

<Original Article>

## The Ergonomic Relationship Between Hand Size and Mesh Fixation Difficulty When Using Endoscopic Hernia Repair Staplers Based on a Questionnaire Survey

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### ABSTRACT

**Background** There are few reports on the ergonomics of endoscopic hernia staplers. This study aimed to clarify the relationship between hand size and difficulty of stapler use.

**Methods** Surgeons, who perform mesh fixation using endoscopic hernia staplers, completed a questionnaire on demographics, general stapler use, glove size, difficulties during mesh fixation, and the degree of satisfaction with endoscopic hernia repair staplers. Participants were divided into “Small” (glove size  $\leq 6.5$ ,  $n = 24$ ) or “Large” (glove size  $> 6.5$ ,  $n = 44$ ) hand size groups, and the group demographics were compared.

**Results** The tacking issue frequency in the small and large hand size groups was  $30.91 \pm 27.59\%$  and  $25.12 \pm 20.87\%$ , respectively. Of the six options listed as reasons for difficulty, ‘stiff handle’ (small: 25.0%; large: 11.4%) and ‘handle size’ (small: 16.7%; large 4.5%) were chosen more frequently in the small hand size group. In the evaluation of staplers, surgeons with small hands were less satisfied with ‘handle shape’ (small: 29.2%; large: 15.9%) and ‘operability’ (small: 29.2%; large: 6.8%).

**Discussion** Although perceived difficulty in mesh fixation with the stapler did not differ by hand size, surgeons with smaller hands were found to have more instrument-related problems.

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## INTRODUCTION

The first laparoscopic mesh repair of an inguinal hernia using a preperitoneal approach was performed in 1990 [1]. Transabdominal preperitoneal hernia repair (TAPP) was introduced in Japan in 1991 [2]. The Japan Society for Endoscopic Surgery reported that, as of 2021, 60.4 % of inguinal hernia repairs were performed using laparoscopic surgery. Among these, 48.6 % were TAPP, and 11.8 % were total extraperitoneal hernia repair (TEP). The survey also indicated that the recurrence rate was 3.0 % after TAPP and 0.4 % after TEP and were often caused due to mesh-associated problems, such as mesh-slip, position error, and inadequate fixation [3].

Several studies investigated mesh fixation in laparoscopic inguinal hernia repairs, such as a prospective randomized trial comparing stapled and unstapled laparoscopic TAPP-repairs [4]. There are also reports of a mesh fixation technique for secure tacking to prevent a recurrence [5], and a meta-analysis comparing fibrin glue with staples [6]. However, to the best of our knowledge, no studies have so far explored the ergonomics of instruments used for this procedure.

The ergonomics of endoscopic hernia repair staplers may be a key factor affecting mesh fixation in laparoscopic inguinal hernia repair. Surgical instruments are generally designed with Western male surgeons in mind [7]. Previous studies have shown that surgeons with a glove size of 6.5 or smaller experience ergonomic difficulties when using laparoscopic tools, such as a grasper, scissors, dissector, needle, energy device, and stapler [8,9]. However, no studies so far have investigated the ergonomics of endoscopic hernia repair staplers or the relationship between hand size and mesh fixation difficulties when using one. Clarifying the relationship between hand size and the problem of mesh fixation using endoscopic hernia repair staplers is essential to reducing surgeon stress and the risk of hernia recurrence due to subsequent incomplete fixation. This study surveyed surgeons to determine the association between hand size and ergonomic mesh fixation problems when using an endoscopic hernia repair stapler.

## MATERIALS and METHODS

The Institutional Review Board of Osaka Medical College approved the analysis of our survey (approval number: 2020-009; July 21, 2020). The questionnaires were given at the Medtronic exhibition booth at the 78<sup>th</sup> Annual Congress of the Japan Surgical Association and the 30<sup>th</sup> Annual Meeting of the Japan Society for Endoscopic Surgery. Japanese surgeons who performed mesh fixation using endoscopic hernia repair staplers in TAPP and TEP were included. The background, purpose, and questions of the study were explained to the participating surgeons. Participants were also informed that the results would be sent back to equipment manufacturer companies to reflect the opinions of Japanese surgeons for

developing the next generation of equipment. Verbal consent was obtained, and their anonymity was assured. Only those surgeons who agreed to fill out the questionnaire were sent the survey and instructed to fill it out in the exhibition booth, where it was collected immediately.

The survey included demographic information (gender, years of experience in laparoscopic hernia repair, glove size, and dominant arm), frequency of and reasons for the difficulties when fixing mesh using a stapler, and specific questions regarding stapler use in mesh fixation (tack shape, fixation force, handle shape, and maneuverability). The questionnaire is provided in **Fig. 1** and typical endoscopic hernia repair staplers are shown in **Fig. 2**.

Based on previous reports, surgeons were divided into two groups: small hand size (glove size  $\leq 6.5$ ) and large hand size (glove size  $> 6.5$ ).<sup>9</sup> Survey data was transcribed into Microsoft Excel and analyzed using R ver. 3.5.2 (R Core Team 2018). Fisher's exact test for categorical variables and Student's t-test for continuous variables were used to compare the groups [10].

## RESULTS

### Demographics

Sixty-eight surgeons participated in our survey (60 males, 5 females, and 3 unstated), with an average clinical experience of 4.69 years in laparoscopic hernia repair. There were 62 right-handed, 1 left-handed, and 2 ambidextrous surgeons. Of these, 24 surgeons had a small hand size, and 44 had a large hand size. Glove size (i.e., hand size) was significantly smaller in females (small vs. large,  $p = 0.088$ ). The mean years of experience in laparoscopic hernia repair (small:  $4.904 \pm 4.98$  vs. large:  $4.57 \pm 5.16$ ;  $p = 0.842$ ) and the dominant arm ( $p = 0.316$ ) did not differ significantly between groups (**Table 1**).

### Tacking

The difficulties of using the endoscopic hernia stapler, measured in terms of the frequency of responses, did not differ between the groups (small:  $30.91 \pm 27.59$  %; large  $25.12 \pm 20.87$  %;  $p = 0.395$ ). The primary tacking issue was the 'taking angle' (small: 58.3 %; large: 72.7 %) (**Fig. 3**). 'Trocar placement' (small: 20.8 %; large: 18.2 %) and 'patient's body figure' (small: 20.8 %; large: 25.0 %) were chosen equally between hand sizes, but 'stiff handle' (small: 25.0 %; large: 11.4 %) and 'handle size' (small: 16.7 %; large 4.5 %) were chosen more frequently in the small hand size group.

### Endoscopic hernia staplers

The surgeons were highly satisfied with the endoscopic hernia repair stapler tack shape and fixation force ('satisfied' was selected most often), and there was no significant difference between the groups in terms of tack shape ( $p = 0.804$ ) and fixation force ( $p = 0.838$ ) (**Figs. 4a and 4b**). More surgeons with large hand sizes were 'satisfied' with the handle

**Questionnaire**

**Basic Information**

Gender: Male Female Year of experience in laparoscopic hernia repair:  
Glove size: Dominant arm: Right Left Both-handedness

**1. Tacking**

1-1. When tacking by the endoscopic hernia staplers, do you ever feel difficulty?

If so, what percentage of the time do you feel this? (Please circle)

0 10 20 30 40 50 60 70 80 90 100 (%)

1-2. If possible, please let us know the reason for the above. Please check all that apply.

Trocar placement Tacking angle Patient's body figure Stiff handle Handle size Other  
( )

**2. Endoscopic hernia staplers**

2-1. How do you feel about the shape of the tack? Please check the one that applies.

Extremely satisfied Satisfied Neither Dissatisfied Extremely dissatisfied

2-2. How do you feel about the fixation force? Please check the one that applies.

Extremely satisfied Satisfied Neither Dissatisfied Extremely dissatisfied

2-3. How do you feel about the shape of the handle? Please check the one that applies.

Extremely satisfied Satisfied Neither Dissatisfied Extremely dissatisfied

2-4. How do you feel about the Maneuverability? Please check the one that applies.

Extremely satisfied Satisfied Neither Dissatisfied Extremely dissatisfied

Fig. 1 Questionnaire survey template

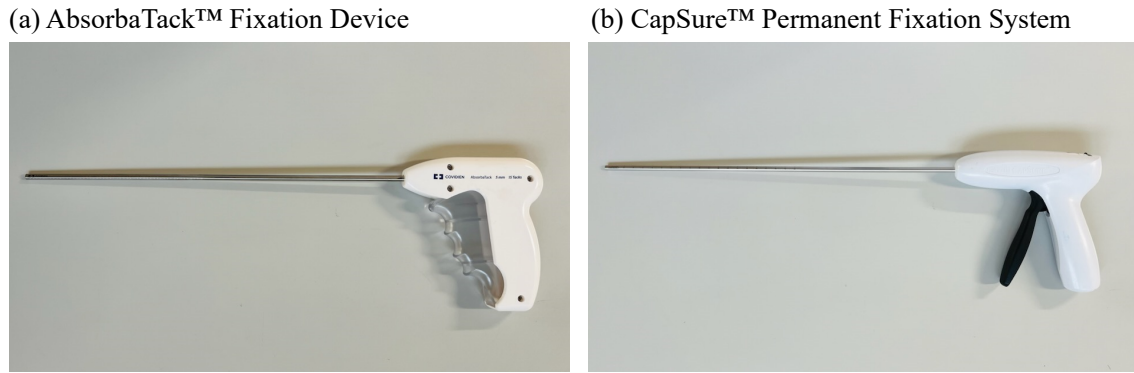


Fig. 2 Endoscopic hernia repair staplers frequently used in Japan

Table 1 Survey participant demographics

Glove size	≤6.5	>6.5	P-value
Number of surgeons	24	44	n/a
Male/Female (%)*	19/4 (79.2/16.7)	41/1 (93.2/2.3)	0.028
Years of experience (mean (sd))	4.90 (4.98)	4.57 (5.16)	0.866
Dominant arm R/L/Both (%)**	22/1/1 (92.0/4.0/4.0)	40/0/1 (90.9/0.0/6.8)	0.328

\* Fisher’s exact test; \*\* Fisher’s exact test

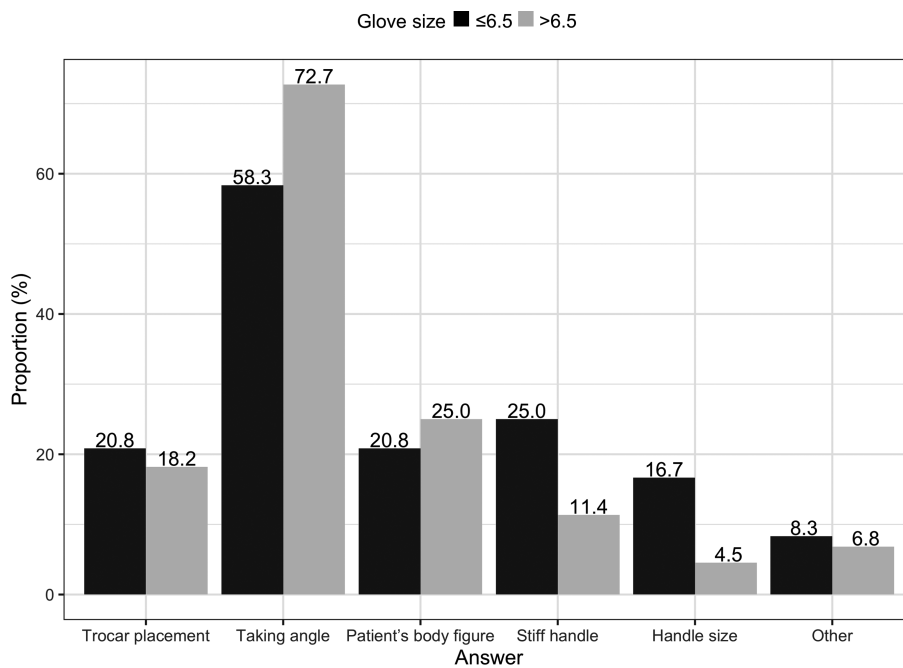


Fig. 3 The tacking issue when using endoscopic hernia staplers

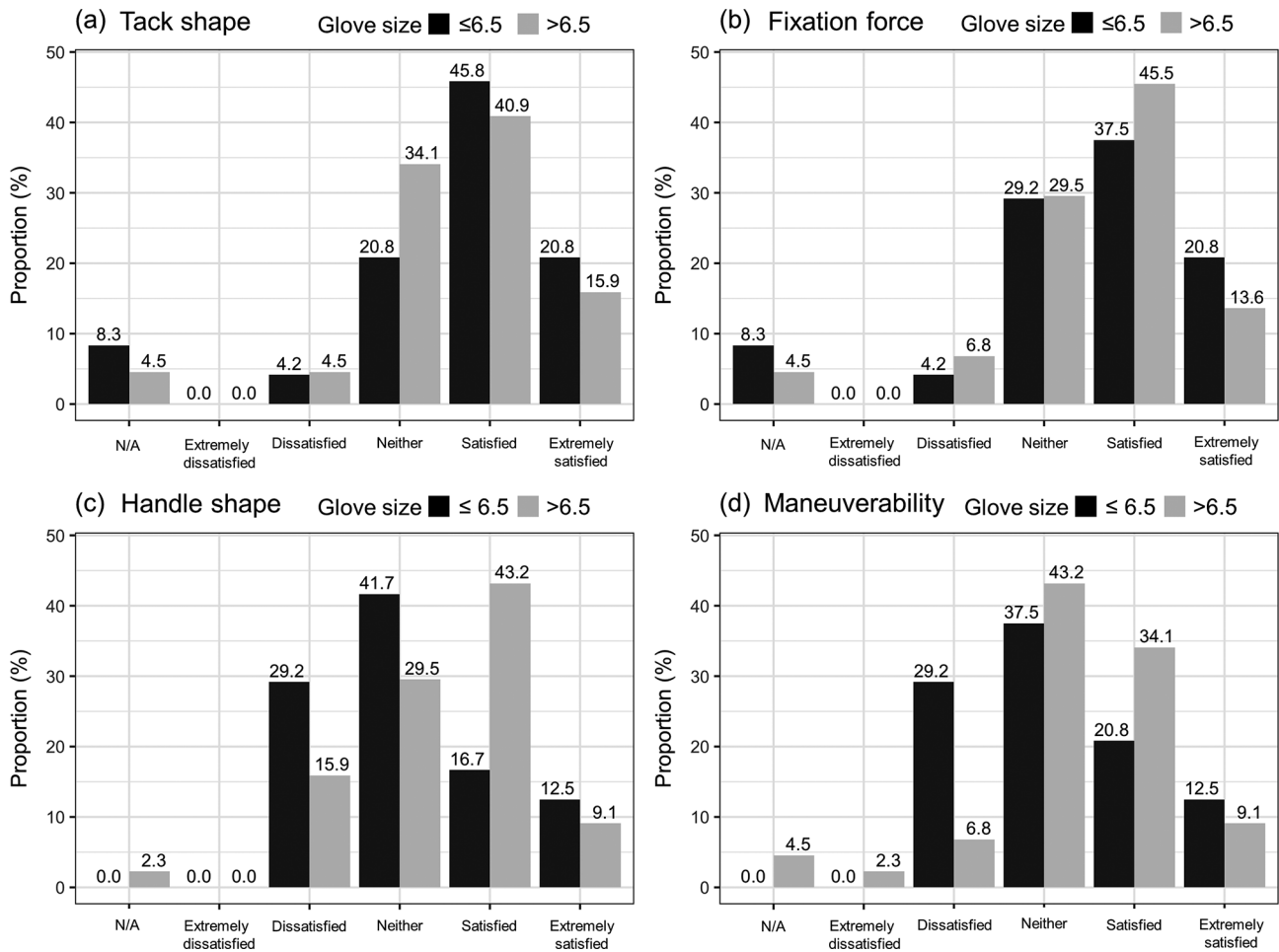


Fig. 4 Degree of satisfaction when using endoscopic hernia staplers

shape (small: 16.7 %; large: 43.2 %), while surgeons with small hand sizes chose ‘neither’ (small: 41.7 %; large: 29.5 %) and ‘dissatisfied’ (small: 29.2 %; large: 15.9 %) more often (Fig. 4c). The handle shape satisfaction did not differ between the groups ( $p = 0.165$ ). Similarly, more surgeons were ‘satisfied’ with the stapler maneuverability in the large hand size group (small: 20.8 %; large: 34.1 %) and ‘dissatisfied’ in the small group (small: 29.2 %; large: 6.8 %); a similar number in both groups chose ‘neither’ (small: 37.5 %; large: 43.2 %) (Fig. 4d). The maneuverability satisfaction did not differ between the two groups ( $p = 0.190$ ).

DISCUSSION

This survey is the first evaluation of the relationship between hand size and ergonomic difficulties in mesh fixation using endoscopic hernia repair staplers. Although the frequency of difficulty in mesh fixation with the endoscopic hernia stapler did not differ significantly between large and small hands, it was clear that surgeons with small hands had

problems with ‘handle size’ and ‘handle stiffness’ related to the instrument. The ergonomic problems of this surgical device are similar to those of other surgical devices, and a review of one-size-fits-all targeting Western men is needed. The results of this study will help promote ergonomic designs that consider physical differences.

The frequency of difficulty in mesh fixation with the endoscopic hernia stapler did not differ by hand size but this may be because many surgeons consider the angle of tacking to be the primary reason for the difficulty. The primary tacking issue was the ‘taking angle’ regardless of hand size, as the perpendicular fixation of the mesh with screws is difficult owing to the trocar placement and angle.

Of the six options listed as reasons for difficulty, ‘handle size’ and ‘handle stiffness’ were selected more often by surgeons with small hands than by surgeons with large hands. These two options were instrument-related questions, while the other options were not. Surgeons with small hands have ergonomic problems with the instrument and also likely have difficulties with other laparoscopic devices [8,9]. This may be

especially true when tacking with an endoscopic hernia repair stapler that requires the operating surgeon to grip the instrument with one hand while providing counter traction with the other. Furthermore, the tacking angle is a crucial factor in fixation. Proper external mesh fixation requires changing the angle with pressure from the body's surface, forcing one-handed operation. These data suggest that surgeons with small hands and weak grip strength may experience more ergonomic difficulties when using endoscopic hernia repair staplers and might benefit from improvements, such as a smaller handle and grip force reduction.

Regarding satisfaction with endoscopic hernia staplers, both groups rated 'tack shape' and 'fixation force' the same, but ergonomics regarding 'handle shape' and 'maneuverability' showed a different response trend between the two groups. About half of the large hand group was satisfied with handle shape and maneuverability, but only approximately 30 % of the small hand group was dissatisfied.

A previous study reported an association between acute mental stress and worsening technical surgical performance [11]. Stressors, such as equipment problems, can cause physical and psychological stress to the surgeon during surgery, resulting in poor surgical performance [12]. Understanding the relationship between hand size and difficulties performing mesh fixation using endoscopic hernia repair staplers is important for reducing stress to the surgeon and subsequent recurrence risk due to incomplete fixation. Fixation complications include hernia recurrence, chronic pain, infection, mesh migration, meshoma and tack hernias [13-17], and inappropriate fixation from instrumentation difficulties increases the complication risk. These data should be considered when designing endoscopic hernia repair staplers because an ergonomic design improves surgical performance and the safety of patients and surgeons [18].

Recent international guidelines recommended tacking for large direct hernias only because fixed and non-fixed meshes are equally associated with low recurrence rates [19]. Various mesh fixation methods exist, including tacks, staples, self-fixing, fibrin sealants, glues, and sutures. A consensus on the 'best' fixation method does not exist, and the method of choice is based on a surgeon's preference [19]. In Japan, the mesh is most commonly fixed by tacking in TAPP hernia repair. We believe that the results of this study will be helpful in promoting ergonomic design that takes into account physical differences.

This survey had some limitations. First, the sample size was small, especially with regard to female surgeons. The lack of statistical differences between the groups may be due to the small number of female surgeons who participated in the survey. However, approximately 6 % of the Japanese Society of Gastroenterological Surgery members and 7.6 % of survey participants were women, indicating that a representative selection of women participated in the survey. Second, the glove size is often based on personal preference. Thus, the glove

size may not perfectly correspond to the individual's hand size. Third, this survey was carried out at the Medtronic (Medtronic, Minneapolis, MN, USA) exhibition booth; Medtronic makes the AbsorbaTack™ instrument. In our survey, the endoscopic hernia repair staplers were not limited to AbsorbaTack™; however, this situation may have generated bias in the participant answers.

Subjective evaluation using a questionnaire revealed that surgeons with small hands have problems with instrument ergonomics in mesh fixation, using a laparoscopic hernia stapler. Future research into this should use objective tools such as surface electromyography and motion analysis [20] to clarify potential problems that subjective evaluation could not clarify.

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