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Wormscope: A New Generation of Small Automated Endoscope: Why it can be Gamechanger?

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1. Abstract

The traditional endoscope has many risks and disadvantages including pain, risk of anesthesia, looping, trauma to the lumen with bleeding, and perforation. In addition, it cannot reach beyond the second part of duodenum as well as it is sometimes difficult to guide. Aim of this study is to design a device of endoscopy which is easy to control and free from the above problems. Worm scope is a small size endoscope (about the size of human finger) that moves automatically in peristaltic movement like worms which is controlled by joystick. It can examine the entire gastrointestinal tract. Therefore, it can replace Esophago-gastro-duodenoscope (EGD), colonoscope, enteroscope and wireless capsule.

2. History of Endoscope

The advancement of technology especially in the last century made many things around us easier, smaller in size, and more efficient. Hence, everything can undergo change and development including the traditional endoscopes.

In 1868, Kussmaul attempted to observe the inside of the stomach with a rigid straight tube, achieving no successful results. Around this time, it was discovered that bright light is gained by sending electricity to a platinum wire. After that, many different types of rigid gastroscopes were, developed with this newly discovered system as the light source. In 1932, Schindler developed a flexible gastroscope with a bending function at the tip. Several experiments were also conducted to make a diagnosis by photographs taken with a miniature camera inserted in the stomach.

In 1950, completely separately from Lange's experiment, Uji et al. developed the gastrocamera. Although Uji's gastrocamera could not withstand practical use either, Tasaka's group at the First Department of Internal Medicine, Faculty of Medicine, University of Tokyo, had started clinical experiments with the gastrocamera in 1953 and added various improvements to make it a truly practical medical device. In 1957, Hirschowitz made a fiberscope. Based on this technology, the gastrocamera equipped with a fiberscope was developed and disseminated widely throughout Japan. As the technology of fiberscopes advanced, endoscopes for colon, esophagus, and duodenum were developed as well [1].

3. Risks and Disadvantages of Traditional Endoscope

The usual endoscope is a good instrument for diagnosis and management of many gastrointestinal diseases, but unfortunately it has many risks and disadvantages including pain, risk of anesthesia, looping (especially with colonoscope), trauma to the lumen with bleeding, and perforation. In addition, it cannot reach beyond the second part of duodenum as well as it is sometimes difficult to guide[2,3,4].

Aim of this study is to design a device of endoscopy which is easy to control and free from the above problems of the usual endoscope. Therefore, this idea does not involve development of the existing endoscope, but rather to invent a new generation of modern endoscopes that are not present before. It is really a new era for endoscopy.

4. Wormscope Definition

Wormscope is a small size endoscope (about the size of human finger) that moves automatically in peristaltic movement like earthworm or silkworm (hence the nomenclature wormscope) which is controlled by joystick (or remote control) (Figure-1). Wormscope can ex-

amine the entire gastrointestinal tract, from mouth to anus including areas that cannot be reached by the usual endoscope which extend from the second part of duodenum to distal ileum. Therefore it can replace Esophago-gastroduodenoscope (EGD) and Colonoscope as well as enteroscope and wireless capsule. It is worth mentioning that this product does not require change in the whole system of the endoscopy unit, but rather to modulate it to be suitable with this new device "WORMSCOPE", for example the monitor will be the same in both systems.

5. Structure and Composition

Wormscope consists of many circles or rings that connected together by movable joints to facilitate its movement. It is supplied with stiff hair around each ring to enhance its movement. The hair are directed backward at 45^0 angle with the body of device (Figure-2). The length of device is about 8 cm and outer diameter is about 10 mm (with the surrounding hair in shrinkage situation). This is the dimensions of adult wormscope, the size of pediatric wormscope should be less. In front of devise, there are lens for camera, hole of channel, and two light sources. The distal half of device is movable in all directions (up, down, right, and left), while the unmovable proximal half contains an electronic chip which receives orders from joystick and send information to the processor. It also contains strong and durable battery that should be charged by wireless charger (like the new chargers of mobile phones).

5.1. Connecting Tube: It is a plastic transparent thin tube, outer diameter about 3-4 mm. It connects the device to junction piece. It should be stiff (to prevent kinking), has smooth surface, and graded in centimeters. It has variable length (according to its use).

5.2. Junction Piece: It is a plastic body contains grooves that connect the connecting tube to other tubes which provide important functions to device including air push, water push, and suction. Each tube has its own valve in front of it which is only open when in use while the two other valves are closed automatically. It also contains a port for instrumentation such as biopsy, snaring ...etc. (Figure-3).

5.3. Joystick: It is a remote control of the device similar to that of video game. The right side contains 4 buttons, the larger for forward direction, the others are for air push, water push, and suction. The left side contains 4 buttons for directions of device (upward, downward, right, and left). In the center, there is 3 way switch which controls the situations of wormscope, when in neutral position, the device is in peristaltic situation (i.e. the hair at 45^0 angle), in upward position, the device is in erection situation (i.e. the hair at 90^0 angle), in downward position, the device is in shrinkage situation (i.e. the hair at 0^0 angle).

The erection and shrinkage situations should be highlighted on the joystick to remind the operator about the status of device inside the body. On each side of joystick, there is also a button for taking pictures and the other for narrow band imaging (NBI) mode. Joystick is connected to the processor via a wire or can be wireless (Figure-4).

6. How it works?

Wormscope moves in forward direction via rings in sequential pattern like worms and enhanced by hair around it. It is controlled by joystick and can be directed in all directions easily. When it is inserted through the mouth or anus, as well as during withdrawal, it must be in shrinkage situation which makes the device at least diameter. This situation also will help its passage through narrow lumens and strictures. After insertion of the device inside body, its advancement should be facilitated by continuous insertion of the connecting tube through the mouth or anus by an assistant because this will decrease the work of pulling the connecting tube by the device. The endoscopist should not do the insertion of connecting tube because he will be busy with control of device by joystick. When use wormscope to examine the upper gastrointestinal tract, choose connecting tube with 2 meters length when there is desire to examine the esophagus, stomach and proximal duodenum, while when the desire is to examine the jejunum and ileum as well choose connecting tube with 5 meters length, but when it is found to be not long enough to reach the terminal ileum (because there is variation in bowel length among people), it can be elongated by another tube (of 2 meters length) which is inserted between the first tube and junction piece. It is imperative when using connecting tube with 5 meters length is to use instruments with length more than 5 meters. The peristaltic movement of the small intestine will aid in propulsion of device which can be augmented with cholinergic agents such as Bethanicol or Neostigmine. It is not recommended to examine the colon from upper direction (i.e. through ileocecal valve) because this will be too lengthy, may cause injury to the ileocecal valve during withdrawal, and also leads to contamination of small bowel by contact of the devise with large bowel mucosa after withdrawal. Therefore, when use worm scope to examine the colon, use the same device from below (i.e. through anus) and choose connecting tube with 2 meters length only. The connecting tube should be tightly connected to the device to prevent its dislodgment inside the body during withdrawal of device. However, even after dislodgment of tube, the device can be driven by joystick to the end of gut till anus where it can be extracted by various methods. The hind part of worm scope should be conical in shape with no sharp edges to prevent its impingement with lumen during withdrawal, also the hair alignment during shrinkage should not exceed the first ring of device for the same reason. The hair around each ring should be distributed in contrast to the rings above and below because this will give more effective movement, in addition, during shrinkage situation, each hair will lie in the space between the hair below which decreases the diameter of device. The angulation of the distal part of device should not exceed $90^0 - 100^0$ angle at all directions. It is worth to mention that there is no need for retroflexion of device up to 180^0 angle because the device can turn back as a whole to see the structures behind and also extreme retroflexion may corrupt the device due to presence of hair. The erection situation will help in fixation or anchoring of the device during in-

strumentation and intervention procedures e.g. biopsy taking, injection, snaring of polyp ...etc. The hair end should be blunted and not sharp in order not to injure the mucosa during erection situation or peristaltic movement. For washing the lens of camera, the operator can direct the device against wall of lumen and push water, the back flow of water will clean the dirt on lens. In some areas of gut with wide space such as stomach, it may be difficult for device to climb against gravity over the body and antrum of stomach to reach the pylorus, this can be overcome by reposition of patient to make the desired area (like pylorus) downward, so the device can move easily with the gravity. It is recommended that when seeing the fundus and gastroesophageal junction is to be done at the end of procedure just before withdrawal of device from stomach because if done at the beginning of procedure it may make a knot in the connecting tube when the device driven backward to see the structures behind then advanced foreword toward the pylorus.

Please follow this link to download the video of animation:

https://www.dropbox.com/scl/fi/76fq4wf08oxwb4wqa0kqh/WORMSCOPEanimation.mp4?rlkey=ppg9lcbyq4d8rzenob3tyd8dq&st=hnvjnqwl&dl=0.

7. Advantages of Wormscope

1.Easy control, the nightmare of some endoscopy (especially colonoscopy) will change into video game. In addition, it is not need along time of training.

2.Better visualization of lumen of gastrointestinal tract because it can be directed to all directions easily.

3.It is more comfortable for the patient because it is not need a special position during the procedure. It is also comfortable for the endoscopist who can work while sitting.

4.Unlike usual endoscope, it causes less pain to patient, thus it can be used without analgesia or anesthesia (except for children).

5.It is safe, it can overcome most of problems of the usual endoscope such as looping, trauma, bleeding, and perforation.

6.Easier cleaning and disinfection because the device is small in size, in addition the connecting tube is transparent which allow better visualization of debris and sites of clogging.

7.It can examine the whole gastrointestinal tract; therefore, it can replace EGD and colonoscope as well as enteroscope and wireless capsule. In addition, it may dispense some other expensive and sophisticated investigations such as magnetic resonant enterogram (MRE), CT enterograghy, Meckel's scan ...etc.

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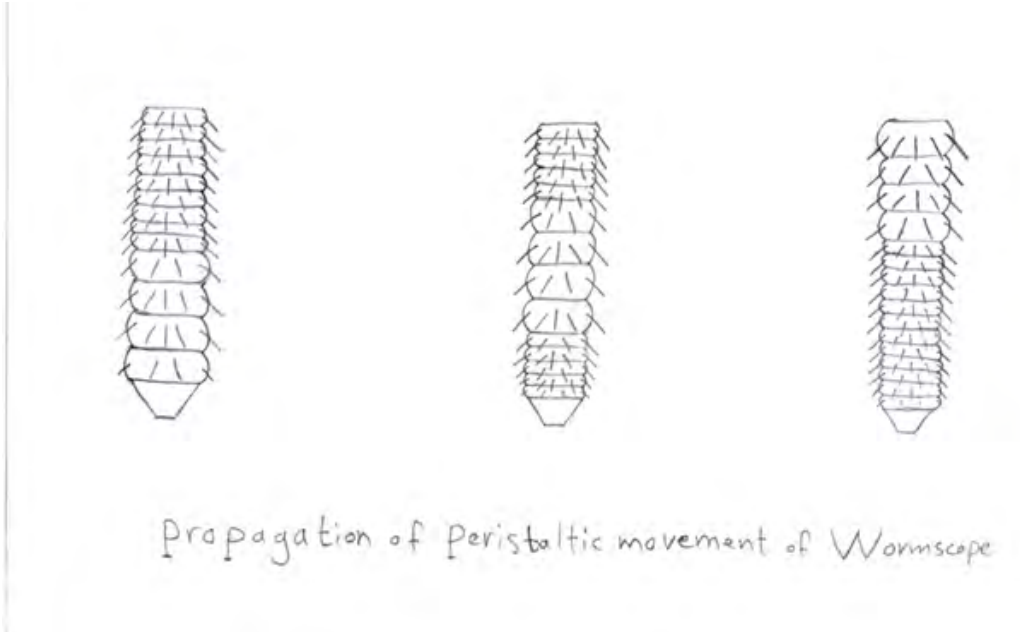

Figure-1

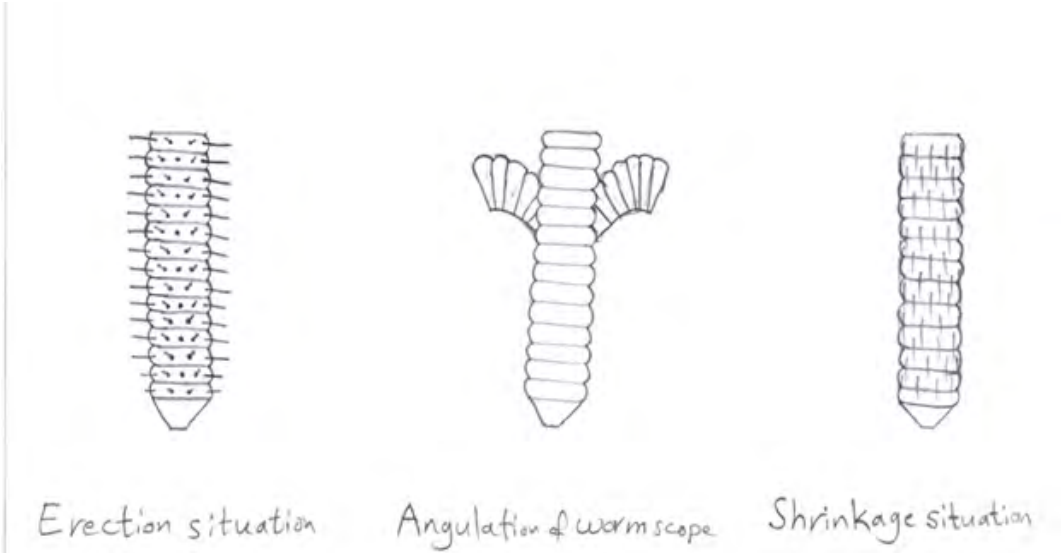

Figure-2

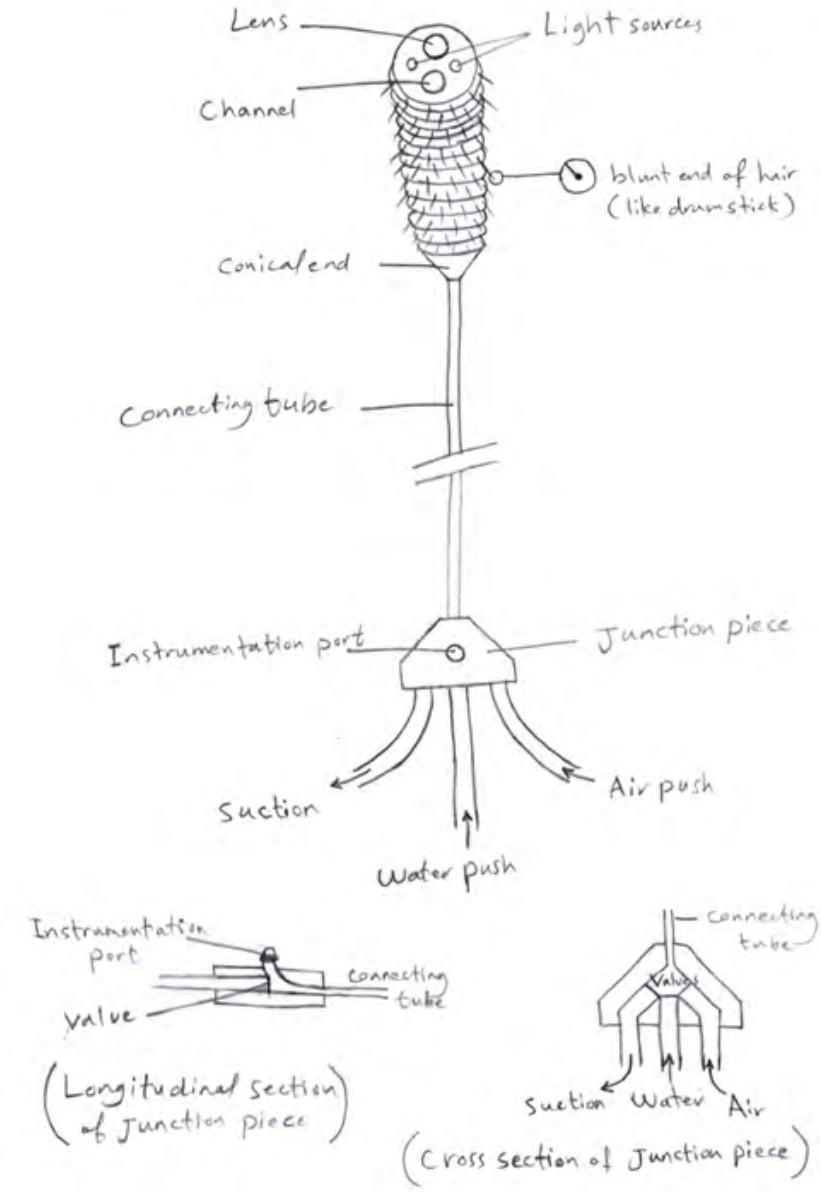

Figure-3

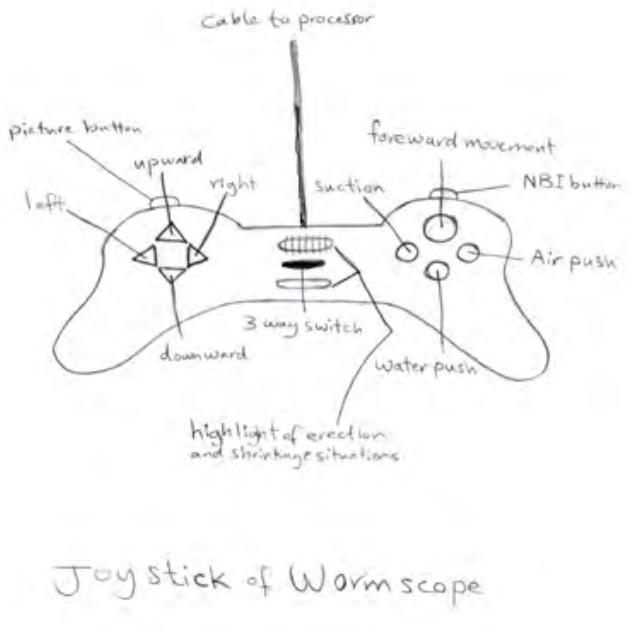

Figure-4

Simple Model of Wormscope