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A review of mechanism used in laparoscopic surgical instruments

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ABSTRACT: ***Many surgical tools are made out of common mechanical components including gears, linkages, pivots, sliders, and other similar items. This article provides a reference table that was developed by comparing and contrasting the mechanical characteristics of 16 patented laparoscopic surgical procedures.The majority of the devices are surgical staplers . For this, laparoscopic surgical tools were selected.Because of the intricate mechanical systems needed to execute their tasks, paper is utilized. For the purpose of Despite the fact that stapling and kinematic maneuvering have comparable tasks, each device studied has a broad range of characteristics. The kind of mechanical components utilized, as well as the design. Engineers will benefit from the reference table that has been prepared. designers, and students in evaluating and suggesting improvements to the mechanical subsystems utilized in surgical equipment. Existing designs may be replaced with other designs. Despite the fact that the table was designed for laparoscopic surgery, its applicability may be broadened to include additional surgical and non-surgical devices.***

KEYWORDS: ***Mechanical Device, Mechanism, Laprascopic Surgery, Surgical Staplers***

1. INTRODUCTION

A mechanism is a mechanical device made up of a series of interconnected links linked by joints in such a manner that the links may move in a regulated relative motion. Many laparoscopic tools are very complicated, having many mechanical components that interact with one another (these devices are getting more sophisticated in order to accomplish more output functions with a single input action). Complexity in mechanism assembly raises production costs due to the increased number of components and time spent finding a suitable solution create (often through trial and error) [1]. As a result, designing the majority of mechanics in a laparoscopic surgical stapler, as well as other medical equipment, may be challenging.

The purpose of this article is to offer surgical device designers with a new approach for developing the internal mechanical systems that are needed to perform particular tasks. To construct a comparison table, the various kinds of mechanical components or joints required to execute a particular function were gathered from sixteen patents. Flexible links, small pulleys, and cable, for example, are possibilities if a laparoscopic stapler must be capable of moving to the left or right to reach a specific area[2]. This article will allow designers to evaluate the choices accessible to them while solving a specific design issue, allowing them to arrive at an optimum solution in less time.

Description of laprascopic surgery

Traditionally, abdominal operations have required a wide incision of 12–24 inches. This extensive dissection was required to provide the surgeon with a viewing field in which to do the surgery. However, this technique had a major role in the patients' delayed recovery [3]. Surgical advancements have resulted in the development of new methods and surgical equipment that may alleviate the excruciating pain associated with big wounds [4]. Patients may return to their regular activities in a shorter amount of time thanks to minimally invasive surgical methods that decrease incision size and hospital stay. New technologies enable surgeons to conduct a wide range of procedures without the stress and suffering associated with previous methods [5].

Laparoscopic surgery is an abdominal surgical method in which only tiny incisions, approximately 5–12 mm in diameter, are used. Rather of looking directly at the organ being treated, the physician watches the operation using a laparoscope, which is an unique video camera system. Other tools are handled via other incision sites while it is introduced through one of the tiny perforated holes[6]. Unlike ‘‘open" surgery, when surgeons physically handle and palpate (touch) the tissue or organ during the process, laparoscopy uses a laparoscopic tool designed to fit inside the body via guides called trocars, which enter through the tiny incision made. A laparoscopic operation is shown in Figure 1. The goal of the design is to convert the surgeon's hand movement via a long, small-diameter trocar into one or more output functions at the distal tip within the human cavity.

As more surgical operations are done through laparoscopy or endoscopy, and as patients and doctors recognize the benefits of the less invasive method, more innovative surgical tools are required.[7] As the need for improved instruments grows, a trustworthy design process and set of analytical tools for developing new or modifying current instruments are required.

Comparison table

Input, intermediary mechanisms, outputs, design, and activation are the five categories in Table 1 that describe characteristics of the mechanical system of a laparoscopic surgical tool. Each of these categories denotes a critical component of the instrument that will allow it to perform its purpose (s). The manner of activating the instrument is represented by the input heading, which is split into self-contained power and manual[8]. Manual refers to the surgeon's hands (one or both) as the source of power, while self-contained defines an instrument as having its own source of energy to operate the device. In none of the 16 surgical staplers studied, the inputs and outputs are directly linked (Figure 1).

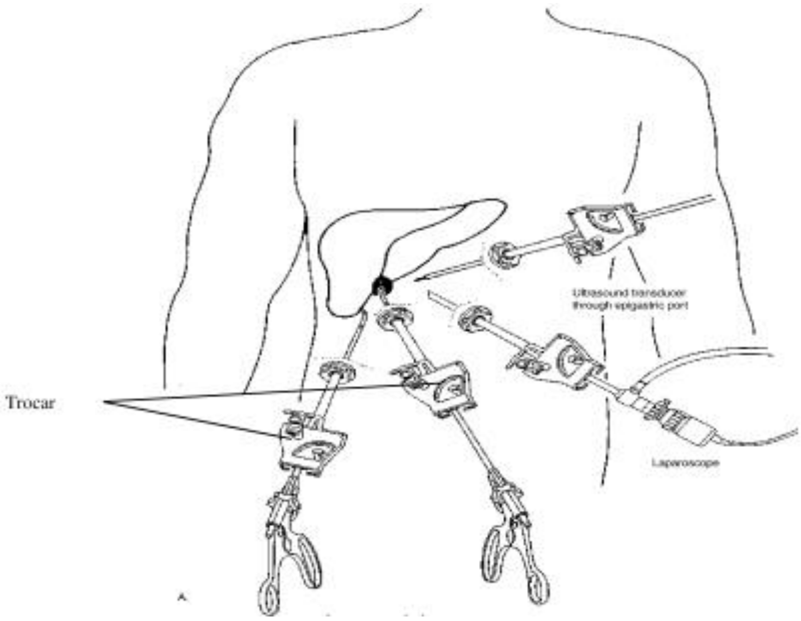

Figure 1: Laparoscopic Surgery with Their Instruments and Procedure.

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The mechanisms inside the handle assembly of the surgical stapler illustrated in Fig. 2 are all components of the intermediate mechanism. By accepting the input action and turning it into usable output function, intermediate mechanisms represent all the mechanical components (e.g. gear rack, ratcheting pawl, and actuation shaft of Fig. 3) needed for the surgical stapler to operate (s). The actuation handle provides the input, which is transferred to the gear rack (42 of Fig. 3) through the ratcheting pawl (44) and subsequently to the actuation shaft (64) before the disposable loading unit may execute the required output functions of clamping, ejecting staples, and cutting. If a sick portion of an organ has to be removed during a laparoscopic procedure, this tool is utilized [9]. As a blade will concurrently attach parallel rows of staples to the tissue on one end of the organ, the device is used to stop bleeding by adding parallel rows of staples to the tissue on the other end of the organ (Table 1).

Table 1: Comparison Table for designing laparoscopic surgical stapler.

Input	Self contained power		Manual	
	Electric motor (Fig. 4)	Pneumatic (Fig. 5)	Rotational (Fig. 6)	Sliding (Fig. 7)
Intermediate mechanisms	Gear trains (Fig. 4)	Gas cylinders (Fig. 5), drive piston, mechanical slide, linkage	Rack and pinion (Fig. 12), springs, rachet, mechanical slide	Linkages (Fig. 15), springs
Output				
Rotate (Fig. 8)	Rotatable collar (Fig. 8)	Rotatable collar	Rotatable collar	Rotatable collar
Yaw (Fig. 8)	None	Pulley, cables and linkage	Flexible links (push/pull), cables/belts, pulleys	Flexible links (Fig. 11), cables/belts, pulleys, spine segment (Fig. 13)
Clamping (Fig. 9)	Lead screw (Fig. 14), sliders	Linkage and cables (Fig. 17)	Mechanical slide (Fig. 14), cam, pulley (Fig. 18), belt/cable, linkage, springs	Mechanical slide, cam (Fig. 16), springs
Eject staples (Fig. 9)		Flexible slide	Mechanical slide, cam, pulley, belt/cable, linkage, springs	Mechanical slide, cam, springs
Cutting (Fig. 10)				
Design		Simple (less parts)		Complex
Activation			Minimal/no control (press a button/trigger)	Direct control

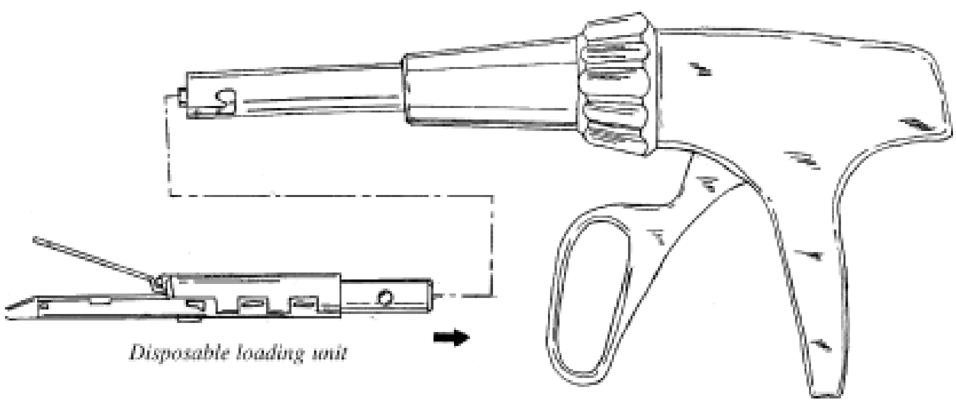

Figure 2: Laparoscopic Surgical Stapler.

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Between the rows of staples, cut the tissue or organ. The staple cartridge is then replaced in the instrument [10]. It is now applied to the opposite end of the tissue or organ, completely dissecting the diseased portion and sealing the remaining ends of the organ. A laparoscopic tool is then used to remove the diseased portion of the organ (Figure 2).

The output heading includes six sub-categories that identify the output(s)/task(s) that laparoscopic surgical staplers typically do. Rotate, yaw, clamp, eject, staple, and cut are the commands. These sub-categories represent frequent movement possibilities found

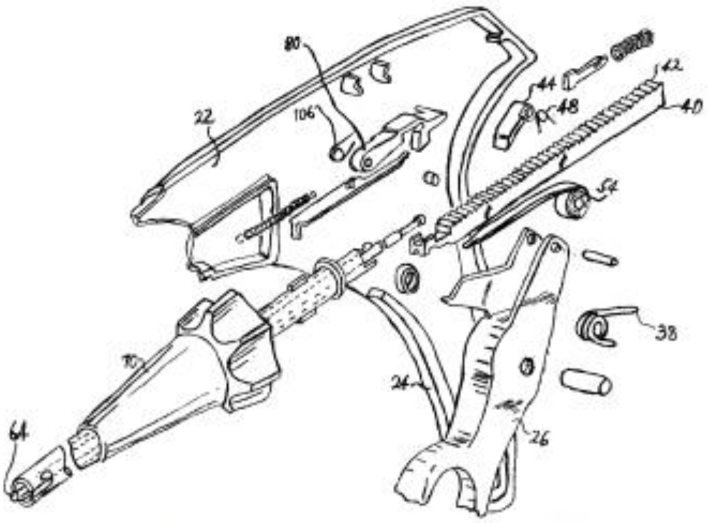

Fig. 3. Components in the handle assembly [8].

Figure 3: Components in the Handle Assembly.

In the 16 patents. The majority of them are included inside surgical staplers for ergonomic reasons, so surgeons may easily operate the instrument while sitting in a comfortable posture. The surgeon may utilize the stapler's yaw and/or rotation capabilities, for example, to move the stapler (from Figure 3) to the area where the tissue is to be treated. The tool must clamp onto the tissue, staple the top and bottom portions of tissue together, then cut between the staples as part of the procedure (for some instruments). The mechanical components that have been utilized to make these activities feasible are located to the right of each of these sub-headings. Some of the subheadings have been combined together to reflect mechanical components or mechanisms that fulfil many functions.

A lead screw and a mechanical slider, for example, under the electric motor column in the self-contained power sub-heading, execute the duties of clamping, ejecting the staples, and cutting the tissue at the same time. The design category requires a qualitative assessment; the number of mechanisms and their application may be basic or complicated. Simple mechanical components are those that have fewer and less complex mechanical components. The control of input motion needed to produce the appropriate output functions falls under the activation category. Surgeons have little or no control over the output of self-contained power.

2. DISCUSSION

The reference table that has been created will be useful to engineers. designers, and students in assessing and proposing improvements to surgical equipment's mechanical subsystems. Existing designs may be swapped out for new ones. Despite the fact that the table was intended

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for laparoscopic surgery, it may be used for a variety of other surgical and non-surgical equipment. Machinery is a mechanical device made up of a series of interconnected links linked by joints in such a manner that the links may move in a regulated relative motion. Many laparoscopic devices are very complicated, having many mechanical components that interact.

3. CONCLUSION

A review of various techniques for developing laparoscopic surgical instruments was given in this article. By looking at current mechanical designs (or patents) and tabulating distinct mechanisms utilized for particular jobs, the comparison table provided may be extended to include additional surgical equipment. This method will enable any designer to save time during the idea generation phase of developing or redesigning a surgical equipment by reducing the amount of time spent brainstorming. It will also make it easier to comprehend the interrelationships between each sub-component that is needed or to be utilized in the completion of complicated activities.

Some laparoscopic tools are made out of common mechanical components including gears, linkages, pivots, sliders, and other similar items. The mechanical characteristics and discrepancies of 16 patented laparoscopic surgical instruments, the majority of which are surgical staplers, were investigated and a reference table was developed. Because of the complicated mechanical systems needed to fulfil their necessary tasks, laparoscopic surgical tools were selected for this study. Each instrument examined differs greatly in design and the kind of mechanical components utilized for the comparable tasks of stapling and kinematic movement. Engineers, designers, and students will benefit from the reference table developed to analyse the mechanical subsystems utilized in surgical tools and propose alternate alternatives for replacing current designs. The table was designed for laparoscopic surgical equipment, but it may be used for other surgical and non-surgical devices as well.

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