

Surgical device design: do instruments fit today's surgeons?

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To cite: Mesiti A, Yeo H. Surgical device design: do instruments fit today's surgeons? *BMJ Surg Interv Health Technologies* 2023;5:e000159. doi:10.1136/bmjst-2022-000159

Received 27 June 2022
Accepted 20 June 2023

Since introduction of laparoscopy in the 1980s, the field of surgery has rapidly transitioned toward minimal access techniques and procedures. Along with this shift, many new surgical devices and instruments have been developed. The design and implementation of these devices is complex and expensive, yet vital to advancing surgery. Medical device companies frequently employ human factors engineers and key opinion leaders to help guide the design of these devices and to understand how to make them useful for physicians. Unfortunately, because surgery has traditionally been a male dominated field, most instruments have been built and designed with the male user in mind.

Biomechanics and anthropometry are integral, related components of device development. Biomechanics refers to the structure and function of mechanical aspects of individuals, such as joint function, while anthropometry refers to measurements of the human body. The design of these devices involves incorporating these inherently intertwined dimensions to make them effective for users. These measurements are highly variable among the differing demographics of surgeons. For example, females have less grip strength, grip span and different hand anthropometry compared with male counterparts¹ and a recent commentary by Hallbeck and Lal underscores the fact these measures vary by ethnicity as well.² A 2001 medical device ergonomics paper defined the goal of designing laparoscopic instruments: to design a handle that accommodates 95% of the defined user population.³ This begs the question, who comprises the aforementioned 'user population'?

The field surgery is continuing to diversify and recruit women. This has been a welcome change. But, as the change in the population of surgeons occurs, design of laparoscopic devices has not seen parallel change. An ergonomics paper by van Veelen *et al* defined the population of laparoscopic surgeons as 90%

male and 10% female.³ While this may have been previously true, this is no longer the case and will continue to change and evolve. Data from the AAMC reports that 44.8% of current general surgery residents are female as of 2021.⁴ Further, an overwhelming 85.2% of obstetrics and gynecology residents, a subspecialty which frequently uses laparoscopy, are women.⁴ Since it is obvious that the population of people using laparoscopic instruments has changed and will continue to change, the design of these instruments must also start to adapt. These key points are summarized in [box 1](#).

While most women and small-handed surgeons can probably agree that palming bowel graspers and Marylands during laparoscopic cases is feasible, where the ergonomic difference is particularly pronounced is with disposable laparoscopic instruments. These devices are made mostly of plastic and then disposed of as medical waste at the end of cases. In the current world of injection moulds and three-dimensional (3D) printers, it seems easy enough to allow for these to be designed in multiple sizes. In fact, a 2020 ergonomics study 3D printed ergonomic handles in multiple sizes and found that surgeons had decreased execution time when using the correct sized handle.⁵

Why does all of this matter? Many will argue that women surgeons have been able to effectively and proficiently use laparoscopic instruments and operate at a level comparable to male counterparts.

Box 1 Summary of key points

Key points:

- ⇒ The user population drives surgical device design.
- ⇒ Ergonomic factors vary across both sex and ethnicity.
- ⇒ The user population of laparoscopic surgical instruments has changed and will continue to change, particularly to include more women.
- ⇒ Laparoscopic device design should be revisited for the current diversity in the population of surgeons.



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**Table 1** Summary of previous literature regarding gender based ergonomic disparities in laparoscopic and endoscopic surgery

Paper	Take away message
Berguer and Hreljac ⁸ <i>Surg Endosc.</i> 2004	Women surgeons and small-handed surgeons reported increased difficulty with certain laparoscopic instruments.
Adams <i>et al.</i> <i>Surg Endosc.</i> 2008	Women and small-handed surgeons reported increased difficulty and needing to use two hands for laparoscopic instruments.
Armijo <i>et al</i> ⁶ <i>Surg Endosc.</i> 2022	Women surgeons have higher rates of muscle activation and fatigue.
Sutton <i>et al</i> ⁷ <i>Surg Endosc.</i> 2014	Women surgeons were more likely to experience discomfort and seek treatment.
Shepherd <i>et al.</i> <i>Surg Laparosc Endosc Percutan Tech.</i> 2016	Women report worse physical and cognitive symptoms related to laparoscopic handle size.
Lineberry <i>et al</i> ⁹ <i>Surg Endosc.</i> 2020.	Women and small-handed surgeons have lower and failing scores and on the fundamentals of endoscopic surgery exam.
Bellini <i>et al.</i> <i>J Clin Med.</i> 2022.	Outlines important studies examining ergonomic challenges for women via a systematic review.
Weinreich <i>et al</i> ¹⁰ <i>Am J Surg.</i> 2022.	Women and small handed surgeons report difficulty with laparoscopic instruments and that it affects the ability to learn procedures.
Hallbeck and Lal ² <i>Am J Surg.</i> 2022.	Underscores the importance of gender, race and ethnicity on hand dimension, spread and grip strength.

Electromyography data during real-time operations found that women surgeons had increased muscle activation and higher fatigue levels compared with men⁶ and women and users with smaller hand sizes are more likely to experience injury after using laparoscopic instruments.^{7,8} Beyond physical implications, instrument size also has the potential to be a source of stress for trainees as it pertains to their education. Surgical residents are now required to pass two simulation examinations: the fundamentals of laparoscopic surgery and the fundamentals of endoscopic surgery but data show women and small-handed surgeons are at a significant disadvantage when it comes to passing.⁹ Additionally, a study found that correlations between perceived hand size and ability to learn how to use instruments and their ability to learn a particular operation.¹⁰ Table 1 summarizes previous studies examining gender-based ergonomic differences with surgical instrumentation.

It has been over 30 years since the adoption of laparoscopic surgery. The trend toward minimally invasive techniques only continues to increase. Since the benefits of minimally invasive surgery to the patient are obvious, decreased infection risk, faster recovery, increased cosmesis, perhaps it is time to start considering the effects of minimally invasive surgery on the surgeon and the surgeon's ability to safely and comfortably use the instruments. Considering surgeon's ergonomics and health is imperative. These factors ultimately affect the longevity of surgeons' careers and their ability to use the instruments correctly and with the most benefit to patients. More importantly, a lack of properly sized instruments for women alludes to the larger, systemic issue: that women and diversity are not always welcome in surgery.

An easy and straightforward way to do this would be to increase the diversity of engineers and key opinion leaders who have a large hand in influencing device design. Increasing the representation of women in the group of people who directly influence the device development will undoubtedly lead to change that will result in devices which benefit all surgeons ergonomically. Additionally, having devices available in multiple sizes or adjustable devices could allow for each surgeon to choose the appropriated size tools. Societies such as the Association of Women Surgeons (AWS), the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and the Society of Surgical Ergonomics all have an interest in working with device companies in order to improve device design. Working more closely with companies such as these could help to improve the ergonomics of surgical devices for all users. It is time to urge medical device companies, engineers and key opinion leaders who influence the design of new medical devices to re-examine the design of laparoscopic instruments for the current user population.

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Contributors Both authors participated in the conception, drafting and editing of this manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests Heather Yeo is a board member for this journal.

Patient consent for publication Not applicable.

Provenance and peer review Commissioned; externally peer reviewed.

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