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Restorative Surgery in Adult Short Bowel Syndrome: Outcomes from a Single-Center Experience with an Illustrative Complex Case

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Abstract

Background: Short bowel syndrome (SBS) is a severe form of intestinal failure often associated with high output jejunostomy, fluid and electrolyte imbalance, and long-term dependence on parenteral nutrition (PN). In patients with type I SBS, restorative surgery may reduce PN dependence and enable conversion to type II or III SBS through restoration of intestinal continuity. **Methods**: We report our single-center experience. Between 2018 and 2025, nine adult patients with chronic type I SBS and high output jejunostomy underwent restorative surgery within a multidisciplinary intestinal rehabilitation program. All patients were PN-dependent preoperatively, and two had intestinal failure-associated liver disease (IFALD). Surgical strategies were individualized according to residual anatomy and focused on restoration of intestinal continuity, without bowel lengthening procedures. Clinical outcomes were descriptively analyzed. **Results**: Intestinal continuity was successfully restored in all patients, resulting in conversion from type I to type II or III SBS. A clinically relevant improvement in intestinal function was observed in all cases. Complete enteral autonomy was achieved in three patients, while the remaining patients experienced a meaningful reduction in PN requirements, including partial or nocturnal supplementation. Five of nine patients developed postoperative complications: one required reoperation and one endoscopic treatment for anastomotic bleeding. No perioperative mortality was recorded. **Conclusions**: In adult patients with type I SBS, restorative surgery enables anatomical and functional conversion to type II or III SBS. When performed within specialized multidisciplinary programs and guided by careful management of hostile abdomen, this approach may result in significant functional improvement and reduced PN dependence.

Keywords: short bowel syndrome; intestinal rehabilitation; restorative surgery; parenteral nutrition; hostile abdomen

1. Introduction

Short bowel syndrome (SBS) is a rare but severe form of intestinal failure resulting from extensive small bowel resection, leading to inadequate nutrient and fluid absorption to sustain life without supplemental parenteral nutrition (PN).[1,2] The most common etiologies include mesenteric ischemia, Crohn's disease, postoperative complications, trauma, and congenital disorders.[3] Despite improvements in medical management and home PN programs, SBS remains a life-threatening condition associated with high morbidity, impaired quality of life, and a substantial healthcare burden.[4]

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The clinical severity of SBS depends on residual bowel length, the anatomical segment preserved, the presence of the colon in continuity, and the preservation of the ileocecal valve. [6] Short bowel length and rapid intestinal transit result in malabsorption, diarrhea, dehydration, electrolyte imbalance, and malnutrition. In this framework, type I SBS, characterized by an end jejunostomy without intestinal continuity, represents the most severe form in terms of fluid loss and metabolic instability, whereas type II and type III SBS are associated with progressively improved absorptive capacity due to partial or complete restoration of intestinal continuity and colonic integration.[1,2,6] Following resection, the intestine undergoes an adaptive process characterized by mucosal hyperplasia, bowel dilation, and changes in motility and transporter expression; this response may be enhanced by enteral feeding, hormonal factors such as glucagon-like peptide-2 (GLP-2), and surgical strategies that optimize bowel geometry and transit time.[7,8]

Within this context, restorative surgery represents a cornerstone of intestinal rehabilitation programs, aiming to increase functional absorptive capacity, reduce intestinal transit, improve nutrient absorption, and minimize long-term PN-related complications such as intestinal failure-associated liver disease (IFALD) and catheter-related infections.[9] Surgical intervention is generally considered after completion of the adaptive phase and stabilization under optimized medical therapy.[10] A major and clinically relevant objective of restorative surgery in SBS is conversion from type I SBS, characterized by high-output jejunostomy, to type II or III SBS through restoration of intestinal continuity whenever excluded bowel segments are available. By re-establishing intestinal continuity and, when feasible, colonic integration, restorative surgery may fundamentally modify the anatomical and functional classification of SBS, thereby improving intestinal absorption and facilitating nutritional rehabilitation. [6,15,16]

Several reconstructive strategies have been described as part of autologous gastrointestinal reconstructive surgery (AGIR), including bowel lengthening procedures such as longitudinal intestinal lengthening and tailoring (LILT) and serial transverse enteroplasty (STEP), antiperistaltic reversed segments, restoration of intestinal continuity, and, more recently, biomimetic approaches such as the Saeki–Spiral–Shark (3S) technique.[11–17] Intestinal transplantation remains an option for patients with irreversible intestinal failure and life-threatening PN-related complications after failure of rehabilitative strategies, although it is associated with substantial morbidity.[18,19] Overall, restorative procedures have been shown to reduce PN dependence and improve quality of life in selected patients, but they remain technically demanding and may be associated with complications such as anastomotic leaks, bowel ischemia, bacterial overgrowth, and redilatation.[5,13,20] In adult patients, these operations are often particularly challenging because of multiple previous abdominal procedures, peritonitis, adhesions, and hostile abdomen.

In this study, we report our recent single-center clinical experience with restorative surgery in adult patients with type I SBS, with particular attention to functional outcomes and to a particularly complex illustrative case.

2. Materials and Methods

2.1. Study Design and Patient Selection

Between 2018 and 2025, nine adult patients with chronic SBS were managed at our institution within a dedicated multidisciplinary intestinal rehabilitation program. All patients presented with intestinal failure secondary to extensive small bowel resection due to heterogeneous etiologies, including intestinal ischemia, Crohn's disease, abdominal trauma, visceral myopathy/intestinal pseudo-obstruction, diverticular disease, and ileal volvulus complicated by duodenal stenosis.

All patients presented preoperatively with type I SBS, characterized by a high output jejunostomy and complete dependence on PN. Surgical candidacy was assessed after completion of the intestinal adaptive phase and optimization of medical and nutritional therapy, including long-term PN. Indications for restorative surgery included persistent PN dependence, impaired intestinal transit, and favorable residual anatomy. Preoperative planning focused on residual small bowel

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length and quality, the presence of the colon in continuity, and preservation of the ileocecal valve when available. Detailed patient characteristics are summarized in Table A1 (Appendix A.1).

2.2. Preoperative Work-Up

In complex cases of SBS, preoperative work-up plays a pivotal role in guiding restorative surgery. Before any surgical intervention, it is essential to obtain the most accurate and detailed understanding possible of the patient's residual anatomy. This includes assessment of the remaining bowel length, gastrointestinal continuity, presence and configuration of anastomoses, potential strictures, excluded segments, and spatial relationships between intestinal loops.

Imaging studies were central to preoperative evaluation. Upper gastrointestinal contrast studies provided valuable morphological and functional information on the gastroduodenal tract and proximal small bowel, allowing identification of delayed transit, areas of stasis, dilatation, or clinically relevant strictures. Cross-sectional imaging was also used to define residual anatomy and to support surgical planning, thereby minimizing intraoperative uncertainty during restorative procedures.

2.3. Surgical Strategy

Restorative surgical procedures were individualized according to anatomical and functional characteristics, with restoration of intestinal continuity representing the primary surgical objective. Tailored reconstructive strategies included jejuno-colic, jejuno-ileal, jejuno-jejunal, gastro-jejunal, and ileo-colic anastomoses, performed alone or in combination depending on residual bowel configuration.

2.4. Postoperative Management and Outcomes

Postoperative care was delivered within a specialized intestinal failure program in close collaboration with nutrition specialists. Early enteral feeding was initiated when tolerated, followed by gradual tapering of PN and strict monitoring of fluid and electrolyte balance. Patients underwent regular clinical, nutritional, and biochemical follow-up, with a follow-up duration ranging from 3 to 58 months.

The main study outcomes were restoration of intestinal continuity, conversion from type I to type II or III SBS, postoperative PN requirements, achievement of enteral autonomy, and postoperative morbidity and mortality.

3. Results

3.1. Clinical Outcomes

All patients were dependent on PN preoperatively and presented with type I SBS.

No bowel lengthening procedures, including STEP, were performed in this cohort. Additional reconstructive maneuvers were guided by intraoperative findings and vascular assessment. Surgical timing was individualized, with restorative procedures undertaken after a median interval of approximately 11 months (range 6–56 months) from the last intestinal resection, aiming to balance intestinal adaptation with operative safety. Surgical and clinical outcomes are summarized in Table A2 (Appendix A.2).

Following restorative surgery and anatomical conversion to type II or type III SBS, a clinically relevant improvement in intestinal function was observed across the cohort. Complete enteral autonomy, defined as full independence from PN, was achieved in three patients, while the remaining patients experienced a meaningful reduction in PN requirements, including partial or nocturnal supplementation.

Intestinal continuity was successfully restored in all patients, resulting in conversion from type I SBS to type II or type III SBS according to the final anatomical configuration.

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Postoperative morbidity was acceptable and manageable within a specialized setting and included postoperative ileus, bleeding requiring endoscopic or surgical management, and infectious complications. No perioperative mortality was observed. Overall, restorative surgery was well tolerated and resulted in improved nutritional status and intestinal function in most patients.

3.2. Illustrative Complex Case: Patient 6

We report a particularly complex case of SBS that could not be classified within existing anatomical categories. A 59-year-old male presented to our center in June 2025 with a diverting jejunostomy located approximately 30 cm distal to the ligament of Treitz, stenosis of the third portion of the duodenum managed with a duodenal drainage catheter, and a mucous fistula of the terminal ileum (40 cm) with the colon preserved (type I SBS with excluded distal bowel and closed duodenum). These findings were the consequence of multiple previous abdominal surgeries performed for desmoid-type fibromatosis of the small bowel.

3.3. Clinical History

The patient's clinical history began in October 2021 with identification of a large mesenteric mass involving the ileal mesentery and the root of the mesentery. Histopathology confirmed desmoid-type fibromatosis with CTNNB1 exon 3 mutation. Initial management consisted of radiological surveillance followed by systemic chemotherapy with methotrexate and vinorelbine, resulting in partial radiological response and subsequent disease stabilization.

In February 2024, the patient developed intestinal obstruction requiring emergency surgery with resection of approximately 1 m of ileum and ileo-ileal anastomosis, which was complicated by anastomotic leakage. Subsequent procedures included resection of the failed anastomosis with creation of a jejunostomy and ileal mucous fistula, repair of a perforation of the third portion of the duodenum with placement of a prepapillary drainage catheter, and multiple reoperations for duodeno-cutaneous fistula managed with an open abdomen technique. Following discharge, the patient was treated at an intestinal failure center with total parenteral nutrition.

3.4. Preoperative Evaluation

In March 2025, the patient was admitted to our institution for evaluation of potential intestinal reconstruction (Figure 1). Endoscopy confirmed a tight stenosis of the third portion of the duodenum. Contrast studies demonstrated limited jejunal continuity proximal to the stoma and preserved distal ileal segments reaching the cecum. CT imaging showed postoperative changes without clear signs of oncological disease recurrence (Figures 2–6).

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Figure 1. Preoperative abdominal photograph showing a left-sided jejunostomy and a duodenal drain in situ, with a mucous fistula in the right flank.

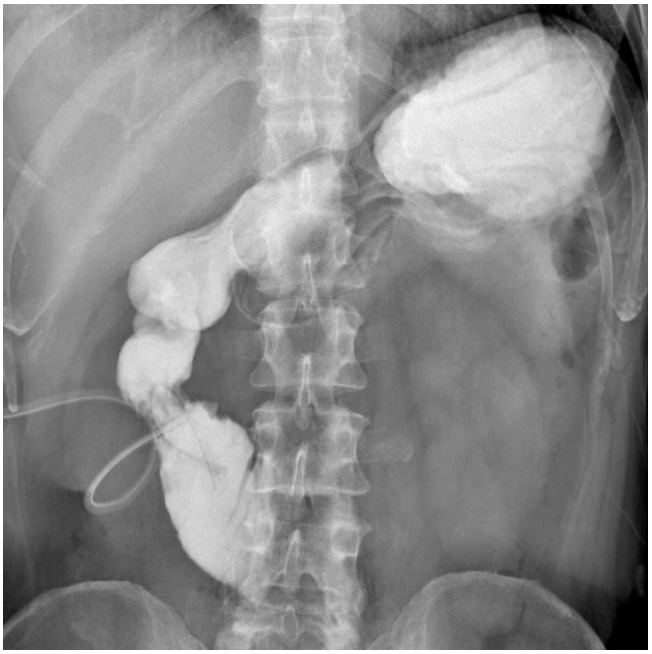

Figure 2. Preoperative upper GI contrast study with oral contrast shows an obstruction of the third portion of the duodenum. A duodenal drain is in place.

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Figure 3. Contrast opacification through the jejunostomy showing a proximal stop at the level of the third portion of the duodenum (30 cm of jejunum).

Figure 4. Following the study described in Figure 3, contrast medium was administered through the ileal mucous fistula, allowing identification of the remaining small bowel up to the ileocecal valve (40 cm).

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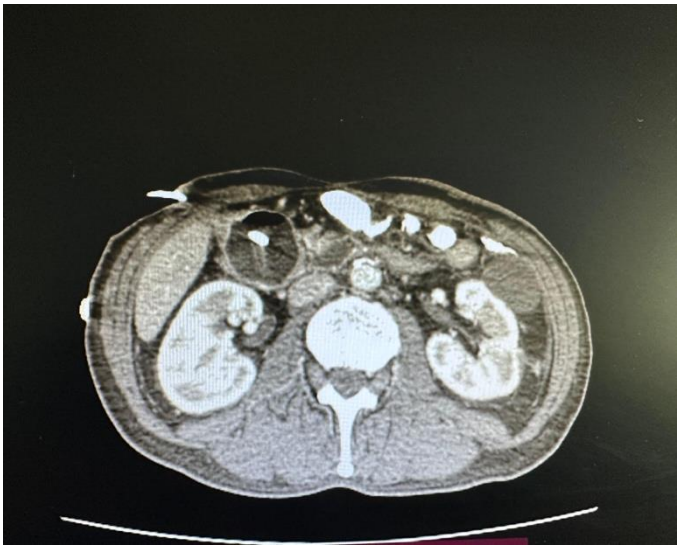

Figure 5. Axial abdominal CT image reports demonstrating dilatation with a duodenal drain in situ.

Figure 6. Coronal abdominal CT image demonstrating duodenal stenosis with a duodenal drain in situ.

3.5. Surgery

Reconstructive surgery was performed in June 2025. Exploratory laparotomy revealed extensive intra-abdominal adhesions requiring careful adhesiolysis (Figure 7). The jejunostomy and ileal mucous fistula were mobilized. Reconstruction was achieved through a transmesocolic mechanical gastrojejunostomy and a side-to-side isoperistaltic jejunoileal anastomosis after confirmation of adequate bowel perfusion (Figures 8 and 9). Abdominal drains were placed near both anastomoses.

3.6. Postoperative Course

The postoperative course was characterized by delayed gastric emptying and delayed functional activation of the gastroenteric anastomosis, likely related to preferential drainage of gastric, pancreatic, and biliary secretions through the indwelling intraduodenal drainage catheter, which diverted digestive fluids away from the newly created anastomosis.

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To manage this condition, an endoscopically placed nasogastric tube was inserted to decompress the stomach and reduce the risk of aspiration pneumonia, while a nasojejunal feeding tube was positioned distal to the anastomosis for enteral nutritional support.

After approximately one month, the patient was discharged with the duodenal drainage catheter left in situ (kept closed) and receiving parenteral nutrition and enteral nutrition through a nasojejunal tube. The nasogastric tube was maintained in place.

In November 2025, a plain abdominal radiograph demonstrated functional recanalization of the gastroenteric anastomosis (Figure 10). Consequently, once the nasogastric tube stopped draining and the patient was able to feed regularly with the tubes in place, both the nasogastric and nasojejunal tubes were removed. One month after the abdominal radiograph, the duodenal drainage catheter was also removed. The patient continued parenteral nutrition with progressive weaning while demonstrating tolerance to total enteral feeding (Figure 11).

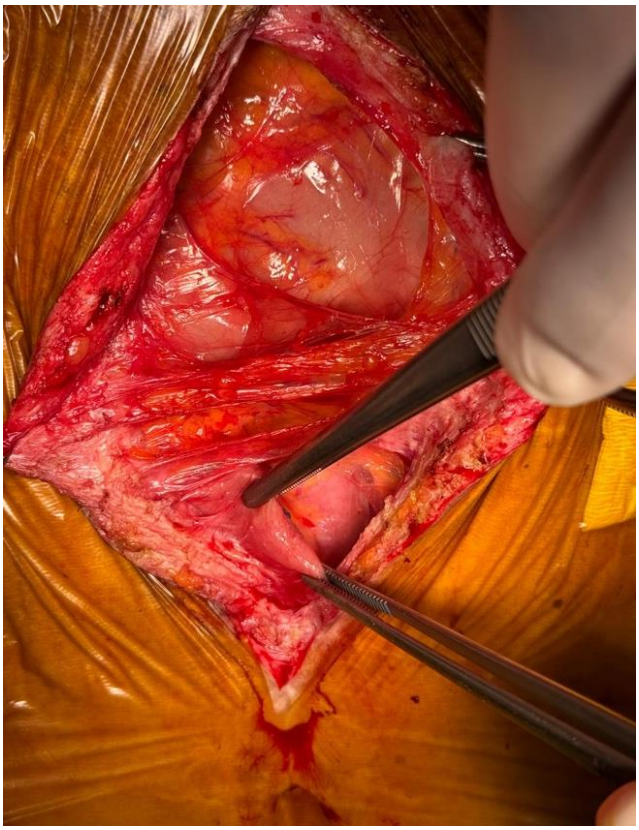

Figure 7. Dense visceroparietal and viscerovisceral adhesions with a hostile abdomen.

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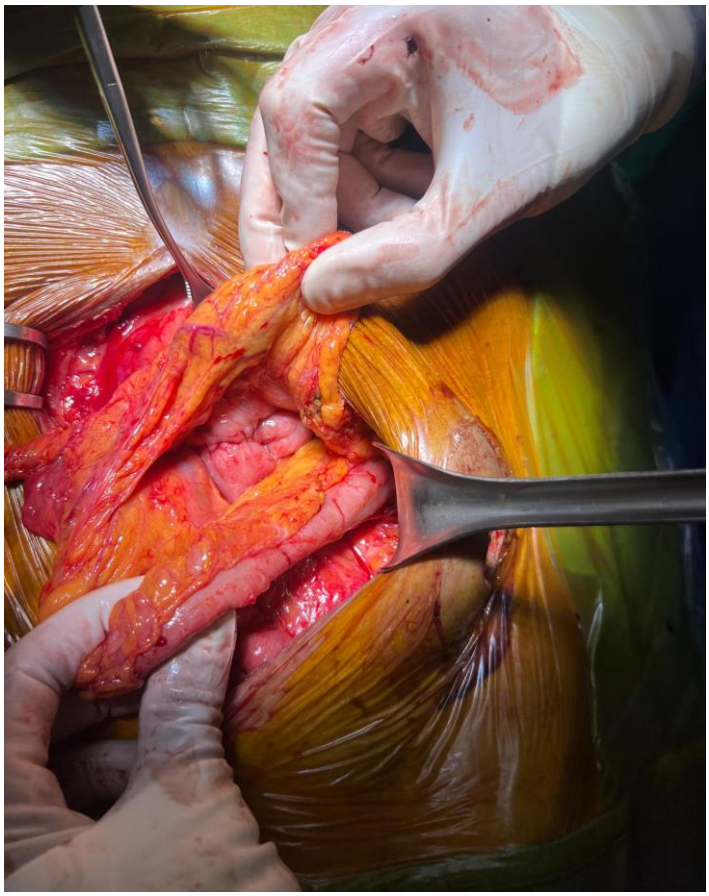

Figure 8. Gastroenteric anastomosis on the posterior wall of the stomach with a transmesocolic loop.

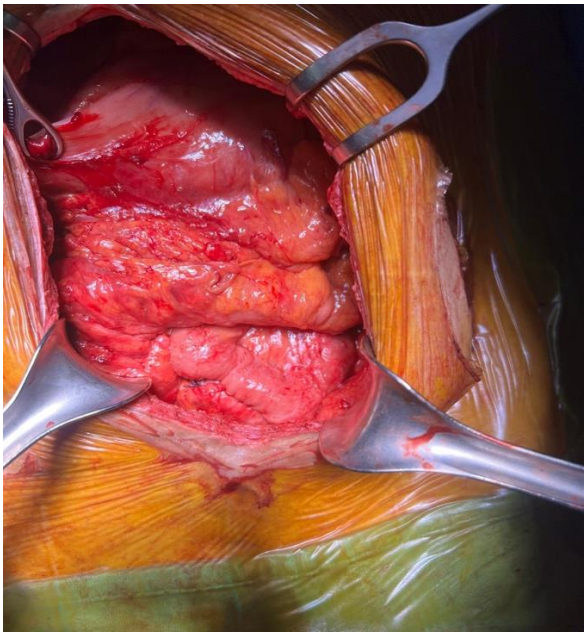

Figure 9. Side-to-side jejunoileal anastomosis..

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Figure 10. Contrast-enhanced radiographic study (oral contrast) performed 3 months after surgery showing normal patency of the gastroenteroanastomosis, with no evidence of duodenal stasis.

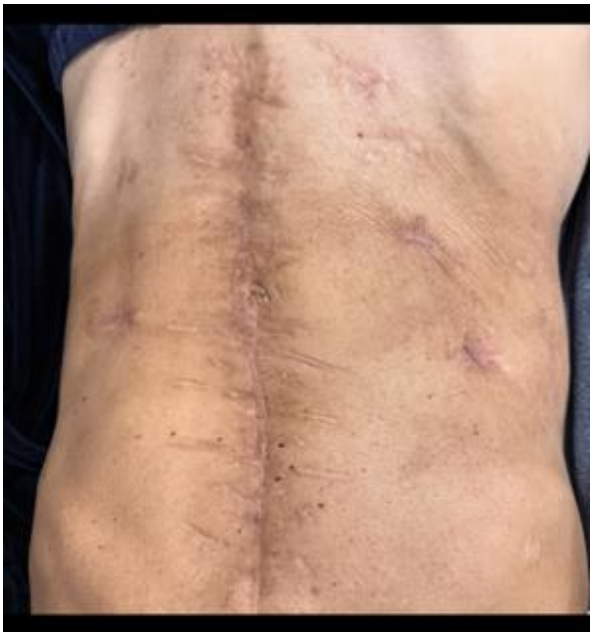

Figure 11. Postoperative abdominal appearance of the patient.

The favorable restoration of anastomotic transit was likely facilitated by pyloric hypotonia secondary to chronic duodenal obstruction. The resulting pyloric dilation and incompetence may have promoted retrograde reflux of duodenal contents into the stomach, thereby facilitating passage through the gastroenteric anastomosis.

This case illustrates the complexity of surgical decision-making in patients with atypical SBS anatomy and highlights the importance of individualized reconstructive strategies based on meticulous preoperative evaluation.

4. Discussion

In this single-center experience, restorative surgery performed within a structured intestinal rehabilitation program was associated with clinically meaningful functional improvement in patients

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with chronic SBS, as demonstrated by a reduction in PN requirements in many cases and the achievement of complete enteral autonomy in a subset of patients (Table 1). Overall, these findings are consistent with previously published data indicating that restorative surgical strategies, when carefully selected and timed, may significantly contribute to intestinal rehabilitation in adult SBS. [5,6,16]

A distinctive feature of our series is that all patients initially presented with type I SBS, characterized by a high output jejunostomy, a condition associated with profound fluid and electrolyte losses and a particularly high burden of PN dependence. In this context, restorative surgery was not merely aimed at reducing PN requirements, but at achieving a fundamental anatomical and functional conversion to type II or type III SBS through restoration of intestinal continuity. This transition represents a critical turning point in the natural history of SBS, as it substantially modifies intestinal physiology, absorptive capacity, and metabolic stability. [6,15,16]

A key component of our surgical approach was the systematic restoration of intestinal continuity whenever anatomically feasible. This strategy is well supported by the literature, which consistently demonstrates that the presence of the colon in continuity plays a pivotal role in enhancing fluid and electrolyte absorption and in salvaging energy through colonic fermentation of carbohydrates into short-chain fatty acids.[6,15] In this context, the reduction in PN requirements observed in most of our patients appears coherent with established physiological principles and prior clinical studies showing that colonic reintegration is among the strongest predictors of PN weaning in SBS.[6,16] Conversely, the variability in achieving complete enteral autonomy likely reflects interindividual differences in residual small bowel length, preservation of the ileocecal valve, baseline motility, and the presence of associated upper gastrointestinal pathology, all factors known to influence long-term functional outcomes.[2,6]

Notably, no bowel lengthening procedures, including STEP, were performed in our cohort. While STEP has been shown to be effective in selected patients, particularly in the presence of markedly dilated small bowel and favorable mesenteric anatomy, its role in adult SBS remains more selective than in pediatric populations.[12,13] Our experience suggests that meaningful functional improvement can still be achieved through anatomy-driven restorative procedures focused on continuity restoration, without bowel lengthening, especially in patients with complex surgical histories. In several cases, persistent partial PN dependence after reconstruction can be reasonably explained by factors frequently reported in the literature, such as extremely short residual bowel length, impaired motility disorders including visceral myopathy or intestinal pseudo-obstruction, or proximal disease such as duodenal stenosis, which may limit nutrient delivery and absorption despite technically successful anastomoses. [2,8]

From a safety standpoint, postoperative morbidity in our series was acceptable and manageable within a specialized intestinal failure setting, with no perioperative mortality observed. This is particularly relevant given that many SBS patients undergoing restorative surgery present with a hostile abdomen, characterized by dense adhesions, distorted anatomy, friable bowel, prior septic events, fistulae, and multiple previous laparotomies. Lundy and Ashburn emphasize that surgery in the hostile abdomen represents one of the most challenging scenarios in abdominal surgery and requires individualized goal setting, careful preoperative optimization, thoughtful timing, and an experience-driven intraoperative strategy focused on safety and preservation of remaining bowel length. [22]

In our practice, adherence to hostile abdomen management principles, including multidisciplinary preoperative optimization, correction of nutritional and metabolic derangements, control of sepsis, and delayed re-entry after the last major resection, likely contributed to the favorable safety profile observed. Furthermore, intraoperative strategies aimed at preserving bowel length, avoiding unnecessary resections, and maintaining a clear exit strategy, as advocated in hostile abdomen surgery, were integral to our operative planning and execution. [22]

An important consideration emerging from our experience is the definition of success in adult SBS. While complete independence from PN represents an ideal endpoint, a sustained reduction in

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PN volume or frequency, often allowing transition to partial or nocturnal PN, may represent a clinically meaningful and patient-centered outcome. Such improvements are associated with reduced catheter-related complications, lower risk of IFALD, and improved quality of life. [4,9,20] This perspective is increasingly reflected in contemporary intestinal rehabilitation programs, where incremental functional gains are recognized as valuable outcomes, particularly in patients with complex anatomy or hostile abdomen features. [5,10]

The limitations of this study include its retrospective nature, small sample size, and heterogeneity in underlying etiologies and reconstructive configurations. Nonetheless, the real-world characteristics of the cohort and the consistency of outcomes with established physiological and surgical principles support the role of restorative surgery as a key component of multidisciplinary intestinal rehabilitation in carefully selected adult patients. Future multicenter studies and prospective registries may help refine patient selection criteria, optimize timing of reconstruction, and better define long-term outcomes, particularly in the challenging subset of patients with hostile abdomen anatomy.

Future Directions

Emerging strategies include combined medical-surgical approaches using GLP-2 analogues, intestinal tissue engineering, and regenerative medicine. [8,21] Personalized surgical planning within multidisciplinary intestinal rehabilitation programs likely represents the future of SBS management.

5. Conclusions

SBS is a complex condition requiring an integrated, multidisciplinary approach. Restorative surgery plays a pivotal role in intestinal rehabilitation by enhancing adaptation and reducing reliance on PN. In patients with type I SBS, conversion to type II or III SBS through restoration of intestinal continuity represents a fundamental anatomical and functional milestone, enabling improved metabolic stability and meaningful clinical recovery. Continued innovation in surgical techniques and adjunctive therapies is essential to further improve long-term outcomes.

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Abbreviations

The following abbreviations are used in this manuscript:

SBS	Short Bowel Syndrome
IFALD	Intestinal Failure-Associated Liver Disease
PN	Parental Nutrition
STEP	Serial Transverse Enteroplasty
LILT	Longitudinal Intestinal Lengthening and Tailoring

Appendix A

Appendix A.1 ***Table A1.*** *Clinical characteristics and outcomes of patients undergoing restorative surgery for short bowel syndrome*

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Appendix B

Appendix A.2 ***Table A2.*** *Outcomes of patients undergoing restorative surgery for Short Bowel Syndrome (SBS)*

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