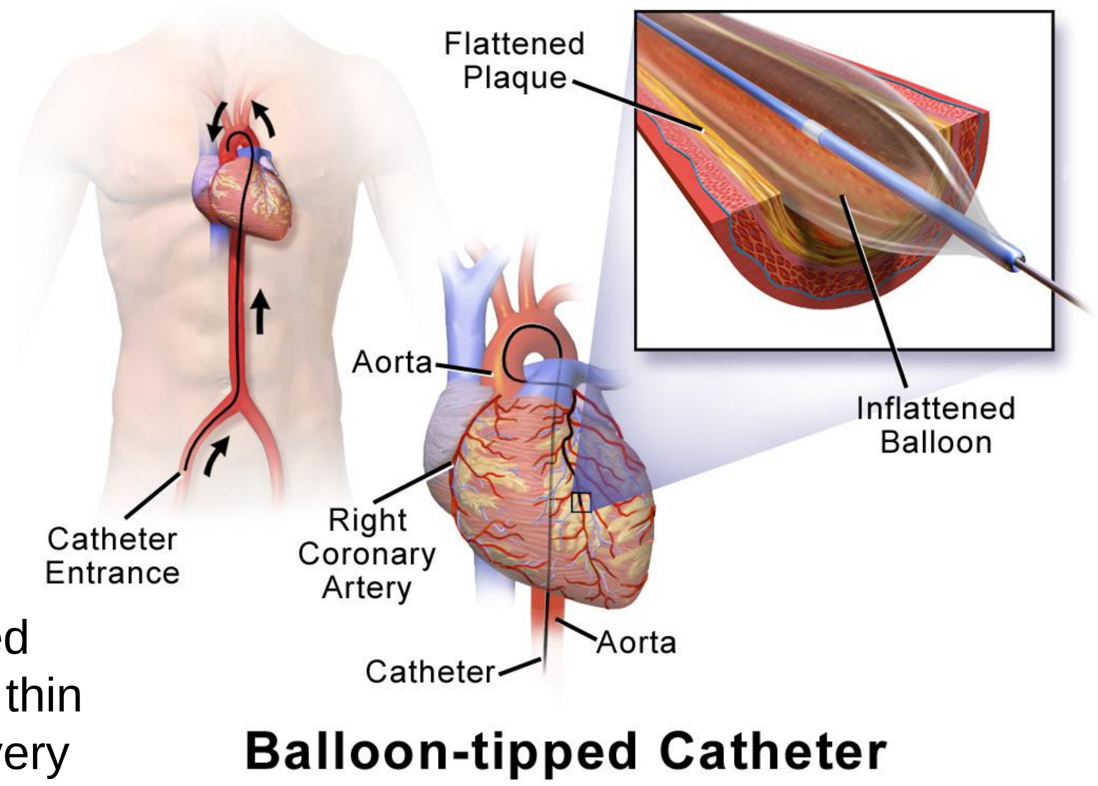
By creating these small incisions, it is possible to insert medical devices that can be used to carry out numerous procedures such as imaging, biopsy and device delivery.

However, to get to the correct place, it is necessary to navigate the arterial system, with its many bends and restricted access.

Gaining access, while not damaging the body, requires delivery devices that are flexible as well as steerable. The surgeon must be able to transmit the push and torque of their hand to the end of the device. To obtain this a wide range of engineering methods and designs have been developed that turn stiff metal tubes into flexible hypotubes and key to this is laser micromachining.

Getting There

To put it in perspective, the image on the right shows the route a surgeon must navigate to deliver and inflate a balloon for an angioplasty procedure. The catheter enters at the groin and has to make its way vertically, before turning 180 deg and steering to the correct location in the coronary artery.



To do this the device must have four attributes

1. Flexibility
2. Torquability
3. Pushability
4. Strength

In order to obtain strength the steerage devices are manufactured from stainless steel. However stainless steel is produced in long thin tubes, which although have torquability and pushability, are not very flexible.

The key to a good steerage device is flexibility.

Making Tubes Flexible

The easiest way to make a tube flexible is to cut it into a spiral and this remains a popular method. The images below, shows a spiral cut into a 3.4mm OD tube. The pitch of the spiral is 0.2mm, and was manufactured by rotating the tube under a laser beam.

This is a fast and effective process, that produces a very flexible delivery device. By altering the pitch of the spiral, different bend radius can be achieved, enabling the flexibility to be changed along the length.

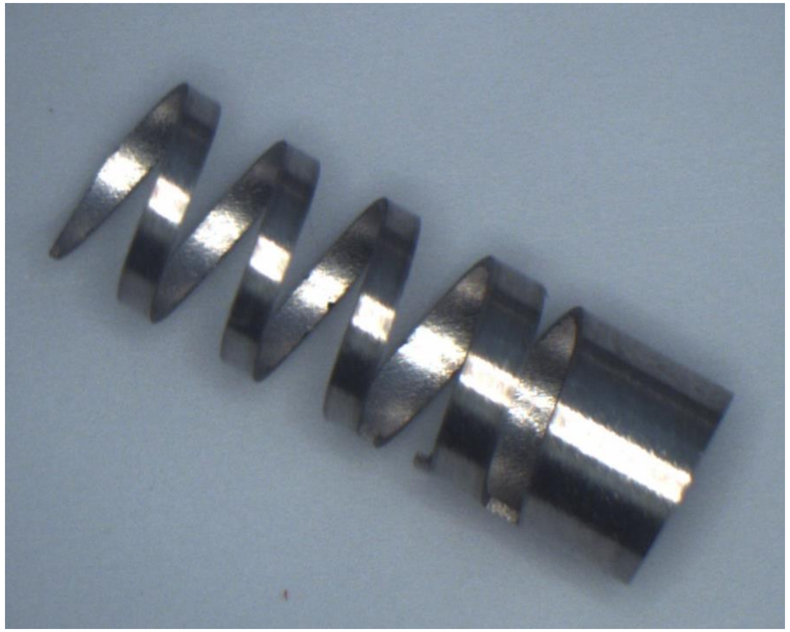
However, although flexible, a full spiral does not provide good torque. Twisting one end of the spiral does not have much effect on the other end, which means the spiral has poor Torquability.

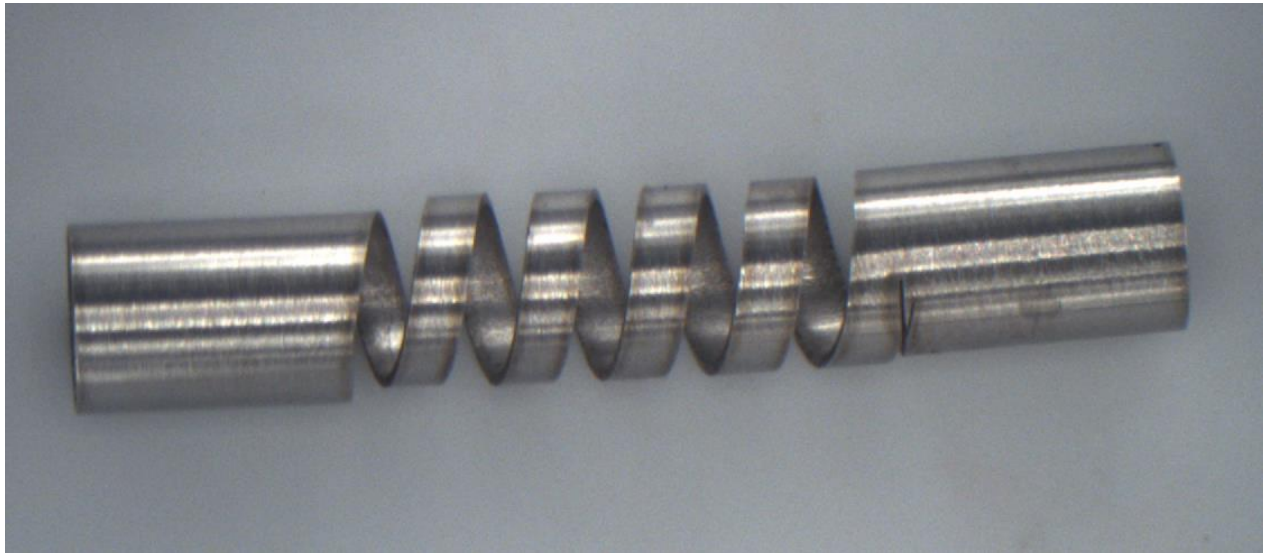
To combat this, the spiral can be broken, such that the cuts do not go round the circumference. This does not significantly reduce the flexibility but improves both the torquability and pushability.

Wider Spirals

In general the width of the cut in a spiral is the diameter of the laser beam at approximately 20um. By overlapping the cut lines, it is possible make spirals that have larger spaces between each spiral arm. Below are spirals with a 2mm distance bwetween the spiral arms.

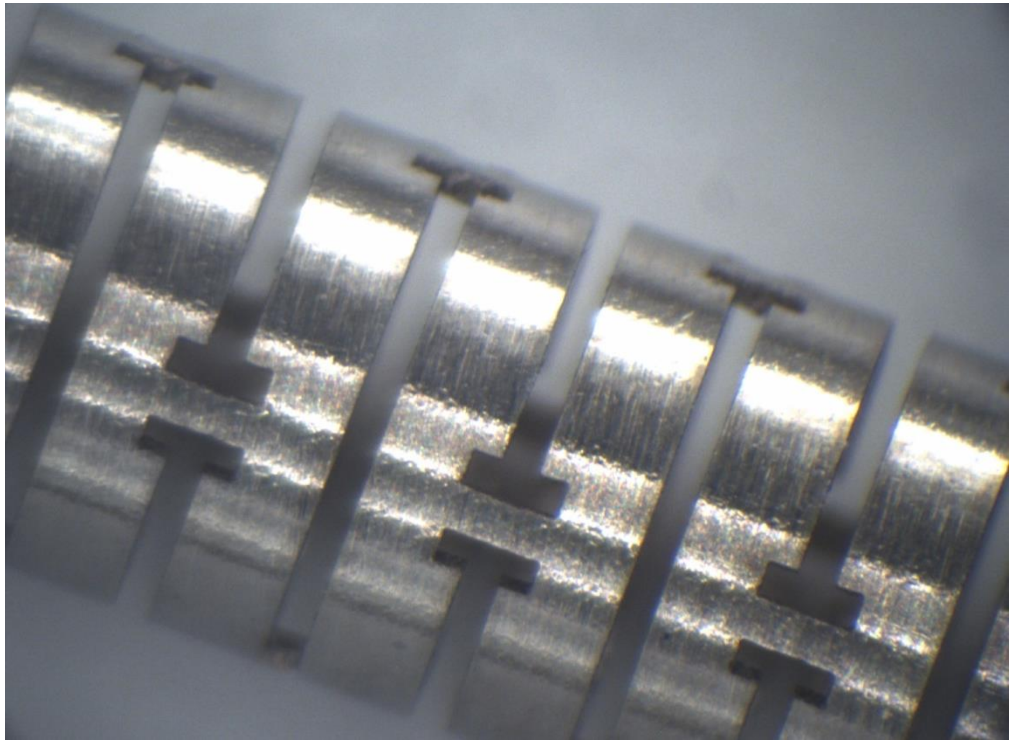
This creates a flexible device that is quite stiff but which can be compressed like a spring. Therefore they have good torquability but poor pushability.





Straight Lines

A different technique to creating a flexible devices is to use straight ‘I’ lines that run partially around the circumference. This creates a device, that has less flexibility than a pure spiral, but has better pushability and torquability.



The use of ‘I’ lines, allows the creation of devices that flex in one plane only. To get flexibility in multiple planes the straight lines are rotated around the device. In most applications a 90deg rotation is sufficient, however more can be added if required.

The downside to this ‘I’ design is that the stainless steel is prone to forming cracks under multiple flexes. Cracks occur at the tips of the ‘I’ lines, where the stress is highest.

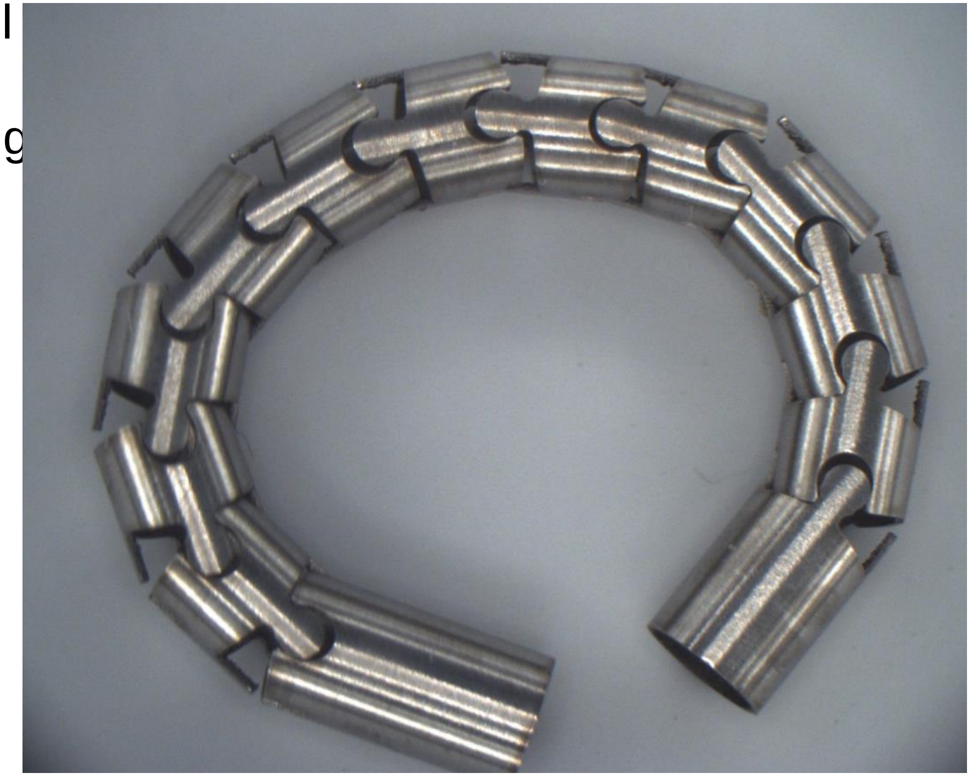
To combat the cracking and failure of the device, ‘ꕯ’ shaped cuts, as in the image on the left, are used to replace the simple ‘I’ shape.

This spreads out the load and produces a device that is longer lasting. The downside being in an increase the length of time to manufacture and hence cost of production

Jigsaw Cuts

Given the length of time that flexible tubes have been in use, it is not surprising that a number of complex and ingenious patterns have been developed.

One of the best designs is a jigsaw cut, where different sections of the tube are completely separate from each other. The sections are held together by a 2D socket and ball joint, which gives the device its inherent flexibility. As with straight line, it is possible to restrict movement to either a sing freedom.



The jigsaw cut is a very flexible system, with excellent torquability and pushability. Although best used with thick wall sections, to prevent the segments dislocating, it can be machined in thinner walls if care is taken.

There are a number of variations in the jigsaw with some designs using straight edges, rather than round. However they all rely on the same principle and require laser cutting to achieve the highest quality.

Manufacturing Hypotubes

Blueacre Technology can manufacture a wide range of hypotube designs for both simple and complex applications.

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