GYNECOLOGY

Minimally invasive myomectomy: practice trends and differences between Black and non-Black women within a large integrated healthcare system

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BACKGROUND: Although multiple professional organizations encourage minimally invasive surgical approaches whenever feasible, nationally, fewer than half of myomectomies are performed via minimally invasive routes. Black women are less likely than their non-Black counterparts to have minimally invasive surgery.

OBJECTIVE: This study aimed to assess the trends in surgical approach among women who underwent minimally invasive myomectomies for uterine leiomyomas within a large integrated healthcare system as initiatives were implemented to encourage minimally invasive surgery, particularly evaluating differences in the proportion of minimally invasive surgery performed in Black vs non-Black women.

STUDY DESIGN: We conducted a retrospective cohort study of women, aged ≥18 years, who underwent a myomectomy for a uterine leiomyoma within Kaiser Permanente Northern California between 2009 and 2019. Generalized estimating equations and Cochran-Armitage testing were used to assess myomectomy incidence and linear trend in the proportions of myomectomy by surgical route—abdominal myomectomy and minimally invasive myomectomy. Multivariable logistic regression analyses were used to assess the associations between surgical route and (1) race and ethnicity and (2) complications, controlling for patient demographic, clinical, and surgical characteristics.

RESULTS: A total of 4033 adult women underwent a myomectomy during the study period. Myomectomy incidence doubled from 0.12 (95% confidence interval, 0.12–0.13) per 1000 women in 2009 to 0.25 (95% confidence interval, 0.24–0.25) per 1000 women in 2019 ($P<.001$). During the 11-year study period, the proportion of minimally invasive myomectomy increased from 6.0% to 89.5% (a 15-fold increase). The proportion of minimally invasive myomectomy in Black women remained lower than in non-Black women (54.5% vs 64.7%; $P<.001$). Black women undergoing myomectomy were younger (36.4±5.6 vs 37.4±5.8 years; $P<.001$), had a higher mean fibroid weight (436.0±505.0 vs 324.7±346.1 g; $P<.001$), and had a higher mean body mass index (30.8±7.3 vs 26.6±5.9 kg/m^2; $P<.001$) than their non-Black counterparts. In addition to patient race, surgery performed between 2016 and 2019 compared with surgery performed between 2009 and 2012 and higher surgeon volume compared with low surgeon volume were associated with an increased proportion of minimally invasive myomectomy (adjusted relative risks, 12.58 [95% confidence interval, 9.96–15.90] and 6.63 [95% confidence interval, 5.35–8.21], respectively). Black race and fibroid weight of >500 g each independently conferred lower rates of minimally invasive myomectomy. In addition, there was an interaction between race and fibroid weight such that Black women with a fibroid weight of ≤500 g or >500 g were both less likely to have minimally invasive myomectomy than non-Black women with a fibroid weight of ≤500 g (adjusted relative risks, 0.74 [95% confidence interval, 0.58–0.95] and 0.26 [95% confidence interval, 0.18–0.36], respectively). Operative, perioperative, and medical complications were low during the 11-year study period. In regression analyses, after controlling for race, age, fibroid weight, parity, low-income residence, body mass index, surgeon volume, and year of myomectomy, the risk of complications was not markedly different comparing abdominal myomectomy with minimally invasive myomectomy. Similar results were found comparing laparoscopic minimally invasive myomectomy with robotic-assisted minimally invasive myomectomy except for women who underwent laparoscopic minimally invasive myomectomy had a lower risk of experiencing any medical complications than those who underwent robotic-assisted minimally invasive myomectomy (adjusted relative risk, 0.27; 95% confidence interval, 0.09–0.83; $P=.02$).

CONCLUSION: Within an integrated healthcare delivery system, although initiatives to encourage minimally invasive surgery were associated with a marked increase in the proportion of minimally invasive myomectomy, Black women continued to be less likely to undergo minimally invasive myomectomy than their non-Black counterparts. Race and fibroid weight alone did not explain the disparities in minimally invasive myomectomy.

Key words: fibroids, minimally invasive myomectomy, open myomectomy, racial differences, surgeon volume, uterine leiomyomas

Introduction

Uterine leiomyomas or fibroids are among the most common benign tumors, affecting approximately 1 in 5 women of reproductive age.[1] Surgical options include minimally invasive myomectomies (MIMs), such as laparoscopic MIM or robotic-assisted laparoscopic MIM, and abdominal myomectomies (AMs). Hysterectomy is the definitive surgical option for women with symptomatic fibroids; however, it is not an option for those who have not yet completed childbearing or wish to preserve their uterus.[2] The American College of Obstetricians and Gynecologists and the American Association of Gynecologic Laparoscopists endorse a minimally invasive surgical approach whenever feasible.[3,4] Compared with AM, MIM offers faster recovery, decreased hospital stay, lower blood loss,

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AJOG at a Glance

Why was this study conducted?

We aimed to describe trends of myomectomy surgical approach for uterine leiomyomas within a large integrated healthcare system focusing on the impact of patient demographic, clinical, and surgical characteristics. We further aimed to evaluate perioperative and medical complications associated with the route of myomectomy.

Key findings

From 2009 to 2019, the proportion of minimally invasive myomectomies increased 15-fold from 6.0% to 89.5%. Black women were less likely than their non-Black counterparts to receive a minimally invasive myomectomy (MIM). In addition to race and ethnicity, factors associated with surgical route included fibroid weight and surgeon experience. There was no difference in postoperative complications between abdominal myomectomy and MIM.

What does this add to what is known?

This study demonstrated changes in practice patterns over time and further highlighted racial differences.

and adhesion formation.[5] Despite these guidelines, the American College of Surgeons National Surgical Quality Improvement Project database demonstrates that only 40% of myomectomies are minimally invasive.[5,6]

Nationally, Black women are more likely than White women to undergo both AM and hysterectomy (relative risk [RR], 2.4 and 6.8, respectively).[7] Although several studies have assessed the association of patient race and ethnicity with the route of hysterectomy,[8–14] there has been a paucity of published studies assessing the association between patient race and ethnicity and myomectomy practice patterns. Furthermore, it is important to assess factors associated with gynecologic surgery for uterine fibroids in Black and non-Black women to understand if observed differences in route of surgery can be attributed to patient characteristics, which may include modifiable and nonmodifiable factors, or system characteristics, which may be amenable to change through quality initiatives.

Beginning in 2008, Kaiser Permanente Northern California (KPNC), an integrated healthcare delivery system, implemented a quality improvement initiative involving leadership engagement, surgeon training, low-volume surgeon reduction, and best practice encouragement to increase the rates of minimally invasive surgery.[15,16] Trend analysis of hysterectomy for benign indications demonstrated an increase in the proportion of minimally invasive hysterectomies from 39.8% in 2008 to 93.1% in 2015 with a higher annual relative rate increase in minimally invasive hysterectomies for racial and ethnic minority patients than their White counterparts. Racial and ethnic disparities in minimally invasive hysterectomy were no longer observed within 2 years of the quality improvement initiation.[15–17] Beginning in 2010 and 2013, region-wide initiatives were taken to increase gynecologic surgeon proficiency with training and limiting privileges in performing laparoscopic MIM and then robotic-assisted MIM to maintain at least 10 cases per year.[16]

We conducted a retrospective data-only cohort study of women who underwent a myomectomy for a uterine leiomyoma within KPNC, which serves >4 million members who are representative of Northern California's diverse population.[18] We aimed to describe the overall trends in MIM from 2009 to 2019 and to assess variations in rates of MIM between Black and non-Black patients. We hypothesized that the rates of MIM would increase during the study period for all patients and that variations between Black and non-Black patients would diminish over time.

Materials and Methods

We used data from the KPNC electronic health records (EHRs) to identify adult women, aged ≥18 years, who underwent a myomectomy for a benign uterine leiomyoma within KPNC hospitals between January 1, 2009, and December 31, 2019. Myomectomy cases were identified using the International Classification of Diseases, Ninth and Tenth Revisions, Clinical Modification (ICD-9-CM and ICD-10-CM) procedure codes and Current Procedural Terminology (CPT) code and ICD-9-CM and 10-CM principal discharge diagnosis codes. Patients were excluded if they had a documented history of previous hysterectomy or concomitant hysterectomy at the time of the myomectomy or had coded pregnancy-related diagnoses 30 days before and after myomectomy. Additional exclusion criteria included diagnosis of leiomyosarcoma or lack of active KPNC membership in the year before myomectomy and 30 days after myomectomy. The study investigators (E.Z., A.L., and A.O.) conducted a structured EHR review on a random sample of 2.6% of the yearly myomectomy cases to validate case selection and found an accuracy of 95.2% with an estimated margin of error of 0.041 (95% confidence interval [CI], 91.1–99.3). Oversight and approval to conduct this study with waiver of consent were approved by the Kaiser Foundation Research Institute's Institutional Review Board, and funding was supported by a grant from the KPNC Community Health Program (RNG210357).

Our primary outcomes of interest were incidence of myomectomy and surgical route of myomectomy over time; specifically, AM and MIM, including laparoscopic and robotic-assisted MIMs. Secondary outcomes included procedure-related complications identified using ICD-9-CM and 10-CM procedure and diagnosis codes and CPT codes. Complications were grouped into 3 categories: operative (eg, bladder, ureteral, intestinal, or vascular), medical (eg, venous thromboembolism, cardiovascular, pulmonary, or urinary or renal), and perioperative (eg, hemorrhage, blood transfusion, wound, gastrointestinal obstruction, or fistula). Exposure characteristics included race and ethnicity (Black vs non-Black) and fibroid weight in grams (as a proxy for fibroid size). Race and ethnicity is self-reported. "Black" is non-Hispanic or non-Latinx Black, "non-Black" includes Hispanic or Latinx of any race, non-Hispanic or non-Latinx Asian (including Pacific Islanders and Native Hawaiian), non-Hispanic or non-Latinx White, and non-Hispanic or non-Latinx other (including 158 more than 1 race, 19 American Indians or Alaskan Natives, and 71 unknowns, a total of 248). We initially compared all race and ethnicity groups when evaluating the proportion of MIM over time and found that Black women consistently had lower MIM (Supplemental Table 1). Given the effect of implicit bias, systemic racism, and societal constructs of race on health outcomes, we decided to compare Black women with non-Black women.

Patient demographic and clinical characteristics considered as additional potential confounders included age categories in years (18−34, 35−44, and ≥45), low-income residence (address of patient residence was in a census block with ≥20% households with income below the federal poverty level), parity (nulliparous, multiparous, or unknown), body mass index (BMI [calculated as weight (kg)/(height [m])^2]), medical comorbidities assessed using the Charlson Comorbidity Index score (a score of 1 or higher is considered increased health risk),[19] history of pelvic surgery (ie, cesarean delivery, adnexal surgery, or myomectomy), and region of the facility where myomectomy took place (hereafter termed "region"). In addition, surgical characteristics of the myomectomy included primary surgeon's route-specific myomectomy volume per surgical year (low, 1−10; medium, 11−20; and high, ≥21), year of myomectomy, operative time in minutes (time from start of skin incision to closure), postoperative length of hospital stay in hours (time exiting the operating room to time of discharge from hospital), any concomitant procedures (yes or no), and estimated blood loss (EBL) in milliliters. Parity and BMI values closest to the myomectomy and up to 1 year prior were used. Concomitant procedures included oophorectomy, salpingectomy, and other procedures because of conditions, such as fistula, incontinence, and prolapse. Fibroid weight and EBL were obtained from pathology reports and the operative notes using natural language processing (NLP) with a web-based text mining platform I2E (Linguamatics, Westborough, MA). The study investigators performed a medical record review to confirm fibroid weight and/or EBL that was not identified using NLP.

The annual incidence of myomectomies from 2009 to 2019 and 95% CI were estimated using total number of myomectomies as the numerator and number of women aged ≥18 years enrolled in the health plan for one or more months of the study year as the denominator. An unadjusted trend test on annual incidence of myomectomy was implemented by fitting a linear model using generalized estimating equations.[20] The test for the trend in the incidence of myomectomies over time was implemented by a standard z test for the null hypothesis that the slope of the linear model was equal to zero using the robust estimate of the standard error. The proportion of myomectomies done by surgical route was estimated for each study year, and Cochran-Armitage testing was used to assess for linear trend in the proportion of myomectomies by surgical route over time.

Descriptive statistics of patient demographic, clinical, and surgical characteristics and secondary outcomes were calculated and expressed as frequencies (proportions) or means (±standard deviation), as appropriate and compared between 2 groups (eg, Black and non-Black women) using chi-squared or Fisher exact tests for categorical variables and independent 2-sample t tests for continuous variables. Approximately 10% of our cohort were without fibroid weight data (pathology report only included dimension values). We reported 417 patients that had missing uterine weight. Of the remaining 90%, the median of the upper half of the fibroid weight in our cohort was 470.8 g; therefore, we created a categorical fibroid weight variable using 500 g as the threshold (≤500, >500, or unknown). Given the inconsistency in the documentation of low or high fibroid burden within the operative note or CPT coding, the decision was made not to use CPT codes to determine the uterine weight (note: uterine weight was missing for 417 patients), but rather to use an objective measure of fibroid weight gathered from mining the pathology reports. All values for fibroid weight were divided into quartiles. The mean uterine weight was 356 g, and the median uterine weight was 240 g. The upper quartile (the 75th percentile) was 470.8 g. We rounded this value to the nearest 100 g, leading to our threshold of 500 g. Before fitting the multivariable regression models, we calculated the crude rate of outcomes, MIM and complications (operative, medical, or perioperative), and performed unadjusted analyses using simple logistic regression to assess the association (expressed as RR and 95% CI) of each potential risk factor of interest with the outcome.

Multivariable logistic regression analysis was used to assess factors associated with MIM. Adjusted RR (aRR) and 95% CI were estimated controlling for race, fibroid weight, surgeon volume, year of myomectomy, age, low-income residence, parity, BMI, Charlson Comorbidity Index score, any previous pelvic surgery, and region. To test the hypothesis that the relationship between fibroid weight and having MIM is different for Black and non-Black women, multiplicative interaction terms with race and fibroid weight were included in the model. A marked interaction term means the effect of an independent variable on dependent variable changes, depending on the value of other independent variables; in this case, the effect of uterine weight on the risk of MIM would depend on race. Women with unknown fibroid weight were not included in this model. For each category of complications, 2 models were developed to estimate aRR (95% CI) of

TABLE 1
Minimally invasive myomectomy: number, incidence, and proportion by surgical route from 2009 to 2019

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total	*P* value
Myomectomy for benign uterine leiomyoma, n	168	287	330	365	349	359	396	413	456	452	458	4033	
Overall incidence (95% CI)[a]	0.12(0.12–0.13)	0.21(0.21–0.21)	0.24(0.24–0.24)	0.26(0.26–0.26)	0.24(0.24–0.25)	0.24(0.23–0.24)	0.25(0.24–0.25)	0.25(0.24–0.25)	0.26(0.26–0.26)	0.25(0.25–0.25)	0.25(0.24–0.25)	0.23(0.23–0.24)	<.001[b]
Route of myomectomy, n (%)													
Abdominal	158 (94.0)	233 (81.2)	245 (74.2)	212 (58.1)	128 (36.7)	124 (34.5)	132 (33.3)	102 (24.7)	91 (20.0)	67 (14.8)	48 (10.5)	1,540 (38.2)	<.001[c]
MIM	10 (6.0)	54 (18.8)	85 (25.8)	153 (41.9)	221 (63.3)	235 (65.5)	264 (66.7)	311 (75.3)	365 (80.0)	385 (85.2)	410 (89.5)	2,493 (61.8)	<.001[c]
Laparoscopic[d]	10 (6.0)	54 (18.8)	85 (25.8)	140 (38.4)	160 (45.8)	133 (37.0)	121 (30.6)	114 (27.6)	137 (30.0)	123 (27.2)	114 (24.9)	1,191 (29.5)	.40[c]
Robotic-assisted laparoscopic[d]	0	0	0	13 (3.6)	61 (17.5)	102 (28.4)	143 (36.1)	197 (47.7)	228 (50.0)	262 (58.0)	296 (64.6)	1,302 (32.3)	<.001[c]

CI, confidence interval; *MIM*, minimally invasive myomectomy.

[a] Myomectomy incidence per 1000 women; [b] Unadjusted trend test in annual incidence of myomectomy was performed using a linear model fitted using generalized estimating equations; [c] Linear trend in the proportion of myomectomy by surgical route was tested using Cochran-Armitage testing; [d] Denominator=yearly myomectomy for benign uterine leiomyoma.

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(1) AM compared with MIM in all myomectomy cases and (2) laparoscopic MIM compared with robotic-assisted MIM controlling for all risk factors included in the model for MIM, except the interaction terms. Risk factors included in the multivariable regression analyses were either statistically significant in the unadjusted analyses or considered clinically relevant according to the study investigators' clinical experiences.

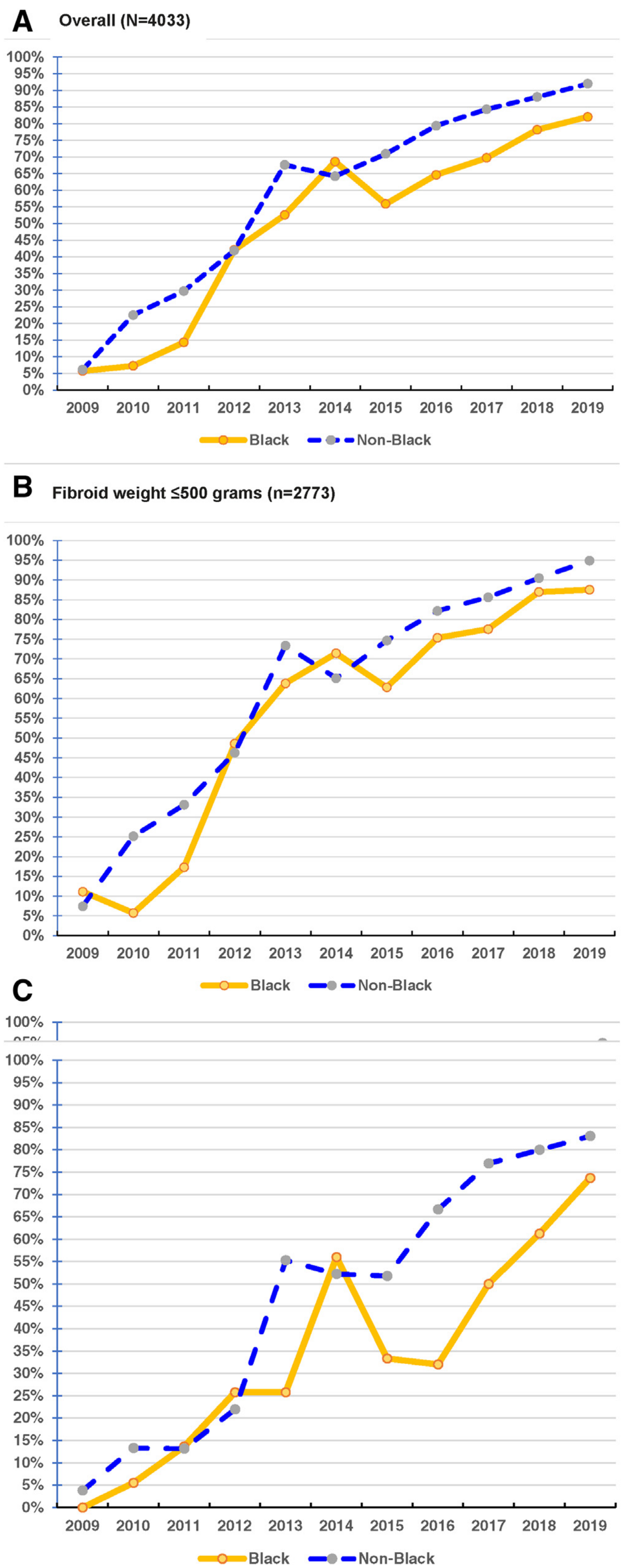
Trend tests were performed using Stata 14 (StataCorp, College Station, TX), and all other analyses were performed using SAS software (version 9.4; SAS Institute Inc, Cary, NC) with the threshold of significance set at 2-sided $P<.05$.

Results

Between 2009 and 2019, a total of 4033 adult women underwent a myomectomy. There was an overall increase in the myomectomy incidence from 0.12 (95% CI, 0.12–0.13) per 1000 women in 2009 to 0.25 (95% CI, 0.24–0.25) per 1000 women in 2019 ($P<.001$) (Table 1). During the 11-year study period, the proportion of MIM increased from 6% in 2009 to 89.5% in 2019, a 15-fold increase, whereas the proportion of AM declined from 94.0% to 10.5%. The proportion of laparoscopic MIM increased from 6.0% in 2009 to 24.9% in 2019, and the proportion of robotic-assisted MIM increased from 3.6% in 2012 to 64.6% in 2019 (Table 1).

The yearly crude proportions of MIM from 2009 to 2019 overall and by fibroid weight categories (≤500 g and >500 g) stratified by Black and non-Black women are illustrated in the Figure. In the full cohort (N=4033), the proportion of Black women who had MIM increased at a slower rate than non-Black women from 2009 to 2011; however, in 2012, the proportions were similar between these 2 race categories (Figure, A). The proportion of MIM for Black women increased at a similar rate to non-Black women from 2015 to 2019; however, the overall proportion of MIM in Black women remained lower than in non-Black women (54.5% vs 64.7%; $P<.001$). When the sample was limited to women with a fibroid weight of ≤500

FIGURE
Unadjusted trends of MIMs for Black and non-Black patients



Unadjusted trends of MIMs for Black and non-Black patients over time were estimated using the Poisson regression with log-link function by including a linear term for calendar year, a dichotomous race variable (Black vs non-Black), and an interaction term of race and year. **A,** Overall (N=4033) annual relative increase for Black and non-Black women were 1.16 (95% CI, 1.08–1.26; *P*<.001) and 1.14 (95% CI, 1.09–1.19; *P*<.001), respectively; however, the interaction term of race and year was not significant (*P*=.70), and the interaction between race and ethnicity and year was not significant (*P*=.98; data not shown). **B,** Fibroid weight of ≤500 g (n=2773). Annual relative increase for Black and non-Black women were 1.15 (95% CI, 1.07–1.23; *P*<.001) and 1.13 (95% CI, 1.08–1.17; *P*<.001), respectively; however, the interaction term of race and year was not significant (*P*=.66). **C,** Fibroid weight of >500 g (n=843). Annual relative increase for Black and non-Black women were 1.20 (95% CI, 1.10–1.32; *P*<.001) and 1.19 (95% CI, 1.13–1.26; *P*<.001), respectively; however, the interaction term of race and year was not significant (*P*=.87).

CI, confidence interval; *MIM*, minimally invasive myomectomy.

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g (2773 [68.8%]), the linear trends were similar to that of the full sample (Figure, B). In women with a fibroid weight of >500 g (843 [20.9%]), the proportion of MIM for Black and non-Black women were lower than those with smaller uterine weight (Figure, C).

Compared with their non-Black counterparts, Black women undergoing myomectomy were younger (36.4±5.6 vs 37.4±5.8 years; *P*<.001), had a higher mean fibroid weight (436.0±505.0 vs 324.7±346.1 g; *P*<.001) and mean BMI (30.8±7.3 vs 26.6±5.9 kg/m^2; *P*<.001), and represented a larger proportion of those residing in a lower-income area (19.6% vs 11.9%; *P*<.001), with a higher Charlson Comorbidity Index score (14.8% vs 9.8%; *P*<.001), and who had undergone a pelvic surgery before myomectomy (15.0% vs 11.6%; *P*=.003) (Table 2). Furthermore, Black women experienced significantly longer mean operative time (177.0±75.2 vs 154.4±67.4 minutes; *P*<.001), larger volume of blood loss from surgery (331.7±500.9 vs 213.6±388.0 mL;

TABLE 2
Demographic, clinical, and surgical characteristics and complications among adult patients who underwent a myomectomy between 2009 and 2019 according to race

Variable	Total (N=4033)	Non-Black (n=2909)	Black (n=1124)	P value[a]
Patient demographic characteristics				
Age (y)	37.1±5.8	37.4±5.8	36.4±5.6	<.001
Age group (y)				<.001
18–34	1280 (31.7)	872 (30.0)	408 (36.3)	
35–44	2404 (59.6)	1766 (60.7)	638 (56.8)	
≥45	271 (8.7)	271 (9.3)	78 (6.9)	
Low-income residence[b]	565 (14.0)	345 (11.9)	220 (19.6)	<.001
Patient clinical characteristics				
Fibroid weight (g)	355.8±400.0	324.7±346.1	436.0±505.0	<.001
Fibroid weight (g)[c]				<.001
≤500	2773 (76.7)	2057 (78.9)	716 (70.9)	
>500	843 (23.3)	549 (21.1)	294 (29.1)	
Parity[c]: nulliparous	2578 (72.2)	1862 (72.1)	716 (72.5)	.79
BMI (kg/m^2)	27.8±6.6	26.6±5.9	30.8±7.3	<.001
BMI (kg/m^2)				<.001
<25.0	1498 (37.1)	1277 (43.9)	221 (19.7)	
25.0–29.9	1238 (30.7)	895 (30.8)	343 (30.5)	
30.0–39.9	1072 (26.6)	639 (22.0)	433 (38.5)	
≥40.0	225 (5.6)	98 (3.4)	127 (11.3)	
Charlson Comorbidity Index score ≥1[c]	424 (11.2)	269 (9.8)	155 (14.8)	<.001
Prior pelvic surgery	507 (12.6)	338 (11.6)	169 (15.0)	.003
Surgical characteristics				
Minimally invasive myomectomy				<.001
Yes	2493 (61.8)	1881 (64.7)	612 (54.5)	<.001
Laparoscopic	1191 (47.8)	949 (50.5)	242 (39.5)	
Robotic-assisted laparoscopic	1302 (52.2)	932 (49.6)	370 (60.5)	
No (abdominal)	1540 (38.2)	1028 (35.3)	512 (45.6)	
Surgeon volume[d]				.15
Low	1875 (46.5)	1326 (45.6)	549 (48.8)	
Median	587 (14.6)	425 (14.6)	162 (14.4)	
High	1571 (39.0)	1158 (39.8)	413 (36.7)	
Operative time (min)[c]	160.7±70.4	154.4±67.4	177.0±75.2	<.001
Postoperative stay (h)[c]	17.7±3.7	15.4±20.7	23.6±29.0	<.001
Estimated blood loss (mL)[c]	247.0±426.3	213.6±388.0	331.7±500.9	<.001
Any concomitant procedures	82 (2.0)	59 (2.0)	23 (2.1)	.97

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P<.001), and longer postoperative hospital stay (23.6±29.0 vs 15.4±20.7 hours; P<.001) than non-Black women (Table 2).

The distribution of patient demographic, clinical, and surgical characteristics of the 3616 women with known fibroid weight was presented according to MIM status (Table 3). Fibroid weight (>500 vs ≤500 g), surgeon volume (medium vs low and high vs low), and year of myomectomy

TABLE 2
Demographic, clinical, and surgical characteristics and complications among adult patients who underwent a myomectomy between 2009 and 2019 according to race *(continued)*

Variable	Total (N=4033)	Non-Black (n=2909)	Black (n=1124)	*P* value[a]
Complications				
Operative complications[e]	44 (1.1)	31 (1.1)	13 (1.2)	.80
Bladder	7 (0.2)	5 (0.2)	2 (0.2)	>.999
Other	37 (0.9)	26 (0.9)	11 (1.0)	.80
Perioperative complications[f]	210 (5.2)	139 (4.8)	71 (6.3)	.049
Hemorrhage	29 (0.7)	20 (0.7)	9 (0.8)	.70
Blood transfusion	43 (1.1)	26 (0.9)	17 (1.5)	.09
Wound	100 (2.5)	67 (2.3)	33 (2.9)	.25
Gastrointestinal	8 (0.2)	3 (0.1)	5 (0.4)	.04
Other	40 (1.0)	30 (1.0)	10 (0.9)	.68
Medical complications	40 (1.0)	23 (0.8)	17 (1.5)	.04
Venous thromboembolism	2 (0.1)	2 (0.1)	0 (0)	>.999
Cardiovascular	20 (0.5)	12 (0.4)	8 (0.7)	.23
Pulmonary	17 (0.4)	6 (0.2)	11 (1.0)	.002
Urinary or renal	7 (0.2)	6 (0.2)	1 (0.1)	.68
Other	1 (0.02)	0 (0)	1 (0.1)	.28

Data are presented as mean±standard deviation or number (percentage), unless otherwise indicated.

[a] Overall comparisons between Black and non-Black tested using the chi-square or Fisher exact tests for categorical variables and independent 2-sample *t* tests for continuous variables; [b] Low-income residence, address of residence in a census block with ≥20% households with income below the federal poverty level; [c] Missing data: parity=463, Charlson Comorbidity Index score=245, fibroid weight=417 g, operative time=14 minutes, postoperative stay=16 hours, and estimated blood loss=222 mL; [d] Primary surgeon's route-specific volume per surgical year (low=1−10; medium=11−20; high=21 and higher); [e] No patient had ureteral, intestinal, or vascular injuries; [f] No patient had fistula complication.

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(2013−2015 vs 2009−2012 and 2016−2019 vs 2009−2012) were statistically marked factors in both unadjusted and adjusted models associated with having undergone a MIM (Table 3).

After controlling for other patient demographic, clinical, and surgical characteristics, Black women were less likely to undergo MIM than non-Black women (aRR, 0.65; 95% CI, 0.52−0.82; *P*<.001); women with a fibroid weight of >500 g were less likely to undergo MIM than those with a fibroid weight of ≤500 g (aRR, 0.40; 95% CI, 0.32−0.49; *P*<.001) (Table 3). Surgeon volume was associated with MIM, with MIM being 7 times more likely to be performed by high-volume surgeons (aRR, 6.63; 95% CI, 5.35−8.21; *P*<.001) than low-volume surgeons. Myomectomies performed in 2013−2015 and 2016−219 were more likely to be MIM than those in 2009−2012 (aRRs, 4.44 [95% CI, 3.53−5.59] and 12.58 [95% CI, 9.96−15.90], respectively; *P*<.001 for both). The interaction terms with fibroid weight and race were significant. Compared with our reference group (non-Black ≤500 g), Black women with a fibroid weight of ≤500 g had a lower RR undergoing an MIM (aRR, 0.74; 95% CI, 0.58−0.95; *P*=.02). Both Black and non-Black women with a fibroid weight of > 500 g had the lowest rates of MIM (aRR, 0.26 [95% CI, 0.18−0.36; *P*<.001] and 0.45 [95% CI, 0.35−0.58; P<001], respectively). Supplemental Table 2 provides all 6 possible race and fibroid weight interaction terms.

Complications associated with myomectomy were low during the 11-year study period. The proportion of women who experienced any operative complications was low in both Black and non-Black women (1.2% in Black women vs 1.1% in non-Black women; *P*=.80). Moreover, the proportion of any medical complication was low in both groups; however, the difference between groups was statistically significant (1.5% vs 0.8%; *P*=.04) (Table 2). A higher proportion of Black women experienced perioperative complications than non-Black women (6.3% vs 4.8%; *P*=.049). Patients who underwent an AM had a higher proportion of operative (1.6% vs 0.8%; *P*=.02) and medical complications (1.6% vs 0.6%; *P*=.002) than those who underwent an MIM (Table 4). After controlling for other factors, including race, age, fibroid weight, parity, low-income residence, BMI, surgeon volume, and year of myomectomy, the risk of complications was not significant for AM and MIM (aRR, 1.24 [95% CI, 0.59−2.61] and 1.13 [95% CI, 0.50−2.58], respectively); however, laparoscopic MIM had a significantly lower risk of experiencing any medical complications (aRR, 0.27; 95% CI, 0.09−0.83; *P*=.02) than robotic-assisted MIM (Table 4).

TABLE 3

Factors associated with minimally invasive myomectomy among adult patients with known fibroid weight from 2009 to 2019 (n=3616)

Factors	MIM, n (%)	Unadjusted RR (95% CI)	Unadjusted *P* value	Adjusted RR (95% CI)	Adjusted *P* value[a]
Primary exposure: Black race (reference=non-Black)	566 (56.0)	0.65 (0.56–0.75)	<.001	0.65 (0.52–0.82)	<.001
Secondary exposure: fibroid weight>500 g (reference=≤500)	404 (47.9)	0.43 (0.37–0.50)	<.001	0.40 (0.32–0.49)	<.001
Race × fibroid weight interaction (reference=non-Black × ≤500 g)					
Non-Black × fibroid weight of >500 g	289 (52.6)	NA	NA	0.45 (0.35–0.58)	<.001
Black × fibroid weight of ≤500 g	451 (63.0)	NA	NA	0.74 (0.58–0.95)	.02
Black × fibroid weight of >500 g	115 (39.1)	NA	NA	0.26 (0.18–0.36)	<.001
Patient demographic characteristics					
Age group (y) (reference=18–34)					
35–44	1385 (63.7)	1.04 (0.89–1.20)	.64	0.88 (0.72–1.08)	.21
≥45	180 (62.9)	1.00 (0.77–1.31)	.996	1.10 (0.77–1.57)	.60
Low-income residence[b] (reference=no)	317 (63.0)	0.98 (0.81–1.19)	.84	1.00 (0.77–1.31)	>.999
Patient clinical characteristics					
Parity (reference=multiparous)					
Nulliparous	1493 (63.4)	0.95 (0.81–1.12)	.51	0.77 (0.62–0.97)	.02
Unknown	244 (60.9)	0.85 (0.67–1.09)	.19	0.90 (0.65–1.25)	.52
Body mass index (kg/m^2) (reference=<25)					
25.0–29.9	703 (63.7)	0.96 (0.82–1.14)	.65	0.98 (0.78–1.22)	.85
30.0–39.9	606 (62.8)	0.92 (0.78–1.10)	.37	1.00 (0.79–1.27)	.99
≥40.0	113 (56.5)	0.71 (0.53–0.96)	.03	0.80 (0.52–1.21)	.29
Charlson Comorbidity Index score (reference=0)					
≥1	242 (66.5)	1.17 (0.93–1.47)	.19	1.15 (0.85–1.56)	.37
Unknown	139 (64.7)	1.08 (0.81–1.44)	.61	0.63 (0.42–0.94)	.02
Previous pelvic surgery (reference=no)	282 (64.2)	1.04 (0.85–1.28)	.70	0.94 (0.70–1.28)	.71
Surgical characteristics					
Surgeon volume[c] (reference=low)					
Medium	464 (85.9)	9.91 (7.62–12.88)	<.001	11.10 (8.15–15.11)	<.001
High	219 (82.6)	7.70 (6.51–9.11)	<.001	6.63 (5.35–8.21)	<.001
Year of myomectomy (reference=2009–2012)					
2013–2015	658 (65.0)	5.19 (4.27–6.31)	<.001	4.44 (3.53–5.59)	<.001
2016–2019	1390 (83.0)	13.62 (11.22–16.53)	<.001	12.58 (9.96–15.90)	<.001

Supplemental Table 2 provides all 6 possible race or fibroid weight interaction terms.

MIM, minimally invasive myomectomy; *NA*, not applicable; *RR*, relative risk.

[a] Unadjusted and adjusted RRs estimated using simple logistic regression and multivariable logistic regressions, respectively. Region of the facility where myomectomy took place was also included in the multivariable logistic regression (result not shown in the table); [b] Low-income residence, address of residence in a census block with ≥20% households with income below the federal poverty level; [c] Primary surgeon's route-specific volume per surgical year (low=1–10; medium=11–20; high=21 and higher).

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TABLE 4
Unadjusted and adjusted risk of complications among adult patients who underwent a myomectomy between 2009 and 2019

Complications	AM vs MIM			Laparoscopic MIM vs robotic-assisted MIM[a]		
	n (%), *P* value[b]	RR[c] (95% CI)	aRR[d] (95% CI)	n (%), *P* value[b]	RR[c] (95% CI)	aRR[d] (95% CI)
Operative	24 (1.6) vs 20 (0.8), *P*=.02	1.96 (1.08–3.56)[e]	1.24 (0.59–2.61)	11 (0.9) vs 9 (0.7), *P*=.52	1.33 (0.56–3.15)	0.44 (0.16–1.21)
Perioperative	91 (5.9) vs 119 (4.8), *P*=.11	1.25 (0.95–1.66)	1.13 (0.78–1.64)	57 (4.8) vs 62 (4.8), *P*=.98	1.01 (0.70–1.45)	0.79 (0.49–1.28)
Medical	25 (1.6) vs 15 (0.6), *P*=.002	2.73 (1.43–5.19)[f]	1.13 (0.50–2.58)	5 (0.4) vs 10 (0.8), *P*=.26	0.57 (0.20–1.61)	0.27 (0.09–0.83)[g]

AM, abdominal myomectomy; *aRR*, adjusted relative risk; *CI*, confidence interval; *MIM*, minimally invasive myomectomy; *RR*, relative risk.

[a] Sample limited to minimally invasive myomectomies; [b] Comparisons of proportions tested using chi-square tests; [c] Unadjusted RR estimated using the simple logistic regression; [d] Adjusted RR (95% CI) estimated using the logistic regression analysis controlling for race, age, fibroid weight, parity, low-income residence, body mass index, Charlson Comorbidity Index score, surgeon volume, year of myomectomy, and region of the facility where myomectomy took place; [e] *P*=.03; [f] *P*=.002; [g] *P*=.02.

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Comment

We described dramatic changes in the rates of MIM for uterine leiomyomas within an integrated healthcare system during the 11-year study period from 2009 to 2019. There was a marked ncrease in MIM; in 2019, 89.5% of myomectomies were performed by minimally invasive surgical routes with very low complication rates. The myomectomies performed through minimally invasive surgical routes within KPNC were greater than those reported using national databases,[21] which may reflect the impact of quality initiatives aimed at changing the surgeon pool. Laparoscopic surgery was becoming more widespread during the study period; it is possible that the changes were a result of overall trends of increasing minimally invasive surgery; however, as being a high-volume surgeon was the factor with the largest magnitude of association with MIM, this may be a contributing factor.

Although the proportions of MIM increased at a similar rate for Black and non-Black women, Black women remained less likely than their non-Black counterparts to receive MIM. Black women undergoing myomectomies experienced longer operating times, longer postoperative hospitalizations, and larger EBL than non-Black women, suggesting that myomectomy cases for Black women may be surgically more challenging. In our analysis, there was a marked interaction between race and fibroid weight, which suggested that factors other than race and fibroid size, which we could not abstract from structured EHR data, may influence decisions about surgical route. Factors, such as number and position of fibroids, which were not measured, may influence decisions about the approach and difficulty of surgery. Multiple studies have shown that Black women are more likely to have larger uteri and faster growing and more numerous fibroids.[22–25] Our findings of increased morbidity for Black women were consistent with the racial disparities that have been reported by others. In 1 retrospective cohort inpatient study by Stentz et al,[26] compared with non-Hispanic White women, Black and Hispanic women were twice as likely and Asian Americans more than twice as likely to undergo AM. In a survey of inpatient myomectomies, Black women had increased surgical morbidity after both AM and laparoscopic MIM, even after controlling for BMI and myoma burden. These findings were further supported by Matsushita et al[27] who found that even after adjusting for fibroid burden, age, and BMI, Black women were more likely to undergo AM.

In our study, we did not observe a statistically marked difference in surgical morbidity for Black women. Year of surgery and the surgical volume had the greatest magnitude of association with MIM. Comparable and low morbidity associated with MIM may be secondary to the increase in high-volume surgeon's proficiency. Previous studies have demonstrated the challenges of MIM and the associated learning curve for surgeons.[28–31]

Strengths and limitations

This study's strengths included a large sample size and the use of comprehensive EHRs, including over a decade of data, fibroid weight, and allowing for evaluation of rare surgical outcomes. However, there were several limitations of our study. Because of the retrospective nature of our study, we could only document trends and associations; we could not infer causation for changes in practice over time. We used fibroid weight, as recorded on pathology records, as a proxy for fibroid burden. However, additional fibroid characteristics, such as the number, location, or largest diameter of fibroid, can also be meaningful and impact a surgeon's decision regarding the route of myomectomy. These factors may impact the differences observed in patient characteristics such that women with greater quantity of fibroids may be more likely to undergo AM. This study did not take into account healthcare costs given that our single-payer system does not necessarily provide a reproducible study environment. Finally, despite efforts to control for all measured confounding factors within multivariable models, it is possible that other unmeasured individual- or provider-level factors, including systemic racism and implicit biases, affected the observed outcomes.

Conclusion

In summary, although the rate of MIM successfully increased for all patients during the 11-year study period, racial differences persisted. Black women continued to have lower rates than their non-Black counterparts. Race and fibroid size alone did not explain the differences in MIM rates. Continued efforts to understand determinants of MIM, including fibroid characteristics, may help close this racial gap in MIM; however, residual differences may remain because of differences in fibroid burden. ■

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Appendix

SUPPLEMENTAL TABLE 1

Rates of minimally invasive myomectomy by race and ethnicity according to study year

Year	Non-Hispanic White			Hispanic			Black			Asian or Pacific Islander			Other		
	Total, N	MIM, n	MIM, %	Total, N	MIM, n	MIM, %	Total, N	MIM, n	MIM, %	Total, N	MIM, n	MIM, %	Total, N	MIM, n	MIM, %
2009	40	1	2.50	28	2	7.14	53	3	5.66	38	3	7.89	9	1	11.11
2010	96	23	23.96	48	7	14.58	69	5	7.25	58	16	27.59	16	3	18.75
2011	88	32	36.36	50	11	22.00	84	12	14.29	81	22	27.16	27	8	29.63
2012	87	38	43.68	64	24	37.50	119	50	42.02	67	28	41.79	28	13	46.43
2013	81	56	69.14	71	50	70.42	99	52	52.53	76	51	67.11	22	12	54.55
2014	93	57	61.29	62	44	70.97	105	72	68.57	71	45	63.38	28	17	60.71
2015	103	75	72.82	72	52	72.22	111	62	55.86	93	65	69.89	17	10	58.82
2016	118	94	79.66	70	50	71.43	113	73	64.60	86	73	84.88	26	21	58.82
2017	100	83	83.00	90	78	86.67	132	92	69.70	116	97	83.62	18	15	58.82
2018	116	103	88.79	75	63	84.00	128	100	78.13	104	97	93.27	29	22	58.82
2019	105	94	89.52	84	79	94.05	111	91	81.98	130	121	93.08	28	25	89.29
Total	1027	656	63.88	714	460	64.43	1124	612	54.45	920	618	67.17	248	147	59.27

MIM, minimally invasive myomectomy.

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SUPPLEMENTAL TABLE 2

Interaction between race and fibroid weight: all 6 possible pairs

Group 1	Group 2	Odds ratio (95% CI)(group 1 vs group 2)	*P* value
Non-Black, ≥501 g fibroid weight	Non-Black, ≤500 g fibroid weight	0.45 (0.35–0.58)	<.001
Black, ≤500 g fibroid weight	Non-Black, ≤500 g fibroid weight	0.74 (0.58–0.95)	.02
Black, ≥501 g fibroid weight	Non-Black, ≤500 g fibroid weight	0.26 (0.18–0.36)	<.001
Black, ≤500 g fibroid weight	Non-Black, ≥501 g fibroid weight	1.65 (1.21–2.24)	.002
Black, ≥501 g fibroid weight	Non-Black, ≥501 g fibroid weight	0.57 (0.39–0.83)	.003
Black, ≥501 g fibroid weight	Black, ≤500 g fibroid weight	0.35 (0.24–0.50)	<.001

CI, confidence interval.

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