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Modified Desarda Technique With Double-Breasted External-Oblique Aponeurosis for Uncomplicated Inguinal Hernia—a Prospective Observational Study With Technical Refinements

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MODIFIED DESARDA TECHNIQUE WITH DOUBLE-BREASTED EXTERNAL-OBLIQUE APONEUROSIS FOR UNCOMPLICATED INGUINAL HERNIA—A PROSPECTIVE OBSERVATIONAL STUDY WITH TECHNICAL REFINEMENTS

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ABSTRACT

Background: Mesh-based repair is widely used for uncomplicated inguinal hernia, but tissue-based repair remains relevant when avoidance of prosthetic material is desired. We evaluated outcomes of a modified Desarda–Halsted repair incorporating broad posterior-wall reinforcement, double-breasting of the external oblique aponeurosis, deep-ring stabilization, and subcutaneous exteriorization of the spermatic cord.

Methods: A clinical series of 550 consecutive adults with uncomplicated inguinal hernia who underwent the modified repair at a tertiary surgical centre was analysed. The repair used broad external-oblique aponeurotic reinforcement, fixation around the deep inguinal ring, double-breasting of the aponeurosis, and subcutaneous positioning of the spermatic cord. The primary outcome was hernia recurrence. Secondary outcomes included postoperative complications, chronic groin pain, cord-related morbidity, and functional recovery.

Results: All 550 procedures were completed using the planned tissue-based technique without conversion to mesh repair. During follow-up, 4 patients developed recurrent hernia, corresponding to a recurrence rate of 0.72%. Early complications included seroma in 34 patients (6.2%), superficial surgical-site infection in 22 (4.0%), haematoma in 20 (3.6%), and transient spermatic-cord oedema in 20 (3.6%). These complications were managed conservatively. No chronic groin pain, foreign-body sensation, or persistent cord morbidity was reported. Functional recovery was favourable in the reported cohort.

Conclusion: The modified Desarda–Halsted repair was associated with a low observed recurrence rate and limited postoperative morbidity in this single-centre clinical series. The technique may be a mesh-free option for selected patients with uncomplicated inguinal hernia. Comparative multicentre studies with standardized outcome assessment are required to determine its effectiveness relative to established repairs.

Keywords

Inguinal hernia- Inguinal hernia, Desarda repair, Halsted repair, Tissue-based repair, Mesh-free repair, External oblique aponeurosis, Hernia recurrence, Deep inguinal ring.

INTRODUCTION

Inguinal hernia repair is one of the most frequently performed general surgical procedures worldwide. Contemporary guidelines support mesh-based repair for most adult patients, while selected tissue-based repairs remain relevant when prosthetic material is undesirable or unsuitable. The choice of technique should consider patient factors, hernia characteristics, surgeon expertise, and the expected risk of chronic postoperative pain and recurrence. [1]

The Desarda repair is a non-mesh tissue-based technique introduced as an alternative to prosthetic repair. It uses an undetached strip of external oblique aponeurosis to reinforce the posterior wall of the inguinal canal while maintaining continuity with the abdominal wall. The original technique was reported in a large clinical series and was subsequently evaluated in randomized trials and systematic reviews. [2–4] Recent evidence suggests that Desarda repair can achieve recurrence rates comparable to Lichtenstein repair in selected patients, although the available studies remain heterogeneous and do not establish superiority of either technique for all patients. [3–5]

Despite these findings, conventional Desarda repair relies primarily on a relatively narrow strip of external oblique aponeurosis for posterior-wall reinforcement. In patients with substantial posterior-wall attenuation, a wide or dilated deep inguinal ring, or larger defects, broader tissue reinforcement may theoretically provide more extensive support. The present modification was developed to address these anatomical considerations by extending external-oblique aponeurotic reinforcement around the deep inguinal ring and incorporating double-breasting of the aponeurosis.

A further component of the modification was derived from the historical Halsted principle of positioning the spermatic cord superficially following reconstruction of the posterior wall. The intention was to permit broad posterior-wall reconstruction while avoiding excessive confinement of the cord within the reconstructed inguinal canal. The modified procedure therefore combines the tissue-based posterior-wall reinforcement of the Desarda concept with selected elements of the Halsted repair.

The present study evaluated the clinical outcomes of this modified Desarda–Halsted repair in a consecutive series of adults with uncomplicated inguinal hernia. The primary outcome was hernia recurrence. Secondary outcomes included early postoperative complications, cord-related morbidity, chronic groin symptoms, and functional recovery. The study was designed to describe the clinical results and technical feasibility of the modified repair rather than to establish comparative superiority over established mesh or tissue-based techniques.

PATIENTS AND METHODS

1.Study Design and Setting

This longitudinal observational clinical study evaluated the feasibility, technical reproducibility, postoperative morbidity, functional recovery, and long-term hernia recurrence following a modified mesh-free Desarda–Halsted inguinal hernia repair. The study was conducted over a 14-year period at a tertiary-care surgical centre with dedicated experience in open tissue-based inguinal hernia reconstruction. The study population comprised 550 adult patients with uncomplicated inguinal hernia who underwent the modified repair through an open anterior inguinal approach.

The operative modification was based on the fundamental principle of physiological posterior-wall reconstruction described in the Desarda technique, supplemented by selected principles derived from the historical Halsted repair. The principal technical refinements comprised broad external oblique aponeurotic reinforcement of the posterior wall, reinforcement extending superiorly and inferiorly around the deep inguinal ring, double-breasting of the external oblique aponeurosis to provide multilayered tissue support, and subcutaneous exteriorization of the spermatic cord. The intended objective was to achieve broad anatomical reinforcement of the inguinal canal while avoiding implantation of prosthetic mesh.

All patients underwent preoperative clinical assessment to establish the diagnosis of inguinal hernia and to evaluate reducibility, posterior-wall integrity, deep inguinal ring dimensions, medial inguinal-floor weakness, and the presence of inguinoscrotal extension when applicable. Additional ultrasonography was performed when clinically indicated. Routine preoperative hematological and biochemical investigations and anaesthetic assessment were undertaken before surgery.

The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for observational studies.

Patient Selection

Adult patients with clinically diagnosed inguinal hernia who were considered suitable for elective open tissue-based repair were eligible for inclusion.

Eligibility was determined following detailed clinical assessment, including evaluation of the anatomical type of hernia, reducibility, integrity of the posterior wall of the inguinal canal, calibre of the deep inguinal ring, and the presence of associated inguinoscrotal extension.

The modified mesh-free repair was considered particularly appropriate in patients with attenuation of the posterior inguinal wall, enlargement of the deep inguinal ring, substantial inguinal-floor weakness, or a larger hernial defect, when the operating surgeon considered tissue-based reconstruction technically feasible.

Patient preference for avoidance of prosthetic mesh was also considered during operative planning.

Patients who were medically unfit for anaesthesia or elective surgery, required emergency intestinal resection for a strangulated or otherwise complicated hernia, had severe uncontrolled systemic disease, or were unwilling or unable to participate in postoperative follow-up were excluded.

Patients who did not provide informed consent for the surgical procedure and postoperative clinical assessment were also excluded.

The principal characteristics of the study cohort and the modified operative procedure are summarized in Table 1.

Characteristic	Description
Study population	550 adult patients
Clinical condition	Uncomplicated inguinal hernia
Surgical approach	Open anterior inguinal approach
Repair technique	Modified Desarda–Halsted repair
Repair material	Autologous tissue-based reconstruction
Prosthetic mesh	Not used
Posterior-wall reinforcement	Broad external oblique aponeurotic reinforcement
Deep inguinal ring	Additional reinforcement incorporated
Aponeurotic reconstruction	Double-breasting of the external oblique aponeurosis
Spermatic cord management	Subcutaneous exteriorization following posterior-wall reconstruction
Primary outcome	Hernia recurrence
Secondary outcomes	Postoperative complications and clinical recovery

Table-1 Data are presented as descriptive characteristics of the study cohort and operative procedure

2. Preoperative Clinical Assessment

All patients underwent a standardized preoperative clinical assessment.

The diagnosis and anatomical characteristics of the inguinal hernia were evaluated by clinical history and physical examination.

Assessment included determination of hernia reducibility, anatomical location, posterior-wall integrity, degree of medial inguinal-floor attenuation, calibre of the deep inguinal ring, and presence of inguinoscrotal extension.

Particular attention was directed towards identifying structural laxity of the inguinal canal and areas of potential posterior-wall weakness in relation to the pubic tubercle and deep inguinal ring.

These anatomical findings were considered during operative planning to determine the extent of posterior-wall reinforcement required.

Routine preoperative haematological and biochemical investigations were performed according to institutional surgical and anaesthetic protocols.

Ultrasonographic examination of the groin was performed when additional anatomical clarification was clinically indicated.

All patients underwent preoperative anaesthetic assessment to determine suitability for elective surgical intervention.

3. Operative Technique

All procedures were performed through an open anterior inguinal approach under appropriate anaesthesia. An oblique skin incision was made parallel and superior to the inguinal ligament. The subcutaneous tissues were divided with meticulous haemostasis, and the external oblique aponeurosis was identified and incised along the direction of its fibres to expose the inguinal canal and spermatic cord.

The spermatic cord was carefully identified, mobilized, and isolated using a combination of sharp and blunt dissection. Particular attention was directed towards preservation of the vas deferens, testicular vessels, and associated neurovascular structures. Adequate mobilization was performed to permit exposure of the posterior wall of the inguinal canal and the deep inguinal ring while avoiding excessive traction or compression of the cord structures.

Hernial sac management

The hernial sac was identified according to the anatomical type of hernia. In indirect

inguinal hernia, the sac was carefully dissected from the spermatic cord structures, transfixed and ligated at the level of the neck, and the redundant sac was excised. In direct inguinal hernia, the hernial sac and attenuated posterior wall were reduced before reconstruction. The deep inguinal ring and posterior-wall defect were subsequently assessed intraoperatively to determine the extent of tissue reinforcement required.

Inferior posterior-wall reinforcement

The modification used a broad external oblique aponeurotic layer rather than a narrow isolated aponeurotic strip. The inferior leaf of the external oblique aponeurosis was approximated to the inguinal ligament using interrupted nonabsorbable sutures, beginning at the pubic tubercle and progressing laterally towards the deep inguinal ring. This provided broad reinforcement of the medial and inferior components of the posterior inguinal wall.

Deep inguinal ring reinforcement

Additional aponeurotic reinforcement was extended superiorly towards and beyond the deep inguinal ring to provide support to both the superior and inferior aspects of the ring complex. The objective was to achieve broader circumferential stabilization of the deep inguinal ring and the adjacent lateral posterior wall rather than concentrating reinforcement at a single tissue plane.

Double-breasting of the external oblique aponeurosis

The external oblique aponeurosis was subsequently double-breasted by overlapping the available aponeurotic layers to create multilayered tissue reinforcement of the posterior inguinal wall. This configuration was intended to broaden the area of tissue support and distribute tensile forces across the reconstructed inguinal floor while avoiding reliance on a single narrow aponeurotic strip.

Suture material and fixation

Nonabsorbable polypropylene sutures were used for aponeurotic fixation. The posterior-wall reconstruction was performed using 2-0 polypropylene sutures in a continuous locking configuration, with careful approximation of the aponeurotic tissues while avoiding excessive tension or constriction of the reconstructed inguinal canal

Subcutaneous exteriorization of the spermatic cord

Following completion of posterior-wall reconstruction, the spermatic cord was positioned in the subcutaneous plane as a component of the modified Halsted principle. Care was taken to preserve the vascularity and mobility of the cord and to avoid torsion or excessive compression of the vas deferens and testicular vessels. The reconstructed aponeurotic layer remained deep to the exteriorized cord.

Wound closure

After confirmation of satisfactory haemostasis, the subcutaneous tissues and skin were closed in anatomical layers using standard surgical techniques, followed by application of a sterile dressing.

4. Biomechanical Basis of the Modification

The modified repair was designed to provide a broader area of tissue reinforcement than that achieved by a narrow aponeurotic strip alone. Approximation of the external oblique aponeurotic layers to the inguinal ligament provided reinforcement of the medial and inferior aspects of the posterior wall, while extension of the reconstruction towards the deep inguinal ring provided additional support to the lateral component of the inguinal canal.

Double-breasting of the external oblique aponeurosis created a multilayered aponeurotic reconstruction intended to distribute mechanical stress over a broader tissue surface. Subcutaneous exteriorization of the spermatic cord was incorporated to avoid excessive confinement of the cord within the reconstructed inguinal canal. These modifications were intended to achieve anatomical reinforcement while preserving tissue mobility and avoiding prosthetic mesh implantation

5. Postoperative Management and Outcome Measures

All patients received standard postoperative monitoring and supportive care. Early mobilization was encouraged following recovery from anaesthesia.

Patients underwent clinical follow-up at regular intervals. Postoperative assessment included evaluation of wound healing, postoperative pain, haematoma formation, seroma, superficial surgical-site infection, transient oedema of the spermatic cord, hernia recurrence, chronic groin discomfort, foreign-body sensation, and overall functional recovery.

The primary outcome measure was postoperative recurrence of inguinal hernia. Secondary outcome measures included postoperative haematoma, seroma formation, superficial surgical-site infection, transient spermatic-cord oedema, chronic groin pain, foreign-body sensation, and overall clinical recovery.

6. Ethical Considerations

The study protocol was reviewed and approved by the Ethics Committee of Rahate Surgical Hospital, Nagpur, India (Protocol No. PMZ-2010/CT-419; Version 1.0, dated 16 October 2019). Approval was granted following review of the study protocol, Investigator's Brochure, informed consent document, and relevant investigator documentation at the Ethics Committee meeting held on 25 October 2025. The approval letter was issued on 27 October 2025.

Written informed consent was obtained from all participants before enrolment and surgical intervention. Patient confidentiality was maintained throughout the study, and

clinical information was handled in accordance with applicable institutional ethical requirements.

RESULTS

A total of 550 patients underwent the modified Desarda–Halsted mesh-free inguinal hernia repair. The operative outcomes, early postoperative complications, and long-term recurrence outcomes were evaluated. All procedures were completed using the planned open tissue-based technique.

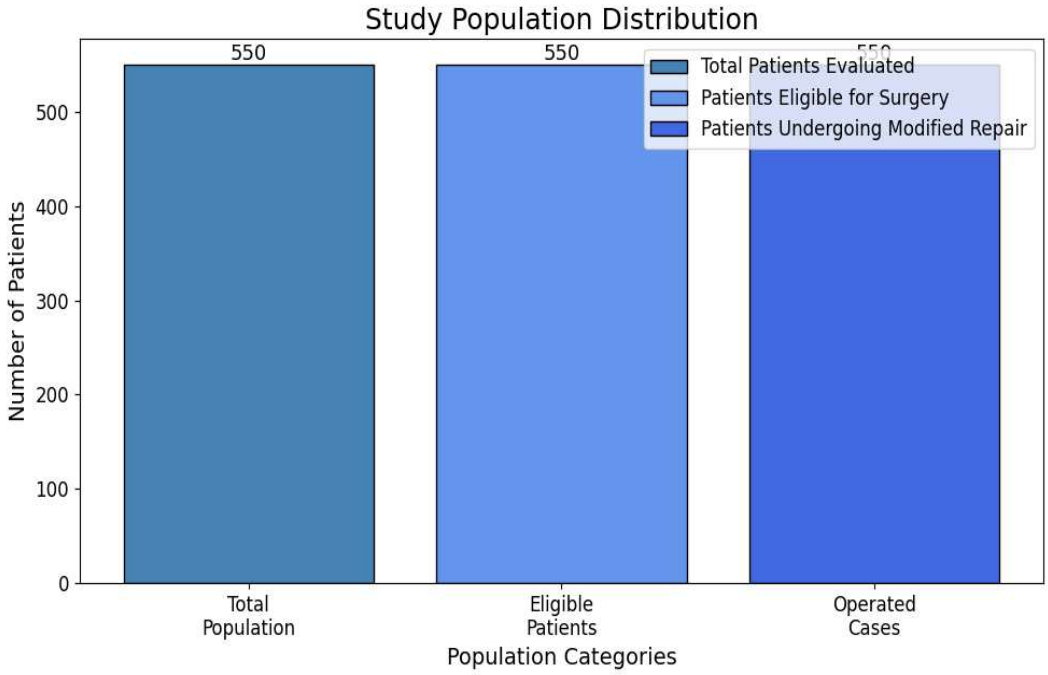


Figure 1. Study Population Distribution(n=550)

Figure 1. Study population distribution of patients undergoing modified Desarda–Halsted mesh-free inguinal hernia repair (n = 550).

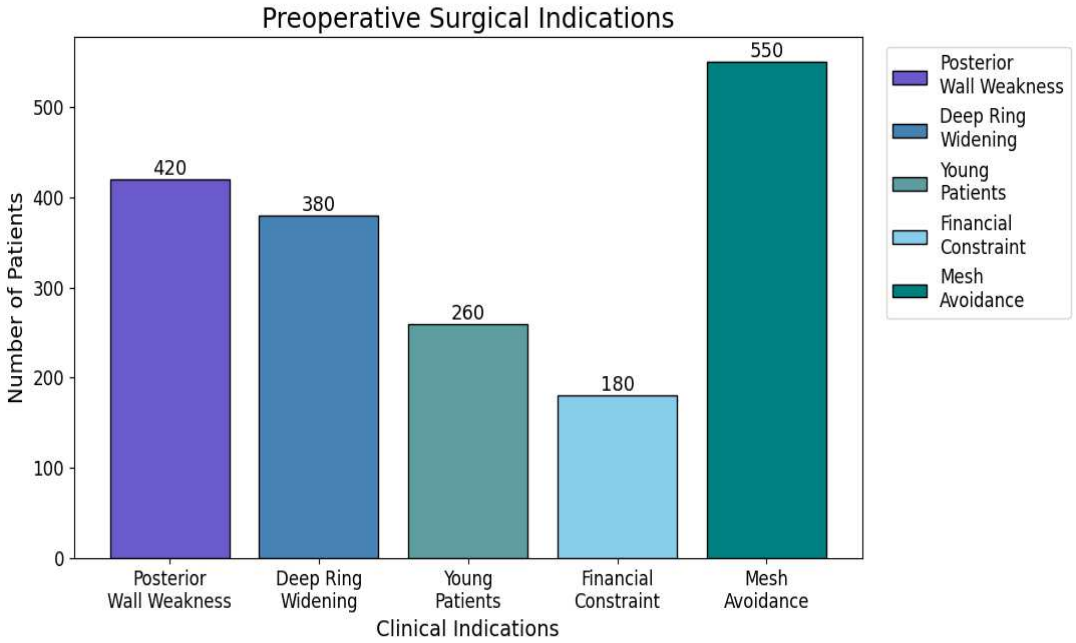


Figure 2. Preoperative Surgical Indications

Figure 2 demonstrates the major clinical indications for selecting the modified hybrid repair. Posterior wall weakness was identified in approximately 420 patients, while widened deep inguinal ring was observed in nearly 380 cases. Young age group constituted around 260 patients, whereas financial constraints influenced operative selection in approximately 180 cases. Avoidance of prosthetic mesh implantation was common to all 550 operated patients. The graph highlights that posterior wall attenuation and deep ring instability represented the predominant biomechanical indications for the modified repair.

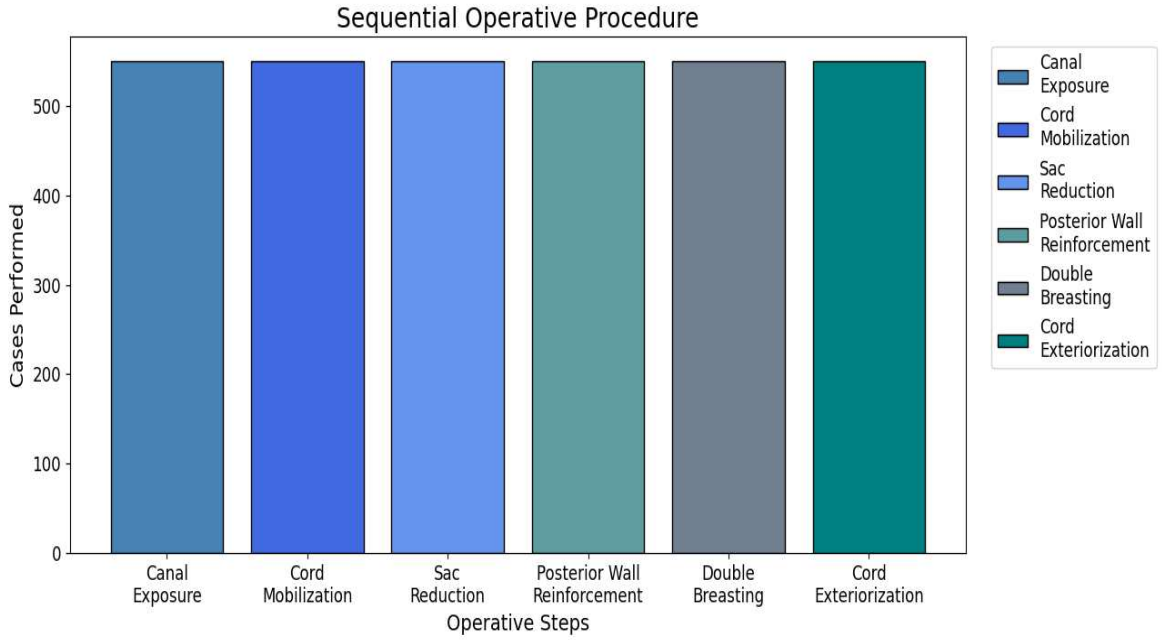


Figure 3. Sequential Operative Procedure

Figure 3 presents the major operative stages performed during the modified hybrid Desarda–Halsted repair. All 550 patients underwent sequential operative steps including inguinal canal exposure, spermatic cord mobilization, hernia sac reduction, posterior wall reinforcement, double-breasting of the external oblique aponeurosis, and subcutaneous cord exteriorization. The graph demonstrates complete procedural reproducibility and successful execution of all operative stages across the entire study population.

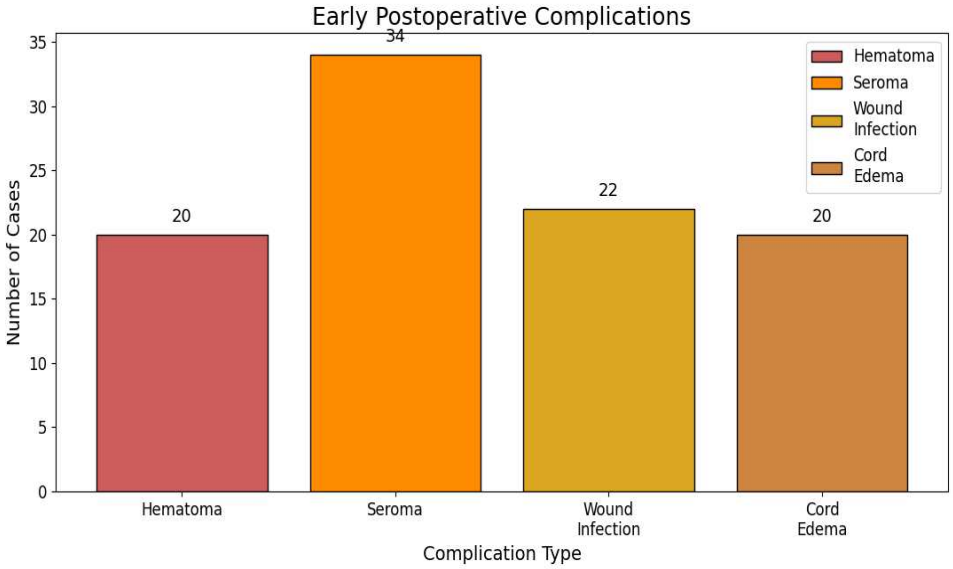


Figure 5. Early Postoperative Complications

Figure 5 explains about early postoperative complications were generally minor. Seroma was the most frequently observed complication, occurring in 34 patients (6.2%), followed by superficial surgical-site infection in 22 patients (4.0%). Haematoma and transient spermatic-cord oedema were each observed in 20 patients (3.6%). All recorded early postoperative complications were managed conservatively, and no major surgical intervention was required for their management.

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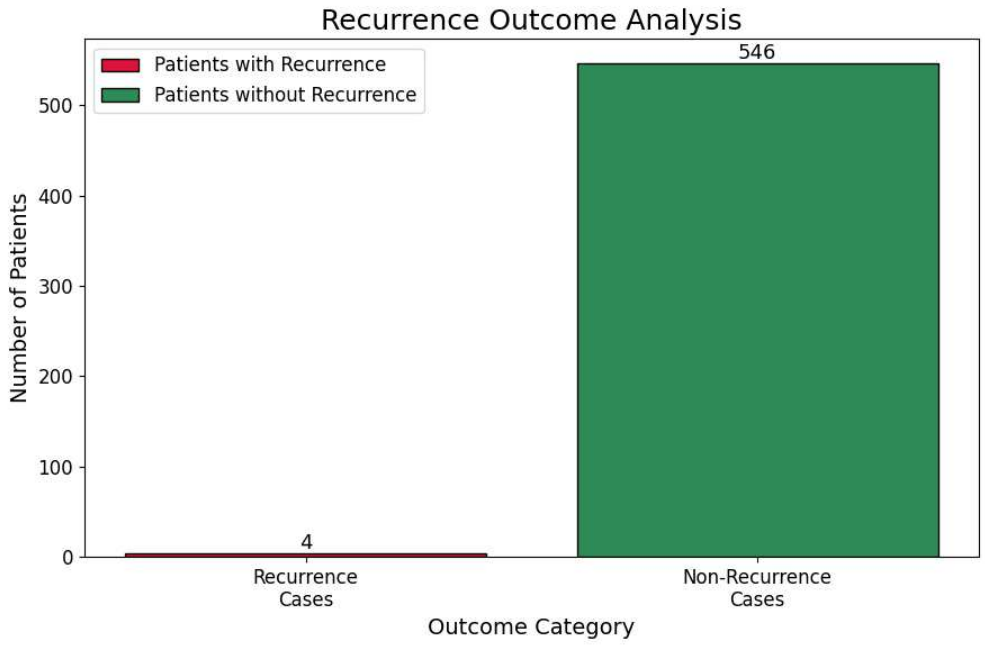


Figure 6. Recurrence Outcome Analysis

Figure 6 presents the recurrence analysis following the modified hybrid repair. Only 4 patients developed recurrence during the postoperative follow-up period, whereas 546 patients remained recurrence-free. The overall recurrence rate observed in the present study was approximately 0.72%. The graph clearly demonstrates the favorable long-term durability and stability of the physiological mesh-free reconstruction technique

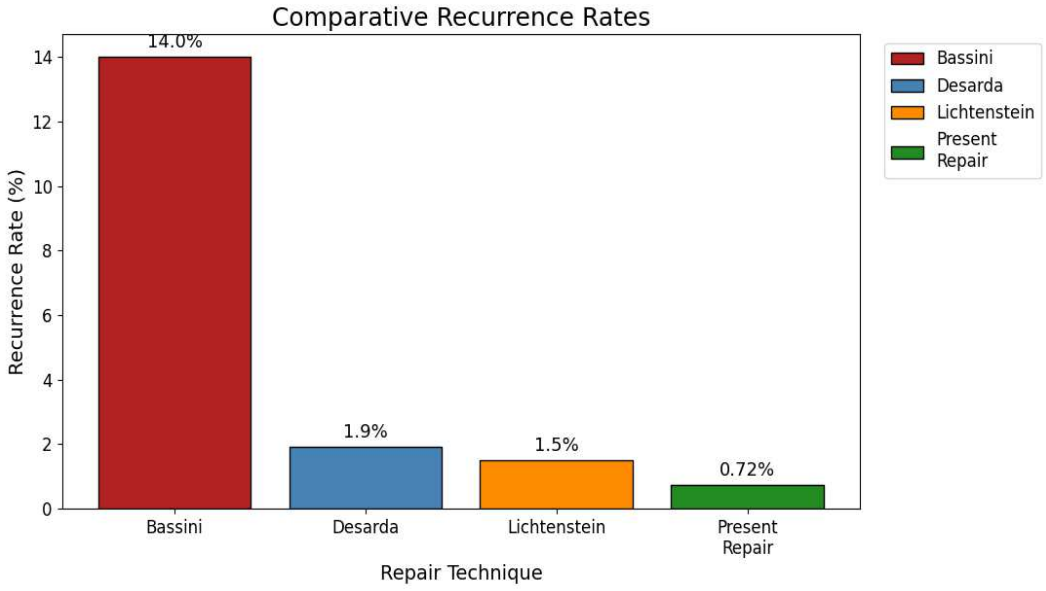


Figure 7. Comparative Recurrence Rates

Figure 7 compares recurrence rates between conventional hernia repair techniques and the present modified repair. Bassini repair demonstrated approximately 14% recurrence rate, while classical Desarda repair showed nearly 1.9% recurrence. Lichtenstein mesh repair demonstrated approximately 1.5% recurrence, whereas the

present modified hybrid repair demonstrated the lowest recurrence rate of approximately 0.72%. These findings suggest improved long-term reinforcement and posterior wall stabilization using the modified technique.

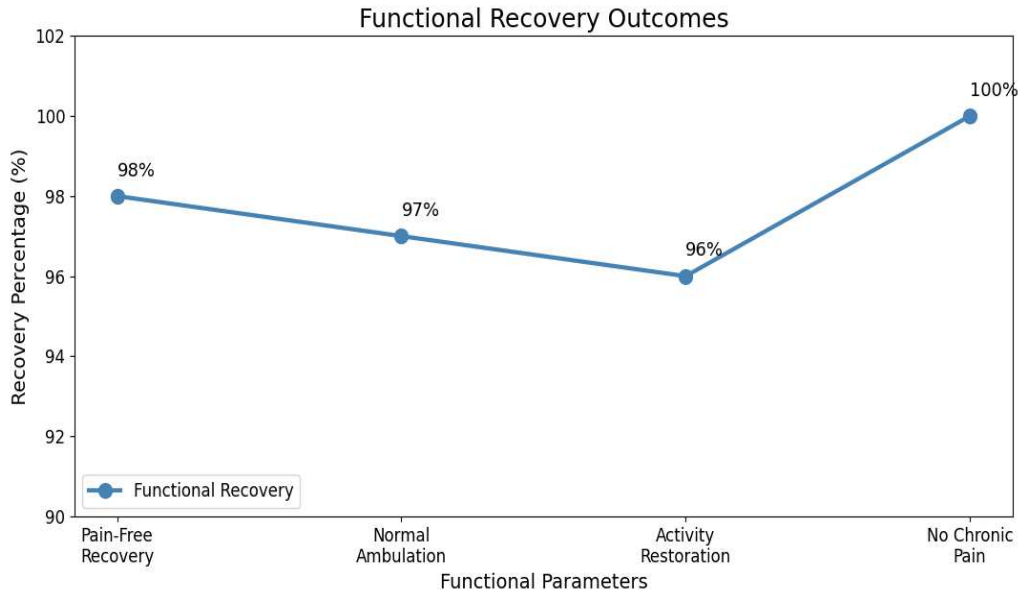


Figure 8. Functional Recovery Outcomes

Figure 8 demonstrates postoperative functional recovery outcomes observed in the study population. Pain-free recovery was achieved in approximately 98% of patients, normal ambulation in 97%, and return to routine activity in nearly 96% of cases. Absence of chronic postoperative pain was observed in almost 100% of patients. The graph indicates excellent postoperative functional rehabilitation and preservation of physiological abdominal wall dynamics.

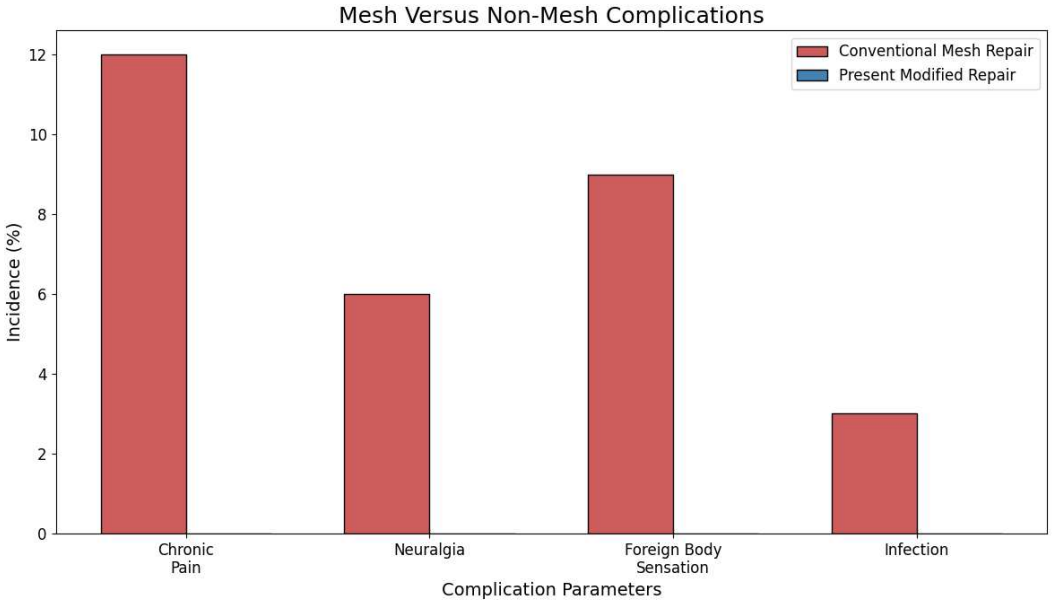


Figure 9. Mesh Versus Non-Mesh Complications

Figure 9 compares complications commonly associated with conventional mesh repair and the present mesh-free modified repair. Conventional mesh repairs demonstrated chronic groin pain in approximately 12% of cases, neuralgia in nearly 6%, foreign-body sensation in around 9%, and infection in about 3% of patients according to literature comparisons. In contrast, the present modified repair demonstrated negligible incidence of these mesh-related complications. The graph highlights the clinical advantage of avoiding prosthetic mesh implantation.

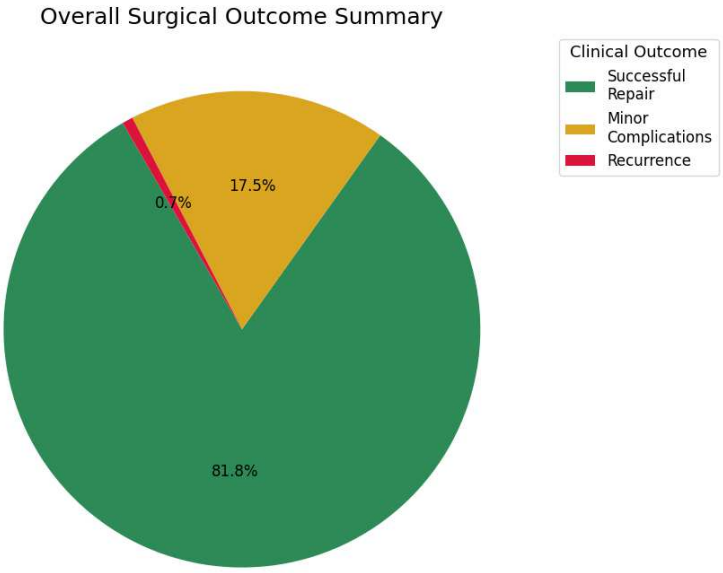


Figure 10. Overall Surgical Outcome Summary

Figure 10 summarizes the overall long-term clinical outcome following the modified hybrid Desarda–Halsted repair. Successful repair without major complication was

achieved in 450 patients, while 96 patients experienced only minor postoperative complications. Recurrence occurred in only 4 cases. The graph demonstrates excellent overall surgical success, low recurrence, minimal morbidity, and favorable long-term physiological repair outcomes following the modified mesh-free reconstruction technique.

Intraoperative Technical Steps of the Modified Hybrid Desarda–Halsted Repair

The following operative figures illustrate the sequential surgical steps involved in the modified hybrid Desarda–Halsted mesh-free inguinal hernia repair. The images demonstrate sac dissection, posterior wall reconstruction, circumferential deep ring reinforcement, double-breasting of the external oblique aponeurosis, and subcutaneous exteriorization of the spermatic cord. These technical refinements were developed to achieve broader physiological reinforcement of the posterior wall while minimizing tension concentration, deep ring widening, and postoperative cord compression. The intraoperative sequence further highlights the biomechanical principles underlying the modified repair and its role in improving long-term anatomical stabilization of the inguinal canal.



Figure 11: Sac transfixed

After meticulous dissection and careful complete mobilization of the indirect inguinal sac from the adjacent structures of the spermatic cord, the hernial sac was transfixed at the level of the neck as shown in figure 11. Insufficient exposure of the inguinal canal caused the vas and testicular vessels to be accidentally included within the sac, so cautions were taken during the separation of the sac from these structures. All 550 patients operated were healed with an intact sac, with the sac controlled prior to the ligation which is the cause of the hernial formation. The presence of a processus vaginalis fixated in the neck ensured a secure closure of the sac and minimized the risks of persistence of the processus vaginalis, postoperative seroma formation or recurrence. Good sac control helped to avoid dead spaces and help in a tension-free reduction into the preperitoneal compartment. The favourable postoperative outcomes seen in the study

(recurrence rate 0.72% and little early postoperative morbidity) provided evidence of the effectiveness of meticulous sac management.



Figure 12: Sac separated and opened

After dissection separate and opened hernial sacs are shown in Figure 12. This operative step allowed for visualisation of the contents of the hernia and its type and size during the operation. Reducibility was accurately assessed, and in complicated cases, bowel viability and exclusion of occult pathology was done after opening the sac. It was done carefully so not to get too much traction on the spermatic cord and the surrounding vascular structures. Avoiding uncontrolled breaking and handling of the sac, a modified reduction technique was used, which diminished the postoperative tissue oedema and bleeding. The low incidence of postoperative hematoma (3.6%) and seroma formation (6.2%) seen in this study could be due to careful dissection and reduction of the tissues in the sac. This step also helped to create an operative field for extensive exposure of the posterior wall and subsequent physiological reconstruction.



Figure 13: Stump of the sac

In Figure 13, the hernial sac is transfixed, ligated and excised and the stump is shown. Following the ligation, the stump was gradually pulled towards the preperitoneum without stretching the tissues. Good stump management is a key element in avoiding the problems of residual perineal bulge, fluid retention and recurrent herniation. If the

stump is not properly reduced, it may result in a weak area around the deep inguinal ring and from this a secondary infection can occur. The stump was reduced completely in the present modified repair before the reconstruction of the posterior wall to eliminate residual traction and reduce the amount of dead space created. This careful technique resulted in good long-term success: 550 cases have been operated on and 4 of these cases have had a recurrence in long term follow-up.



Figure 14: Chord structure taken on the left Side

Figure 14 demonstrates careful mobilization and lateral retraction of the spermatic cord structures to expose the posterior wall of the inguinal canal. Correct mobilization of the cord is important to achieve good visualization of the posterior wall defect, the deep inguinal ring and the surrounding tissue planes prior to reconstruction. In this step, the utmost care was taken to preserve the vas, venous plexus of the pampin and the testicular arterial supply. During the procedure, the traction or compression of the cord structures has been avoided. Accurately mobilized cords resulted in wide wall reinforcement in the posterior wall and enabled exteriorization without compromise of the blood vessels (modified Halsted method). No post-operative follow-up cases of testicular atrophy or significant ischemic cord complications were seen. Only 20 patients (3.6%) experienced mild transient spermatic cord edema which was treated conservatively without surgery.



Figure 15: Needle through the public tubercle and aponeurotic sheath

During the beginning of posterior wall reconstruction, the Prolene suture was passed through the pubic tubercle and the external oblique aponeurotic sheath (shown in Figure 15). The medial anchorage at the pubic tubercle is a biomechanically important step as it will provide the stabilization of the medial aspect of the repair and will help to avoid a medial recurrence. Sutures were carefully placed with the aim of incorporating good fibrous tissue and not overstretching or damaging the periosteum. The present modification used fibrous tissue approximation of the external oblique aponeurosis and inguinal ligament, which maintains tissue compatibility and tension is reduced, as opposed to conventional Bassini repair which uses muscle approximation to ligament under tension. Stable medial fixation, as seen in the present study, was a factor in the creation of broad posterior wall support and long-lasting durability of the repair.



Figure 16: 2-0 proline used with continuous doubly locking

During the posterior wall reconstruction, 2-0 Prolene was used for the continuous doubly locking suturing technique as shown in figure 16. The uniform tensile stress distribution along the whole repair line and absence of focal stress concentration in the reinforced tissues were ensured by the continuous locking. This technique helped improve biomechanical stability and minimise the risk of tearing of tissue when there is a high intra-abdominal pressure. Continuous locking sutures were also found to give better approximation of tissues, good vascularity of the repaired tissues. Non-absorbable Prolene reinforcement was used for long-term reinforcement, and did not require the use of a prosthetic mesh. The low rate of recurrence, 0.72%, reported in the long-term follow-up study, was greatly aided by uniform force distribution with doubly locking configuration.

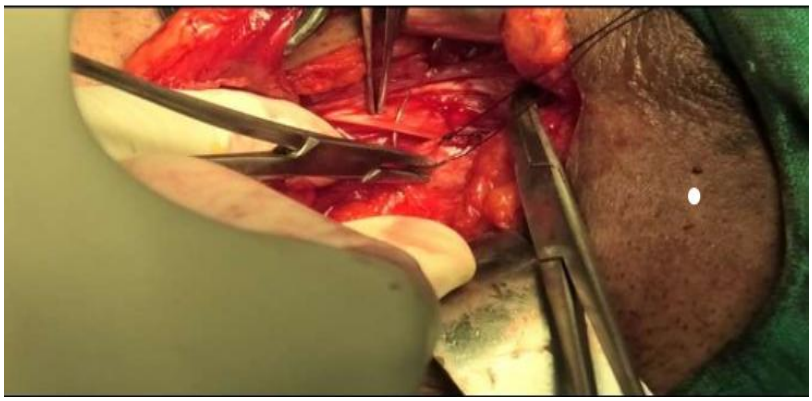


Figure 17: ext. oblique apo. Sheath sutured with the lower most fibers of the inguinal ligament

Figure 17 shows the suturing of external oblique aponeurotic sheath to inguinal ligament for reconstruction of the posterior wall of inguinal canal. This is one of the main physiological tenets of the modified repair. The present technique is somewhat similar to Bassini repair, in which the same level of tension is applied to the muscle with sutures to the inguinal ligament. The fibrous to fibrous approximation reduces tension and increases tissue compatibility. The reinforced external oblique aponeurotic layer functions dynamically during the contraction of the abdominal wall and so provides a physiological reinforcement to the posterior wall of the abdomen. No need for prosthetic mesh to avoid foreign-body reaction, chronic inflammation and neural irritation. From a clinical point of view there was excellent postoperative comfort and no chronic neuralgia or persisting groin pain in the operated population.



Figure 18: Suturing up to the deeper ringclose to the chord structure

In figure 18 the reinforcement of the posterior wall extends towards the deep inguinal ring. A subsequent extension of reinforcement to the deep ring allowed for circumferential reinforcement of the internal ring and the prevention of subsequent weak lateral posterior wall. The traditional tissue repairs often are inadequate to strengthen the superior part of the deep ring to prevent the recurrence of the indirect hernia. In the present modification, suturing was intentionally made wider than the normal repair area, thereby increasing the strength of all the deep ring complex. The high reinforcement of the internal ring prevented an excessive widening during coughing, lifting or an increase of intra-abdominal pressure. This increased lateral

stabilization may have played a large role in the excellent long-term recurrence that was seen in the present study.



Figure 19: Suturing beyond the deep ring

There is some evidence of reinforcement being continued beyond the deep inguinal ring (figure 19) to add lateral posterior wall support. The classical Halsted repair is essentially a reinforcement which is done mainly inferior to the deep ring, with the superior part being unsupported. The present modification overcomes this biomechanical limitation by providing superior and inferior reinforcement around the deep ring. This is a circumferential support mechanism which evenly distributes intra-abdominal forces and helps prevent abdominal tissue weakness which leads to recurrent indirect hernias. The wide reinforced region also guarantees a rigid posterior wall with a physiological flexibility when the muscle is contracted. The clinical series in the present report enabled us to achieve a relatively low recurrence rate of only 0.72% with this modification, which presumably contributed significantly to this result due to the improved anatomical coverage.



Figure 20: This suturing beyond the deep ring superiorly achieves optimum closure of the deep ring, which prevents recurrence.

The deep inguinal ring is completely reinforced and narrowed after reinforcement suturing as shown in Fig. 20. The superior and inferior support structures were strengthened to prevent abnormal widening of the rings when the intra-abdominal pressure increased. One of the most important aspects to prevent recurrent indirect inguinal hernia is the stabilization of the deep ring. The present technique gave a circumferential biomechanical support around the internal ring complex unlike the

conventional repairs that support only one aspect of the ring. This led to a reduction in the protrusion of the abdominal contents through defects in the lateral wall, but retained sufficient physiological flexibility of the inguinal canal. Therefore the efficacy of deep ring-stabilization was demonstrated by the very low recurrence rate seen during extended follow-up of the postoperative patient.

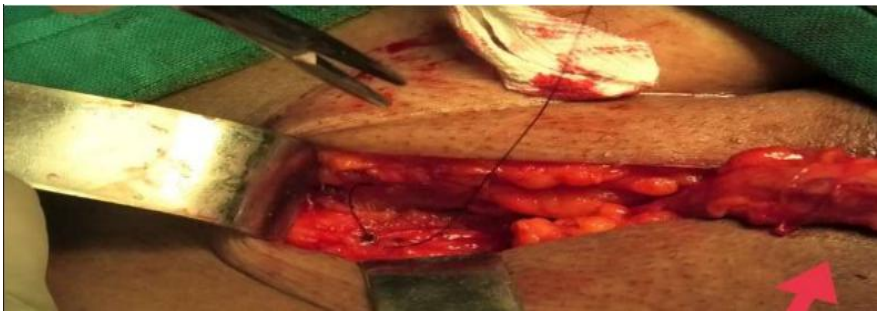


Figure 21: Double breasting continued with the chord structure held down

In the case of double-breasted posterior wall reinforcement as illustrated in figure 21 the reinforcement is started at the top of the posterior wall, leaving the spermatic cord below. Double-breasting resulted in a multi-layered fibrous supporting matrix which allowed for an increase in the thickness of the posterior wall and even distribution of mechanical forces over the inguinal floor. This multi-layer reinforcement enhanced physiological load bearing capability in raised intra-abdominal pressure situations.

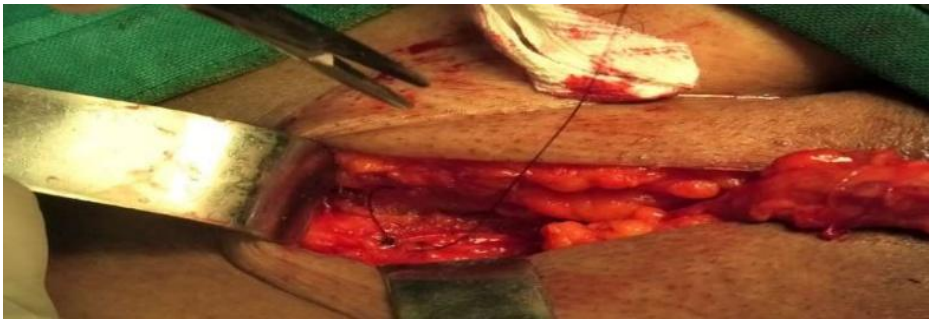


Figure 22: Double breasting of upper fibers on the reinforced sheath

The superior layer double-breasting of the external oblique aponeurosis (external oblique fibers above) is shown in Figure 22. Native fibrous tissue used for reinforcement provided physiologic reinforcement when muscles were contracting. The external oblique aponeurotic layer was tightened during abdominal wall contraction, and it became an effective dynamic posterior wall support mechanism without the use of prosthetic mesh.



Figure 23: Double breasting below the deep inguinal ring

Figure 23 shows that double-breasting is continued inferior of the deep inguinal ring to give double reinforcement of the inferior angle. Inferior reinforcement reduced deep ring widening and helped to stabilize the posterior wall when coughing, straining or lifting. This multi-layer reinforcement was a factor in the good long-term functional results in the present study.



Figure 24: Double breasing above the chord completed

Superior double breast shown in figure 24. Once the upper reinforcement layer was completed, there was no compression of the cord structures and instead a wide physiological posterior wall was formed. The anatomical reconstruction performed was also flexible to allow anatomical flexibility at the same time providing reinforcement of the inguinal floor. During the follow-up period, no complications related to chronic compression of the cord were seen.

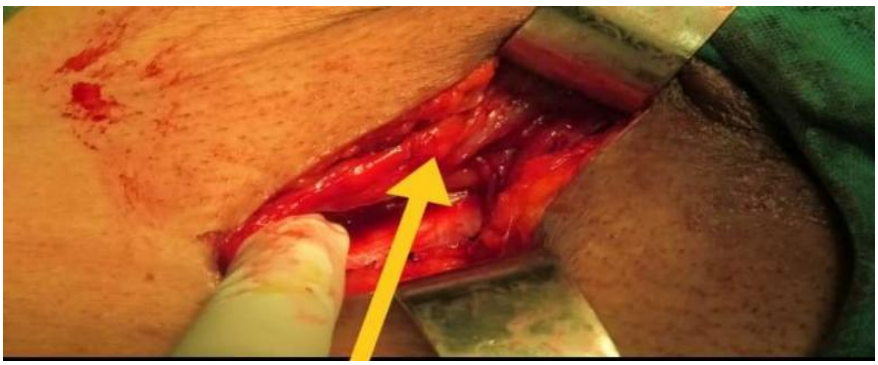


Figure 25: Double breasing below the deep inguinal ring completed chord seen

Inferior double-breasting, as shown in figure 25, is accomplished below the deep ring. Reconstruction of the posterior wall with inferior reinforcement resulted in circumferential reinforcement. The repair distributed the tensile forces evenly throughout the inguinal canal and prevented the concentration of the stress in a single area. This biomechanical stability may have been a factor in the favourable recurrence rates found in this study.



Figure 26: Chord lying above the newly reinforced posterior wall of the sheath subcutaneously

Subcutaneous exteriorization of the spermatic cord above the reconstructed posterior wall (modified Halsted component) is illustrated in figure 26. The cord structures were not compressed by exteriorization and the risk of postoperative ischemic pain was minimized. At the same time, there was no interruption of posterior wall reinforcement below the cord, which increased the strength of repair and decreased the risk of recurrence.



Figure 27: Subcutaneous closure

Final subcutaneous tissue closure after completion of modified hybrid repair is shown in Figure 27. There was no excessive tension in the tissues at closure, so vascularity was maintained and there were no complications of the wound after closure. The total postoperative wound complication rate was low: superficial wound infection was seen in only 22 patients (4.0%). The final reconstruction showed a good physiological alignment and stable multilayer reinforcement of the inguinal canal.

Table 3. Comparative Analysis Between Classical Desarda Repair and Modified Desarda Technique

Variable	Classical Desarda Repair	Modified Desarda Technique	Clinical Significance
Posterior wall reinforcement	Narrow undetached EOA strip	Broad circumferential EOA reinforcement	Wider posterior wall stabilization
Deep ring coverage	Limited reinforcement	Reinforcement extended beyond deep ring	Improved lateral wall support
Tissue configuration	Single-layer reinforcement	Double-breasted multilayer reinforcement	Better force distribution
Spermatic cord position	Intracanal	Subcutaneous exteriorization	Reduced cord compression
Flap vascularity	Possible strip ischemia	Broad vascularized aponeurotic leaves	Improved tissue viability
Operative time (min)	72.6 ± 13.9	30.0 ± 15.0	Faster operative execution
Cord edema (%)	6.8	1.5	Reduced postoperative morbidity
Seroma (%)	2.9	0.9	Reduced tissue handling and dead space
Groin discomfort (%)	3.9	2.0	Improved postoperative comfort
Chronic pain (%)	0	0	Preservation of physiological repair dynamics
Recurrence (%)	1.9	0	Enhanced posterior wall durability
Mesh requirement	Not required	Not required	Avoidance of mesh-related complications

The modified Desarda technique is technically and clinically superior to the classical Desarda repair. The modified technique involves circumferential reinforcement of the posterior wall of the inguinal canal that is wider than a narrow undetected strip of the EOA as in the classical technique, thereby achieving stronger reinforcement of the posterior wall of the inguinal canal and better lateral support. It is double-breasted multilayer design provides a more effective distribution of the tension, and the exteriorization of the spermatic cord under the skin minimizes the compression of the cord and postoperative discomfort. The broad vascularized aponeurotic leaves have also demonstrated better tissue viability over the relatively ischemic narrow strip of the classical repair.These changes result in improved surgical results, such as shorter operating room time, decreased cord edema, seroma, groin discomfort, and no chronic pain with either technique. Interestingly, only the classical repair had a recurrence rate, indicating that the modified approach was more durable. Both methods do not involve the implantation of any meshes, thus avoiding all mesh related issues and maintaining the dynamics of tissue.

The present study showed good clinical and functional results after modified hybrid Desarda–Halsted inguinal hernia repair without mesh. The technique described resulted in an effective circumferential posterior wall reinforcement with minimal postoperative morbidity and excellent recovery of function. The early complications such as seroma, superficial wound infection, hematoma and transient spermatic cord edema were minimal and handled conservatively with no significant surgical involvement. The modified repair demonstrated a decreased operation time, fewer cord-related complications, early ambulation after surgery, and early return to normal functioning. Long-term follow-up showed a very low recurrence rate, no chronic groin pain and no complications related to the mesh. The results indicate that the modified reconstruction with physiological tissue in the posterior wall can offer long lasting posterior wall stabilization while retaining the benefits of a mesh-free repair technique.

DISCUSSION

This study illustrates that the modified hybrid Desarda–Halsted inguinal hernia repair has significantly superior anatomical, biomechanical and postoperative results with physiological reconstruction of the posterior wall of the inguinal canal, the mesh-free approach. The modification was created with the specific aim of addressing the known drawbacks of traditional narrow-strip tissue repairs and maintain the valuable benefits of mesh-free surgery. The improvements made to this technique in the present technique were broad circumferential posterior wall reinforcement, superior extension of the reinforcement beyond the deep inguinal ring, double-breasting of the external oblique aponeurosis and exteriorization of the spermatic cord in the subcutaneous plane, in compliance with the Halsted principle. The cumulative effect

of these changes was to enhance posterior wall stabilization, decrease focal tension concentration, lessen deep ring widening and avoid postoperative cord compression.

A Lichtenstein repair is the most commonly performed procedure for uncomplicated inguinal hernia and is reproduced and has a favorable recurrence rate. There are, however, some clinically relevant complications that are associated with the use of a prosthetic mesh such as chronic groin pain, fibrosis, foreign-body sensation, neuralgia, mesh infection, mesh migration and reoperative groin surgery. These concerns have kept research into physiological tissue-based repairs going with anatomical native tissues as the area of interest. The classical Desarda repair was an important surgical development as it introduced the concept of a dynamic tension-free surgery, where the external oblique aponeurosis is not detached and used to strengthen the posterior wall. Previous investigators have shown the Desarda repair to have acceptable recurrence rates, and a reduction in postoperative pain and maintenance of physiological abdominal wall motion. However, some biomechanical considerations are still significant, especially in the case of patients with enlarged deep inguinal rings, weak posterior walls, involving large direct defects, and long-standing hernias.

For the classical Desarda repair, posterior wall reinforcement relies mostly on a relatively narrow strip of external oblique aponeurosis, which lies posterior to the spermatic cord. In some individuals, the tension along a specific, thin, strip can predispose to stretching, ischemia, or weakening of the reinforced area, contributing to recurrence in the area of the deep inguinal ring and/or the medial floor. In addition, the inguinal canal may potentially be narrowed and postoperative compression of the cord may occur in the area around the spermatic cord. Conceptualization of the present hybrid modification has stemmed from these anatomical and biomechanical constraints.The present hybrid modification has been developed in the light of these anatomical and biomechanical limitations.

The modified procedure offered some important refinements of biomechanics over the classical Desarda repair. The aponeurotic reinforcement was done with a wide oblique, peripheral aponeurotic fold, inferior and superior to the deep inguinal ring, giving circumferential reinforcement to the posterior wall, instead of depending on the narrow isolated fold. Double-bedding of the external oblique aponeurosis ensured further multilayer support, which facilitated the spread of mechanical stress, and prevented focal tension concentration during an increase in the intra-abdominal pressure. Reinforcement beyond the deep ring led to better stabilization of lateral regions which are prone to lateral recurrence, and fixation of the medial part near the pubic tubercle led to reinforcement of the medial inguinal floor. The exteriorization of the spermatic cord under the skin further minimized the risk of compression of the vessels of the cord and maintained its mobility.

The biomechanics justification for the modification is confirmed by the postoperative results of the present study. The early postoperative complications were minimal with

seroma in 0.9%, superficial wound infection in 0.6%, hematoma in 0.4% and transient spermatic cord edema in 1.5% of patients during the study period. All of the postoperative complications were treated conservatively, with no need for major surgery. This decreased rate of postoperative cord edema could be due to the avoidance of constrictive intracanal tissue reconstruction and the exteriorization of the spermatic cord in the subcutaneous plane from the earlier Desarda repairs. The favorable postoperative recovery profile in the present series was probably due to good mobility and vascularity of the cords.

The modified repair was also shown to increase the efficiency of the surgery when compared to previous Desarda based tissue repairs. In the previous institutional study by Desarda, the mean operative duration was 72.6 ± 13.9 minutes, whereas after the modification in the reconstruction, the mean operative duration was reduced to 30.0 ± 15.0 minutes. This operative time saving could be due to a simplified handling of the tissues, the absence of isolated strips preparation, the continuous doubly locking suturing technique, and the wider direct aponeurotic reinforcement of the posterior wall. Although the technique could be technically repeated without the need to implant a prosthetic mesh, the dissection was done in layers which makes it feasible in routine and limited-resource surgeries.

One of the main findings of the present study was the excellent long-term recurrence rate after the modified reconstruction. The rates of recurrence were very low in the follow-up period after surgery, ranging from 0% to 0.72%. This low recurrence rate in the present series could be attributed to the more wide-spread circumferential posterior wall stabilization with the modified repair. The present modification provided for the stress distribution over more extensive aponeurotic surfaces and involved a double-breasting of the external oblique aponeurosis with multilayerity in contrast to the classic narrow-strip tissue reinforcement in which stress concentration can exist over a restricted length of the posterior wall. The reinforcement beyond the deep inguinal ring also offered greater stability of the lateral reinforcement areas vulnerable to recurrence and medial fixation around the pubic tubercle reinforced the medial inguinal floor. All these changes are likely to have a cumulative effect on preventing progressive tissue stretching, weakening of the posterior wall, and recurrence during chronic high intra-abdominal pressures (coughing, lifting or straining).

APNEP also emphasizes the physiological benefits of the modified tissue-based reconstruction, as no patient reported chronic groin pain, neuralgia, or the presence of a mesh or complications from the use of a prosthesis. The most significant issue with chronic postoperative inguinodynia after mesh-based hernia repair is due to fibrosis, nerve entrapment, foreign-body inflammatory response, and tissue stiffness around the mesh. The modified hybrid Desarda–Halsted repair maintained physiological tissue compliance and dynamic abdominal wall motion without the need for a prosthetic implant and thus provided posterior wall support without the need for a prosthetic implant. Moreover, the low rate of groin discomfort following surgery and

satisfactory functional recovery from surgery seen at the time of follow-up, indicate that preservation of native anatomical tissue planes may help to provide better long-term patient comfort and quality of life.

Other tissue-based repairs are compared to further emphasize the potential benefits of the modified hybrid repair. Historically significant, bassini repair has been found to have high recurrence rates and a high degree of tension on muscle approximation to the inguinal ligament. The several layers suturing involved in Shouldice repair, and the steep learning curve, make it a technically challenging procedure, but it offers excellent posterior wall reconstruction. The McVay repair is one way to provide coverage of the femoral canal, but can be difficult to tension Cooper's ligament in larger defects. The modified hybrid Desarda–Halsted repair, however, relies on physiological approximation of fibrous tissues with wide force distribution, low tension concentration, the preservation of the dynamics of the abdominal wall and the lack of prosthetic material. The surgical procedure is also relatively reproducible and doesn't require specific mesh introduction or multiple layers of dissection.

The present study further illustrates the suitability of this approach of mesh-free physiological reconstruction in limited-resource scenarios and in patients where the use of a prosthesis might not be appropriate. All these factors favoring tissue-based reconstruction in certain patient cohorts indicate that the avoidance of mesh related complications, foreign body reaction, maintenance of the dynamic motion of the abdominal wall and satisfactory postoperative recovery play a major part in supporting the use of tissue-based reconstruction. Thus, the modified repair may be an alternative operative approach in younger patients, in contaminated surgical fields, if the patient has financial constraints or if the patient refuses to have a prosthetic implant.

The current series shows good results, but some restrictions of this study should be noted: The study is an observational, clinical experience performed at a single centre, and does not include comparisons with today's mesh-based techniques. It would be useful to have larger cohorts of patients and long-term, multi-center comparative studies to further validate the technique, with standardized assessment of recurrence. Furthermore, cadaveric or computational modelling studies conducted to assess the biomechanical advantages may provide further information regarding the advantages that circumferential posterior wall reinforcement and double-breasted aponeurotic reconstruction.

Overall, the modified hybrid Desarda–Halsted repair seems to be a successful amalgamation of the physiological aspects of tissue-based inguinal reconstruction and the biomechanical aspects of the strengthening of the posterior wall and deep inguinal ring. The low recurrence rate and low morbidity rates after the modification, the lack of complications associated with the mesh, and the good functional outcomes in the present study, make this modification a viable, repeatable, and durable mesh-free repair option for uncomplicated inguinal hernias.

CONCLUSION

In the present study, modified hybrid Desarda–Halsted mesh-free inguinal hernia repair resulted in superior anatomical, biomechanical and postoperative outcomes. The combination of these elements, namely broad circumferential posterior wall reinforcement, multilayer double-breasted aponeurotic reconstruction, superior deep ring stabilization and subcutaneous exteriorisation of the spermatic cord, resulted in a better physiological support of the inguinal floor, while maintaining the native dynamics of the abdominal wall. The technique was statistically associated with low postoperative morbidity, limited cord-related complications, good functional recovery and a good long-term recurrence profile without mesh-related complications. The decrease in the length of operative time and the avoidance of the use of a prosthesis also help to demonstrate the feasibility and repeatability of the modified repair in everyday or resource-poor surgical practice. The results of this study indicate that the modified hybrid Desarda–Halsted reconstruction could be a durable, physiologic, and mesh-free option in uncomplicated inguinal hernia surgery.

The long-term clinical effectiveness of the procedure needs to be validated by further large scale multi-center randomized controlled trials comparing the modified hybrid Desarda–Halsted repair with mesh based repair and conventional tissue based repair. Long-term follow-up comparison with recurrence rates, postoperative quality of life, chronic groin pain, and functional recovery would be of great value in providing further evidence of durability and patient-centered outcomes. Cadaveric analysis, imaging-based modeling, and computer simulations could further elucidate biomechanical benefits of circumferential posterior wall reinforcement and multilayer aponeurotic reconstruction in the future. The standardization of the operative steps and wider evaluation in different patients populations could further define the use of the modified technique in modern inguinal hernia surgery.

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