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Dartos Fascia as an Interpositional Layer in Hypospadias Urethroplasty: A Systematic Review

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ABSTRACT

This systematic review evaluated the role of dartos fascia as an interpositional layer in primary hypospadias repair. The search was conducted in PubMed, EMBASE, Scopus, CENTRAL, and Web of Science (2019–2025) for studies involving patients ≤18 years undergoing hypospadias repair. Primary outcomes were urethrocutaneous fistula (UCF), dehiscence, meatal/urethral stenosis, and reoperation; secondary outcomes included infection and cosmetic scores. Narrative synthesis was used. Results: Eleven studies met the criteria, predominantly distal TIP. No randomized trial compared any second layer versus none; one cohort (n=425) showed similar UCF rates with periurethral/dartos coverage versus none (6.7% vs 7.3%). A randomized trial favored double- over single-layer dartos (3.3% vs 23.3%). Another trial found ventral preferable to dorsal dartos, with fewer flap-related complications at similar UCF rates. Tunica vaginalis flap reduced UCF and improved cosmetics but is more invasive. Platelet-rich fibrin adjunct lowered UCF and infection in two studies. Spongioplasty produced comparable UCF but higher meatal stenosis, though selected robust spongiosum allowed zero fistulas. Dartos remains the workhorse; double-layer and ventral harvest optimize outcomes, while tunica vaginalis and PRF offer effective alternatives in selected cases. Further randomized trials are needed to clarify the necessity of a second layer.

KEYWORDS *Hypospadias, urethroplasty, dartos fascia, urethrocutaneous fistula, tunica vaginalis flap.*

INTRODUCTION

Hypospadias is a common congenital anomaly of the male genitalia (1 in 300 births), characterized by a ventrally displaced meatus, often with chordee and a dorsal hooded prepuce. Surgery aims to straighten the penis and reconstruction of a functional, cosmetically acceptable urethra. TIP urethroplasty, first described by Snodgrass, is the preferred technique for most distal and midshaft cases, whereas on-lay or staged approaches are typically used for proximal or complex cases. No single technique serves as a universal gold standard, as each has distinct advantages and complication profile.(Wu et al., 2020)

The most frequent postoperative complication remains the urethrocutaneous fistula (UCF), with reported rates of approximately 4% in distal repairs, alongside other issues such as meatal stenosis, glans dehiscence, and in proximal cases, urethral stricture or diverticulum formation.[1] The pathogenesis of fistula formation is multifactorial, involving factors such as poor vascularization of the neourethra, overlapping suture lines between the urethral closure and the overlying skin, local infection, hematoma, and increased urethral pressure from distal obstruction. Ischemia at the repair site is a critical contributor; it can result from excessive

dissection, tension on suture lines, or inadequate tissue coverage, leading to necrosis and breakdown.

A cornerstone principle in modern hypospadias repair to mitigate these risks is the interposition of a well-vascularized tissue layer between the neourethra and the skin closure. This layer serves several vital functions: it provides an additional vascular supply to support healing, creates a physical barrier to separate suture lines, adds bulk to prevent dead space, and may contribute to hemostasis. Dartos fascia, harvested from either the dorsal or ventral penile shaft or prepuce, has become the most widely used interpositional tissue due to its excellent accessibility, reliable vascularity, and minimal donor-site morbidity (Maheshwari et al., 2022). However, its application is not standardized, with variations including single versus double layers, dorsal versus ventral harvest, and the timing of flap elevation.

Alternatives to dartos have been developed, each with its own rationale and historical context. The tunica vaginalis flap (TVF), harvested from the parietal layer of the tunica vaginalis of the testis, offers a robust, highly vascularized pedicled flap with a different angiosome. It has been advocated, particularly in proximal or re-operative cases, where local dartos may be insufficient due to scarring or poor tissue quality. However, its use requires a separate incision and carries a small risk of testicular complications, adding to operative complexity (Mansour et al., 2024). Spongioplasty involves the ventral approximation of the corpus spongiosum tissue around the neourethra. Its proposed advantages include utilizing native, well-vascularized urethral tissue to reinforce the ventral aspect of the repair, potentially improving hemostasis and cosmesis. A limitation is its dependence on the availability and robustness of the patient's own spongiosal tissue, which can be variable, especially in severe hypospadias. Inadequate spongioplasty may paradoxically contribute to meatal stenosis (Pezzoli et al., 2025). More recently, biologic adjuncts such as platelet-rich fibrin (PRF), an autologous concentration of platelets and growth factors derived from the patient's blood, have been investigated. PRF is applied as a membrane over the repair, theoretically enhancing healing through the local release of growth factors, providing a scaffold for tissue regeneration, and offering a barrier function with anti-infective properties. Its appeal lies in its autologous nature, low cost, and minimal added surgical time (Ramez et al., 2025).

Prior to 2019, systematic reviews and meta-analyses generally supported the use of a second layer to reduce fistula rates, but the evidence base had significant limitations. Many studies were retrospective, single-center series with small sample sizes. Comparisons were often heterogeneous, mixing different surgical techniques, hypospadias severities, and outcome definitions. There was a paucity of high-quality randomized controlled trials (RCTs) directly comparing specific technical nuances, such as double versus single dartos or dartos versus TVF in well-defined patient groups. Furthermore, the role of newer adjuncts like PRF was scarcely evaluated. Consequently, while the principle of interposition was accepted, definitive guidance on the optimal choice of tissue and technique remained elusive, often based on surgeon preference and anecdotal experience rather than robust comparative evidence (Pezzoli et al., 2025).

The past five years (2019–2025) have seen a notable increase in comparative studies, including several RCTs, that directly evaluate these technical variations and alternative tissues. This evolving literature provides an opportunity to move beyond the question of whether to use a second layer, towards a more nuanced understanding of which layer or technique is optimal

in specific clinical scenarios. To guide pediatric urologists in contemporary, evidence-based practice, an updated and focused synthesis of these recent findings is urgently needed.

Therefore, this systematic review aims to provide a comprehensive analysis of evidence published between 2019 and 2025 regarding the use of dartos fascia and its alternatives as interpositional layers in primary hypospadias repair. The primary research questions are: (RQ1) Is an interposition layer necessary, or can selected distal hypospadias repairs succeed with meticulous urethroplasty alone? (RQ2) Among dartos fascia techniques, what is the optimal method (e.g., single vs. double layer, dorsal vs. ventral harvest, timing of harvest)? (RQ3) How does dartos fascia compare to alternative interpositional tissues such as the tunica vaginalis flap, spongioplasty, and platelet-rich fibrin in terms of efficacy and safety? This review provides the first synthesis focused exclusively on evidence from the last five years, directly comparing technical variations of dartos flaps and contemporary alternatives. By critically appraising this recent literature, we aim to offer clear, evidence-based recommendations that can refine surgical technique, improve patient outcomes, and identify key gaps to direct future high-quality research in hypospadias repair.

METHOD

This review included studies of children ≤18 years undergoing primary hypospadias repair (distal–proximal), excluding reoperations. The intervention was a dartos fascia interposition layer, allowing any variation in origin, transfer, or single vs double layering; platelet-rich fibrin (PRF) was treated as an adjunct. Comparators included no layer, alternative dartos techniques, or other tissues such as tunica vaginalis flap (TVF) or spongioplasty. Primary outcomes were urethrocutaneous fistula, dehiscence, meatal/urethral stenosis, and reoperation; secondary outcomes included infection, HOSE/PPPS cosmetic scores, satisfaction, and donor-site morbidity, with ≥3 months follow-up.

A comprehensive search of PubMed, EMBASE, Scopus, Cochrane CENTRAL, and Web of Science (01 Jan 2019– 30 Sept 2025) was performed using controlled vocabulary and keywords for hypospadias and interposition layers. Only human pediatric studies were included, without language restrictions. Data extracted covered study design, patient characteristics, operative details, interposition method, comparators, follow-up, outcomes, and complications. Due to clinical and methodological heterogeneity, no meta-analysis was conducted; instead, a narrative synthesis prioritized RCTs and structured comparisons of dartos vs no layer, dartos technique variations, and dartos vs alternative tissues, considering anatomical subgroups and center-level factors.

RESULT AND DISCUSSION

Characteristics of Included Studies

Table 1 summarizes 11 studies published between 2019 and 2025: 4 RCTs, 3 prospective controlled (non-randomized quasi-experiments or controlled) studies, and 4 retrospective comparative cohorts. Most (8 of 11) were single-center tertiary pediatric surgical experiences; 3 were multi-center or multi-surgeon. Sample sizes ranged from 21 to 120 patients (44–84 in RCTs). Most focused on distal hypospadias, with few including proximal or midshaft

cases without subgroup analysis. All involved TIP (Snodgrass) urethroplasty in at least one arm; some mentioned onlay or two-stage repairs for proximal cases, but comparisons were typically within the same repair type.

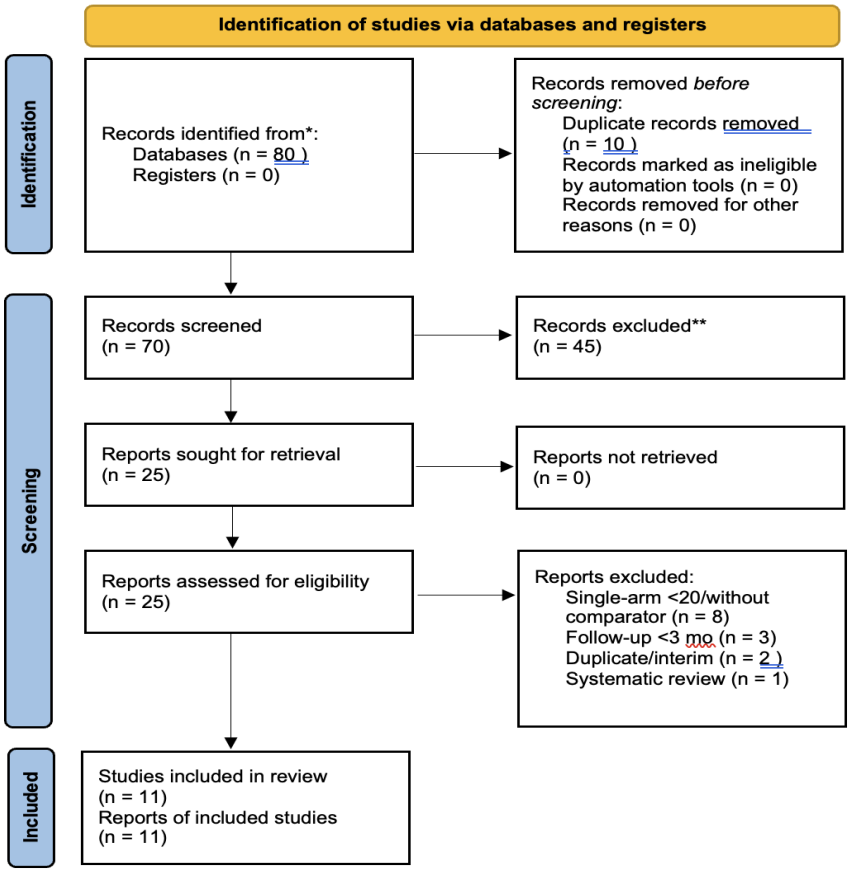

Figure 1. PRISMA flowchart

RQ1: Interposition Layer (periurethral/dartos) vs No Interposition Layer

No randomized trials in 2019–2025 directly compared urethroplasty with vs without an interposition layer, so evidence for "no-cover" repairs remains limited. The largest recent cohort (n=425 distal/midshaft) reported similar fistula rates with and without a second layer (6.7% vs 7.3%), though nonrandomized design likely reflects selection of favorable, low-risk cases for the no-layer approach (Zulli et al., 2024). Notably, over one-third of fistulas co-occurred with meatal stenosis, suggesting that outflow obstruction and urethral calibration technique may strongly influence outcomes in distal repairs. These findings imply that, in select distal cases, meticulous urethral closure may be more impactful than the choice of interposition. However, without RCT data and with uncertain applicability to proximal or revision cases, routine multilayer coverage remains recommended until clearer comparative evidence emerges.

RQ2: Comparisons Among Dartos Flap Techniques

Across recent head-to-head studies, three technical choices matter. First, double vs single dartos: one RCT (n=60) showed significantly lower UCF with double-layer coverage (3.3% vs 23.3%; p=0.02) without increased stenosis or torsion (Naumeri et al., 2021). Second, ventral vs dorsal dartos in distal TIP: another RCT (n=60) reported similar UCF (6.7% vs 10%) but fewer flap-related complications with ventral tissue (necrosis 0% vs 26.7%; torsion 0% vs 13.3%), suggesting benefit when ventral tissue is adequate (Tahmasbi et al., 2025). Third, preparing a dorsal flap before urethroplasty reduced bleeding (≈16 vs 27 mL) with comparable short-term UCF/stenosis outcomes (Issi & Bilir, 2022).

RQ3: Dartos Fascia vs Alternative Interposition Layers

Across 2019–2025, the strongest comparative evidence favors the tunica vaginalis flap (TVF) over dartos for distal and midshaft TIP repairs. An RCT (n=84) reported significantly lower UCF with TVF (4.9% vs 20.9%) and higher cosmetic scores, though with longer operative time and minor donor-site risk (Ramez et al., 2025). A quasi-experimental study (n=41) similarly showed reduced UCF (14.3% vs 45%) and fewer wound infections, supporting TVF as particularly beneficial in proximal or redo cases where dartos is insufficient (Mamud et al., 2024).

Two studies evaluating platelet-rich fibrin (PRF) applied over dartos demonstrated improved healing: fistula rates were lower (4–10% vs 18–35%) and infections markedly reduced (0% vs 22%), positioning PRF as a safe, inexpensive adjunct with minimal added operative time (Mansour et al., 2024; Abdelazim et al., 2024). Three studies assessing spongioplasty reported fistula rates comparable to dartos (~4–10%), though meatal stenosis varied more widely (4–13%), reflecting reliance on the adequacy of available spongiosum and meticulous technique (Maheshwari et al., 2022; Verma et al., 2021; Chandni et al., 2024).

This five-year review updates the role of dartos fascia and alternative interposition layers in hypospadias repair. Interpositional tissue remains key in reducing fistula, and technique optimization is the current focus. Although some distal cases with a thick urethral plate may heal without a second layer, the low added risk of a dartos flap supports its continued routine use; separating urethral and skin suture lines remains fundamental.

Our review highlights meaningful refinements to dartos use. Naumeri et al.'s RCT showed that a double dartos layer can reduce fistula rates to near zero without increasing ischemic or stenotic complications, particularly benefiting proximal, thin-plate, or revision cases (Naumeri et al., 2021). Ventral dartos flaps have emerged as an alternative to the traditional dorsal approach; Tahmasbi's RCT demonstrated similar fistula rates but lower torsion risk, though ventral dartos may be limited in proximal repairs (Tahmasbi et al., 2025). Issi and Bilir noted that harvesting the flap before urethroplasty improves visualization without altering outcomes (Issi & Bilir, 2022).

Among alternative layers, the tunica vaginalis flap (TVF) consistently offers the lowest fistula rates and is preferred when dartos is insufficient, although donor-site morbidity and operative complexity limit routine use (Ramez et al., 2025; Karabacak et al., 2025). Platelet-rich fibrin is a low-cost, autologous adjunct that reduces infection and may further lower fistula rates. Spongioplasty is effective only when the spongiosum is robust; double-breasting may improve support and cosmesis, but insufficient tissue risks meatal stenosis (Maheshwari et al., 2022; Verma et al., 2021; Chandni et al., 2024).

Limitations include small sample sizes, single-center bias, non-uniform outcome definitions, and lack of meta-analysis due to heterogeneity. Nonetheless, trends are consistent: dartos remains the workhorse, with technique refinements improving results, while TVF, PRF, and spongioplasty serve selective roles based on tissue quality and case complexity. Future research should include multicenter RCTs comparing dartos versus no layer in anatomically favorable distal repairs and longer-term follow-up into adolescence to clarify functional outcomes.

CONCLUSION

Recent studies from the past five years reinforce that a well-vascularized interpositional layer is essential in hypospadias urethroplasty, with *dartos fascia* continuing as the primary choice. Utilizing a double-layer *dartos*, preferably harvested ventrally when anatomy permits, effectively reduces fistula risk without significantly increasing surgical complexity. When *dartos* tissue is insufficient, the *tunica vaginalis* flap provides stronger protection but at the cost of a more invasive procedure. Platelet-rich fibrin shows promise as an adjunct, while spongioplasty proves beneficial if a robust spongiosum is available. Limited evidence exists comparing repairs without a second layer, supporting layered coverage as the current standard. Future research should focus on well-designed randomized controlled trials to definitively clarify the necessity and optimal configuration of interpositional layers in hypospadias repair.

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