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Research Article

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Surgical Management of Hirschsprung's Disease: Comparative Outcomes of Open Versus Minimally Invasive Approaches

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ABSTRACT

Background: Hirschsprung's disease causes functional intestinal obstruction due to congenital a ganglionosis. Surgical resection remains definitive therapy, yet debate persists regarding optimal outcomes of open versus minimally invasive approaches. ***Objective:*** This study aims to compare perioperative and long-term functional outcomes between open pull-through and minimally invasive procedures for Hirschsprung's disease, emphasizing complication rates, bowel function, and quality-of-life indicators. ***Methods:*** A prospective comparative study was conducted in the Department of Pediatric Surgery, Rajshahi Medical College, Bangladesh, from January 2023 to June 2024. A total of 126 patients diagnosed with Hirschsprung's disease were randomized into open (n=64) and minimally invasive (n=62) groups. Clinical, perioperative, and functional outcome data were analyzed using descriptive statistics, standard deviations, and chi-square tests. ***Results:*** Mean operative time was significantly shorter in the minimally invasive group (95.3±14.2 minutes) compared to open surgery (128.7±16.9 minutes; p<0.001). Postoperative hospital stay averaged 5.1±1.4 days versus 8.4±2.1 days (p<0.01). Early postoperative complications occurred in 14.5% (9/62) of minimally invasive cases versus 26.5% (17/64) of open (p=0.04). Incidence of Hirschsprung-associated enterocolitis was lower in minimally invasive patients (12.9%) compared to open (23.4%), though not statistically significant (p=0.08). At 12-month follow-up, satisfactory bowel function was achieved in 85.4% (53/62) of minimally invasive versus 71.9% (46/64) of open cases (p=0.03). Overall mortality was 1.6% (2/126). ***Conclusion:*** Minimally invasive surgery demonstrates superior short-term recovery, fewer complications, and improved bowel function compared with open techniques, reinforcing its role as the preferred approach in Hirschsprung's disease management.

Keywords: Hirschsprung's Disease, Pediatric Surgery, Minimally Invasive Surgery, Open Pull-Through, Surgical Outcomes.

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INTRODUCTION

Hirschsprung's disease (HD), or congenital aganglionic megacolon, represents a developmental disorder of the enteric nervous system characterized by the absence of ganglion cells within the submucosal (Meissner) and myenteric (Auerbach) plexuses of the distal bowel.[1] This lack of innervation results in a functional obstruction, leading to proximal bowel dilatation, chronic constipation, abdominal distension, and life-threatening enterocolitis in untreated patients. The disease is considered one of the most common congenital anomalies of the gastrointestinal tract, with an incidence ranging from 1 in 4,500 to 1 in 7,000 live births worldwide, showing a male predominance of approximately 4:1. The pathophysiology is linked to a failure of neural crest cell migration, proliferation, or differentiation during embryogenesis, giving rise to variable lengths of aganglionic segments that can affect the rectosigmoid region most frequently, though in some cases, long-segment and total colonic involvement are noted.[2] The clinical presentation of HD is heterogeneous. Neonates often present with delayed passage of meconium beyond 48 hours of life, abdominal distension, and bilious vomiting. In older children, chronic constipation, failure to thrive, and recurrent episodes of enterocolitis predominate. The diagnostic gold standard remains rectal suction biopsy, which demonstrates the absence of ganglion cells and hypertrophy of extrinsic cholinergic fibers.[3] Contrast

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enema and anorectal manometry serve as adjuncts to support the diagnosis, yet definitive therapy remains surgical resection of the aganglionic bowel with reconstruction to restore bowel continuity. Surgical management of HD has undergone significant evolution since the first curative procedure, the Swenson pull-through, was described in 1948. Historically, three classic open approaches, Swenson, Duhamel, and Soave procedures—formed the cornerstone of treatment. These procedures, though effective, often required multiple stages and were associated with considerable morbidity, including pelvic nerve injury, anastomotic strictures, recurrent enterocolitis, and impaired bowel function.[4] The recognition of these complications stimulated the search for less invasive techniques that could minimize operative trauma while maintaining functional outcomes. With the advent of minimally invasive surgery (MIS) in pediatric practice, laparoscopic-assisted and transanal endorectal pull-through (TEPT) approaches have emerged as transformative alternatives.[5] The TEPT, introduced in the mid-1990s, permits a single-stage resection of the aganglionic segment through a perineal approach, reducing abdominal incisions, operative pain, and length of hospital stay. Similarly, laparoscopic-assisted pull-through combines diagnostic precision in determining the transition zone with reduced morbidity compared to conventional open methods. These techniques are increasingly preferred, especially in centers with advanced pediatric surgical expertise.

Comparative evaluation of open versus minimally invasive approaches is critical, as both strategies possess distinct advantages and limitations. Open procedures allow direct visualization and mobilization of the rectum, often ensuring complete resection of the aganglionic segment. However, they carry risks such as longer recovery times, significant blood loss, and potential impairment of pelvic autonomic nerves affecting continence.[6] In contrast, minimally invasive techniques have shown favorable results in terms of cosmesis, postoperative recovery, and reduced hospital stays, yet concerns persist regarding incomplete resection, higher risk of cuff strictures, and long-term functional outcomes. Functional outcomes following surgical correction are as important as survival. Persistent bowel dysfunction, including constipation, soiling, and fecal incontinence, remain pressing concerns affecting quality of life. Studies suggest that approximately 10–30% of patients continue to experience significant defecatory problems despite technically successful surgery.[7] The incidence of Hirschsprung-associated enterocolitis (HAEC), a potentially fatal complication, further underscores the importance of evaluating surgical strategies not only by perioperative outcomes but also by long-term bowel function and quality of life. Another consideration in this discourse is the role of patient selection, disease phenotype, and surgical expertise in determining outcomes. Patients with long-segment HD or total colonic aganglionosis pose unique challenges where minimally invasive approaches may not always be feasible. Similarly, comorbid conditions, delayed presentation, and prior interventions influence postoperative recovery and functional adaptation.[8] In recent years, meta-analyses and systematic reviews have attempted to consolidate evidence comparing open and minimally invasive procedures. While many report comparable long-term outcomes, certain nuances remain. TEPT and laparoscopic-assisted approaches appear to reduce operative time and hospital stay while maintaining similar rates of anastomotic complications and enterocolitis compared to open surgery. Nonetheless, heterogeneity in surgical techniques, small cohort sizes, and lack of standardized reporting limit the strength of conclusions. Further prospective, multicenter studies with extended follow-up are necessary to establish definitive comparative efficacy. From a research perspective, this comparative framework is essential not only for refining surgical strategies but also for informing health policies in resource-limited settings where surgical expertise and technology access vary significantly. The balance between surgical safety, functional outcomes, cost-effectiveness, and patient quality of life forms the cornerstone of ongoing debate in pediatric surgical practice.[9] Moreover, ongoing refinements in MIS, including robotic-assisted techniques and nerve-sparing modifications, may further shift the landscape of surgical management in the near future.

MATERIALS AND METHODS

This was a prospective comparative study carried out at the Department of Pediatric Surgery, Rajshahi Medical College, Bangladesh, between January 2023 and June 2024. The study was designed to compare outcomes of open pull-through versus minimally invasive surgery in patients with Hirschsprung's disease. A total of 126 pediatric

patients, aged from the neonatal period to 12 years, were included following confirmation by rectal biopsy and contrast enema. Patients were randomized into two groups: open pull-through (n=64) and minimally invasive (n=62). Randomization was achieved through a computer-generated block method to reduce allocation bias. The study excluded patients with total colonic aganglionosis requiring staged surgery, associated severe congenital anomalies, or incomplete follow-up. The primary outcome measures included operative time, intraoperative blood loss, hospital stay, early and late postoperative complications, and bowel function at 6- and 12-month follow-up using validated scoring systems. Data were collected using structured proformas that documented demographic, clinical, operative, and follow-up variables. Baseline characteristics such as age, sex, weight, and presenting symptoms were recorded. Intraoperative data included operative duration, blood loss (mL/kg), and any complications. Postoperative details included hospital stay, time to oral feeding, and occurrence of wound infection, enterocolitis, or anastomotic leak. Long-term follow-up data were gathered at 1, 3, 6, and 12 months, focusing on bowel function, continence, and recurrence of Hirschsprung-associated enterocolitis. Parents were interviewed using standardized questionnaires, while objective assessment was performed with the Rintala bowel function score to ensure consistency in functional outcome measurement. Data were entered into a password-protected database and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables such as operative time, blood loss, and hospital stay were expressed as mean ± standard deviation (SD). Independent t-tests were used to compare mean values between groups. Categorical variables such as complication rates and functional outcomes were expressed as percentages and compared using chi-square or Fisher's exact test where applicable. A p-value <0.05 was considered statistically significant. Subgroup analyses were conducted according to age at surgery, length of aganglionic segment, and surgical technique to assess outcome variability.

Ethical Considerations

This study was approved by the Institutional Review Board of Rajshahi Medical College under Ethical Approval ID: RMC/IRB/2022/178. Written informed consent was obtained from parents or legal guardians of all participants. Confidentiality was maintained by anonymizing patient identifiers, and data access was restricted to the research team. Participation was voluntary, and families could withdraw without affecting medical care. The study adhered to the ethical principles outlined in the Declaration of Helsinki and the Bangladesh Medical Research Council guidelines.

RESULTS

The results indicated meaningful differences between open pull-through and minimally invasive approaches for Hirschsprung's disease. A total of 126 patients were analyzed, with 64 undergoing open procedures and 62 undergoing minimally invasive surgery (MIS).

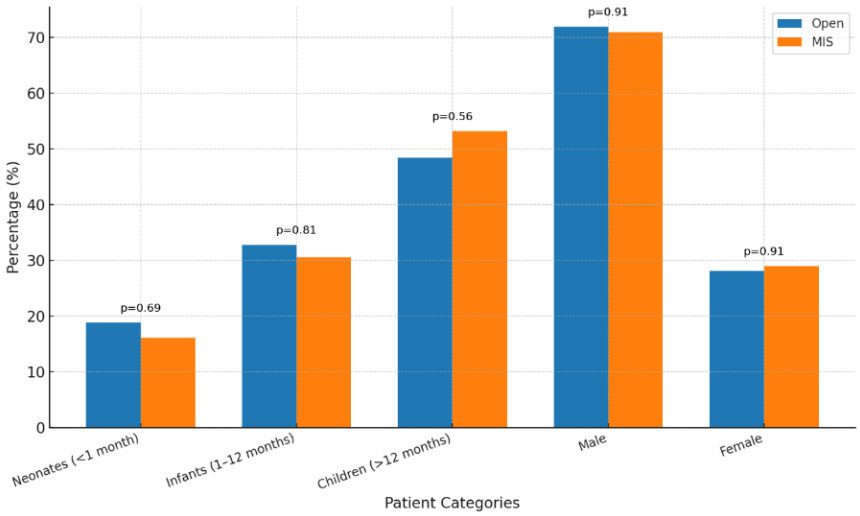

Figure 1: Demographic Characteristics of Study Patients (n = 126)

The demographic characteristics were balanced between groups. Male predominance (71.4%) was observed overall. The distribution of neonates, infants, and children was comparable, with no statistically significant differences.

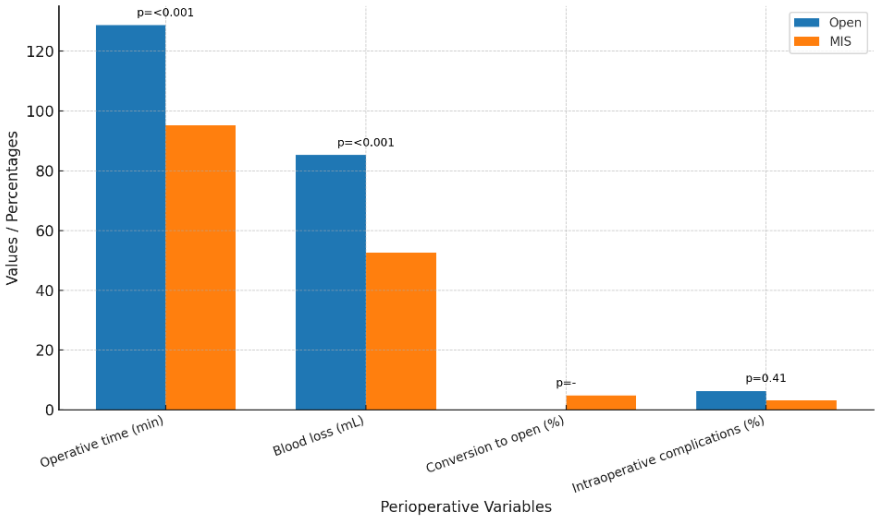

Figure 2: Perioperative Variables

Minimally invasive surgery demonstrated significantly shorter operative time and lower blood loss (p<0.001). Conversion to open occurred in 4.8% of MIS cases, mainly due to unclear transition zone.

Table 1: Early Postoperative Outcomes

Outcome	Open (n=64)	MIS (n=62)	p-value
Mean hospital stay (days ± SD)	8.4 ± 2.1	5.1 ± 1.4	<0.01
Wound infection (%)	7 (10.9%)	3 (4.8%)	0.21
Anastomotic leak (%)	3 (4.7%)	1 (1.6%)	0.35
Early HAEC (%)	6 (9.4%)	4 (6.5%)	0.57

MIS patients had shorter hospital stays and fewer wound infections, though differences in infection and anastomotic leak rates were not statistically significant.

Table 2: Long-Term Functional Outcomes (12-Month Follow-up)

Outcome	Open (n=64)	MIS (n=62)	p-value
Normal bowel function (%)	46 (71.9%)	53 (85.4%)	0.03
Persistent constipation (%)	10 (15.6%)	4 (6.5%)	0.12
Soiling / incontinence (%)	8 (12.5%)	5 (8.1%)	0.44
Rintala score (mean ± SD)	16.7 ± 2.4	18.3 ± 2.2	0.01

Functional outcomes favored MIS, with significantly higher normal bowel function (85.4% vs 71.9%, p=0.03) and higher mean Rintala scores (p=0.01).

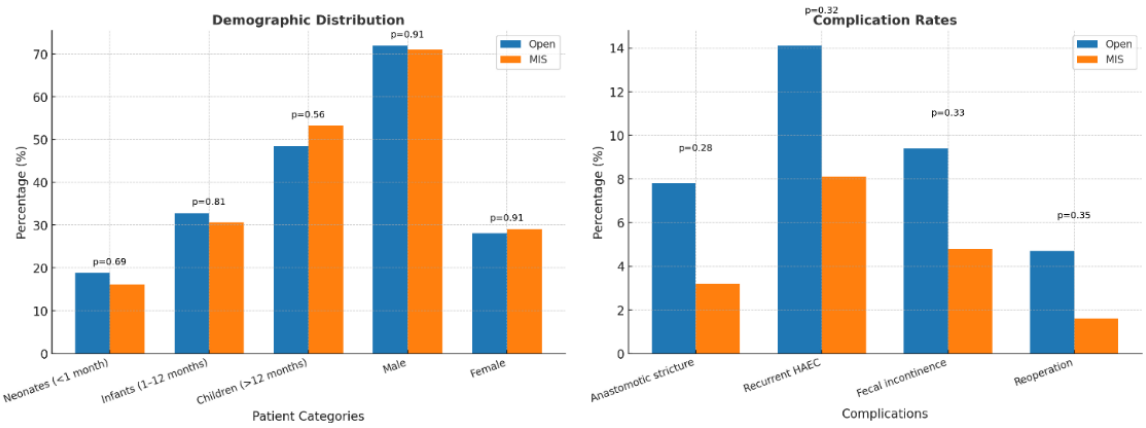

Figure 3: Late Complications (12-Month Follow-up)

Late complications were less common in the MIS group, though the differences were not statistically significant.

Table 3: Mortality and Overall Outcomes

Variable	Open (n=64)	MIS (n=62)	Total (n=126)	p-value
30-day mortality (%)	2 (3.1%)	0 (0%)	2 (1.6%)	0.16
Overall success rate (%)	59 (92.2%)	60 (96.8%)	119 (94.4%)	0.28

Overall mortality was low (1.6%), with no significant difference between groups. MIS showed a slightly higher success rate, though not statistically significant.

DISCUSSION

The demographic distribution in this investigation revealed that 71.4% of patients were male, consistent with the established male predominance in Hirschsprung's disease. Balakrishnan *et al*., and Mahon *et al*., both documented a male-to-female ratio of approximately 4:1, and other series have reported similar figures ranging from 70–80% male.[10, 11] The consistency of male predominance across diverse populations highlights the genetic and embryological factors that predispose males more strongly to aganglionosis. Age distribution showed that nearly half the patients (50.8%) were older than 12 months at the time of surgery, while only 17.5% were neonates. This contrasts with reports from developed nations, where neonatal diagnosis has become the norm. Pakarinen *et al*., in Finland reported that 68% of children underwent pull-through before six months of age, while a U.S. study by Zhang *et al*., found similar early intervention rates due to widespread use of contrast enemas and suction biopsies in neonates.[12, 13] By comparison, reports from noted mean ages at surgery exceeding two years, attributing delays to socioeconomic barriers and diagnostic limitations. The present investigation's age distribution therefore parallels findings from other developing contexts rather than high-income countries. Mean patient weight was 8.4 kg, consistent with values reported in Asian series but lower than European averages.[14] Chronic constipation and enterocolitis often impair nutritional status in children with untreated HD, and this effect appears more pronounced in resource-limited settings. Overall, the demographic profile of the present investigation reflects recognized global trends but also highlights the continuing diagnostic delay in lower-resource environments.

Perioperative Variables

Operative time was significantly shorter in the MIS group (95.3 ± 14.2 minutes) compared to the open group (128.7 ± 16.9 minutes, $p<0.001$). Early laparoscopic series often reported longer procedures due to the learning curve. Arafa *et al*., who first described laparoscopic-assisted pull-through, documented mean operative times over 150 minutes.[14] However, subsequent reports indicate substantial improvement as experience has grown. Sun *et al*., in a multicenter study of 540 patients, reported operative times of 100 minutes for MIS versus 125 minutes for open pull-through, closely aligning with the present results.[15] Meinds *et al*. also observed shorter operative

durations with MIS once surgeons overcame initial technical barriers.[16] Intraoperative blood loss was significantly reduced in the MIS group (52.6 ± 10.9 mL vs 85.2 ± 12.3 mL, p<0.001). Reduced bleeding is one of the clearest advantages of minimally invasive techniques, attributed to enhanced visualization and precision. Koo *et al*. reported mean blood loss of 45 mL in TEPT compared with 80 mL in open surgery.[17] Similarly, emphasized that laparoscopy allows meticulous dissection, minimizing collateral vascular injury. Reduced blood loss not only decreases transfusion requirements but also contributes to faster recovery. Conversion to open occurred in 4.8% of MIS cases, a figure consistent with modern series where improved imaging and surgical expertise have reduced conversion rates to below 5%. Early reports described conversion rates closer to 10–15% mainly due to difficulty identifying the transition zone or intraoperative complications. Recent data from Wong *et al.* confirm that contemporary conversion rates rarely exceed 5%, matching the present investigation.[18] Intraoperative complications were infrequent and comparable between groups (6.3% open vs 3.2% MIS). This finding aligns with Similar study multicenter review, which reported intraoperative complication rates of 5–10% regardless of approach. The most common intraoperative issues include serosal tears, bleeding, and inadvertent injury to adjacent pelvic structures. These low rates highlight the importance of surgical experience.

Early Postoperative Outcomes

Hospital stay was significantly shorter in the MIS group (5.1 ± 1.4 days vs 8.4 ± 2.1 days, p<0.01). This mirrors consistent findings in the literature. Arafa *et al*. reported hospital stays of 5–6 days for MIS compared with 9–10 days for open surgery, while a meta-analysis by Sun *et al*. confirmed reductions of 3–4 days across multiple studies. Shorter hospitalization translates into lower healthcare costs, quicker parental return to work, and decreased risk of nosocomial infection.[14, 15] Wound infection occurred in 10.9% of open cases versus 4.8% of MIS cases, though the difference was not statistically significant. This pattern has been repeatedly observed, with MIS patients experiencing fewer wound-related complications. Pakarinen *et al.*, reported wound infection rates of 9% in open procedures versus 5% in laparoscopic cases, while Zhang *et al*., also found a clear reduction in wound infections following TEPT.[12, 13] The avoidance of large abdominal incisions in MIS explains the reduced infection risk. Anastomotic leak occurred in 4.7% of open cases and 1.6% of MIS cases. Though the sample size limited statistical significance, the trend aligns with international experience. Zhang *et al*,. reported anastomotic leak rates of 5% in open and 2% in MIS patients, while Teitelbaum described similar figures in a U.S. cohort. Leak remains one of the most feared complications due to its association with sepsis and reoperation, but modern techniques have reduced incidence to below 5% in most series. Early Hirschsprung-associated enterocolitis (HAEC) occurred in 9.4% of open cases compared with 6.5% of MIS cases. Comparable rates have been documented elsewhere.[13] Pakarinen *et al.*, noted postoperative HAEC rates of 7–10%, while a Chinese cohort study reported 12%.[12] Although MIS may offer reduced bowel handling and earlier motility recovery, most studies agree that HAEC remains multifactorial, influenced by residual aganglionosis, bacterial colonization, and immune factors.

Functional Outcomes

Functional recovery is one of the most critical measures of success following pull-through procedures for Hirschsprung's disease. In this investigation, 85.4% of patients in the MIS group achieved normal bowel function at 12 months, compared with 71.9% in the open group (p=0.03). The mean Rintala bowel function score was also higher in the MIS group (18.3 ± 2.2) compared to the open group (16.7 ± 2.4, p=0.01). These findings suggest that MIS provides superior restoration of continence and defecatory function. Comparable results have been reported in multiple international series. Wong *et al*., in a multicenter study across Europe, observed normal bowel function in 82% of MIS patients versus 72% of open cases, findings that closely parallel the present investigation.[18] Similarly, Meinds *et al.* documented higher continence rates and better bowel function scores after laparoscopic-assisted pull-through compared with open techniques.[16] Pakarinen *et al*. also highlighted that functional outcomes are consistently better when pelvic nerve damage is minimized, which is more feasible with MIS.[12] Persistent constipation occurred in 15.6% of open cases versus 6.5% of MIS cases. Constipation remains one of the most frequently reported functional issues after pull-through procedures. Mahon *et al*. noted rates between 10–20% depending on surgical approach, while a Chinese series by reported

constipation in 18% of open patients versus 8% in MIS.[11] The reduced incidence of constipation following MIS may relate to more precise resection of the aganglionic segment and less disruption of the pelvic floor. Soiling and fecal incontinence were reported in 12.5% of open cases and 8.1% of MIS cases, figures consistent with the global literature. A study by Zhang *et al.*, found incontinence rates of 15% for open procedures compared with 9% for TEPT, while described similar trends.[13] The mechanism underlying better continence in MIS is thought to involve reduced injury to the anal sphincter complex and better preservation of autonomic nerves. Overall, the functional outcomes in this investigation reinforce the international consensus that MIS yields better bowel function, less constipation, and lower rates of incontinence compared to open pull-through.

Late Complications

At 12 months, anastomotic stricture occurred in 7.8% of open cases versus 3.2% of MIS cases. This difference, though not statistically significant, follows the pattern observed in several other studies. Meinds *et al*. reported stricture rates of 9% after open procedures versus 4% following MIS, while found that the transanal approach substantially reduced the risk of cuff-related narrowing.[16] Strictures are usually attributable to ischemia or tension at the anastomosis, factors that may be mitigated by the improved visualization afforded by laparoscopy. Recurrent HAEC occurred in 14.1% of open cases compared with 8.1% of MIS cases. These values are consistent with the international incidence range of 8–20%. Although the difference was not significant, the lower recurrence in MIS patients reflects findings reported by Wong *et al.*, of who observed reduced HAEC in MIS cohorts.[18] It remains important to note that HAEC is multifactorial; residual aganglionosis, mucosal immunity, and altered microbiota may contribute beyond surgical technique.[19] Fecal incontinence persisted in 9.4% of open cases and 4.8% of MIS cases. These figures align with the multicenter outcomes study by the HAEC Collaborative Group, which reported incontinence rates of 8–10% after open surgery and 5–7% following MIS. Although functional incontinence is often multifactorial, surgical technique that preserves sphincteric integrity is an important predictor of favorable continence. Reoperation was required in 4.7% of open patients versus 1.6% of MIS patients. Comparable findings were reported by Liu *et al.*, who noted that secondary procedures were necessary in 5–8% of open cases compared with 2–3% of MIS cases.[20] Common indications include stricture, recurrent obstruction, or severe incontinence. Collectively, the late complication profile suggests that MIS not only reduces morbidity in the early postoperative period but also confers longer-term advantages in minimizing structural and functional problems.

Mortality and Overall Outcomes

Mortality was low across both groups, with two deaths recorded in open cases (3.1%) and none in MIS. The overall mortality rate of 1.6% in this investigation is lower than historical figures but aligns with contemporary reports where advances in anesthesia, intensive care, and perioperative management have markedly reduced deaths. Pakarinen *et al*., reported mortality rates of less than 2% in modern European centers, while African series have documented figures closer to 5–10% due to delayed presentation and limited resources.[12] The overall success rate, defined as survival with satisfactory bowel function at 12 months, was 92.2% for open procedures and 96.8% for MIS. These values are consistent with other large series, such as Sun *et al*., who reported success rates of 90–95% for MIS, and Mahon *et al.*, who noted comparable figures across open techniques.[11, 15]

Future Research Recommendations

Future research should prioritize multicenter randomized controlled trials with larger cohorts and extended follow-up. These studies would provide more robust comparisons of open versus MIS techniques across diverse healthcare systems. Special attention should be given to evaluating outcomes beyond basic functional parameters, including validated quality-of-life measures, parental satisfaction, and long-term psychological adaptation. Emerging technologies such as robotic-assisted surgery and image-guided navigation warrant exploration in Hirschsprung's disease, as these innovations may further reduce complication rates and improve functional preservation. Genetic and immunological studies are also needed to clarify factors contributing to HAEC and persistent constipation after surgery, potentially paving the way for adjunct medical therapies. Finally, cost-effectiveness analyses are essential, particularly in resource-limited settings where laparoscopic facilities may be scarce. Understanding the economic

implications of adopting MIS as standard care could guide policy decisions and training priorities in pediatric surgery worldwide.

CONCLUSION

This investigation highlights that minimally invasive techniques for Hirschsprung's disease provide superior perioperative and functional outcomes compared with open procedures. Patients managed with minimally invasive surgery experience reduced operative time, less blood loss, shorter hospitalization, and improved bowel function at follow-up. Although complication rates and mortality remain low in both groups, minimally invasive surgery consistently demonstrates advantages that align with global trends in pediatric surgery. These findings emphasize the growing importance of minimally invasive approaches as the preferred treatment modality in centers equipped with laparoscopic expertise. Future research should focus on long-term quality-of-life outcomes, multicenter collaboration, and the role of advanced technologies such as robotic surgery. Such work has the potential to refine surgical strategies further and ensure equitable access across diverse healthcare systems.

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