RESEARCH PAPER

Beyond Meatal Location: Meta-Analysis Of Second-Layer Tissue Coverage And Urethrocutaneous Fistula After Pediatric Tip Urethroplasty

[1] Marta Hendry, [2] Krisna Murti, [3] Besut Daryanto, [4] Iche Andriyani Liberty
[1,2,3,4] Universitas Sriwijaya, Indonesia
Email: martahendry5pu@gmail.com, Krisna.arinafril@unsri.ac.id, urobes.fk@ub.ac.id, icheandriyaniliberty@fk.unsri.ac.id

ABSTRACT
Hypospadias is a common congenital anomaly in boys, and urethrocutaneous fistula (UCF) remains the leading complication after tubularized incised plate (TIP) urethroplasty despite routine use of a vascularized second-layer cover. A systematic review and meta-analysis following PRISMA 2020 searched PubMed, Embase, and Scopus (2000–2025) for randomized and comparative observational studies of boys ≤18 years undergoing TIP urethroplasty with a defined second-layer (tunica vaginalis flap, dartos fascia, Buck's fascia, spongioplasty, platelet-rich fibrin/plasma) compared with another strategy or no second layer; UCF was the primary outcome. Random-effects pairwise meta-analyses and prespecified subgroup analyses by meatal location and follow-up duration were performed. Thirty-seven studies contributed six pairwise comparisons. Tunica vaginalis flap and double dartos flap produced the largest and most consistent reductions in UCF versus a single dartos layer, with stable effects across distal and more proximal meatal locations and both shorter and longer follow-up. Platelet-rich fibrin/plasma augmentation and Buck's fascia also significantly lowered UCF risk, whereas ventral versus dorsal dartos orientation showed no meaningful difference and spongioplasty plus dartos demonstrated only a non-significant trend toward benefit. Second-layer choice is pivotal for fistula prevention after pediatric TIP urethroplasty; tunica vaginalis and double dartos flaps should be preferred where feasible, while regenerative platelet-based layers and Buck's fascia are promising adjuncts that warrant confirmation in adequately powered randomized trials.

Keyword: hypospadias, urethrocutaneous fistula, TIP
How to cite this article: Hendry M, Murti K, Daryanto B, Liberty IA. Beyond Meatal Location: Meta-Analysis Of Second-Layer Tissue Coverage And Urethrocutaneous Fistula After Pediatric Tip Urethroplasty. Int J Drug Deliv Technol. 2026;16(16s): 673-684. DOI: 10.25258/ijddt.16.16s.73

INTRODUCTION

Hypospadias is one of the most common congenital anomalies in boys, with a reported prevalence of approximately 1 in 250–300 live male births and a wide spectrum of anatomic severity.[1] Over the past three decades, tubularized incised plate (TIP) urethroplasty has become the standard technique for primary repair because it is versatile, technically straightforward, and provides satisfactory cosmetic and functional outcomes across distal and many proximal variants.[2] Nevertheless, urethrocutaneous fistula (UCF) remains the most frequent complication after hypospadias surgery, with rates commonly ranging between 6% and 20% depending on patient- and technique-related factors.[3]

To reduce UCF, surgeons routinely interpose a vascularized second-layer tissue over the neourethra, most commonly preputial dartos fascia, tunica vaginalis flap, or modifications such as double dartos flaps, Buck's fascia, and adjunctive platelet-rich products.[4] Although numerous single-center series have been published, uncertainty persists regarding which second-layer strategy offers the most reliable protection against fistula, and whether effectiveness differs by hypospadias severity or follow-up duration.[5] This systematic review and meta-analysis therefore aimed to synthesize comparative evidence on second-layer tissue coverage in pediatric TIP urethroplasty, focusing on UCF as the primary outcome and evaluating the consistency of effects across meatal locations and follow-up intervals.

METHODS

Study design and reporting

This systematic review and meta-analysis evaluated second-layer tissue coverage in pediatric tubularized incised plate (TIP) urethroplasty and followed PRISMA 2020 guidelines.

Search strategy

PubMed, Embase, and Scopus were searched on 20 January 2026 using controlled vocabulary and free-text terms for hypospadias/TIP urethroplasty ("hypospadias", "tubularized incised plate", "TIP urethroplasty", "Snodgrass"), second-layer tissues

("dartos flap", "tunica vaginalis", "Buck's fascia", "spongioplasty", "second layer", "interposition flap", "double dartos", "platelet-rich fibrin", "platelet-rich plasma"), and complications ("urethrocutaneous fistula", "urethral stricture", "meatal stenosis", "wound dehiscence", "reoperation"). Limits were humans, journal articles, and publication years 2000–2025; non-English studies were eligible if methods and outcomes were extractable. Reference lists of key reviews and meta-analyses were hand-searched.

Eligibility criteria

Eligible studies enrolled boys ≤18 years with any hypospadias type undergoing primary or redo TIP urethroplasty, compared at least one defined second-layer strategy (e.g. tunica vaginalis flap, dorsal/ventral or double dartos flap, Buck's fascia, spongioplasty, PRP/PRF) against another technique or no second layer, and reported urethrocutaneous fistula (primary outcome) and/or major complications (stricture/meatal stenosis, dehiscence, reoperation). Randomized trials and comparative observational studies were included; case series <10 patients, single-arm studies, non-clinical reports, and articles without extractable data were excluded.

Study selection, data extraction, and risk of bias

Two reviewers independently screened titles/abstracts and full texts, resolving disagreements by discussion or a third reviewer. Data were extracted into a standardized Excel form (study design, patient characteristics, meatal location, second-layer technique, follow-up, and outcome counts). Risk of bias was assessed with RoB 2 for randomized trials and ROBINS-I for non-randomized studies.

Statistical analysis

Pairwise meta-analyses were performed in Review Manager using random-effects models, reporting risk ratios with 95% confidence intervals. Heterogeneity was evaluated with Chi^2 and I^2 statistics, and prespecified subgroup analyses by meatal location and follow-up duration (<12 vs ≥12 months) were undertaken when data allowed.

RESULT

total of 319 records were identified across PubMed, Embase, and Scopus; after removing duplicates, 278 titles/abstracts were screened and 61 full texts were assessed for eligibility. Ultimately, 37 comparative studies met the inclusion criteria and were included in the quantitative synthesis, contributing to six pairwise meta-analyses (TVF vs dartos, ventral vs dorsal dartos, DDF vs SDF, PRP/PRF vs SDF, Buck's fascia vs dartos, and spongioplasty + SDF vs SDF).

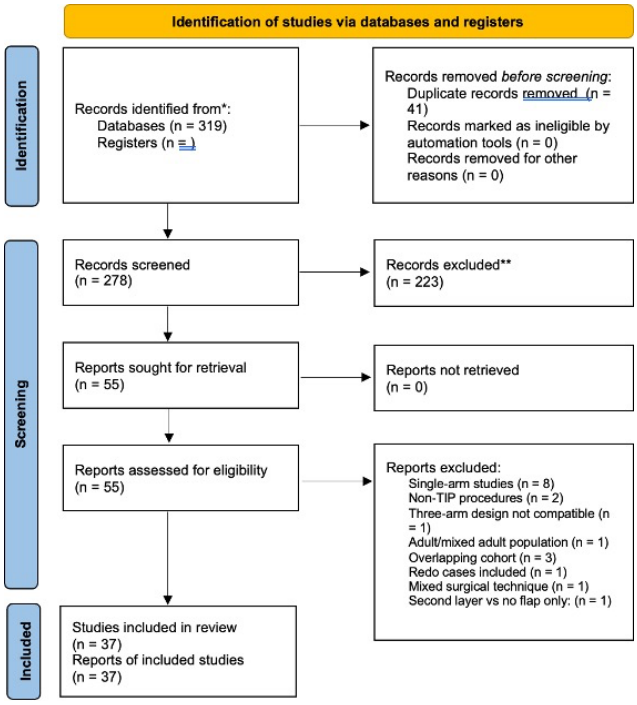


Figure 1. Prima Flowchart

Table 1. Characteristic S*tudy*

Author	Year	Country	Study Design	Populasi	Comparison	Meatal Location
Dhua et al.[6]	2012	India	Prospective comparative	50	TVF vs Dorsal Dartos	Mixed (distal–proximal)
Babu & Hariharasudhan[7]	2013	India	Retrospective comparative	47	TVF vs Dorsal Dartos	Midshaft
Basavaraju & Balaji[8]	2017	India	Retrospective comparative	62	TVF vs Dorsal Dartos	Mixed (distal–proximal)

			Non-randomized controlled			
Gajbhiye et al.[9]	2018	India	Trial	48	TVF vs Dartos	Distal + midpenile
Kurbet et al.[10]	2018	India	RCT	40	TVF vs SDF	Mixed (distal–proximal)
Patel et al.[11]	2018	India	RCT	55	TVF vs SDF	Mixed (distal–proximal)
Han et al.[12]	2020	South Korea	RCT	50	TVF + Dartos vs SDF	Mixed (distal–scrotal)
Ramez et al.[4]	2025	Egypt	RCT	84	TVF vs SDF	Distal + midpenile
Ahmed et al.[13]	2025	Pakistan	Quasi-experimental	100	TVF vs VDF	Distal only
Jia et al.[14]	2016	China	Retrospective comparative	356	VDF (MBVDF) vs Dorsal Dartos	Mixed (distal–midshaft)
Maily et al.[15]	2020	Iraq	Prospective comparative	85	Dorsal Dartos vs VDF	Distal Only
Yiğit & Avlan[16]	2022	Turkey	Retrospective comparative	89	VDF vs Dorsal Dartos	Mixed (distal–proximal)
Tahmasbi et al.[17]	2025	Iran	RCT	60	VDF vs Dorsal Dartos	Distal Only
Kamal[18]	2005	Saudi Arabian	Case-control	76	DDF vs SDF	Distal
Erol et al.[19]	2009	Turkey	RCT	77	DDF vs SDF	Distal (Coronal/subcoronal)
Yildiz & Bakan[20]	2010	Turkey	Case-control	52	DDF vs SDF (TIP subgroup)	Distal
Yiğiter et al.[21]	2010	Turkey	Prospective comparative	60	DDF vs SDF	Distal+Midshaft
Maarouf et al.[22]	2012	Egypt	Retrospective comparative	100	DDF vs SDF	Distal
Safwat et al.[23]	2012	Egypt	Prospective comparative	58	DDF vs SDF	Distal
Suoub et al.[24]	2013	Jordan	Case-control	94	DDF vs SDF	Mixed (distal-proximal)
Cimador et al.[25]	2013	Italy	RCT	73	DDF vs SDF	Distal
Gupta & Singh[26]	2016	India	RCT	65	DDF vs SDF	Distal
Murtadha et al.[27]	2021	(Basra)	Prospective comparative	44	DDF vs SDF	Distal
Naumeri et al.[28]	2021	Pakistan	RCT	60	DDF vs SDF	Distal+midpenile
Al-Taher et al.[29]	2022	Jordan	Retrospective cohort	163	DDF vs SDF	Distal (glandular-midshaft)
Mahmoud et al.[30]	2019	Egypt	RCT	180	PRP + SDF vs SDF	Midpenile

Eryilmaz et al.[31]	2020	Turkey	RCT	40	PRP + SDF vs SDF	Midpenile
Elsayem et al.[32]	2021	Egypt	RCT	30	PRP + SDF vs SDF	Mixed (coronal-proximal)
Mansour et al.[33]	2024	Egypt	RCT	44	PRP + SDF vs SDF	Distal only
Elnashar et al.[34]	2024	Egypt	RCT	60	PRF vs SDF	Distal (coronal-distal penile)
Dahal et al.[35]	2022	Pakistan	RCT	74	Buck's + Dartos vs Dartos alone	Distal+midpenile
Ji et al.[36]	2023	China	China	113	Spongioplasty + Buck's vs Dorsal Dartos	Distal only
Hamid & Baba[37]	2024	India	India	174	Buck's Fascia vs Dartos	Distal (coronal-distal penile)
Bilici et al.[38]	2011	Turkey	Turkey	161	Dartos + Spongioplasty vs Dartos alone	Distal+midpenile
Verma et al.[39]	2021	India	RCT	30	Dartos vs Spongioplasty	Distal only
Daboos et al.[40]	2024	Egypt	RCT	220	Spongioplasty + SDF vs	Distal+midpenile
Chandni et al.[41]	2024	Pakistan	RCT	120	Spongioplasty + SDF vs SDF	Distal+midshaft

Tunica Vaginalis Flap Versus Dartos Flap

Primary Analysis

Nine comparative studies enrolling a total of 536 boys (259 TVF, 277 dartos flap) reported urethrocutaneous fistula (UCF) as an outcome. In the primary pooled analysis, TVF was associated with a significantly lower risk of UCF compared with dartos flap (12/259 vs 57/277 events; risk ratio [RR] 0.30, 95% confidence interval [CI] 0.17–0.52; $p < 0.0001$). No statistical heterogeneity was detected across studies ($Tau^2 = 0.00$; $Chi^2 = 3.93$, df = 8, $p = 0.86$; $I^2 = 0\%$), indicating a highly consistent protective effect of TVF.

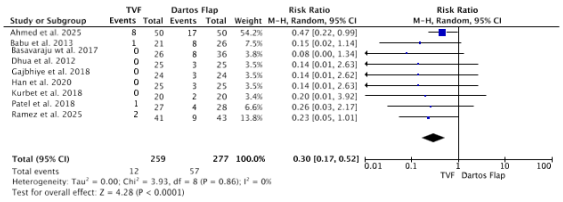


Figure 2. Primary Analysis TVF vs Dartos Flap

Subgroup Analysis by Meatal Location

When restricted to studies reporting outcomes by meatal location, seven studies (188 TVF, 201 dartos flap) demonstrated an even more pronounced reduction in UCF with TVF (3/188 vs 32/201 events; RR 0.18, 95% CI 0.08–0.45; $p = 0.0002$; $I^2 = 0\%$).

Subgroup Analysis by Follow-up Duration

In studies with follow-up less than 12 months (4 studies; 118 TVF, 124 dartos flap), TVF remained significantly protective against UCF (10/118 vs 31/124 events; RR 0.38, 95% CI 0.20–0.73; $p = 0.003$; $I^2 = 0\%$). Among studies with follow-up of 12 months or longer (5 studies; 141 TVF, 153 dartos flap), the effect was even more pronounced (2/141 vs 26/153 events; RR 0.17, 95% CI 0.06–0.47; $p = 0.0007$; $I^2 = 0\%$).

When all subgroups were pooled, the overall estimate confirmed the superiority of TVF (15/447 vs 89/478 events; RR 0.26, 95% CI 0.17–0.42; $p < 0.00001$; $I^2 = 0\%$), with no significant interaction between subgroups (test for subgroup differences: $Chi^2 = 2.61$, df = 2, $p = 0.27$; $I^2 = 23.3\%$).

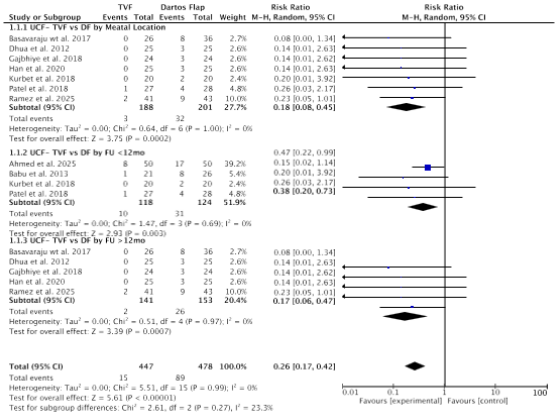


Figure 3. Sub Group Analysis TVF vs Dartos

Ventral Dartos Versus Dorsal Dartos

Four studies including 590 patients (292 ventral dartos, 298 dorsal dartos) compared the orientation of dartos flap coverage. UCF occurred in 20/292 patients in the ventral dartos group and 12/298 in the dorsal dartos group, yielding a pooled RR of 1.52 (95% CI 0.66–3.52; $p = 0.33$). Heterogeneity was low ($Tau^2 = 0.15$; $Chi^2 = 3.75$, df = 3, $p = 0.29$; $I^2 = 20\%$). No statistically significant difference in UCF risk was observed between ventral and dorsal dartos coverage.

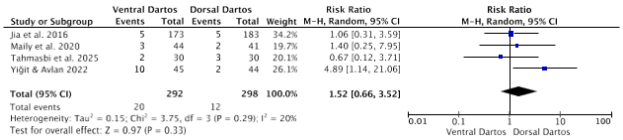


Figure 4 Primary analysis Ventral Dartos vs Dorsal Dartos

Double Dartos Flap Versus Single Dartos Flap

Primary Analysis

Eleven comparative studies enrolling 928 boys (416 DDF, 512 SDF) were included. In the primary pooled analysis, DDF was associated with a markedly lower risk of UCF compared with SDF (6/416 vs 80/512 events; RR 0.18, 95% CI 0.09–0.35; $p < 0.00001$). Statistical heterogeneity was absent ($Tau^2 = 0.00$; $Chi^2 = 3.89$, df = 11, $p = 0.97$; $I^2 = 0\%$), supporting the robustness of the overall estimate.

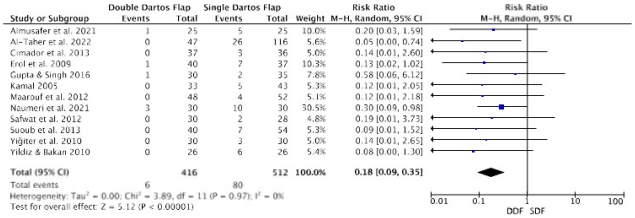
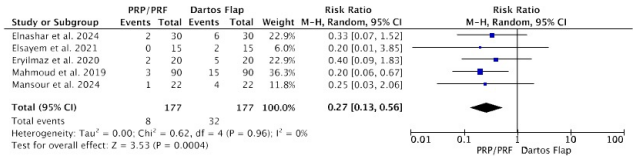


Figure 5. Primary Analysis Double Dartos Flap vs Single Dartos Flap



Subgroup Analysis by Meatal Location

In distal hypospadias, seven studies (269 DDF, 282 SDF) demonstrated a significant reduction in UCF with DDF (3/269 vs 47/282 events; RR 0.17, 95% CI 0.07–0.42; p = 0.0001; I² = 0%). In

mixed meatal locations (distal–midshaft–proximal), four studies (147 DDF, 230 SDF) also favored DDF (0/147 vs 41/230 events; RR 0.19, 95% CI 0.07–0.50; p = 0.0008; I² = 0%).

Subgroup Analysis by Follow-up Duration

For studies with follow-up less than 12 months (5 studies; 155 DDF, 172 SDF), DDF remained superior (2/155 vs 19/172 events; RR 0.21, 95% CI 0.07–0.67; p = 0.008; I² = 0%). In studies with follow-up of 12 months or longer (6 studies; 231 DDF, 310 SDF), the protective effect was even more pronounced (1/231 vs 51/310 events; RR 0.10, 95% CI 0.03–0.30; p < 0.0001; I² = 0%).

Pooled across all subgroups, DDF reduced UCF risk by approximately 84% compared with SDF (9/802 vs 150/994 events; RR 0.16, 95% CI 0.10–0.27; p < 0.00001; I² = 0%), with no significant interaction between subgroups (test for subgroup differences: Chi² = 1.06, df = 3, p = 0.79; I² = 0%).

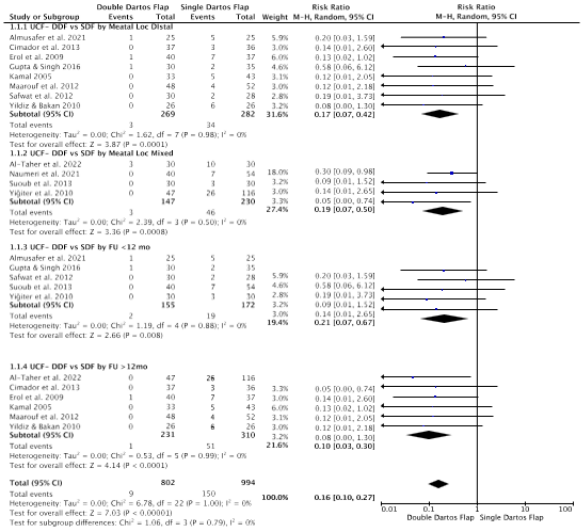


Figure 6. Sub Group Analysis Double Dartos Flap vs Single Dartos Flap

PRP/PRF Versus Single Dartos Flap

Five comparative studies including 354 boys (177 PRP/PRF, 177 single dartos flap) reported UCF after TIP urethroplasty. UCF occurred in 8/177 patients in the PRP/PRF group and 32/177 in the single dartos group, resulting in a pooled RR of 0.27 (95% CI 0.13–0.56; p = 0.0004). Between- study heterogeneity was negligible (Tau² = 0.00; Chi² = 0.62, df = 4, p = 0.96; I² = 0%), supporting the consistency of the observed effect.

Figure 7. Analysis of PRP/PRF Versus Single Dartos Flap Buck's Fascia Versus Dartos

Three comparative studies including 361 boys (189 Buck's fascia, 172 dartos flap) reported UCF after TIP urethroplasty. UCF occurred in 8/189 patients in the Buck's fascia group and 26/172 in the dartos group, yielding a pooled RR of 0.29 (95% CI 0.14–0.63; p = 0.002). Between-study heterogeneity was negligible (Tau² = 0.00; Chi² = 0.23, df = 2, p = 0.89; I² = 0%).

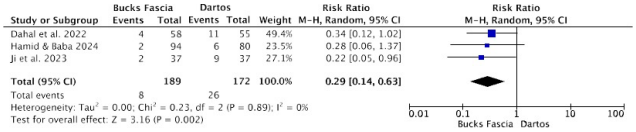


Figure 8. Analysis Buck's Fascia Versus Dartos

Spongioplasty Combined with SDF Versus SDF Alone

Four comparative studies including 531 boys (271 spongioplasty + SDF, 260 SDF alone) reported UCF after TIP urethroplasty. UCF occurred in 9/271 patients in the spongioplasty + SDF group and 29/260 in the SDF-alone group, giving a pooled RR of 0.35 (95% CI 0.12–1.08; p = 0.07). Although the point estimate favored the addition of spongioplasty, the confidence interval crossed unity and the result did not reach conventional statistical significance. Between-study heterogeneity was moderate (Tau² = 0.61; Chi² = 5.96, df = 3, p = 0.11; I² = 50%), indicating variability in effect size across the included studies.

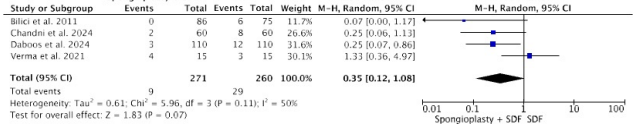


Figure 9. Analysis of Spongioplasty Combined With SDF Versus SDF Alone

DISCUSSION

Tunica Vaginalis Flap: Mechanism and Evidence

The superiority of TVF over dartos flap is biologically plausible and consistent with prior observations.[42] The tunica vaginalis is a well-vascularized, robust tissue layer that provides a reliable waterproofing barrier over the neourethra.[43] Unlike preputial dartos, which may be attenuated or dysplastic in boys with hypospadias, the tunica vaginalis is anatomically remote from the hypospadiac field and thus less likely to be affected by the intrinsic tissue abnormalities associated with the condition.[7] A prior meta-analysis by Liet al. (2020), which included six comparative studies, similarly reported a significant advantage of TVF over dartos fascia for reducing overall complications and UCF.[42] The present analysis extends these findings by showing that the beneficial effect of TVF is maintained across different meatal locations and follow-up durations, supporting the notion that its protective impact is stable over time rather than merely delaying fistula presentation.

Double Dartos Flap: Reinforcing the Barrier

The finding that DDF reduces UCF risk by approximately 82–84% compared with SDF is striking and represents the largest effect size observed in this review. The rationale for double-layer coverage is mechanical: interposing two vascularized tissue layers creates a more robust and reliable barrier between the neourethral suture line and the overlying skin, reducing the likelihood of suture-line disruption and fistula tract formation.[29] The benefit of DDF appears consistent across different meatal locations and follow-up durations, supporting its applicability in a broad spectrum of hypospadias phenotypes. These results are in line with previous comparative and network meta-analyses that have singled out double dartos coverage as one of the most effective techniques for preventing UCF after TIP urethroplasty.[5]

PRP/PRF: A Regenerative Adjunct

The 73% reduction in UCF with PRP/PRF augmentation represents a clinically compelling finding. Beyond serving as a mechanical barrier, platelet-rich concentrates deliver growth factors (PDGF, TGF-β, VEGF) that enhance angiogenesis and tissue remodeling, potentially targeting the biological basis of fistula formation.[34,44] The absence of heterogeneity ($I^2 = 0\%$) strengthens the consistency of this effect. However, current evidence is limited by small study sizes and non-standardized preparation protocols, underscoring the need for multicenter trials with harmonized PRP/PRF techniques before routine adoption.

Buck's Fascia: An Underexplored Alternative

Buck’s fascia provides a mechanically supportive, well-defined fascial layer for neourethral coverage. Our pooled analysis suggests significant UCF reduction versus dartos. This is congruent with reports describing Buck’s fascia-based integral covering techniques in one-stage hypospadias repair and broader clinical series suggesting feasibility and efficacy.[45,46] However, surgeons should remain attentive to suture tension and tissue handling, because excessive tightening or compromised fascial quality may theoretically contribute to urethral narrowing or stricture risk, an issue explicitly raised in Buck’s fascia coverage reports.[46]

Ventral Versus Dorsal Dartos: Orientation Does Not Matter

The pooled estimate for ventral versus dorsal dartos coverage did not demonstrate a significant difference. This is clinically plausible because, when executed properly, both approaches can provide vascularized interposition. However, individual studies in the literature have reported conflicting conclusions regarding whether dorsal or ventral dartos is superior, reflecting differences in patient selection (distal vs more complex anatomy), flap design, and surgeon experience.[16,17] In clinical practice, the choice is often dictated by anatomy and technical constraints: dorsal dartos can be favored when dorsal preputial tissue is abundant, whereas ventral dartos may be attractive when dorsal tissues are limited. Yet both may carry distinct risks (e.g., torsion or skin ischemia depending on flap mobilization and rotation), and these trade-offs may dilute outcome differences when pooled.[17]

Spongioplasty: Promising but Inconclusive

The combination of spongioplasty with a single dartos flap was associated with a tendency toward lower UCF rates, but the available data remain inconclusive and show notable between-study variability. Gildor et al. (2024) suggested that an additional spongiosum layer may reduce fistula incidence without increasing glans dehiscence, but the

variability in surgical technique (extent and method of spongiosum mobilization) likely contributes to the inconsistent results observed across studies.[47] Larger, well-designed trials with standardized spongioplasty protocols are needed to clarify the role of this technique.

Consistency of Subgroup Analyses

A notable strength of this review is the consistency of findings across pre-specified subgroup analyses. For both TVF versus dartos and DDF versus SDF, the protective effects remained significant and directionally consistent when stratified by meatal location and follow-up duration. Importantly, the tests for subgroup interaction were non-significant in both comparisons, indicating that the superiority of these techniques is not confined to a specific hypospadias phenotype or follow-up interval. The observation that effect sizes were numerically larger in longer follow-up subgroups (≥12 months) suggests that short follow-up studies may underestimate the true benefit by missing late-presenting fistulae.

Limitations

Several limitations should be acknowledged. First, the majority of included studies were non-randomized, introducing the potential for selection, performance, and detection biases despite the use of validated risk- of-bias tools (RoB 2 for RCTs and ROBINS-I for non-randomized studies). Second, the number of studies was small for certain comparisons (e.g., Buck's fascia, 3 studies; spongioplasty, 4 studies), limiting statistical power and the ability to perform subgroup analyses. Third, the primary outcome was restricted to UCF; data on other important outcomes such as meatal stenosis, cosmetic appearance, and functional voiding parameters were insufficiently reported across the included studies. Fourth, operative technique and surgeon experience, which are known to influence complication rates, could not be adjusted for in the analysis. Fifth, publication bias cannot be excluded, particularly for comparisons with few studies, although the consistent direction and magnitude of effects across different study designs and settings mitigate this concern to some extent.

Clinical Implications

The findings of this review have direct implications for surgical decision-making in pediatric TIP urethroplasty. The evidence strongly supports the use of TVF, DDF, PRP/PRF augmentation, or Buck's fascia over a standard single dartos flap to minimize UCF risk. In settings where tunica vaginalis is technically accessible (particularly for midshaft and proximal cases), TVF offers a well-established option with consistent evidence of benefit. For distal cases where tunica vaginalis may be less accessible, a double dartos flap provides an equally, if not more, effective alternative. PRP/PRF augmentation represents an attractive adjunct, particularly in cases with poor tissue quality, although standardization of preparation protocols remains a priority.

Future Directions

Well-designed multicenter randomized controlled trials directly comparing TVF, DDF, and PRP/PRF augmentation are needed to establish a definitive hierarchy of second-layer strategies. Future studies should incorporate standardized reporting of secondary outcomes (stricture, meatal stenosis, cosmesis, uroflowmetry), longer follow-up (≥24 months), and stratification by hypospadias severity. Individual patient data meta-analysis would allow more granular exploration of effect modifiers such as patient age, urethral plate quality, and surgeon volume.

CONCLUSION

This meta-analysis shows that second-layer tissue coverage meaningfully reduces urethrocutaneous fistula after pediatric TIP urethroplasty, with tunica vaginalis flap and double dartos flap providing the most consistent and durable risk reduction compared with a single dartos layer. Adjunctive strategies such as PRP/PRF augmentation and Buck’s fascia coverage also appear beneficial, whereas dartos flap orientation has no clear impact and spongioplasty data remain inconclusive. Overall, surgeons should preferentially use a well-vascularized, often double-layer, intermediate cover over the neourethra, while high-quality multicenter randomized trials are still needed to refine the optimal hierarchy of second-layer techniques.

REFERENCES

1. Halaseh, S. A., Halaseh, S., & Ashour, M. (2022). Hypospadias: A Comprehensive Review Including Its Embryology, Etiology and Surgical Techniques. *Cureus*.

https://doi.org/10.7759/cureus.27544

2. Duarsa, G. W. K., Tirtayasa, P. M. W., Daryanto, B., Nurhadi, P., Renaldo, J., Tarmono, T., Utomo, T., Yuri, P., Siregar, S., Wahyudi, I., Situmorang, G. R., Palinrungi, M. A. A., Hutasoit, Y. I., Hutahaean, A. Y. A., Zulfiqar, Y., Sigumonrong, Y. H., Mirza, H., & Rodjani, A. (2019). Common Practice of Hypospadias Management by Pediatric Urologists in Indonesia: A Multi- center Descriptive Study from Referral Hospitals. *Open Access Macedonian Journal of Medical Sciences*, *7*(14), 2242–2245. https://doi.org/10.3889/oamjms.2019.628
3. Sheng, X., Xu, D., Wu, Y., Yu, Y., Chen, J., & Qi, J. (2018). The risk factors of Urethrocutaneous fistula after hypospadias surgery in the youth population. *BMC Urology*, *18*(1), 64. https://doi.org/10.1186/s12894-018-0366-z
4. Ramez, M., Hashem, A., Bazeed, M., Dawaba, M. S., & Helmy, T. E. (2025). Tunica vaginalis or dartos as second layer coverage for distal and mid-shaft penile hypospadias, quo vadis? *World Journal of Urology*, *43*(1). https://doi.org/10.1007/s00345-024-05419-x
5. Yuan, Y., Wang, Y. W., Liang, Y. N., Wang, Y. Y., Ho, J. J., Peng, T. Y., Zhao, Z., & Deng, N. (2023). A meta-analysis: single or double dartos flap layer in tubularized incised plate urethroplasty to prevent urethrocutaneous fistula? In *Frontiers in Pediatrics* (Vol. 11). Frontiers Media SA. https://doi.org/10.3389/fped.2023.1091242
6. Dhua, A., Aggarwal, S., Sinha, S., & Ratan, S. (2012). Soft tissue covers in hypospadias surgery: Is tunica vaginalis better than dartos flap? *Journal of Indian Association of Pediatric Surgeons*, *17*(1), 16. https://doi.org/10.4103/0971-9261.91080
7. Babu, R., & Hariharasudhan, S. (2013). Tunica vaginalis flap is superior to inner preputial dartos flap as a waterproofing layer for primary TIP repair in midshaft hypospadias. *Journal of Pediatric Urology*, *9*(6), 804–807. https://doi.org/10.1016/j.jpurol.2012.10.022
8. Basavaraju, M., & Balaji, D. (2017). Choosing an ideal vascular cover for Snodgrass repair. *Urology Annals*, *9*(4), 348. https://doi.org/10.4103/UA.UA_90_17
9. Gajbhiye, V., Singh, N., Singh, S., & R. S, V. (2018). TUNICA VAGINALIS FLAP (TVF) AS AN ALTERNATIVE TO DARTOS FLAP IN PRIMARY HYPOSPADIAS REPAIR-OUR EXPERIENCE. *Journal of Evolution of Medical and Dental Sciences*, *7*(16), 1970–1973. https://doi.org/10.14260/jemds/2018/443
10. Kurbet, S. B., Koujalagi, R. S., Geethika, V., & Nagathan, V. (2018). A 1-year randomized controlled trial to compare the outcome of primary repair of hypospadias with vascular cover using tunica vaginalis flap with those using preputial dartos fascia. *African Journal of Paediatric Surgery*, *15*(1), 42–47. https://doi.org/10.4103/ajps.AJPS_104_17
11. Patel, J. L., Chandrakar, S., Memon, M. A., & Mishra, B. (2018). Outcome of standard tabularized incised plate urethroplasty repair using dartos flap and tunica vaginalis flap in of hypospadias cases. *International Surgery Journal*, *5*(3), 850. https://doi.org/10.18203/2349-2902.isj20180433
12. Han, J. H., Song, S. H., Lee, J. S., Park, S., Kim, S. J., & Kim, K. S. (2020). Efficacy of additional tunica vaginalis flap coverage for protecting against urethrocutaneous fistulas in tubularized incised plate urethroplasty: A prospective, randomized controlled trial. *Investigative and Clinical Urology*, *61*(5), 514–520. https://doi.org/10.4111/icu.20200024
13. Ahmed, R., Ashraf, Y., Ahmed, A., Jabbar, M. S., Rehman, M. H. U., & Jarral, S. (2025). A Comparative Study on Ventral Dartos Flap Vs Tunica Vaginalis Flap in Hypospadias Repair, Decreasing the Incidence of Fistula Formation. *Life and Science*, *6*(3), 07. https://doi.org/10.37185/LnS.1.1.927
14. Jia, W., Liu, G., Zhang, L., Wen, Y., Fu, W., Hu, J., Wang, Z., He, Q., & Xia, H. (2016). Comparison of tubularized incised plate

urethroplasty combined with a meatus-based ventral dartos flap or dorsal dartos flap in hypospadias. *Pediatric Surgery International*, *32*(4), 411–415. https://doi.org/10.1007/s00383-016-3860-y

15. Maily, J. A. H. Al, Gali, S., & Ghazi, M. J. (2020). Comparison between dorsal and ventral dartos flap interposition in a tubularized incised plate repair of distal hypospadias. In *International Journal of Pharmaceutical Research* (Vol. 12, pp. 3243–3245). Advanced Scientific Research. https://doi.org/10.31838/ijpr/2020.SP2.357
16. Yiğit, D., & Avlan, D. (2022). Dorsal Versus Ventral Dartos Flap to Prevent Fistula Formation in Tubularized Incised Plate Urethroplasty for Hypospadias. *Urology Journal*, *19*(04).
17. Tahmasbi, F., Aliasgarzadeh, J., Mohammad-Rahimi, M., & Lotfi, B. (2025). Comparison of the Surgical Results of Ventral and Dorsal Dartos Flaps in Tubularized Incised Plate Urethroplasty for Distal Hypospadias: A Randomized Clinical Trial. *Urology Research and Practice*, *51*(3), 111–116. https://doi.org/10.5152/tud.2025.25012
18. Kamal, B. A. (2005). Double dartos flaps in tubularized incised plate hypospadias repair. *Urology*, *66*(5), 1095–1098. https://doi.org/10.1016/j.urology.2005.05.020
19. Erol, A., Kayikci, A., Memik, O., Cam, K., & Akman, Y. (2009). Single vs. Double Dartos Interposition Flaps in Preventing Urethrocutaneous Fistula after Tubularized Incised Plate Urethroplasty in Primary Distal Hypospadias: A Prospective Randomized Study. *Urologia Internationalis*, *83*(3), 354–358. https://doi.org/10.1159/000241682
20. Yıldız, A., & Bakan, V. (2010). Comparison of Perimeatal-Based Flap and Tubularized Incised Plate Urethroplasty Combined with Single- or Double-Layer Dartos Flap in Distal Hypospadias. *Urologia Internationalis*, *84*(3), 265–268. https://doi.org/10.1159/000288226
21. Yiğiter, M., Yildiz, A., Oral, A., & Salman, A. B. (2010). A comparative study to evaluate the effect of double dartos flaps in primary hypospadias repair: no fistula anymore. *International Urology and Nephrology*, *42*(4), 985–990. https://doi.org/10.1007/s11255-010-9735-6
22. Maarouf, A. M., Shalaby, E. A., Khalil, S. A., & Shahin, A. M. (2012). Single vs. double dartos layers for preventing fistula in a tubularised incised-plate repair of distal hypospadias. *Arab Journal of Urology*, *10*(4), 408–413. https://doi.org/10.1016/j.aju.2012.09.002
23. Safwat, A., Al-Adl, A. M., & El-Karamany, T. (2012). Vascularized dartos flap in conjunction with tubularized incised plate urethroplasty: Single versus double flaps for management of distal hypospadias. *Current Urology*, *6*(2), 67–70. https://doi.org/10.1159/000343511
24. Suoub, M., Sawaqed, F., & Al-Khitan, S. (2013). Effect of Double Layer Dartos Flap in Reduction of Fistula Rate Post Hypospadias Repair. In *J Med J* (Vol. 47, Number 4).
25. Cimador, M., Pensabene, M., Sergio, M., Catalano, P., & de Grazia, E. (2013). Coverage of urethroplasty in pediatric hypospadias: Randomized comparison between different flaps. *International Journal of Urology*, *20*(10), 1000–1005. https://doi.org/10.1111/iju.12092
26. Gupta R, & Singh A. (2016). Use of dorsal dartos pedicled flap single or double layered in preventing the fistula rate following tubularized incised plate repair in distal hypospadias: A prospective randomized study. *IJSS J Surg*.
27. Almusafer, M., Gatea Mezban, S., & Faisal, M. (2021). THE OUTCOME OF DOUBLE DARTOS VERSUS SINGLE LAYER FLAP IN SNODGRASS URETHROPLASTY FOR DISTAL HYPOSPA-DIAS REPAIR IN BASRA TRAINING CENTER OF UROLOGY. In *Basrah Journal of Surgery Original Article* (Vol. 27, Number 2).
28. Naumeri, F., Munir, M. A., Ahmad, H. M., Sharif, M., Awan, N. U., & Butt, G. (2021). Comparison of Urethrocutaneous Fistula Rate After Single Dartos and Double Dartos Tubularized Incised Plate Urethroplasty in

Pediatric Hypospadias. *Cureus*. https://doi.org/10.7759/cureus.13378

29. Al-Taher, R., Nofal, M., Yousef, A. J., Rashdan, M., Tarawneh, A., Alsmadi, J., Hasan, E., Alshareefi, D., Alenezi, D., & Abdulrasoul, B. (2023). Double dartos flap layer in tubularized incised plate urethroplasty to prevent urethrocutaneous fistula in uncircumcised patients with distal hypospadias. *Asian Journal of Andrology*, *25*(1), 93–97. https://doi.org/10.4103/aja202251
30. Mahmoud, A. Y., Gouda, S., Gamaan, I., & Baky Fahmy, M. A. (2019). Autologous platelet-rich plasma covering urethroplasty versus dartos flap in distal hypospadias repair: A prospective randomized study. *International Journal of Urology*, *26*(4), 475–480. https://doi.org/10.1111/iju.13912
31. Eryilmaz, R., Şimşek, M., Aslan, R., Beger, B., Ertaş, K., & Taken, K. (2020). The effect of plasma rich platelet graft on post-operative complications in mid-penile hypospadias. *Andrologia*, *52*(7). https://doi.org/10.1111/and.13652
32. Elsayem, K., Darwish, A. S., AbouZeid, A. A., Kamel, N., Dahab, M. M., & El Naggar, O. (2022). Autologous platelet gel improves outcomes in tubularized incised plate repair of hypospadias. *Journal of Pediatric Surgery*, *57*(3), 488–491. https://doi.org/10.1016/j.jpedsurg.2021.03.058
33. Mansour, A. M., Ismail, E. A., Abdalla, M. O., El Nashar, A. M., Ismail, I. Y., & Abdelhalim, K. M. (2024). Additive outcome of platelet rich fibrin neourethral coverage of tubularized incised plate in primary distal hypospadias repair. *BMC Urology*, *24*(1). https://doi.org/10.1186/s12894- 024-01591-9
34. Elnashar, A. M., Albishbishy, M., Sheir, H., Elayyouti, M., Elsherbiny, M., Elzohiri, M., Ghazaly Waly, M. El, & Elsaied, A. (2025). Comparative Study Between Autologous Platelet-rich Fibrin Membrane and Local Flaps as Intervening Layer in Management of Distal Hypospadias. *Journal of Pediatric Surgery*, *60*(1). https://doi.org/10.1016/j.jpedsurg.2024.161994
35. Dahal, S., Mahat, B., Hussain, N., Saleem, M., & Rahman, U.-. (2022). Buck's Fascia in Addition to Dartos Fascia is an Effective Intermediate Layer in Repair of Hypospadias. *Pakistan Journal of Medical and Health Sciences*, *16*(11), 307–308. https://doi.org/10.53350/pjmhs20221611307
36. Tianfu, D., Bo, X., Xue, Z., Lei, L., Chaoyue, J., & Jianxing, L. (2023). Analysis of The Curative Effect of Tubularized Incised Plate Urethroplasty for Distal Hypospadias with The Dysplastic Corpus Spongiosum Covering Technique. *Urology Journal*, *20*(3), 162–166. https://doi.org/10.22037/uj.v20i.7438
37. Hamid, R., & Baba, A. A. (2024). Comparison of outcome of TIP urethroplasty with or without Buck's Fascia repair. *BMC Urology*, *24*(1), 133. https://doi.org/10.1186/s12894-024-01468-x
38. Bilici, S., Sekmenli, T., Gunes, M., Gecit, I., Bakan, V., & Isik, D. (2011). Comparison of dartos flap and dartos flap plus spongioplasty to prevent the formation of fistulae in the snodgrass technique. *International Urology and Nephrology*, *43*(4), 943–948. https://doi.org/10.1007/s11255-011-9943-8
39. Verma, A., Murtaza, S., Kundal, V. K., Sen, A., & Gali, D. (2021). Comparison of Dartos flap and spongioplasty in Snodgrass urethroplasty in distal penile hypospadias. *World Journal of Pediatric Surgery*, *4*(3). https://doi.org/10.1136/wjps-2021-000294
40. Daboos, M., Abdelmaboud, M., Azab, A., Abdelaziz, M., & Eldamanhory, H. (2024). Evaluation of Tubularized Incised Plate Urethroplasty with Spongioplasty–Dartosoraphy Reinforcement in Pediatric Hypospadias: A Randomized Controlled Study. *European Journal of Pediatric Surgery*, *34*(06), 473–481. https://doi.org/10.1055/s-0044-1779277
41. Chandni, Chaudhary, M. A., & Iqbal, A. (2024).

Outcomes of double-breasted spongioplasty as additional tissue coverage in tubularized incised plate urethroplasty. *Journal of Pediatric Surgery Open*, *5*, 100111. https://doi.org/10.1016/j.yjpso.2023.100111

42. Yang, H., Xuan, X. xiao, Hu, D. lai, Zhang, H., Shu, Q., Guo, X. dong, & Fu, J. fen. (2020). Comparison of effect between dartos fascia and tunica vaginalis fascia in TIP urethroplasty: a meta-analysis of comparative studies. *BMC Urology*, *20*(1). https://doi.org/10.1186/s12894-020- 00737-9
43. Yahya Moosa, Z., & Mohammed AL-hallak, Y. (n.d.). Tunica Vaginalis Flap Versus Inner Preputial Dartos Flap as Waterproof Layer for Proximal Staged Hypospadias Repair: A Comparative Study. In *Indian Journal of Forensic Medicine & Toxicology* (Vol. 14, Number 3).
44. Abdelazim, O., Abdullateef, K. S., Khedr, E., & Tarek, M. (2024). The use of an autologous platelet-rich fibrin membrane in urethroplasty for cases of distal hypospadias. *Egyptian Pediatric Association Gazette*, *72*(1). https://doi.org/10.1186/s43054-024-00304-z
45. Zhang, Y., Chao, M., Zhang, W., Tang, Y., Chen, H., Zhang, K., Lu, R., Zhang, X., & Lou, D. (2021). Using Buck's Fascia as an Integral Covering in Urethroplasty to Restore the Anatomical Structure of the Penis in One-Stage Hypospadias Repair: A Multicenter Chinese Study Comprising 1,386 Surgeries. *Frontiers in Pediatrics*, *9*. https://doi.org/10.3389/fped.2021.695912
46. Zhou, Q., Zhang, W., Ni, X., & Song, H. (2023). Surgical efficacy of tubularized incised plate urethroplasty applying for Buck's fascia coverage in the treatment of hypospadias. *Journal of Pediatric Surgery Open*, *4*, 100091. https://doi.org/10.1016/j.yjpso.2023.100091
47. Schwarztuch Gildor, O., Shumaker, A., Beberashvili, I., Stav, K., & Neheman, A. (2024). Reducing fistula rate in hypospadias repair: A comparative study between standard tubularized incised plate repair and incorporation of a layer of spongiosum tissue. *Journal of Pediatric Urology*, *20*(4), 675–679. https://doi.org/10.1016/j.jpurol.2024.04.004