



# Robotic parastomal hernia repair: A single-center cohort study

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## Abstract

Parastomal hernia is a common occurrence following stoma construction, necessitating surgical intervention in symptomatic cases. This study presents a comprehensive analysis of Robotic-Assisted Parastomal Hernia Repair (r-PSHR), utilizing the Da Vinci Xi™ Surgical System. Retrospective analysis was conducted on patients undergoing r-PSHR at a high-volume center. Surgical variables, complications, and recurrence rates were assessed. The primary technique involved a modified Sugarbaker intraperitoneal onlay mesh. Eighty-six patients underwent r-PSHR, predominantly females (59.3%), with mean age 60.8 years. Mean BMI was 31.0. Most patients were classified as ASA 2 (31.4%) or ASA 3 (65.1), with 64.6% having no prior PSH repair. Index procedures primarily involved laparoscopic colonic resections (27.8%) and open abdominoperineal resections (27.8%). Parastomal hernias were mainly associated with end ileostomy (50%) and end colostomy (47.7%). A hybrid modification was required in 22.1% of cases, with only one conversion to open repair. Mean operative time was 257 min. Thirty-day morbidity was 40.7% and includes ileus (24.4%), deep surgical-site infections (7.0%), acute kidney injury (5.8%), and sepsis (5.8%). Grade IIIB complications occurred in 5.8% of cases. Thirty-day readmissions were observed in 19.8% of cases. There were five cases (5.8%) of recurrence within 15 months post-surgery. This study highlights the effectiveness of r-PSHR in managing parastomal hernia. R-PSHR shows promising outcomes with an acceptable post-operative occurrence profile and a favorable recurrence rate.

**Keywords** Robotic · Parastomal hernia repair · Robotic Sugarbaker · Modified Sugarbaker

## Introduction

Parastomal hernia (PSH) consists of the herniation of the abdominal content through an incision used for stoma formation [1]. The incidence can range from 0 to 48% varying on the type of stoma, being more common in colostomies [2, 3], with most PSH appearing within 2 years from stoma construction [2]. The majority of PSH are asymptomatic and can be managed non-operatively, but when poor appliance

function, skin breakdown, pain, incarceration, or obstruction occurs, surgical repair is recommended [4].

Multiple approaches to PSH repair are described in the literature with varying success rates [5]. Primary repair is associated with nearly 100% recurrence and should be avoided [6]. Relocation of the stoma is an option but is associated with a similar risk of PSH development as the index operation [7]. Similar to abdominal wall hernia repair literature, numerous studies have demonstrated that PSH repair with prosthetic mesh reduces recurrent hernia with an acceptable complication profile and offers the most durable repair option [8]. PSH repairs using mesh, either synthetic or biologic, placed as an on-lay, within the abdominal wall, or as intra-peritoneal sublay have been described [9]. One of the intra-peritoneal sublay approaches with the lowest recurrence rate is the Sugarbaker repair. First described by Paul Sugarbaker in 1985, the repair involved first reducing the hernia content during laparotomy [10]. The stoma bowel loop is lateralized to the trephine edge, and both the trephine/hernia defect and the stoma bowel loop are covered with an

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intraperitoneal mesh. The mesh is sutured to the trephine/hernia defect edge. In the original description, the trephine/hernia defect opening was not closed, and the mesh did not significantly overlap onto the abdominal wall. Later modifications of the procedure include closure of the defect with more extensive lateralization of the stoma bowel loop and at least 5 or more cm of mesh overlap around the newly narrowed trephine and lateralized stoma loop of bowel. With the advent of laparoscopy, the Sugarbaker approach was adapted to a less-invasive approach while maintaining a low recurrence rate and was associated with reduced wound morbidity and a lower length of stay (LOS) as compared to open surgery [11]. However, traditional laparoscopic PSH repairs are technically more challenging than other abdominal wall hernia repairs because the stoma limb can interfere with and limit access to the abdominal wall. The introduction of robotic-assisted laparoscopic surgery addressed a number of the challenges associated with laparoscopically PSH repair, such as the limited degrees of freedom of straight instruments, two-dimensional optic and the poor ergonomics [12].

While robotic surgery for ventral wall hernia has expanded rapidly, there is a limited number of reports of robotic-PSH repairs (r-PSHR). These reports are small case series with limited follow-ups. Herein, we report a large series of r-PSHR from a high-volume center with 30-day postoperative outcomes and short-term follow-up.

## Methods

Data on all consecutive patients older than 18 years who underwent an r-PSHR procedure at the Mayo Clinic, Rochester, MN, between January 1, 2021 and July 7, 2023 were retrospectively extracted from a prospectively maintained database on robotic-assisted procedures. The following variables were collected: characteristics of patients [age, sex, body mass index (BMI), ostomy type, European hernia society classification grade based on preoperative CT scan [13], intraoperative characteristics [type of procedure, operating time, type of mesh used, estimated blood loss (EBL), conversion rate, additional hernia repair], postoperative data [complications, length of stay (LOS), 30-day morbidity, 30-day readmission, 30-day reoperation, follow-up, recurrence]. Endpoints of this study were early recurrence rate, complication rate, length of stay, conversion rate, 30-day readmission, and 30-day reoperation. Only descriptive statistics were used. The robotic Da Vinci® Xi Surgical System (Intuitive Surgical, Sunnyvale, California, USA) was used in all the procedures.

Categorical variables were reported as numbers and percentages, while continuous variables were reported as means and standard deviations.

The robotic modified Sugarbaker intraperitoneal on-lay mesh (IPOM) technique, as described by Ayuso et al. [14] in the literature and expanded upon in an article by Ferrari & Violante [15], was utilized in all procedures. Three robotic ports are strategically placed on the contralateral side from the stoma. In certain cases, where reducing the hernia proved challenging using the robotic platform, a “hybrid” modification is employed, necessitating making a small peristomal skin incision into the hernia sac lateral to the where the stoma appliance would be located [16]. This modification step is crucial in some cases to safely reduce the hernia content effectively before closing the fascial defect especially in larger PSH. Robotically, after lowering the intra-abdominal pressure to 8 mmHg, the hernia defect is closed with a running non-absorbable 0 barbed suture. In cases where a hybrid approach is required, the defect is closed using permanent suture through the incision made into the hernia sac, which is not removed. It is important to avoid excessive narrowing of the fascial defect, as this could potentially cause stomal outflow obstruction or ischemia. If there is a midline hernia defect that requires repair, it is closed robotically with a running permanent 0 barbed sutures. Following the closure of the defect, the stoma bowel limb is robotically lateralized to the abdominal wall peritoneum, for a length of 10–12 cm, with running non-absorbable 2–0 barbed suture. The mesenteric edge at the interface with the bowel serosa is carefully secured to the peritoneum on both sides of the stoma bowel limb. This lateralization with the mesentery facing medially allows a large panel of composite mesh to be secured to the abdominal wall without concern for the stoma limb of bowel serosa contacting the mesh. The stoma limb bowel serosa has only contact with the anterior abdominal wall peritoneum. These running sutures cannot be too tight as they potentially can compress the limb against the abdominal wall resulting in an obstruction. If the stoma limb bowel mesentery is not facing medially to allow appropriate lateralization, the stoma is disconnected at the skin level and the bowel is then oriented appropriately to perform the lateralization. The stoma is then re-matured in the standard manner with absorbable sutures at the mucocutaneous junction. Once the bowel is lateralized, a large piece of composite mesh is secured over the entire lateralized bowel limb, with a mesh overlap of 7–8 cm from the stoma trephine or edge of the any defect closure line. When midline hernia defects are being addressed concurrently, a single sheet of mesh is used for the PSH and midline hernia repair. The mesh is secured to the abdominal wall along the entire circumference with permanent running 0 barbed suture. Across the mesh-lateralized bowel mesentery interface, a running permanent 2–0 barbed suture is used. This mesentery suture line has very superficial mesentery to mesh bites with minimal travel between bites. The interior aspect of the mesh is secured to the abdominal wall with absorbable laparoscopic tacks to

ensure rapid mesh incorporation of the large side panels of mesh into the abdominal wall. All patients in this series had barrier coated medium-pore mesh used. The protective barrier was always applied outward toward the abdominal contents while the uncoated side was applied against the lateralized stoma limb mesentery and abdominal wall. The mesh selected was based upon institutional contract availability.

Patients were evaluated clinically 3, 6, and 12 months after surgery in the first year, and then once a year either in person or via telemedicine. If recurrence was suspected on clinical examination, or if patients reported symptoms of recurrence, a CT scan was performed to confirm the recurrence. In case it was confirmed, further surgical options or non-operative management was discussed with the patient.

### Statistical methods

Categorical variables were reported as frequencies with percentages (%), and quantitative variables were expressed as mean  $\pm$  standard deviation (SD). Kaplan–Meier analysis was performed to evaluate the recurrence rate in the 2 years following surgery. All the statistical calculations were made using Stata 17 SE (StataCorp LLC, Texas, USA).

### Ethical statement

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement guidelines for reporting observational studies, and the methodological quality and synthesis of case series guide [17, 18].

The study received approval from the Institutional Review Board (ID 23–005902) in compliance with The Code of Ethics of the World Medical Association, specifically following the principles outlined in the Declaration of Helsinki, which govern experiments involving human participants. Informed consent was obtained from all human subjects involved in the experimentation, ensuring the protection of their privacy rights throughout the study.

### Results

Eighty-six patients underwent r-PSHR, with the majority being female (59.3%) (Table 1). The mean age at surgery was  $60.8 \pm 13.3$  years, with a mean BMI of  $31.0 \pm 6.3$ . Most of the patients were ASA 2 (31.4%) or ASA 3 (65.1%). Most patients (64.6%) had never had a PSH repair while 36.0% had at least one prior repair.

Table 2 provides the comprehensive list of underlying diseases, with the three most common being colorectal cancer (34.9%), ulcerative colitis (25.6%), and Crohn's disease (17.5%).

**Table 1** Patients' characteristics and surgical data

Gender	
Female	51 (59.3)
Male	35 (40.7)
Age (years), mean $\pm$ SD	$60.8 \pm 13.3$
Body mass index (Kg/m <sup>2</sup> ), mean $\pm$ SD	$31.0 \pm 6.3$
ASA	
1	1 (1.16)
2	27 (31.4)
3	56 (65.1)
4	2 (2.3)
Number of previous repairs	
0	53 (61.6)
1	31 (36.0)
2	1 (1.2)
3	1 (1.2)
EHS classification	
I	36 (41.9)
II	15 (17.5)
III	21 (24.4)
IV	14 (16.2)
Ostomy type	
End colostomy	41 (47.7)
Loop-end ileostomy	2 (2.3)
End ileostomy	43 (50)
Hybrid modality	19 (22.1)
Operative time (minutes), mean $\pm$ SD	$257 \pm 72.9$
Estimated blood loss (ml), mean $\pm$ SD	$45.8 \pm 52.4$
Intraoperative fluids (ml), mean $\pm$ SD	$2371.3 \pm 720.8$
Additional hernia repair	29 (33.7)
Conversion	1 (1.2)
Length of stay (days), mean $\pm$ SD	$4.9 \pm 3.8$
30-day morbidity	35 (40.7)
Ileus	21 (24.4)
Urinary retention	4 (4.6)
Urinary tract infection	1 (1.2)
Anemia requiring transfusion	2 (2.3)
Deep surgical-site infection	6 (7.0)
Perforation	3 (3.5)
Pneumonia	2 (2.3)
Acute kidney injury	5 (5.8)
Small bowel obstruction	1 (1.2)
Sepsis	5 (5.8)
30-day readmission	17 (19.8)
30-day reoperation	5 (5.8)
30-day recurrence	1 (1.2)
Follow-up (months), mean $\pm$ SD	$15.0 \pm 7.4$

**Table 2** Underlying disease

Colorectal cancer	0 (34.9)
Ulcerative Colitis	22 (25.6)
Crohn's disease	15 (17.5)
Diverticulitis	6 (7.0)
Inertia coli	5 (5.8)
Recurrent rectal prolapse	3 (3.5)
Obstructive defecation syndrome	2 (2.3)
Fecal incontinene	2 (2.3)
Iatrogenic bowel perforation	1 (1.2)

**Table 3** Index Surgery

Robotic colonic resection	5 (5.8)
Robotic abdominoperineal resection	2 (2.3)
Laparoscopic colonic resection	24 (27.8)
Laparoscopic abdominoperineal resection	2 (2.3)
Hand-assisted colonic resection	5 (5.8)
Open colonic resection	24 (27.8)
Abdominoperineal resection	24 (27.8)

Table 3 displays the complete list of index surgeries, where the most common procedures included laparoscopic colonic resections (27.8%), open colonic resections (27.8%), and open abdominoperineal resections (27.8%).

Parastomal hernias were classified using the European Hernia Society (EHS) classification based upon preoperative CT scan, with the majority falling into class I (41.9%) and class III (24.4%). Most of the hernias in this series were associated with an end ileostomy (50%), followed by an end colostomy (47.7%) and end-loop ileostomy (2.3%).

A hybrid modification with lateral peristomal incision into the hernia sac was required for full reduction of the hernia content in 22.1% of the cases. The mean operative time was  $257 \pm 72.9$  min, with an estimated blood loss of  $45.8 \pm 52.4$  ml and a mean intraoperative fluid administration of  $2371.3 \pm 720.8$  ml. Only one conversion to laparotomy (1.2%) was necessary. An additional ventral hernia repair was performed in 33.7% of cases. The complete list with the types of macroporous mesh used during the procedures is reported in Table 4: different types of mesh were used during the study period, based upon institutional contract availability, but our preference is Parietene™ DS Composite Mesh (Medtronic, Minneapolis, MN, USA), which has an anti-adhesive barrier that remains for up to 6 months reduces bowel adhesions to the mesh.

The mean length of hospital stay was  $4.9 \pm 3.8$  days, with a reported 30-day morbidity of 40.7%, with ileus being the most common complication (24.4%), followed by deep surgical-site infection (7.0%), acute kidney injury (5.8%), and

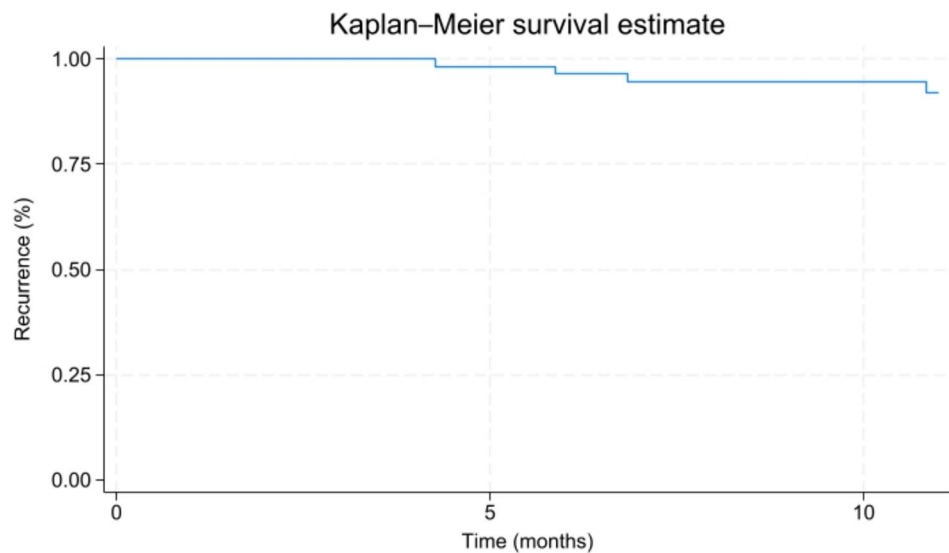
**Table 4** Mesh used

Parietene	
15×10	1 (1.2)
20×15	13 (15.1)
25×20	20 (23.3)
PHS HERN POLY 4 6	1 (1.2)
Symbotex	
15×10	5 (5.8)
15×15	2 (2.3)
15×20	19 (22.1)
17×10	3 (3.5)
19×18	1 (1.2)
20×12	9 (10.5)
20×25	5 (5.8)
20×30	4 (4.7)
Ventralight 20×15	1 (1.2)
Ventralight ST circular 11	1 (1.2)
Ventralight ST circular 15	1 (1.2)

sepsis (5.8%). There were five complications (5.8%) of grade IIIB according to the Clavien–Dindo classification, including three perforations and two cases of small bowel obstruction (SBO) which required operative intervention within the 30 days postoperative timeframe. The thirty-day readmission rate was 19.8% (17 cases).

One patient underwent exploratory laparoscopy on POD 4 for acute abdomen, and a perforation of a peptic ulcer at the gastroduodenal junction was found and closed with a Graham patch. Another patient with multiple recurrence of parastomal hernia was re-operated on POD 2 for peritonitis secondary to a small bowel enterotomy. The patient underwent laparotomy, mesh removal, abdominal washout, resection of the perforated tract of the small bowel and anastomosis. Two patients were operated for SBO: one underwent exploratory laparoscopy, and a single loop of small bowel was found to be incarcerated behind a small portion of the outer edge of the mesh. The obstructed portion of the bowel was released, and laparoscopic tacks were placed for reinforcement of the mesh. No resection was necessary, and the patient has not experienced recurrence. Another patient was taken to the OR for a bowel obstruction on POD 9 after a CT scan demonstrated an obstruction of small bowel within one of the 8 mm robotic trocar sites. This was repaired with a local exploration at the trocar site. The patient was subsequently discharged on POD 11 with regular bowel function. Lastly, one patient was readmitted on POD 20 for feculent peritonitis due to a perforation in the lateralized segment of colon. The patient underwent emergency laparotomy, mesh removal, large bowel resection, and multiple abdominal washouts, before construction of an end transverse colostomy.

**Fig. 1** Kaplan–Meier analysis for parastomal hernia recurrence after r-PSHR



The mean follow-up in this series was  $15.0 \pm 7.4$  months. Kaplan–Meier analysis for recurrence is presented in Fig. 1, which shows a recurrence rate of 5.8% at 12 months after r-PSHR.

## Discussion

Herein, we present a large series of robotic Sugarbaker parastomal hernia repairs. Our experience using exclusively a robotic modified Sugarbaker IPOM technique demonstrates that it is a safe approach with reasonable short-term outcomes and a low recurrence rate at 15 months of follow-up.

Although the use of the robotic platform has become commonplace in abdominal wall hernia surgery, there is a notable gap in the literature regarding r-PSHR. Most available articles are limited to small case series, addressing various ostomy types including ileal-conduits [19–22]. The largest previously reported series of robotic Sugarbaker PSH repair included 15 patients with a mean age of  $64.9 \pm 9.3$  years, BMI of  $30.1 \pm 4.7$  kg/m<sup>2</sup>. The majority of hernias were associated with ileostomies (40%), reported mean operative time was  $182.0 \pm 51.9$  min, LOS was  $4.2 \pm 1.9$  days, with an overall complication rate of 13.4% and a recurrence of 6.7%, with a mean follow-up time of  $14.2 \pm 9.4$  months [14]. Due to the significant disparity in numbers between the two cohorts, conducting a meaningful comparison proves challenging. Nevertheless, what we can confirm is that even with a longer follow-up period, the recurrence rate with the robotic Sugarbaker repair approach remains relatively consistent, showing minimal variation between 1 and 2 years.

Before the robotic era, the Sugarbaker technique was widely used first in an open fashion as described by its inventor and second with the laparoscopic approach.

Stelzner et al. [23], in a retrospective study which included 20 patients with paracolostomy hernias who underwent open modified Sugarbaker, reported a mean operating time of 200 min, with a median size of the mesh used of  $20 \times 30$  cm. The postoperative complication rate was not reported, but the authors described two major complications (1 reoperation for a bowel obstruction and a pulmonary embolism) and minor postoperative complications, such as prolonged postoperative bowel paralysis, gastritis, pain at the site of the traction sutures, and a wound seroma which required surgical drain. During a mean follow-up of 3 years, a recurrence rate of 15% was observed. Since the complication rates were not explicitly stated, from the comparison with the results of this open series, it can be inferred that the r-PSHR should offer similar if not superior outcomes in terms of recurrence rates.

One of the largest series of laparoscopic Sugarbaker procedures originated from a Finnish nationwide study [24] that involved 68 patients. The mean age of these patients was  $68.4 \pm 10.6$  years, with a majority being female (53.8%), and the most common stoma type was colostomy (78%). The average operative time was  $132.4 \pm 70.6$  min, and the mean blood loss during surgery was  $64.2 \pm 105.5$  ml. Only 14.3% of the patients required additional hernia surgery. The mean hospital stay for these patients was  $6.9 \pm 7.1$  days, with a reoperation rate of 20.6%. Furthermore, there was a 30-day complication rate of 47.1%. A recurrence rate of 21.5% was observed after a mean follow-up of 39.0 months. Interestingly, the 30-day morbidity rate in this case closely resembled the outcomes observed in our robotic cohort (40.7%) although this could be even higher considering the relatively long LOS that could be explained by a non-reported presence of ileus. In fact, it is worth noting that in this Finnish study, there were no reported cases of ileus. However,



a relatively high incidence of surgical-site infections was observed, affecting 26.5% of the patients. It is also important to highlight again the excellent results in terms of recurrence of the r-PSHR especially if we consider the high prevalence of IBDs in this robotic series. A systematic review [25] reported that patients affected by either ulcerative colitis or Crohn's disease have an increased risk of recurrence after hernia repair surgery as high as 27% in a follow-up with a mean duration of 36 months. If we further analyze the complications observed in this robotic series, there are some observations that are worth mentioning. Although the relatively high morbidity rate (40.7%), it is important to highlight that our population included a larger number of patients with a higher ASA score, and a high rate of patients with IBDs. Furthermore, we must highlight that most of the complications were mild and short lived, with ileus representing the most common.

In a recent systematic review and meta-analysis focusing on PSH repair, incorporating data from 10 studies, and involving 347 patients who underwent a Sugarbaker procedure, a 6.4% incidence of surgical-site infections and 3.1% bowel obstructions rate were reported [26]. A similar systematic review and meta-analysis by Mazzola et al., comprising 327 patients who underwent Sugarbaker repair, reported a rate of 2.8% for stoma outlet obstruction, 3.4% for mesh infection, and 2.7% for bleeding [27]. In a recent series of 61 consecutive laparoscopic Sugarbaker repairs, the most common complications were stomal outlet obstructions (4.9%), bowel perforations (4.9%), stoma-cutaneous fistula (1.6%), pneumonia (3.3%), pulmonary insufficiency (3.3%) and urinary tract infection (1.6%) [28]. Surprisingly, none of these publications reported any cases of ileus, which is in absolute contrast to our robotic series where ileus emerged as the most common complication, in 24.4% of the patients. In the authors' opinion, postoperative ileus could be mainly related to manipulation and lateralization of the stoma limb, and its relative initial constriction related to the mesh, regardless of the approach. It also could be that what we label "ileus" could represent a transient functional obstruction at the level of the repair. Thus, we believe that the complete absence of ileus among postoperative complications in previous series could be mainly related to underreporting or heterogeneity in definition [29, 30]. Apart from the low recurrence rate, the robotic platform has several advantages compared to traditional laparoscopy, such as high-resolution 3-D imaging, better ergonomics, and wristed instruments with tremor filtering that can enhance surgical precision [31–33].

An important point to note is that most studies on parastomal hernia repair and hernia repair in general are subject to several limitations that may impact the outcomes. Hernia surgery is characterized by arguably the highest level of heterogeneity, with numerous variables that can vary from one study to another. These variables include the type and size

of hernias, variations in patient characteristics, anatomical differences, surgical approaches and techniques, as well as variations in the types of mesh used [34]. Moreover, patient outcomes following parastomal hernias remain understudied, or are limited to the immediate post-operative period [5]. Taken together, these factors present a significant challenge when it comes to comparing the results of different studies and may not fully reflect reality.

The cost of robotic surgery is currently a prominent concern in the literature. While cost data for r-PSHR is not yet available, our institution firmly believes in this innovative surgical approach and predicts it will surpass laparoscopy in the near future [35]. Further research is needed to assess the cost-effectiveness of r-PSHR, which we will address in future publications. However, we anticipate the overall cost of robotic surgery to decline rapidly as new platforms enter the market, potentially making r-PSHR more accessible [36].

The present study aimed to present a large cohort of patients who underwent a standardized r-PSHR approach. The study aims to offer insights to address some unanswered questions surrounding the optimal surgical management of parastomal hernia. The authors acknowledge that most of these limitations are relevant to the current study. It is important also to highlight that the study has a retrospective design and involves two surgeons performing the procedures under investigation. Moreover, the study was conducted at a tertiary referral center, which might affect its applicability to a more diverse population.

## Conclusion

The robotic modified Sugarbaker IPOM is a safe procedure with reasonable short-term outcomes. Further high-quality studies are needed to fully elucidate the long-term clinical outcomes of this procedure and possible advantages compared to other approaches.

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**Data availability** N/A.

## Declarations

**Conflict of interest** The authors declare no conflict of interest.

**Ethical approval** Institutional Review Board approved this study.

**Patient consent statement** All patients signed Minnesota Research Authorization form.

**Research involving human participants and/or animals** Ethical approval was waived by the local IRB in view of the retrospective

nature of the study and all the procedures being performed were part of the routine care.

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