



# Trends in minimally invasive and open inguinal hernia repair: an analysis of ACGME general surgery case logs

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## Abstract

**Background** Groin hernia repair is one of the most commonly performed surgical procedures and is often performed by surgical interns and junior residents. While traditionally performed open, minimally invasive (MIS) groin hernia repair has become an increasingly popular approach. The purpose of this study was to determine the trends in MIS and open inguinal and femoral hernia repair in general surgery residency training over the past two decades.

**Methods** Accreditation Council for Graduate Medical Education (ACGME) national case log data of general surgery residents from 1999 through 2022 were reviewed. We collected means and standard deviations of open and MIS inguinal and femoral hernia repairs. Linear regression and ANOVA were used to identify trends in the average annual number of open and MIS hernia repairs logged by residents. Cases were distinguished between level of resident trainees: surgeon-chief (SC) and surgeon-junior (SJ).

**Results** From July 1999 to June 2022, the average annual MIS inguinal and femoral hernia repairs logged by general surgery residents significantly increased, from 7.6 to 47.9 cases ( $p < 0.001$ ), and the average annual open inguinal and femoral hernia repairs logged by general surgery residents significantly decreased, from 51.9 to 39.7 cases ( $p < 0.001$ ). SJ resident results were consistent with this overall trend. For SC residents, the volume of both MIS and open hernia repairs significantly increased ( $p < 0.001$ ).

**Conclusions** ACGME case log data indicates a trend of general surgery residents logging overall fewer numbers of open inguinal and femoral hernia repairs, and a larger proportion of open repairs by chief residents. This trend warrants attention and further study as it may represent a skill or knowledge gap with significant impact of surgical training.

**Keywords** Inguinal hernia · Femoral hernia · ACGME case log · Surgical education · Minimally invasive · Open

Groin hernia repair, including both inguinal and femoral, is one of the most commonly performed surgical procedures [1]. Lifetime occurrence of a groin hernia is 27–43% in men and 3–6% in women [2]. Hernia repair procedures are

broadly categorized as open or minimally invasive (MIS) repairs. Minimally invasive surgical approaches include laparoscopic and robotic techniques.

The use of MIS approaches to groin hernia repair has steadily increased over the last two decades [1]. This shift has been driven by advances in technology and the recognition of the benefits of minimally invasive surgery, including faster recovery times and less postoperative pain [3, 4]. Despite the trend toward an MIS approach, open hernia repair remains an important surgical option. Open repair is often the preferred approach for strangulated or incarcerated hernias, after prior pelvic surgery, and in contaminated cases [5]. Furthermore, open hernia repair may be necessary when MIS approaches cannot be completed or are not recommended due to patient comorbidities. Currently, there is no consensus in the literature regarding the best technique

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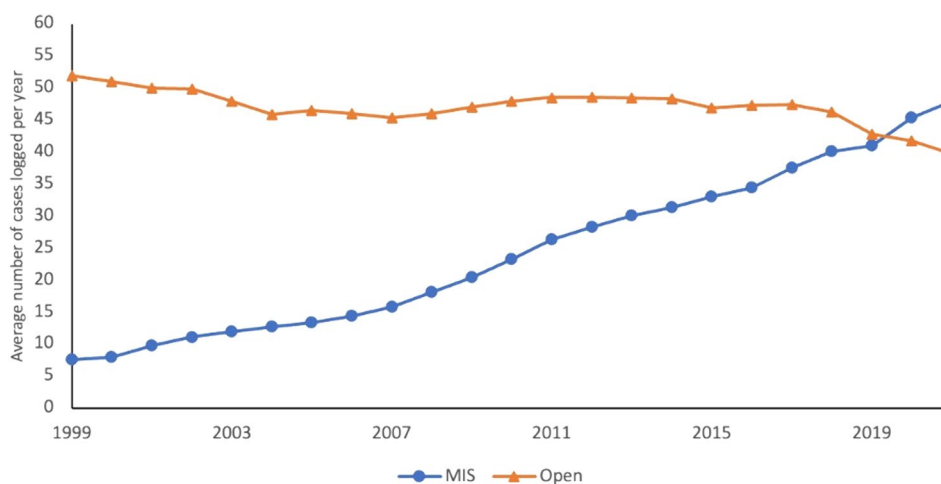
for inguinal hernia repair [6–8]. There is a continued need for general surgery residents to gain proficiency in both open and MIS hernia repair.

Previous studies have examined the use of MIS versus open techniques for groin hernia repair. A Veterans Affairs Surgical Quality Improvement Program (VASQIP) database study of 2008 to 2019 found that 80.7% of inguinal hernia repairs had been performed open, with 14.4% performed laparoscopically, and 4.9% performed robotically [9]. Other studies have similarly observed the trend toward MIS hernia repair [10]. There is, however, limited literature on trends of open versus MIS hernia repair in general surgery residency training. Multiple studies evaluated trends across all procedures in general surgery residency case log data, demonstrating decreased open and increased MIS cases [11–15]. Collectively, these studies addressed the timeframe from 1993 through 2018. We build upon these studies, with a specific focus on inguinal and femoral hernia repair. The purpose of this study was to determine the 20-year trends of open versus MIS groin hernia repairs by general surgery residents based on ACGME case log data. We hypothesize that MIS hernia cases have increased during this time period, with an associated decrease in open cases.

## Materials and methods

We reviewed publicly available Accreditation Council for Graduate Medical Education (ACGME) national case log data of general surgery residents from 1999 through 2022. We collected the means and standard deviations of open and minimally invasive inguinal and femoral hernia repairs logged by general surgery residents of all levels and in each academic year. We then stratified the data to distinguish between surgeon-chief (SC) and surgeon-junior (SJ) residents.

**Fig. 1** Total annual trends in the number of inguinal and femoral hernia cases logged by general surgical residents based on approach (Open vs. MIS) from 1999 to 2022



We note the following details about the ACGME national case log database. The ACGME data does not distinguish between inguinal and femoral hernia repairs; it instead combines the data for the two procedures. The ACGME data categorizes all MIS repairs, including robotic cases, as “laparoscopic.” The ACGME case log guide for general surgery residents defines an SC resident as a resident who “performed the case in the role of Surgeon during the 12 months of Chief Year,” and defines an SJ resident as a resident who logged cases “prior to the Chief Year, [and who has] substantial responsibility for the case and performs over 50% of the surgical procedure” [16].

We used Microsoft Excel (Microsoft, Redmond, WA) to conduct simple linear regression and ANOVA to identify trends in the annual average number of open and MIS hernia repairs logged by all general surgery residents. We then utilized the same statistical approach to separately analyze changes in the average number of open and MIS hernia repairs logged by SC and SJ residents. Finally, we supplemented our review by analyzing the annual change in the number of general surgery residents and general surgery residency programs registered in the ACGME database.

## Results

From July 1999 to June 2022, general surgery residents logged an increasing number of MIS inguinal and femoral hernia cases and a decreasing number of open cases. The average annual number of logged MIS hernia repairs significantly increased, by a rate of 1.8 cases per year ( $R^2=0.979$ ,  $p<0.001$ ), and the average annual number of logged open hernia repairs significantly decreased, by an average rate of 0.2 cases per year ( $R^2=0.476$ ,  $p<0.001$ ). As shown in Fig. 1, in the academic year 1999–2000 general surgery residents logged averages of 51.9 open and 7.6 MIS hernia repairs. By academic year 2021–2022, general surgery

residents logged averages of 39.7 open and 47.9 MIS hernia repairs (Table 1). Academic year 2020–2021 was the first year when the average number of logged MIS hernia repairs exceeded the average number of logged open hernia repairs, with an average of 45.4 MIS versus 41.8 open cases. The trend of increasing logged MIS repairs as compared to logged open repairs continued in 2021–2022.

We then stratified the data between SC and SJ residents. SJ residents followed the overall trend: SJ residents' logged MIS hernia repairs significantly increased ( $R^2=0.981$ ,  $p<0.001$ ) and SJ residents' logged open hernia repairs significantly decreased ( $R^2=0.788$ ,  $p<0.001$ ). For SC residents, however, logged MIS and open hernia repair case numbers both significantly increased ( $R^2=0.826$ ,  $p<0.001$  open;  $R^2=0.959$ ,  $p<0.001$  MIS) (Fig. 2). Comparing SC and SJ residents, SJ residents logged a greater average number of open and MIS repairs than SC residents. SJ residents also had a greater rate of increase in average number of logged MIS repairs, with an increase of 1.18 average cases per year as compared to an increase of 0.66 average cases per year for SC residents.

The number of general surgery residents significantly increased between academic years 1999–2000 and 2021–2022, with an average growth of 16.8 residents per year ( $p<0.001$ ) (Fig. 3). Over this same period, the number of general surgery residency programs did not significantly increase, with an average increase of 0.89 programs per year ( $p=0.058$ ).

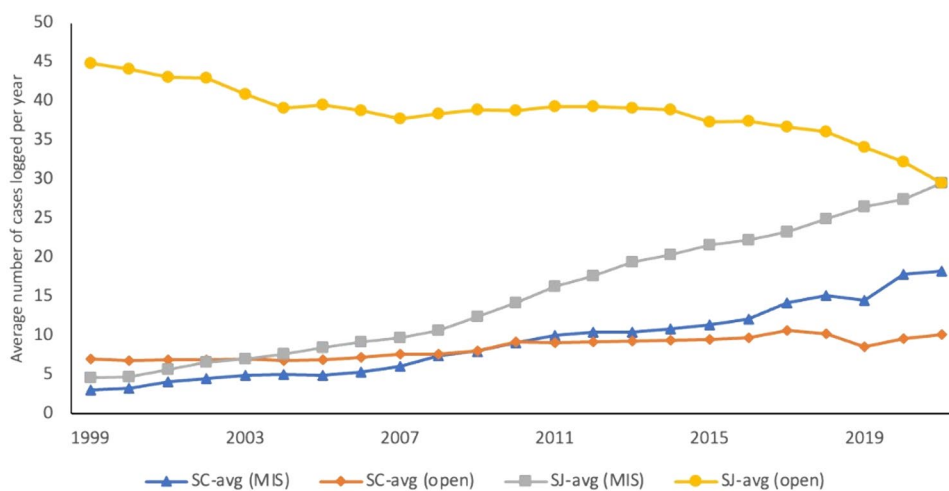
## Discussion

Our study found that general surgery residents are logging increasing numbers of MIS hernia repairs and overall decreasing numbers of open repairs. When case logs are stratified by resident seniority, we observed an increase in MIS repairs in both SJ and SC residents, a decrease in open repairs logged by SJ residents, and an increase in open repairs for SC residents. These trends are significant for a decrease in total open repairs, and an increase in the proportion of open repairs performed by SC residents. These results are somewhat consistent with the ACGME case log analysis performed by McCoy et al., which studied case log data from academic years 1999–2000 to 2010–2011 and found a decrease in open abdominal procedures performed by general surgery residents, including appendectomies, colectomies, and antireflux procedures [11]. With respect to inguinal and femoral hernia repair, McCoy et al. found a 265% rise in MIS cases and a concomitant 8.5% decrease in open cases [11]. Several other studies have similarly described the trend of increasing MIS inguinal and femoral hernia repairs and decreasing open repairs [12–15]. Despite these percentage trends, these studies consistently showed

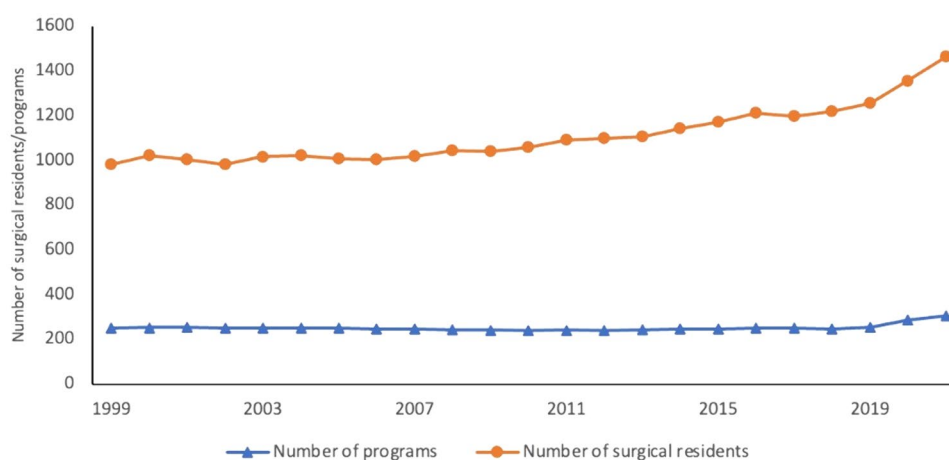
**Table 1** Average Number of Minimally Invasive and Open Inguinal and Femoral Hernia Repairs Logged by General Surgery Residents in the ACGME Case Log Database

Case type	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011
Logged repairs	59.5	59	59.8	61	59.8	58.6	59.9	60.4	61.2	64.1	67.4	71.2
Total inguinal/femoral hernia repairs												
Total	7.6	8	9.8	11.1	11.9	12.7	13.4	14.4	15.8	18.1	20.4	23.3
MIS	12.8%	13.6%	16.4%	18.2%	19.90%	21.70%	22.40%	23.80%	25.80%	28.20%	30.30%	32.70%
Open	51.9	51	50	49.9	47.9	45.9	46.5	46	45.4	46	47	47.9
	87.20%	86.40%	83.60%	81.80%	80.10%	78.30%	77.60%	76.20%	74.20%	71.80%	69.70%	67.30%
Logged repairs	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018	2018–2019	2019–2020	2020–2021	2021–2022	P-value
Total inguinal/femoral hernia repairs												
Total	74.8	76.8	78.4	79.7	79.9	81.7	84.9	86.4	83.8	87.2	87.6	
MIS	26.3	28.2	30	31.4	33	34.4	37.5	40.1	41	45.4	47.9	<0.001
	35.20%	36.70%	38.30%	39.40%	41.30%	42.10%	44.20%	46.40%	48.90%	52.10%	54.70%	
Open	48.5	48.6	48.4	48.3	46.9	47.3	47.4	46.3	42.8	41.8	39.7	
	64.80%	63.30%	61.70%	60.60%	58.70%	57.90%	55.80%	53.60%	51.10%	47.90%	45.30%	<0.001

**Fig. 2** Total annual trends in the number of inguinal and femoral hernia cases logged by surgeon-chief and surgeon-junior residents based on approach (Open vs. MIS) from 1999 to 2022



**Fig. 3** Overall annual trends in the number of general surgery residency programs and general surgery residents logging cases in the ACGME case log database from 1999 to 2022



that open hernia repairs were performed more frequently than MIS repairs. The most recent annual data addressed by these studies is 2018. Our results continue to demonstrate this percentage trend, with a 530% increase in MIS repairs and a 23% decrease in open repairs. However, our results add to the literature in demonstrating that the average number of logged MIS hernia repairs exceeded open cases for the first time in 2020.

Notwithstanding the increase in MIS procedures, open hernia repairs are still commonly performed and remain important in surgical education and patient care. The open approach is often preferred in cases of strangulation, incarceration, after previous pelvic surgery, or for a recurrent hernia following MIS repair [10, 17]. In light of the absence of a consensus about the best repair technique, patients may opt for an open approach. General surgery residents thus continue to require proper training in open hernia procedures.

Studies have found that repetition and surgeon mastery of the procedure are associated with decreased risk of hernia recurrence [18]. The literature differs as to the number of

cases required to achieve surgical competence. Merola et al. and Van Kesteren et al. stated that surgical residents need approximately 31–40 open hernia repairs in order to reach an operative time similar to that of a senior surgeon [19, 20]. In contrast, Stride et al. found that procedural target numbers were generally not effective in predicting competence in inguinal hernia repair [21]. Our study found that, as of 2022, residents were logging 39.7 open inguinal and femoral hernia repairs. Extrapolating the data from the prior studies it appears that general surgery residents still receive sufficient operative experience in open techniques to transition to independent practice [19–21]. However, if the trend toward decreased open hernia repair continues, a skill and knowledge gap may arise.

A notable finding of our study is that SC residents are performing increasing numbers of open hernia repairs, in contrast to the overall trend of decreased open repairs. One reason for this divergence may be that an open approach is more likely to be used for repair of complex hernias (e.g., incarcerated, strangulated, recurrent, or hernias with infected

prosthetic material), and these hernias may require a more mature skillset. Additionally, as chief residents transition from residency to fellowship or practice, they may assign themselves to more open hernia repairs regardless of complexity in order to ensure competency and proficiency as they assume increased levels of responsibility and prepare for independent practice.

The decrease in the number of open repairs could point to the need for targeted educational efforts to mitigate a potential knowledge and skill gap. Surgical simulation that focuses on open technique may provide an opportunity for learning and skill acquisition. The success of simulation in laparoscopic and endoscopic skill acquisition is well documented [22–26]. Fundamentals of Laparoscopic Surgery (FLS) and Fundamentals of Endoscopic Surgery (FES) programs developed by The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) have been successfully adopted by the American Board of Surgery to establish laparoscopic and endoscopic competency. Several studies have demonstrated that competency in these simulated skills do predict transfer to actual cases where laparoscopic and endoscopic skills are needed [22–24]. Similarly, Charokar et al. demonstrated statistically significant improvement in laparoscopic skills after a 12-week structured training program [25]. With specific attention to open simulation models, Nazari et al. developed an inguinal hernia model for open Lichtenstein hernia repair [26]. Both faculty and residents rated the training model to have high fidelity with actual anatomy and that the model was useful for training. These types of simulation training may provide the repetition necessary to safely perform the procedure on an actual patient. Though the Nazari et al. model was limited in its ability to provide variable experience such as anatomic differences and patient characteristics (weight, body habitus), simulation targeted towards open technique may become increasingly important as we continue to see a decrease in open inguinal hernia repairs [26].

Utilizing ACGME case log data presented several limitations for this study. First, the ACGME case log is primarily for accreditation, rather than a comprehensive record of residents' operative experiences. As a result, residents may choose not to input additional cases after they have reached their required minimum and SC resident cases may be understated. Collins et al. demonstrated that only 75% of cases were logged in the ACGME database compared to the actual cases performed in the electronic health records [27]. The ACGME database lists only numbers of cases logged. It does not assess resident proficiency, degree of actual resident participation in the cases, autonomy, and complexity of the case. We can only assume that residents performed at least 50% of their logged cases, as recommended in the ACGME guidelines. Additionally, because the ACGME database only distinguishes between SC and SJ residents,

we were unable to study cases performed on a post-graduate year basis. Lastly, while the ACGME database permits residents to record when a case is performed robotically, the information distinguishing between robotic and laparoscopic procedures is not included in the publicly available case log data.

The trend from open to MIS inguinal and femoral hernia repair has impacted general surgery residency training, with a steady decrease in open repairs logged by residents, and a larger proportion of open repairs performed by chief residents. This transition warrants attention and further study. If the trend of decreased open repairs continues, a skill and knowledge gap may arise potentially highlighting the need for other targeted educational strategies.

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## Declarations

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