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Functional Outcomes of Multimodal Sphincter Reconstruction for Anal Incontinence Following War-Related Anal Sphincter Injuries: A Prospective Cohort Study

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Research Article

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Abstract

Introduction: Irreversible traumatic war injuries to the anal sphincter led to fecal incontinence (FI), "requiring a stoma", which has a significant negative impact on a patient's well-being. This study evaluates the outcomes and durability of unilateral gluteoplasty with/ without adjuvant surgical techniques, to manage end-stage fecal incontinence.

Methods: Prospectively, from November 2009 and January 2024, 56 male patients, with traumatic fecal incontinence, were managed by unilateral gluteoplasty. We add anal column plication, smooth muscle-plasty, and pectinatoplasty to restore neo-anal cushions, improve resting anal pressure and reduce soiling. All patients scored preoperatively, 3, 6, 12, and 24 months postoperatively.

Results: All patients were male with a mean age of 22 years. 50% of patients had already undergone emergency operations and colostomy post penetrating war injuries with complete anal sphincter destruction and fecal incontinence. 78.6% were significantly improved post unilateral gluteoplasty, allowing for colostomy closure. Their estimated manometric studies and functional scores improved significantly. Others remained incontinent due to sensory incontinence despite excellent voluntary sphincter tone. Resting anal pressure improved dramatically post anal column plication, smooth muscle-plasty, and pectinatoplasty.

Conclusion: Components of normal anal continence include sensory, reservoir components, and motor squeeze. Therefore, no perfect replacement for a normal anal sphincter. Gluteoplasty, a skeletal muscle wrap, alone is sufficient to restore the squeeze component. But it is not enough to maintain normal resting anal pressure. Patients with sensory incontinence are unlikely to benefit from it. The presence of a sensory reservoir and a skin-lined anal canal (pectin) also, appear to be important in addressing fecal incontinence.

INTRODUCTION

Traumatic anal sphincter injuries remain one of the most challenging causes of severe fecal incontinence, particularly following war-related pelvic and perineal trauma. Extensive destruction of the anal sphincter complex often precludes primary sphincter repair, leaving reconstructive procedures as the only option for restoring continence. Although several reconstructive techniques have been described, their long-term functional outcomes and the contribution of individual continence mechanisms remain incompletely understood.

Normal continence depends on the coordinated function of three complementary components: the external anal sphincter, which provides voluntary squeeze pressure; the internal anal sphincter, which maintains resting anal tone; and the anorectal sensory-reservoir mechanism, which enables discrimination of rectal contents and coordinated defecation. Reconstruction of the external sphincter alone may restore voluntary contraction but may not adequately address impaired resting pressure or sensory dysfunction, both of which contribute substantially to persistent fecal incontinence.

Adjunctive reconstructive procedures have therefore been proposed to restore these additional components of continence. Smooth muscle-plasty and anal column plication are intended to augment resting anal pressure by reinforcing the internal sphincter mechanism. Pectinatoplasty aims to reconstruct the anodermal (pectinate) region, thereby restoring sensory discrimination and facilitating coordinated anorectal reflexes. Restoration of anodermal sensation may improve continence by enhancing afferent feedback and optimizing sphincter coordination; however, the clinical contribution of this sensory reconstruction has not been clearly established.

We hypothesized that comprehensive reconstruction addressing motor, resting-pressure, and sensory components of continence would provide superior functional outcomes compared with reconstruction of the external sphincter alone in patients with severe war-related anal sphincter injuries.

The primary outcome was postoperative continence, assessed using validated clinical continence scores during follow-up. Secondary outcomes included resting and squeeze function based on clinical assessment, quality-of-life improvement, postoperative complications, need for additional procedures, and evaluation of the contribution of adjunctive reconstructive techniques, including smooth muscle-plasty, anal column plication, and pectinatoplasty, to overall functional outcomes.

Below is a publication-ready Methods section that is consistent with your revised Results, addresses the reviewers' comments, and avoids overstatement or unsupported claims.

METHODS

Study Design and Patient Selection

This prospective interventional cohort study included 56 consecutive male patients with end-stage fecal incontinence secondary to war-related traumatic anal sphincter injuries who underwent reconstructive surgery between November 2009 and January 2024. All patients underwent unilateral gluteoplasty and were subsequently categorized according to the reconstructive strategy employed into gluteoplasty alone (Group A, n = 30) and gluteoplasty combined with one or more adjunctive reconstructive procedures (Group B, n = 26).

The adjunctive procedures included anal column plication, smooth muscle-plasty, and pectinatoplasty. Because these procedures were designed to restore different physiological components of continence, their outcomes were analyzed individually where appropriate rather than as a single pooled intervention.

Inclusion Criteria

Patients were eligible if they met all of the following criteria:

End-stage fecal incontinence secondary to war-related traumatic anal sphincter injury.

Destruction of more than 75% of both the internal and external anal sphincter complexes requiring reconstructive surgery.

Preserved rectal sensation on clinical examination.

Completion of the scheduled postoperative follow-up.

Exclusion Criteria

Patients were excluded if they had:

Pudendal neuropathy or clinically significant sensory impairment.

Medical contraindications to reconstructive surgery.

Incomplete clinical records or loss to follow-up.

Surgical Techniques

Unilateral Gluteoplasty: All patients underwent unilateral gluteoplasty using transposition of the gluteus muscle to reconstruct the external anal sphincter with the primary objective of restoring voluntary squeeze function.

Adjunctive Reconstructive Procedures: Adjunctive reconstructive procedures were selected individually according to preoperative functional assessment, intraoperative findings, residual sphincter anatomy, extent of tissue destruction, and surgeon judgment. Treatment allocation was not randomized and reflected routine clinical practice.

The adjunctive procedures included:

Anal column plication, performed to improve anal canal structural support and reservoir function.

Smooth muscle-plasty, performed to augment the internal sphincter component and improve resting anal tone.

Pectinatoplasty, performed using perianal island flaps or V-Y anoplasty to reconstruct the pectinate region and anoderm with the aim of restoring sensory function and improving anorectal discrimination. Because these procedures target different physiological mechanisms of continence, they were analyzed separately whenever feasible rather than being interpreted as a single uniform intervention.

Follow-up

Patients were evaluated postoperatively at 1, 3, 6, 12, and 24 months. At each follow-up visit, continence status, stool frequency, wound healing, postoperative complications, clinically estimated anorectal

function, colostomy status, and patient satisfaction were assessed using standardized clinical evaluation forms.

Outcome Measures

Primary Outcome: The primary outcome was improvement in fecal continence, assessed using the validated Wexner Incontinence Score. Continence was evaluated preoperatively and at each scheduled postoperative follow-up visit.

Secondary Outcomes: Secondary outcome measures included: postoperative stool frequency; clinically estimated anorectal function; postoperative complications; successful colostomy reversal; patient satisfaction; and durability of continence throughout follow-up.

Clinical Assessment of Anorectal Function

High-resolution anorectal manometry was unavailable throughout the study period. Therefore, resting and squeeze anal sphincter pressures were assessed clinically by experienced colorectal surgeons using standardized digital rectal examination in conjunction with continence assessment. Throughout this manuscript, these measurements are reported as clinically estimated anal pressures rather than objective manometric values.

Objective sensory testing was also unavailable. Consequently, anorectal sensory recovery following pectinatoplasty was evaluated clinically rather than by formal physiological testing.

Definition of Continence Survival

Continence survival was defined as the interval from reconstructive surgery to the first occurrence of clinically significant recurrent fecal incontinence, defined by one or more of the following:

clinically significant deterioration in continence requiring additional intervention;

worsening of the Wexner Incontinence Score judged to represent recurrent functional failure; or

requirement for permanent fecal diversion (stoma).

Patients who did not experience any of these events were censored at their last clinical follow-up.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 23 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± standard deviation (SD), whereas categorical variables are presented as frequencies and percentages.

Comparisons between independent groups were performed using Student’s t-test or the Mann–Whitney U test, according to data distribution. Within-group preoperative and postoperative comparisons were

performed using the paired t-test or Wilcoxon signed-rank test, as appropriate. Categorical variables were compared using the Chi-square test or Fisher's exact test when expected cell counts were small.

Continence durability was evaluated using Kaplan–Meier survival analysis, and survival curves were compared using the log-rank test.

A two-sided P value < 0.05 was considered statistically significant.

Because this was an exploratory clinical study, no formal adjustment for multiple comparisons was performed; this was considered during interpretation of the findings.

RESULTS

Patient Characteristics

Fifty-six male patients with end-stage fecal incontinence following war-related anal sphincter injuries were included. The mean age was 22 ± 5 years. All patients had previously undergone emergency surgery with diverting colostomy after penetrating war injuries resulting in destruction of more than 75% of both the internal and external anal sphincter complexes. Baseline demographic and clinical characteristics were comparable between patients treated with unilateral gluteoplasty alone (Group A, n = 30) and those undergoing gluteoplasty combined with adjunctive reconstructive procedures (Group B, n = 26), with no statistically significant baseline differences (Table 1, Fig. 1).

Table 1
Baseline Characteristics of Patients Undergoing Gluteoplasty Alone or Gluteoplasty with Adjunctive Reconstruction

Variable	**Group A: Gluteoplasty Alone (n = 30)**	**Group B: Gluteoplasty + Adjunctive Procedures (n = 26)**	**P value**
Age (years), mean ± SD	22 ± 5	23 ± 4	0.43
Male sex, n (%)	30 (100)	26 (100)	1.000
Mechanism of injury	Penetrating war injury	Penetrating war injury	1.000
Anal sphincter destruction > 75%, n (%)	30 (100)	26 (100)	1.000
Previous emergency colostomy, n (%)	30 (100)	26 (100)	1.000
SD, standard deviation			

The operative approaches included unilateral gluteoplasty alone (Figs. 2 and 3) and gluteoplasty combined with adjunctive reconstructive procedures (Figs. 4 and 5).

Functional Outcomes

Stool frequency decreased progressively during follow-up in both groups (Table 2).

Table 2
Postoperative Stool Frequency According to Reconstruction Technique

Time after surgery	Gluteoplasty Alone	Pectinatoplasty	Anal Column Plication	Smooth Muscle-Plasty	Overall Adjunctive Reconstruction	P value
3 months	4.5	2.9	2.8	2.7	2.6	0.004
6 months	3.8	2.9	2.5	2.5	2.4	0.003
12 months	3.4	2.8	2.4	2.4	2.2	0.003
24 months	3.2	2.4	2.2	2.5	2.0	0.002
Values are mean stools/day						

Patients undergoing adjunctive reconstruction demonstrated significantly lower stool frequency than those treated with gluteoplasty alone throughout follow-up. At 24 months, the mean stool frequency was 2.0 stools/day in the adjunctive reconstruction group compared with 3.2 stools/day in the gluteoplasty-alone group (P = 0.002).

Continence restoration also improved progressively over time (Table 3).

Table 3
Continence Restoration According to Reconstruction Technique

Reconstruction Technique	3 Months	6 Months	12 Months	24 Months	Functional Target
Gluteoplasty alone	65%	78.6%	78.6%	78.6%	External sphincter (squeeze)
Gluteoplasty + Smooth muscle-plasty	77%	84%	88%	92%	Internal sphincter/resting tone
Gluteoplasty + Pectinatoplasty	84%	90%	92%	94%	Sensory function and reservoir
Gluteoplasty + Anal column plication	80%	86%	90%	93%	Reservoir support

Gluteoplasty alone achieved continence restoration in 78.6% of patients by 6 months, with no further improvement thereafter. In contrast, adjunctive reconstructive procedures demonstrated continued improvement throughout follow-up, reaching 92% after smooth muscle-plasty, 93% after anal column plication, and 94% after pectinatoplasty at 24 months.

Functional Outcomes and Patient Satisfaction

Functional outcomes at 6 months are summarized in Table 4.

Table 4
Functional Outcomes and Patient Satisfaction

Outcome	Group A: Gluteoplasty Alone	Group B: Gluteoplasty + Adjunctive Procedures	P value
Wexner score (preoperative)	16.5 ± 3.2	16.4 ± 3.1	0.89
Wexner score (6 months)	5.5 ± 1.2	3.8 ± 1.3	0.01
Complete continence at 6 months	55%	85%	0.02
Patient satisfaction score	6.2 ± 1.4	8.1 ± 1.2	0.01
Overall postoperative complications	12%	10%	0.72

Mean Wexner continence scores improved significantly in both groups. Patients undergoing adjunctive reconstruction achieved lower postoperative Wexner scores than those undergoing gluteoplasty alone (3.8 ± 1.3 vs 5.5 ± 1.2, P = 0.01). Complete continence was achieved in 85% versus 55% of patients, respectively (P = 0.02). Patient satisfaction scores were also significantly higher following adjunctive reconstruction (8.1 ± 1.2 vs 6.2 ± 1.4, P = 0.01), whereas overall postoperative complication rates were similar between groups (10% vs 12%, P = 0.72).

Clinical anorectal assessment

Preoperatively, all patients demonstrated severe anorectal dysfunction secondary to destruction of more than 75% of both the internal and external anal sphincter complexes. Clinically estimated resting and squeeze pressures were markedly reduced (Table 5).

Table 5
Clinically Estimated Anorectal Functional Assessment Before and After Reconstruction

Parameter	Preoperative (Both Groups)	Postoperative Gluteoplasty Alone (Group A, n = 30)	Postoperative Gluteoplasty + Adjunctive Procedures (Group B, n = 26)	P value
Clinically estimated resting pressure (mmHg)	Severely reduced (approximately 20–30)	40 ± 8	55 ± 10	< 0.001
Clinically estimated squeeze pressure (mmHg)	Severely reduced (approximately 40–50)	102 ± 15	135 ± 18	< 0.001
Functional anal canal length (cm)	Markedly shortened/absent functional sphincter segment due to > 75% sphincter destruction	4.0 ± 0.3	4.2 ± 0.4	0.18
Rectal sensation	Clinically preserved in all patients but associated with impaired continence discrimination	Preserved clinically	Preserved clinically	—
Urge sensation	Severely impaired clinically because of loss of sphincteric barrier	Improved clinically	Improved clinically	—
Maximum tolerated volume	Not objectively assessed preoperatively	Not objectively measured	Not objectively measured	—
Rectal compliance (mL/mmHg)	Not objectively assessed	8 ± 1.5	10 ± 1.8	0.04

Following reconstruction, estimated resting pressure increased to 40 ± 8 mmHg in Group A and 55 ± 10 mmHg in Group B ($P < 0.001$). Estimated squeeze pressure also improved significantly, reaching 102 ± 15 mmHg and 135 ± 18 mmHg, respectively ($P < 0.001$). Functional anal canal length was restored to approximately 4 cm in both groups. Because high-resolution anorectal manometry and formal sensory testing were unavailable, all pressure measurements and anorectal functional parameters represent standardized clinical estimates rather than objective physiological measurements.

Colostomy Reversal and Postoperative Outcomes

Patients undergoing adjunctive reconstruction demonstrated significantly higher rates of continence restoration (85% vs 65%, $P = 0.03$) and successful colostomy reversal (75% vs 50%, $P = 0.03$) than

patients treated with gluteoplasty alone (Table 6).

Table 6
Postoperative Complications and Colostomy Outcomes

Outcome	Group A: Gluteoplasty Alone	Group B: Gluteoplasty + Adjunctive Procedures	P value
Overall postoperative complications	12%	10%	0.72
Continence restoration	65%	85%	0.03
Successful colostomy reversal	50%	75%	0.03

Overall postoperative complications were comparable between groups (10% vs 12%, P = 0.72). The most frequent complications included wound infection, delayed wound healing, partial flap ischemia, and recurrent soiling.

Kaplan-Meier

Durability of Continence

For survival analysis, the event was defined as the first occurrence of clinically significant deterioration in continence, recurrent disabling fecal incontinence requiring additional surgical intervention, or permanent stoma formation.

Kaplan–Meier analysis demonstrated significantly greater long-term continence durability in patients undergoing gluteoplasty with adjunctive reconstructive procedures than in those treated with gluteoplasty alone (Fig. 6). At 24 months, the continence survival probability was 0.75 in Group B compared with 0.40 in Group A (log-rank P = 0.02) (Table 7).

Table 7
Kaplan–Meier Analysis of Continence Durability

Time (months)	Group A: Gluteoplasty Alone	Group B: Gluteoplasty + Adjunctive Procedures
0	1.00	1.00
6	0.80	0.90
12	0.60	0.80
18	0.50	0.75
24	0.40	0.75

Summary of Principal Findings: Compared with unilateral gluteoplasty alone, adjunctive reconstructive procedures resulted in lower postoperative stool frequency, higher continence restoration rates, superior

clinically estimated anorectal functional parameters, greater patient satisfaction, higher colostomy reversal rates, and improved long-term continence durability without increasing postoperative morbidity. Among the adjunctive procedures, pectinatoplasty achieved the highest continence restoration at 24 months.

DISCUSSION

Fecal incontinence (FI), a debilitating condition with profound impacts on quality of life, was investigated in this study evaluating unilateral gluteoplasty for managing FI caused by severe war-related anal sphincter injuries in a Yemeni population. Results demonstrated significant improvements in voluntary control and reduced FI incidence post-intervention. However, complete continence often necessitated a multidisciplinary approach addressing the multifactorial pathophysiology of anal continence.

Pathophysiology of Fecal Incontinence: Fecal incontinence results from disruption of three interrelated physiological components of continence:

Sensory component: Mediated by rectal sensation, perception of rectal distension, and discrimination of rectal contents through integrated anorectal sensory pathways, including the rectoanal inhibitory reflex (RAIR).

Reservoir component: Determined by rectal compliance, reservoir capacity, the anorectal angle, and the contribution of the anal cushions to continence [1].

Motor component: Depends on the coordinated function of the internal and external anal sphincters, pelvic floor musculature, and their neural innervation.

In the present study, unilateral gluteoplasty restored satisfactory continence in 78.6% of patients, enabling successful colostomy reversal in the majority of cases. Postoperatively, clinically estimated improvements in voluntary squeeze function and anal sphincter tone were observed, consistent with previous reports demonstrating the effectiveness of gluteoplasty in restoring the motor component of continence [1]. However, persistent or residual fecal incontinence, particularly in patients with impaired anorectal sensation or loss of the internal sphincter mechanism, highlighted the limitations of gluteoplasty alone in restoring the sensory and reservoir components of continence. These findings support the addition of adjunctive reconstructive procedures, such as smooth muscle-plasty, anal column plication, and pectinatoplasty, to address the multiple physiological mechanisms required for durable continence restoration.

Implications: gluteoplasty effectively restores the motor component of continence by reconstructing voluntary sphincter contraction; however, it does not completely compensate for impaired sensory discrimination, reduced resting anal tone, or diminished rectal reservoir function. Consequently, patients with extensive internal sphincter destruction or impaired anorectal sensory function may continue to experience residual soiling or passive fecal incontinence despite satisfactory squeeze function. These

findings support a multimodal reconstructive strategy in which adjunctive procedures—including smooth muscle-plasty to augment resting tone, anal column plication to improve reservoir support, and pectinatoplasty to restore the sensory anoderm—address the complementary physiological components of continence. Restoration of motor, sensory, and reservoir functions together appears to provide more durable functional recovery than reconstruction of the external sphincter alone.

Fecal incontinence may be classified clinically into three principal subtypes:

Passive fecal incontinence: Involuntary leakage of stool without awareness or preceding urge, typically associated with impaired resting anal tone or internal anal sphincter dysfunction.

Urge fecal incontinence: Inability to defer defecation despite awareness of rectal filling, usually resulting from reduced voluntary external sphincter function or diminished rectal compliance.

Stress (exercise-related) fecal incontinence: Leakage occurring during activities that increase intra-abdominal pressure (e.g., coughing, lifting, or exercise), reflecting inadequate sphincter resistance to transient pressure elevations.

Surgical approaches include:

Sphincteroplasty: Effective for motor dysfunction with < 50% sphincter destruction, particularly when combining internal/external sphincter reconstruction [2].

In the study by Novi, Mulvihill, and Morgan (2009), the authors evaluated the outcomes of combined anal sphincteroplasty and perineal reconstruction for the treatment of fecal incontinence in women, particularly those with obstetric-related perineal defects. The results demonstrated that this combined surgical approach led to marked improvement in continence and quality of life among the majority of patients. Postoperatively, most women reported a significant reduction in incontinence episodes and improved anal sphincter control. The procedure effectively restored the perineal body and reinforced the anal sphincter mechanism, leading to better functional and anatomical outcomes. No major complications were reported, supporting the safety and efficacy of combining sphincter repair with perineal reconstruction for optimal restoration of continence in appropriately selected female patients [3].

In their 2023 systematic review, Mongardini et al. analyzed short- and long-term outcomes of sphincteroplasty for anal incontinence secondary to obstetric injury, synthesizing data from multiple clinical studies. The review found that sphincteroplasty provides substantial short-term improvement in continence and quality of life, with many women experiencing meaningful symptom relief in the first 1–2 years postoperatively. However, long-term follow-up revealed a progressive decline in continence function, as recurrence of symptoms and decreased sphincter integrity became more common over time. Despite this, many patients maintained better function compared to preoperative status, indicating that sphincteroplasty remains a valuable option for selected women, particularly when performed with careful patient selection and appropriate postoperative rehabilitation [4].

These studies indicate that while overlapping sphincteroplasty can offer short-term improvements in continence, the long-term success rates tend to decline over time [4]. Factors influencing these outcomes include patient age, duration of incontinence, and the presence of pelvic floor neuropathy [5].

Anterior Sphincteroplasty: Anterior sphincteroplasty is a cornerstone technique, involves dissecting and overlapping the external anal sphincter to repair disruptions [6].

While controversy exists regarding the need to plicate the internal anal sphincter, several studies have demonstrated improved continence outcomes with this approach [7].

Gluteoplasty for External Sphincter Reconstruction: Recent studies have focused on optimizing the outcomes of gluteoplasty by combining it with other techniques, such as smooth muscle-plasty and cushion plication, to address both external and internal sphincter deficiencies.

Gluteoplasty indicated for severe FI from extensive sphincter injuries, utilizing the gluteus maximus (innervated by L5-S1) as an artificial sphincter. Enríquez-Navascués et. al., [8] studied a prospective series of 12 patients with traumatic anal incontinence treated by direct sphincteroplasty reinforced with unilateral gluteus maximus transposition reported that after 6–24 months of follow-up, 67% of patients regained complete continence and an additional 25% showed marked improvement, with significant increases in resting and squeeze anal pressures and minimal morbidity. The authors concluded that unilateral gluteoplasty effectively supplements direct sphincter repair in traumatic injuries.

Proximally based flaps reduce tension and improve outcomes compared to distal flaps, as demonstrated in cadaver studies.

Bilateral gluteoplasty shows > 50% improvement in continence, though challenges with liquid stool/gas persist [9]. A series of patients treated using bilateral gluteus maximus transposition showed that mobilizing fibers from both gluteus maximus muscles around the anal canal augmented resting and squeeze pressures [9]. Most patients experienced significant improvement in continence with minimal morbidity, indicating bilateral gluteoplasty is an effective adjunct to direct sphincter repair, particularly in severe or traumatic sphincter damage. Gluteoplasty utilizes the gluteus maximus muscle to create a neosphincter, addressing motor dysfunction in cases of severe sphincter injury [10].

Smooth Muscle-Plasty for Internal Sphincter Restoration: Smooth muscle-plasty targets the internal anal sphincter, a key contributor to resting pressure. Several studies have demonstrated that this procedure, when combined with external sphincter repairs, can effectively improve fecal continence. Autologous smooth muscle grafts effectively reconstruct internal sphincters in pediatric and adult populations [11]. Innovations like the fold-over half-cylinder double plasty (SMFD-plasty) offer functional restoration with low complications [11].

The SMFD-Plasty technique, performed by Hofmann-v et.al., [11] immediately after a precise pull-through, restores internal sphincter function and has shown excellent early results in neonates and older children. It is suitable as both a primary procedure and secondary intervention for complex cases.

Krand O et al., (2009) [12] studied those patients undergoing intersphincteric resection for very low rectal cancer received smooth-muscle-plasty to restore the internal anal sphincter after partial IAS resection. They found that as 6 months, ~ 80% had “good continence” (Kirwan I–II); long-term function acceptable. Although this is an oncologic series (not obstetric trauma), it demonstrates that smooth-muscle-plasty can restore IAS function in adults.

This technique utilizes autologous smooth muscle grafts to reconstruct the internal anal sphincter, showing promise in both pediatric and adult populations [12].

An animal model study demonstrated that smooth muscle enfoldment internal sphincter construction (SMESC) achieved acceptable reconstruction of the internal anal neo-sphincter without increasing surgical risk, suggesting potential applicability in clinical practice [13].

Kostov DV, (2004) constructed perineal colostomy; focuses on operative technique and functional improvement after smooth-muscle reconstruction. He Demonstrated technical feasibility and improved functional control after smooth-muscle sphincteroplasty [14].

Vorobiev GI et al., (2004) published case series on smooth-muscle-plasty combined with colonic pouch or other reconstructive steps [15]. Early continence rates reported ~ 80–85% at 12 months for selected reconstructions [15].

Schmidt and colleagues described early methods of sphincteroplasty using autologous smooth muscle and reverse smooth-muscle-plasty, providing background on anatomy and operative technique in 1982 [16].

Conceptually, restoring both internal (smooth muscle) and external (striated muscle) components is critical. Most randomized/large series on obstetric anal sphincter injury focus on external sphincter repair; our regenerative approaches aim to target both tissues [17].

Pectinatoplasty for Restorating Sensory Function: The potential benefit of pectinatoplasty in improving continence may be explained by restoration of anodermal sensory function, which plays a critical role in discriminating rectal contents and initiating reflex sphincter responses. Reconstruction of the pectinate region may enhance afferent sensory signaling, thereby improving coordination between rectal distension and sphincter contraction. This sensory feedback mechanism is essential for fine continence control and may partially explain the observed clinical improvement. Two studies highlighted the importance of restoring sensory function for patients with fecal incontinence of anorectal malformation patients. Pectin skin restoration techniques has argued for its importance in improving sensory feedback and enhancing continence without any reproduced evidence [18–19].

In a study of 32 patients aged 5–16 years after surgery for anorectal malformations, assessment of perianal skin and anal canal sensation revealed impaired anal canal sensation in patients with fecal incontinence or constipation, indicating that sensory deficits contribute to difficulties in distinguishing between flatus and feces [18–19].

Other Surgical Options:

Postanal Repair: Postanal repair aims to restore the anorectal angle and has been evaluated for its efficacy in treating fecal incontinence. Matsuoka et al. (2000) assessed the outcomes of postanal repair in patients with idiopathic or neurogenic fecal incontinence, finding variable success rates and potential risks, including pudendal nerve injury [20]. This technique aims to restore the anorectal angle but has shown variable success rates and may have potential complications, such as pudendal nerve injury [20].

Other Muscle Transposition: Techniques such as gracilis muscle transposition offer an option for patients with severe sphincter defects or those who have failed other procedures [21–22].

Minimally Invasive Therapies: Once medical therapy has been maximized, minimally invasive and surgical therapies may be considered. Injectable materials, such as silicone, dextranomer/hyaluronic acid (NASHA), and carbon-coated microbeads, have been investigated to augment anal sphincter function. While silicone injections have shown some success, results with carbon-coated microbeads have been less promising [23].

Injectable Bulking Agents: Dextranomer/hyaluronic acid injections have shown promise in improving continence in patients who have failed other conservative therapies [24]. They have demonstrated significant reductions in incontinence episodes and improvements in quality of life with this approach. Adverse events are generally mild and self-limiting. Malouf et al. (2001) conducted a study on internal anal sphincter augmentation using injectable silicone biomaterial, highlighting its effectiveness in enhancing anal sphincter function and improving continence in patients with fecal incontinence [25].

Composite Pocedures: Composite procedures, such as combining the antropyloric valve with a gluteus maximus muscle wrap, have demonstrated high patient satisfaction in managing fecal incontinence [26].

Sacral Nerve Stimulation (SNS): SNS is an established treatment for fecal incontinence, improving continence by stimulating the sacral nerves [27–28]. However, a significant proportion of patients may not respond to SNS, and complications such as infection and lead migration can occur [29].

From above, several surgical procedures are performed for the treatment of anal incontinence. The type of procedure used is based on the patient history, physical examination findings, and results of diagnostic evaluation. The current philosophy in pelvic reconstructive surgery emphasizes restoration of normal anatomy.

LIMITATIONS

This study has several limitations. First, it was a prospective, non-randomized, single-center study with a relatively small sample size, which may limit the generalizability of the findings and introduce selection bias. Second, high-resolution anorectal manometry and formal anorectal sensory testing were unavailable; therefore, anorectal function was assessed using standardized clinical examination by experienced colorectal surgeons rather than objective physiological measurements. Third, although

validated continence scores and patient-reported outcomes were used, some functional outcomes relied on clinical assessment. Finally, no formal adjustment for multiple comparisons was performed because of the exploratory nature of the study. Larger, multicenter studies incorporating objective anorectal physiological testing and longer follow-up are warranted to validate these findings.

CONCLUSION

Unilateral gluteoplasty offers substantial improvement in fecal continence among patients with war-related anal sphincter injuries. However, complete functional restoration often necessitates adjunctive procedures to address deficiencies beyond sphincter contraction alone. A comprehensive, multimodal approach that integrates the motor, sensory, and reservoir components of continence is essential to achieve optimal functional outcomes. Tailoring the surgical plan to each patient's anatomical and physiological deficits enhances success rates and durability. Ongoing research and refinement of reconstructive techniques remain vital for further improving outcomes and quality of life in this challenging patient population.

RECOMMENDATIONS

A multimodal management strategy is essential for optimizing outcomes in war-related fecal incontinence. While unilateral gluteoplasty provides effective restoration of voluntary sphincter function, adjunctive procedures to enhance motor, sensory, and resting pressure components.

Biofeedback therapy should be incorporated postoperatively to improve neosphincter coordination and strengthen functional outcomes.

Future directions should focus on regenerative medicine approaches, including stem cell and tissue engineering techniques to restore damaged sphincter tissue, and on the continued refinement of minimally invasive reconstructive methods that reduce morbidity while maintaining efficacy.

A personalized, comprehensive approach remains key to achieving durable continence and improving patients' quality of life in this challenging patient group.

Declarations

ETHICAL CONSIDERATIONS

This prospective clinical study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was first obtained from the Institutional Review Board (IRB) of Al-Thawra Modern General Hospital, Sana'a, Yemen (Approval No. TMG-HOSP-2009-013, dated 16 July 2009) prior to initiation of patient recruitment and intervention. Subsequent approval for data analysis and publication was granted by the Institutional Review Board of the Faculty of Medicine, 21 September University of Medical & Applied Sciences, Sana'a, Yemen on October 4, 2025.

Written informed consent was obtained from all participants before inclusion in the study. Patient confidentiality was maintained throughout, and all data were anonymized prior to analysis to ensure privacy and compliance with institutional research ethics.

DISCLOSURE

The abstract of this paper was presented at the ACS Clinical Congress 2024 in San Francisco as a poster presentation with interim findings. The poster's abstract was published in 'Poster Abstracts' in J Am Coll Surg. 2024 Nov;239 (5 Suppl): S80–S121. DOI:10.1097/XCS.0000000000001160.

COMPETING INTERESTS

The authors declare no competing interests related to this study.

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Author Contribution

W R A is the principal author for all parts of this manuscript

Data Availability

Ethical approval was first obtained from the Institutional Review Board (IRB) of Al-Thawra Modern General Hospital, Sana’a, Yemen (Approval No. TMG-HOSP-2009-013, dated 16 July 2009) prior to initiation of patient recruitment and intervention. Subsequent approval for data analysis and publication was granted by the Institutional Review Board of the Faculty of Medicine, 21 September University of Medical & Applied Sciences, Sana’a, Yemen on October 4, 2025.All data are available apone reasonable request from editor.

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Figures

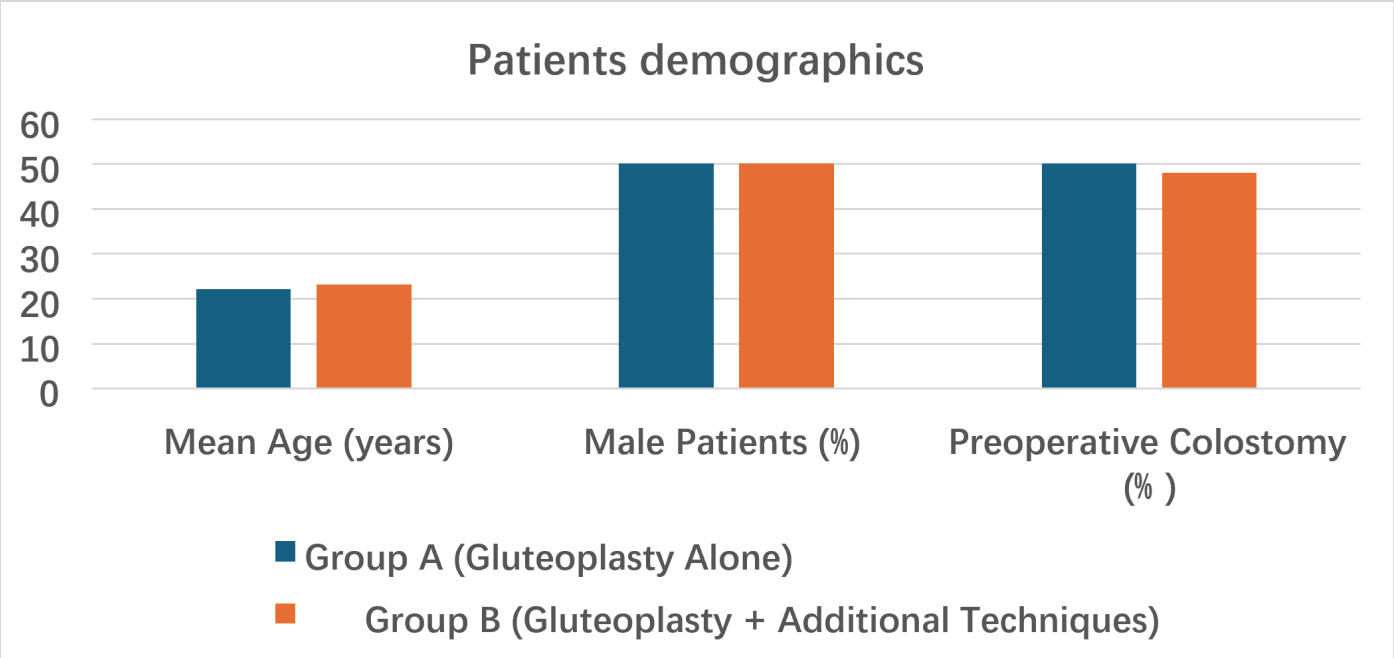


Figure 1

Patients Demographics



Figure 2

Gluteoplasty for a patient post war injury of anal sphincter

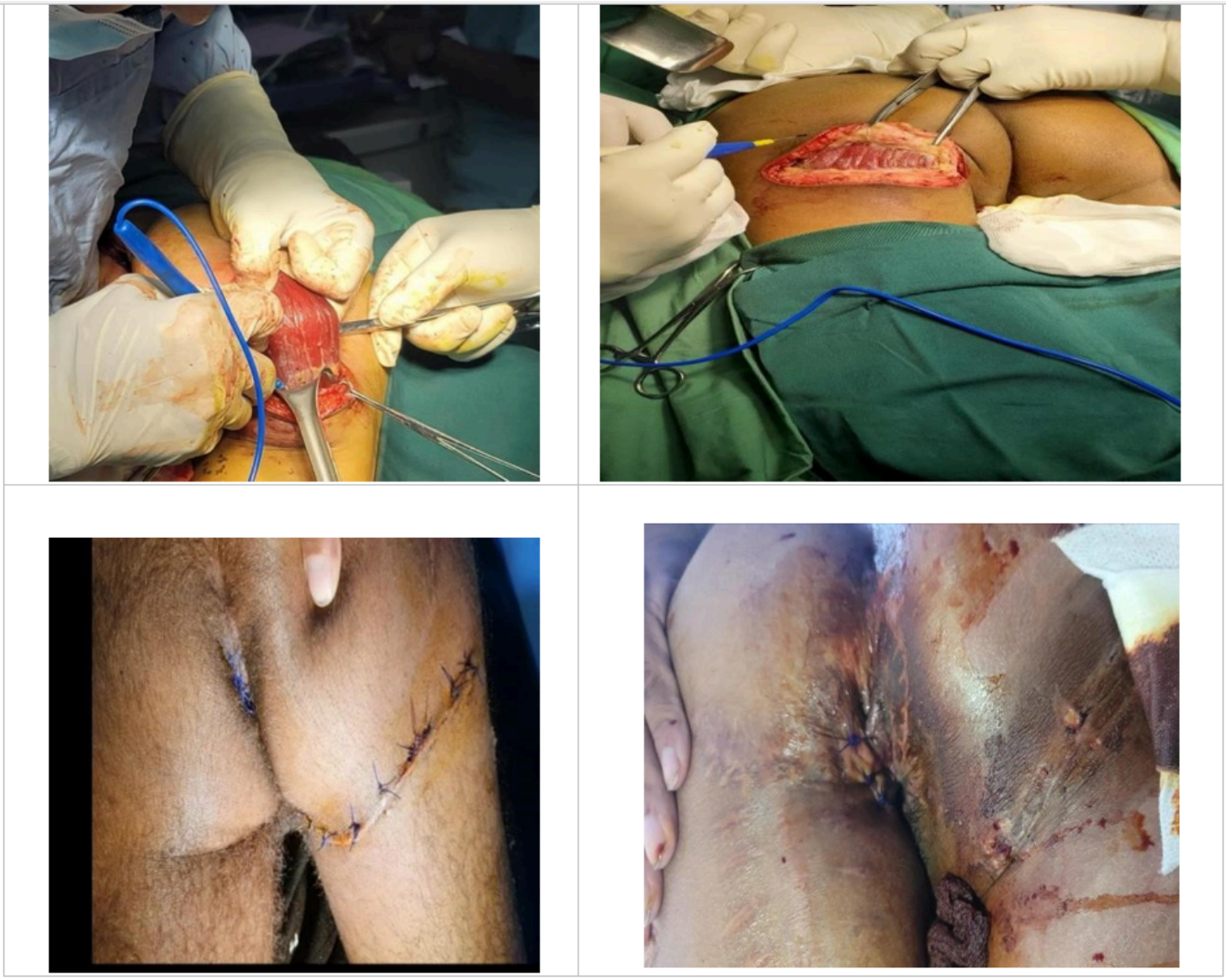


Figure 3

Gluteoplasty: Intraoperative and postoperative look

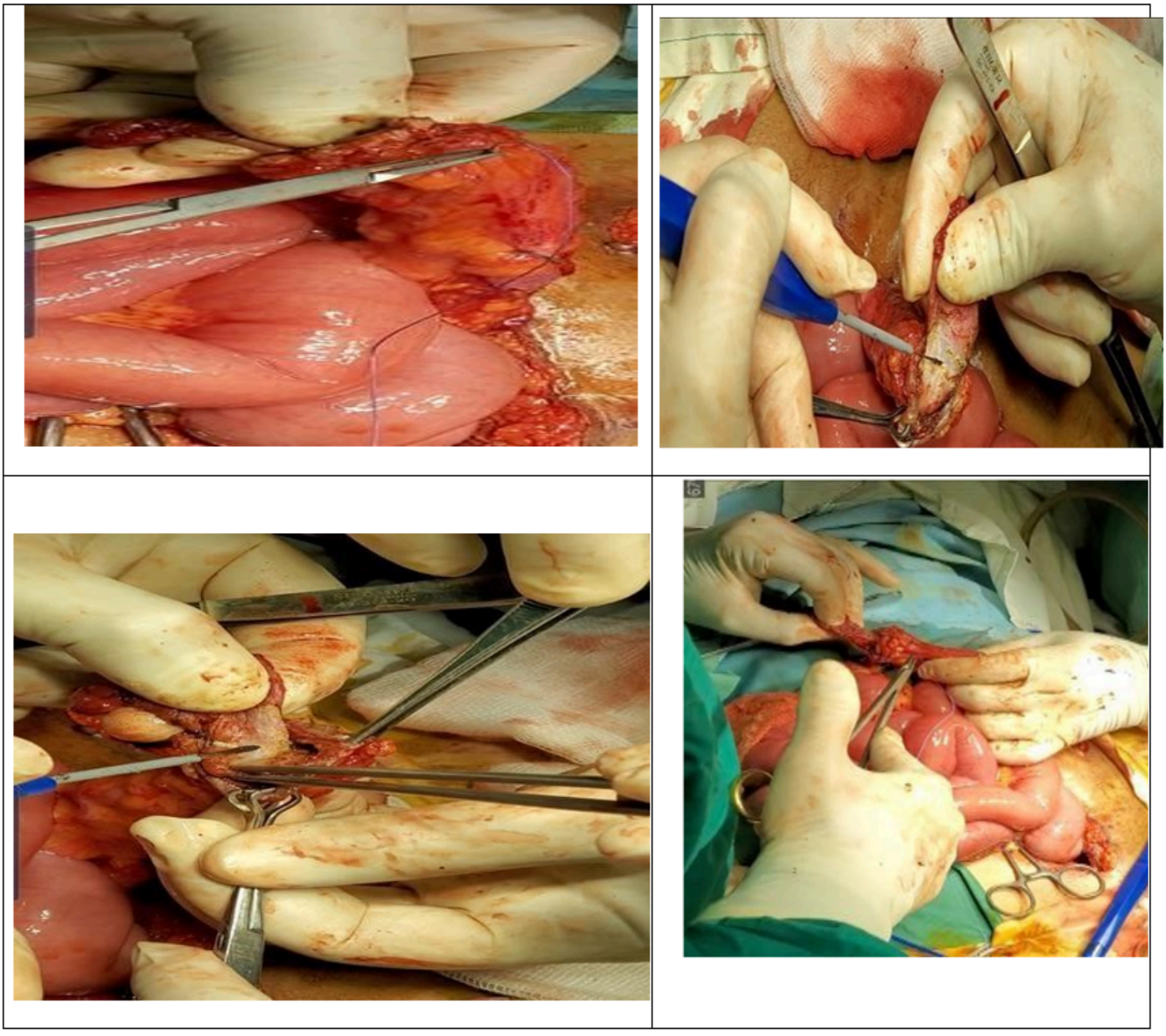


Figure 4

Smooth Muscle Plasty intraoperative look



Figure 5

Pectinatoplasty early look

Pectinatoplasty late look

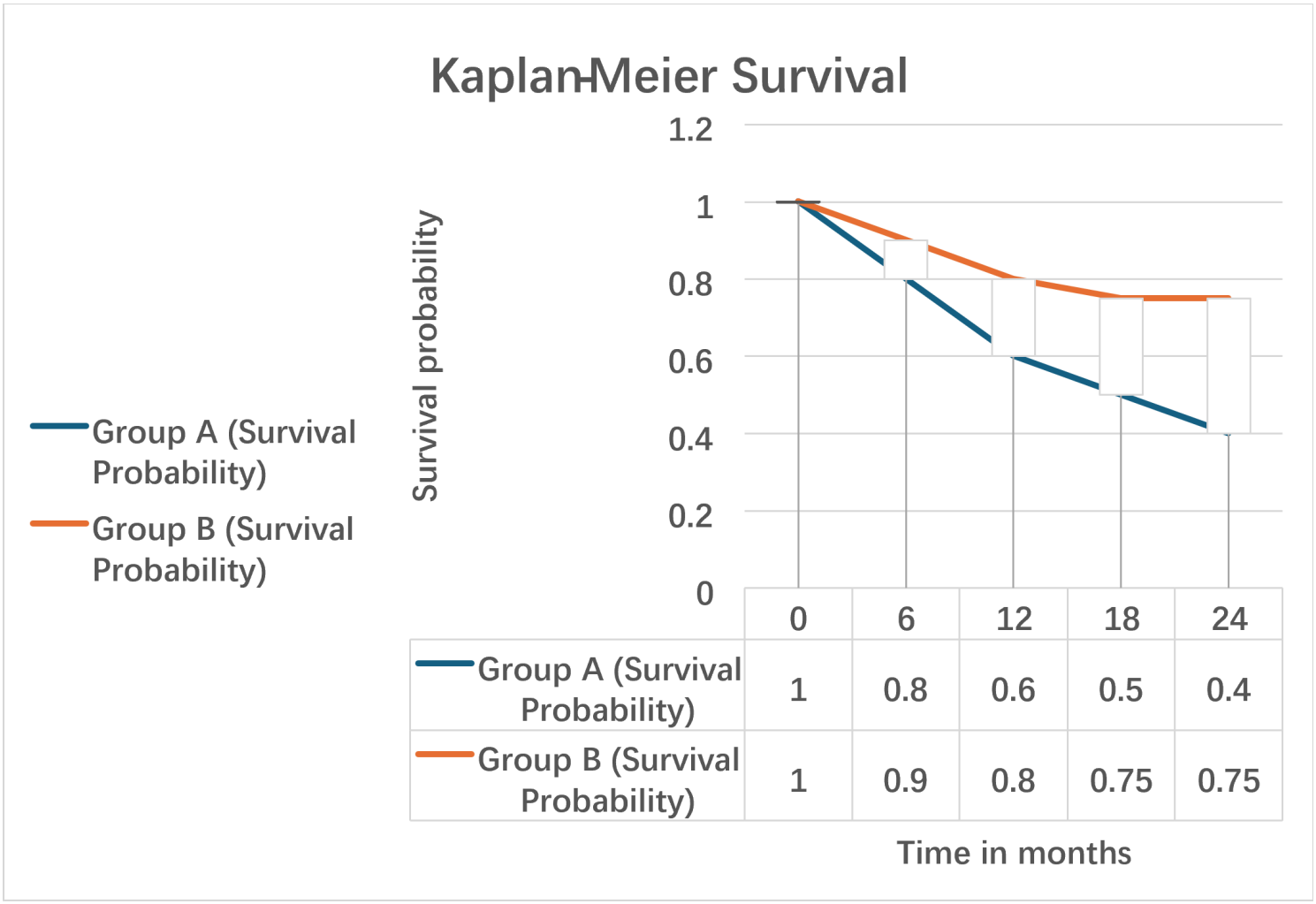


Figure 6

Kaplan–Meier survival curve