Mechanical Engineering Solutions For Healthcare Accessibility And Affordability In Public Health

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KEYWORDS

Public Health, Mechanical, Laparoscopic, Health monitoring

ABSTRACT

The commercial outlook for the healthcare industry is bright these days, both globally and in India. The need for prosthetics, implants, and surgical equipment, among other specialised or customised medical devices, is growing daily. Investigating personalised medical gadgets is crucial to take advantage of upcoming business prospects. In order to expand this commercial opportunity in terms of customised medical devices, additive manufacturing, or AM, can be extremely important. Further investigation into the public healthcare system revealed that the laparoscopic surgical method necessitates the use of specially made, ergonomic surgical instruments. Because laparoscopic surgery is done by staring at a monitor rather than making direct touch with the organs like open surgery does, surgeons doing this sort of procedure often lack hand-eye coordination. Surgical mistakes were discovered with this surgical method. The laparoscopic surgical instrument is the only interface device, and it must be designed to improve coordination and feel responsive during the procedure.

1. Introduction

The healthcare industry is a developing one, with projected spending of US$8.7 trillion by 2020. The aforementioned paper highlights the significance of advancements in the healthcare sector, such as 3D printing, which is further defined by terms like fast prototyping and additive manufacturing [3]. It is anticipated that the healthcare sector in India will increase from US$ 160 billion in 2017 to US$ 280 billion in 2020. According to a different recent estimate, the Indian healthcare industry will generate $372 billion by 2022. The US Food and Drug Administration released a report that emphasised the need for medical devices and personalised or customised medicine to meet the growing demand in the healthcare industry and better and more effectively serve society [1].

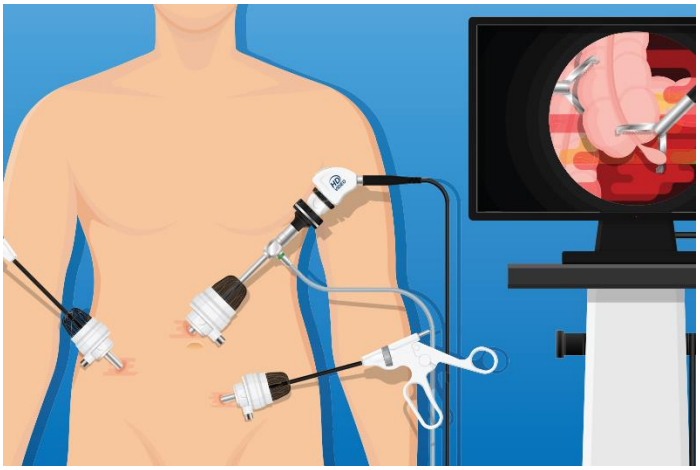

Figure 1: Laparoscopy

Customisation is the process of meeting a customer's or a group of customers' needs by producing a good or service that meets their needs. One of the keys to a successful product is incorporating user comfort and other consumer needs into the design and development process [2]. In order to please their client’s, customised items are becoming more and more popular in the market today. As a result, businesses must adapt to the rapidly changing market and shorten their time to market. Rapid prototyping (RP) or additive manufacturing (AM) are regarded as the greatest technologies available for efficiently achieving customisation. Moreover, additive manufacturing (AM) technologies are widely employed in the biomedical and healthcare sectors to create individualised or customised

surgical implants for fields like dentistry and orthopaedics [5]. However, there hasn't been much research done on using AM to create other customised medical devices, such surgical equipment [14]. Furthermore, AM or RP can investigate ergonomic design and development of other items, including hand tools. [11].

In this instance, section 1 of the paper examines the introduction, and section 2 discusses the review of the laparoscopic surgical tool detection technique. Section 4 presents a discussion of the suggested laparoscopic surgical tool diagnostic model, while Section 5 wraps up the project.

2. Literature Review

According to a survey, there are over 234.2 million major surgeries performed globally each year, and the number of surgical procedures is rising. Additionally, it was mentioned that surgical errors and complications are the primary cause of the rising mortality toll, underscoring the need of surgical safety. Additionally, [4] revealed that 5.2 million injuries worldwide are attributed to medical errors, with 43 million of those injuries occurring in India. Surgery can be categorised in a variety of ways, including according to the body part being operated on (hand or head), the degree of incision (open or laparoscopic), and the aim (plastic or transplant). Open and laparoscopic operations are among the surgical procedures that are most significant in terms of the length of hospital stay for the patient. which requires more hospital days for open surgery than for laparoscopic surgery [12]. Putting more emphasis on open and laparoscopic operations, it is estimated that 7.5 million laparoscopic surgeries—also referred to as keyhole or minimally invasive surgery—are performed annually worldwide. Since it requires less time to heal and less time in the hospital than open surgery, the number is steadily rising worldwide [6].

The initiative to produce healthcare equipment with ergonomic features to improve user comfort is also developed by this research. The purpose and objectives of the research will be formulated in the following section with this in mind. The purpose of this project is to use additive manufacturing to create a healthcare product that is ergonomically designed and personalised [7]. It also aims to provide a method for anthropometric measurements to be used in individual customisation or personalisation.

The objectives of this research to achieve the aim are,

1. To determine which healthcare product is appropriate for customisation and to gather anthropometric data from the intended audience in order to customise the product.
2. To include desired ergonomic elements to improve comfort when utilising the selected medical device.

In this sense, this research explores the advantages of AM by concentrating on creating a customised, ergonomic prototype of a medical device based on anthropometric measurements. This research suggests a design process and strategy for individualised customisation of the healthcare product based on the hand profile measurements collected from the intended population. Thus, the "one size fits all" idea that was employed in mass production for the process of product development is eliminated.

Application Of Laparoscopic Surgical Tool

The primary goal of this project is to propose an individual customisation strategy through the ergonomic design of a healthcare product and customisation utilising hand anthropometric data of the targeted demographic, while also investigating the benefits of additive manufacturing technology. Recognising human limitations is important for product development since it helps reduce human mistake, particularly when developing medical devices. It emphasised how crucial it is to take hand size into account while creating instruments for laparoscopic surgery. This research addressed the inadequate size of the human hand and proposed a design method to accomplish individual customisation by creating a prototype laparoscopic forceps handle [13] while keeping these recommendations in mind.

Figure 2: Laparoscopic Surgical Tool

Additionally, the importance of a surgeon's body posture during a laparoscopic treatment to enhance efficiency. To improve comfort during the surgical operation and boost the surgeon's effectiveness, the laparoscopic forceps handle was adjusted to bring the wrist posture of the hand into a neutral position. concentrating even more on the significance of adjusting the laparoscopic surgical tools' handles in relation to the size of the surgeon's hand in order to improve physician comfort. The present study aims to improve user comfort by customising the proportions of laparoscopic forceps handles based on the hand anthropometric data of the targeted population. It was recognised that while designing hand tools, particularly for laparoscopic surgery, hand size is a significant variable to take into account [8]. The communication gap in hand-eye coordination caused by laparoscopic surgery is the reason for the increased focus on this method. Because the surgeon in this case lacks hand-eye coordination, the internal organs are not immediately touched throughout the procedure. Consequently, extended laparoscopic procedures cause greater discomfort for the surgeons. Ideally, this study includes hand anthropometric data from the targeted population.

Proposed Laparoscopic Surgical Tool For Public Health

The development of a customised laparoscopic forceps handle using hand anthropometric data and additive manufacturing technologies is described in this part as a research contribution to knowledge [9]. Literature has documented the challenges with customisation and ergonomics associated with laparoscopic surgery, which cause discomfort for the surgeons [10]. To lower the danger associated with lengthy surgical operations, a customised design and prototype of the laparoscopic forceps handle was achieved in order to improve surgeon comfort. Furthermore, a method of individual customisation was suggested [15], which is applicable to various hand tools in addition to surgical instruments. Finally, in order to validate the newly produced modified laparoscopic forceps handle, in-person interviews were done. The following are the research contributions to knowledge from this study:

1. emphasised the use of hand anthropometric measurements to customise the handle of laparoscopic forceps.
2. emphasised that the production of specialised goods can directly benefit from the utilisation of users' hand anthropometric measurements.
3. Listed the several methods for individualised customisation strategies that are easily adjustable based on hand size.

4. Draw attention to the use of ergonomic criteria for modified laparoscopic forceps handles in order to improve surgeon comfort and, consequently, lower surgical mistakes.
5. Highlighted the importance of using additive manufacturing to create customised laparoscopic forceps handles for each individual.

Four primary domains are covered in this work: healthcare, which selects the product for customisation; ergonomics, which improves comfort; anthropometry, which tailors the product to the proportions of the human body; and additive manufacturing, which uses AM technology to fabricate the customised healthcare product. The research is multidisciplinary and integrates healthcare, additive manufacturing, ergonomics and anthropometry, and customisation. Millions of people worldwide immediately benefit from advancements in healthcare services, and the healthcare sector has a direct social influence. The provision of a range of healthcare services, from basic medical care to intricate surgical treatments, is contributing to the field's growing prominence.

Furthermore, research highlights the significance of the healthcare industry in generating employment opportunities and preserving the rural economy. The field of healthcare is the main focus of research in this setting. Products that are personalised or customised more successfully appeal to consumer wants. Human body proportions or anthropometric measurements can be used to customise products. Ergonomics is the study of work and products that best meet user needs and maximise worker productivity. According to this research, it is expected that increasing a product's customisation, ergonomics, and anthropometry will raise user comfort levels. The new industrial revolution is thought to be AM technology. Unlike the traditional manufacturing method, which adds material layer by layer to build the desired result, this technology has already completely rewritten the notions of the production process. AM shortens the time required for production and may provide customised items at a relatively low cost. Currently, additive manufacturing (AM) technology is being investigated for both prototyping and final product fabrication. Therefore, AM technology is another field of study that is taken into consideration to shorten the manufacturing time and add customisation to the product.

3. Conclusion and future scope

The commercial outlook for the healthcare industry is bright these days, both globally and in India. The need for prosthetics, implants, and surgical equipment, among other specialised or customised medical devices, is growing daily. Additionally, this work included information regarding the research's contribution to knowledge, including the significance of employing hand anthropometric data to customise laparoscopic devices and how these measurements are directly used in the creation of customised products. Current work has also established an individual customisation strategy and emphasised the need for ergonomic aspects to improve user comfort. The critical significance that additive manufacturing plays in attaining individual customisation strategy and in customising the design of laparoscopic surgical equipment is also highlighted.

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