Changing the way ENT surgeries are performed

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EPFL - LIS laboratory - Dexterous Endoscopes

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Abstracts

Each year, several million surgical procedures are performed in the ear, nose, and throat (ENT) region. Due to the complexity of accessing these areas and the lack of suitable equipment, many procedures that could be minimally invasive are instead carried out as open surgeries. This approach makes operations longer and more complicated, increases the risk of complications, and results in higher costs for patients and the healthcare system. The objective of the start-up dexterous endoscope is to create a new type of ENTscopes using variable stiffness to provide a new solution.

Acknowledgments

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Finally, I would like to thank the CHUV surgeons for their warm welcome.

Contents

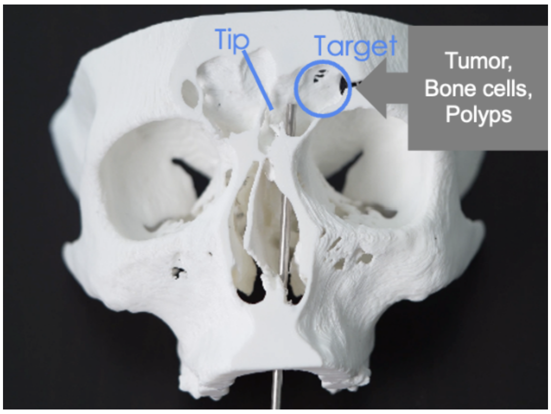
Introduction

Each year, several million surgical procedures are carried out in the field of otorhinolaryngology (ENT). These often involve the removal of benign or malignant tumors in the sinuses, the nasopharynx, or the larynx, as well as the excision of polyps on the vocal cords. The primary instrument used in such procedures is the endoscope. This medical optical device consists of a tube equipped with a camera, LEDs, and a working channel—a secondary tube, generally 2 to 4 mm in diameter, through which surgical instruments (such as forceps) can be introduced. However, these anatomical regions are particularly narrow and difficult to access. Specialists are therefore confronted with a major limitation: no endoscope currently available is truly adapted to their needs when performing endoscopic surgery in these areas. In the absence of appropriate equipment, surgeons are often compelled to perform open procedures. These operations are considerably longer and carry greater risks for patients. They may even require the simultaneous intervention of two surgeons. Consequently, such procedures cannot be performed on an outpatient basis, leading to extended recovery times for patients and higher costs for healthcare institutions. It is within this context that the start-up Dexterous Endoscopes was founded, with the aim of developing a new generation of endoscopes incorporating variable stiffness technology, specifically designed to meet the requirements of ENT specialists. During my internship, I contributed to the assembly of endoscopes, the development of a prototype endoscopic tower, and also gained experience with the administrative and business aspects of the start-up.

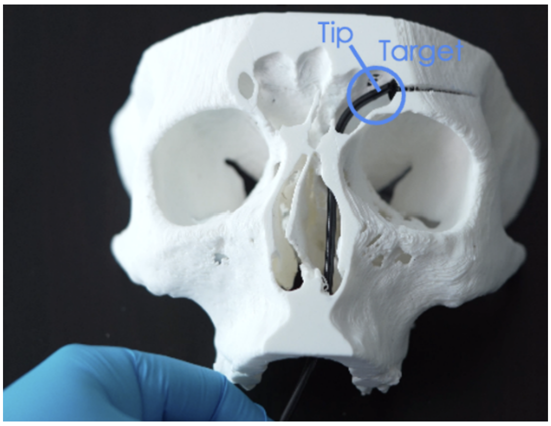
What can we find on the market ?

On the market, two main types of endoscopes can be distinguished. On the one hand, there are rigid endoscopes, which are essentially hollow metallic rods. This type of endoscope offers high stability and makes it possible to apply the necessary force during biopsies or surgical procedures. However, rigid endoscopes can only reach anatomical areas that are directly aligned with the operator's axis. Their limited field of action prevents them from accessing the regions of particular interest in ENT surgery. On the other hand, flexible endoscopes are composed of a supple tube. These devices allow easy access to remote and anatomically complex areas, making them well suited for diagnostic procedures aimed solely at visualizing and analyzing tissues. However, their flexibility also constitutes a major limitation. Once the endoscope has been positioned in the target area for tissue sampling or intervention, the application of force causes instability. The instrument bends and deviates from the intended location, making tissue sampling impossible.

(a) Rigid scope



(b) Rigid scope - surgical view



(c) Soft endoscope - surgical view

(d) Soft endoscope

Figure 1: Comparison of rigid and flexible endoscopes.

Objectives and Technical principle

To address this problem, the proposed solution lies in the use of variable stiffness technology. The objective is to design a flexible instrument capable of reaching remote areas, which can then be rigidified in the desired position, thereby allowing tissue sampling or surgical intervention to be performed effectively.

To achieve this, the concept involves using multiple fibers bundled together within a single tube. Under normal conditions, the fibers are flexible, allowing the endoscope to bend and navigate confined anatomical spaces. When rigidity is required, a pump connected to the endoscope evacuates the air from the tube. This causes the fibers to be pressed closely against each other, increasing the friction between them and thereby enhancing the overall stiffness of the device. This variable-stiffness mechanism enables the endoscope to combine the flexibility needed for navigation with the stability required for precise surgical manipulation or tissue sampling.

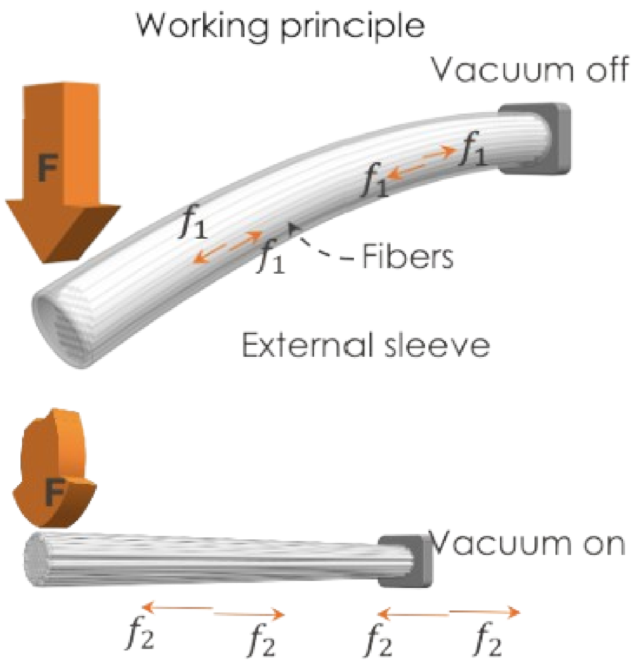


Figure 2: Working principle of the variable stiffness mechanism.

The endoscopic tower

Although the endoscope itself is the central focus of the start-up's work, another aspect is equally fundamental: the endoscopic tower. This system represents the direct and essential link between the endoscope and what the surgeon observes and analyzes.

An endoscopic tower may take the form of a simple monitor displaying the live video feed from the camera, but it can also be a far more advanced system costing several hundred thousand dollars. Such systems may include multiple modules, for example machine learning models designed to assist the surgeon in analyzing what is observed during the procedure (e.g., detecting tumors or polyps), real-time image and color processing to enhance contrast and better identify abnormal structures, a user-friendly interface to improve the operator's experience, as well as integrated patient data management and secured archiving solutions.

What can we find on the market ? (Endoscopic Towers)

There is a wide variety of endoscopic towers available on the market, but this component is crucial to consider, as towers are often not cross-compatible: each company generally develops endoscopic towers that function exclusively with their own endoscopes. Developing a dedicated endoscopic tower therefore becomes a necessity. On the market, companies have taken very different approaches. Some, such as Olympus, design highly sophisticated and comprehensive towers, equipped with numerous modules, but which are also bulky and very expensive. Others, such as Ambu, focus instead on simpler yet user-friendly interfaces and highly portable systems (no larger than a tablet), which are modular and adaptable to both simple consultations under local anesthesia and far more complex procedures.

(a) Ambu tower

(b) Olympus tower

Figure 3: Examples of commercially available endoscopic towers.

Designing and prototyping the endoscopic tower

Since the start-up had not yet begun to focus on the development of an endoscopic tower, the idea was for me to design and build a first prototype during the summer. The initial step consisted in studying the existing solutions available on the market and identifying the components and functionalities that appeared essential for a first version of such a tower. A number of scientific papers also address this topic, particularly regarding the integration of AI-based assistance for surgeons within endoscopic towers—a subject that is currently at the heart of ongoing discussions. While such features already exist in the field of digestive endoscopy, no equivalent solution is currently available for ENT.

We therefore decided to begin by creating a relatively simple tower—lightweight, compact, and highly user-friendly—but also modular, allowing for display on a larger screen and leaving open the possibility of later integrating additional modules to increase complexity and functionalities. Once the core functionalities were defined, we developed a software environment providing a customizable interface for the surgeon (e.g., user login, language settings, brightness adjustments, full-screen endoscopic camera feed). The basic features included real-time photo and video capture from the endoscope camera feed. Buttons integrated into the endoscope and connected to the interface also allowed the surgeon to trigger photo capture and immediately view the images within the system. We further implemented the possibility for the surgeon to record audio notes during the procedure, as well as to store and review all data collected during surgery in a personal patient file. This file could then be transferred to the hospital network to ensure simplified patient follow-up.

Figure 4: Software interface prototype.

The second step involved designing and constructing the hardware. For now, the architecture is relatively simple, consisting of a Raspberry Pi 5 connected via a dedicated module to the camera, which is in turn linked to the endoscope. We then designed and 3D-printed several components to create a casing for the interface, aiming for a modular structure adaptable to different clinical situations. To achieve this, we included interchangeable parts that allow the interface to be tilted and placed on a table or mounted directly onto an existing endoscopic tower, making our interface flexible and suitable for a variety of applications.

(a) Casing Assembly

(b) Raspberry Pi (Main component)

Figure 5: Hardware components and assembly of the endoscopic tower prototype.

Cadaver trials

To test the endoscope under optimal conditions and obtain the most constructive feedback from the professionals who will ultimately use these technologies, the start-up works in close collaboration with the Lausanne University Hospital (CHUV). Regular trials are conducted on cadavers in the presence of ENT endoscopists and surgeons. I had the opportunity to attend two of these sessions in August and September. These progress checkpoints provide a unique opportunity to test both the endoscope and the endoscopic tower intensively under realistic conditions, and to collect valuable feedback on what works, what does not, and which features surgeons would like to see implemented. This process is essential to ensure that the final product aligns as closely as possible with their expectations and clinical needs.

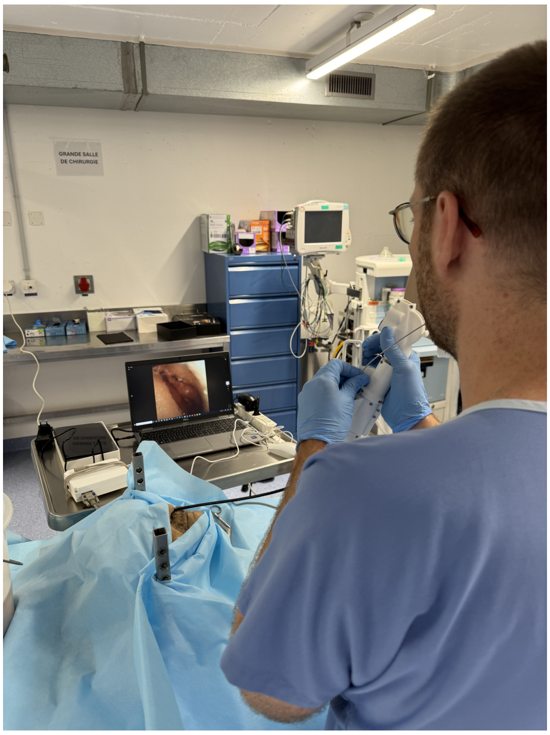


Figure 6: Cadaver trials at CHUV.

Next Goals

For the start-up, the objective is to continue developing their products (both the endoscope and the endoscopic tower), to keep testing them, and to increase awareness of their technology. In the longer term, the goal is to obtain the necessary regulatory approvals to commercialize the products and contribute to the advancement of ENT surgical procedures in the future.

On my side, I will continue working with the start-up to assist with the manufacturing process and further develop the endoscopic tower. Now that the basic functionalities of the tower are operational, the next objectives are to enhance it by developing a machine learning model to assist surgeons in tumor detection, and to implement real-time image processing to adjust colors and contrast. Finally, another goal is to create a 3D map from the videos captured by the endoscope, which will allow surgeons to more easily analyze what was observed during the procedure and also serve as a reference for patient follow-up, enabling them to assess the patient's previous condition in future operations.

Conclusion

In conclusion, this internship has been an extraordinary experience. Being particularly interested in the start-up environment, it was incredible to be fully immersed in this world and to gain insight into all the mechanisms behind setting up and running a start-up. I am very pleased to have had the opportunity to engage with many different aspects of start-up life and happy to have contributed, in my own way, to the development of the product by starting to work on the interface. It was fantastic to feel truly included and to have the chance to share my ideas. Finally, I am delighted to continue working with the team and to watch the start-up grow.