

Modified versus traditional Devine procedure for pediatric concealed penis: a systematic review and meta-analysis[#]

Jinwei Mao,¹ Jie Deng,² Xiqi Peng,² Xunbao Wang,² Song Wu,^{1*}

¹Shantou University Medical College, Shantou, 515063, China

²Department of Urology, South China Hospital, Medical School, Shenzhen University, Shenzhen, 518116, China

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Background: Concealed penis (CP) is a common congenital condition in pediatric urology, and surgical correction remains the mainstay of treatment. The modified Devine procedure (MDP) has been increasingly used, but its comparative safety and effectiveness relative to the traditional Devine procedure (TDP) remain unclear. This study aimed to compare the safety and effectiveness of the MDP with the TDP for the treatment of pediatric CP.

Methods: This systematic review and meta-analysis was conducted in accordance with the PRISMA 2020 and AMSTAR guidelines. Prospective, retrospective, and randomized controlled studies comparing MDP and TDP for pediatric CP were included. Five databases (China National Knowledge Infrastructure, Medline, PubMed, Cochrane Library, and Web of Science) were searched from their inception to May 2025. Data extraction was performed independently by two authors, and discrepancies were resolved by a third reviewer. Statistical analyses were performed using Stata 16.0 software. Weighted mean difference (WMD) and odds ratio (OR) with 95% confidence intervals (CI) were calculated. Study quality and risk of bias were assessed using the Newcastle–Ottawa Scale and ROBINS-I tool.

Results: Twenty-two studies describing 1512 patients were included. Compared to the TDP, the MDP had an advantage in length of stay (weighted mean difference [WMD] = -1.19 , 95% CI [-1.03 , -0.15], $p < 0.01$), estimated blood loss (WMD = -4.32 , 95% CI [-7.64 , -1.01], $p < 0.05$), prepuce oedema time (WMD = -1.37 , 95% CI [-2.49 , -0.25], $p < 0.05$), postoperative penis length (WMD = 0.52 , 95% CI [0.25 , 0.80], $p < 0.01$), postoperative penis extension length (WMD = 0.90 , 95% CI [0.58 , 1.22], $p < 0.01$), complications (odds ratio [OR] = 0.15 , 95% CI [0.10 , 0.24], $p < 0.01$), prepuce oedema (OR = 0.21 , 95% CI [0.13 , 0.34], $p < 0.01$), penile retraction (OR = 0.21 , 95% CI [0.06 , 0.79], $p < 0.05$), postoperative pain (OR = 0.18 , 95% CI [0.05 , 0.64], $p < 0.01$), satisfaction (OR = 8.35 , 95% CI [2.42 , 28.78], $p < 0.01$), and effectiveness (OR = 4.64 , 95% CI [2.61 , 8.26], $p < 0.01$). The two surgical groups were comparable in terms of operative time. Several included studies had small sample sizes, and EMBASE was initially not searched due to institutional access restrictions, which may have led to the omission of relevant studies.

Conclusion: Modified Devine procedure is superior to the traditional Devine procedure in the treatment of pediatric concealed penis. However, these results should be interpreted as preliminary trends, and further randomized controlled trials with larger sample sizes are needed to validate and strengthen these observations.

Key Words: devine procedure, pediatric patients, concealed penis, meta-analysis

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*Corresponding Author: Song Wu.

Email: wusong@szu.edu.cn

Introduction

Concealed penis (CP) is a common congenital external genital malformation, which is characterized by normal development of the corpus cavernosum, but due to the abnormal attachment of the prepuce to the corpus cavernosum, the penis cannot be exposed normally and appears as a short ‘beak’ or ‘hill’.¹⁻³ This deformity not only affects the development of

the patient's reproductive organs but also may lead to urinary retention, urinary tract infection, psychological problems, and so on, which seriously affects the patient's quality of life.⁴⁻⁶ Therefore, the treatment of CP, especially surgical treatment, has been a research hotspot in the field of urology.

The traditional Devine procedure (TDP) is the classic procedure for the treatment of CP, which focuses on achieving penile exposure by removing the dysplastic meatus and fibrous cords, loosening the corpus cavernosum, and fixing the root of the penis.⁷ However, the TDP has some limitations, such as unsatisfactory postoperative penile exposure and many postoperative complications (e.g., prepuce oedema, penile retraction, incision infection, etc.).⁸ In recent years, the modified Devine procedure (MDP) has been gradually introduced into clinical practice, which has made several technical improvements on the basis of TDP, including finer tissue processing, more reasonable fixation, and optimized treatment of the penile root, aiming to improve surgical results and reduce postoperative complications.⁹⁻¹¹ Several regional and global studies have shown that compared with the TDP, the MDP has significant advantages in lengthening penile length, improving penile appearance, and reducing postoperative complications.¹²⁻¹⁴

Although there have been studies that have initially explored their efficacy, there is a lack of systematic comparative studies of these two surgeries for the treatment of CP. Therefore, this study comprehensively evaluated the difference in efficacy between the MDP and the TDP in the treatment of pediatric CP by Meta-analysis, aiming to provide a more scientific basis for clinical treatment.

Materials and Methods

Literature search

This meta-analysis, with reporting according to PRISMA standards, is fully compliant with the PRISMA 2020 checklist (Supplementary Material S1).¹⁵ Quality assessment was performed according to AMSTAR 2,¹⁶ and each question was described with rigour and full consistency. This systematic review has been registered with PROSPERO (registration number: CRD420251032653).

The literature search and study selection were conducted independently by two investigators. Any discrepancies were resolved through discussion, and when necessary, by consultation with a third

reviewer. The databases China National Knowledge Infrastructure, Medline, PubMed, Cochrane Library, and Web of Science were searched from their establishment to May 2025. The PubMed database search formula is as follows: penis and Devine (Supplementary Material S2). In addition, the reference lists of the included studies were manually screened to identify any potentially relevant articles.

Eligibility criteria

We included studies with prospective, retrospective, or randomized controlled trial (RCT) designs. We refined the framing of the clinical question explicitly using the PICO framework: Population: Pediatric patients diagnosed with CP; Intervention: MDP; Comparison: TDP; Outcomes: operative time (OT), prepuce oedema time (POT), estimated blood loss (EBL), length of stay (LOS), postoperative penis length (PPL), postoperative penis extension length (PPEL), prepuce oedema, penile retraction, postoperative pain, complications, satisfaction, and effectiveness (Supplementary Material S3). The following exclusion criteria were applied: (1) animal studies; (2) studies with non-extractable data; (3) single-arm designs; (4) studies without relevant outcomes; (5) studies involving adult participants; and (6) editorials, letters, or expert opinions.

Exclude duplicate references

All retrieved records from the selected databases were imported into EndNote version 20.6 (Clarivate Analytics) for reference management. Duplicate references were identified and removed using the "Find Duplicates" function of the software, which compares key bibliographic fields such as title, author, year, and DOI.

Study quality assessment

The quality of non-randomized studies was evaluated using the ROBINS-I tool,¹⁷ which assesses seven domains: confounding, intervention classification, deviations from intended interventions, participant selection, missing data, outcome measurement, and selective reporting. Each domain was graded as low, moderate, serious, critical, or no information, with the overall risk defined by the highest domain rating. Two reviewers conducted the assessments independently and resolved discrepancies through discussion.

Randomized controlled trials (RCTs) were appraised using the Cochrane Risk of Bias tool,¹⁸ and

visual risk of bias summaries were generated with Review Manager (RevMan) 5.4.

Data extraction

Data extraction was independently performed by two authors using a standardized form. The collected information included the first author, year of publication, study design, sample size, patient age, surgical technique, and outcome indicators such as OT, POT, EBL, LOS, PPL, PPEL, prepuce edema,

penile retraction, postoperative pain, complications, satisfaction, and efficacy.

Statistical analysis

We performed meta-analyses using Stata statistical software version 16 (Stata Corp., College Station, TX, USA). Continuous variables were weighted mean difference (WMD), while dichotomous variables were assessed using the odds ratio (OR). All outcomes were reported with 95% confidence intervals (95% CI) and *p*-values. Heterogeneity among studies was

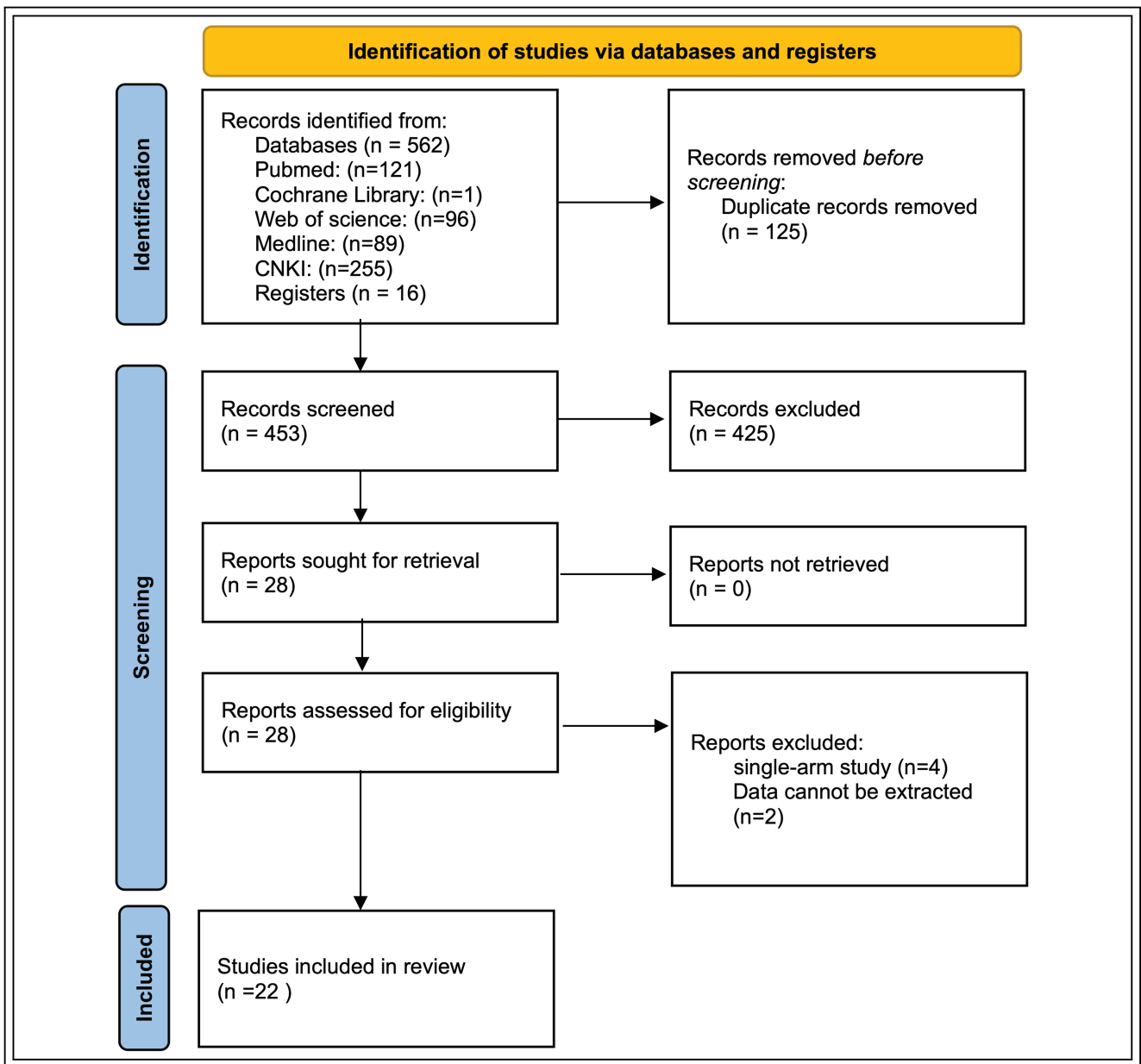


FIGURE 1. Flow diagram of the study selection process

evaluated using the Q-test and chi-square test. Differences were considered significant if $I^2 > 50\%$.¹⁹ A random-effects model was applied when substantial heterogeneity was detected ($I^2 \geq 50$ per cent or $p < 0.1$); otherwise, a fixed-effects model was used. Sensitivity analyses were further performed for outcomes with high heterogeneity.²⁰

Publication bias analysis

Publication bias was assessed using a funnel plot, and the symmetry of the plot was visually inspected to subjectively evaluate potential bias among the included studies. In addition, Begg's test and Egger's test were performed for quantitative assessment. A p value greater than 0.05 was considered indicative of no publication bias, whereas a p value of 0.05 or less suggested the presence of publication bias.

Results

Description of studies

A total of 562 records were identified from five databases, and an additional 16 were obtained through manual reference searches. After removing 125 duplicates using EndNote 20.6, 425 records were excluded based on titles and abstracts as they were irrelevant to the study topic. The remaining 28 full-text articles were reviewed in detail, leading to the exclusion of 4 single-arm studies and 2 with insufficient data for extraction. Ultimately, 22 studies were included in the meta-analysis, comprising 5 retrospective studies^{12,13,17,21-23} randomized controlled trials,^{2,7-9,14,24-35} with a total of 1512 participants (Figure 1).

Table 1 summarizes the baseline characteristics of the included studies, including author, publication year, study design, surgical procedure, sample

TABLE 1. Baseline data for studies included in the meta-analysis

Author	Year	Type	Procedure	Sample (n)	Age (mean \pm SD)	Preoperative penis length (mean \pm SD)
Pu et al. ⁹	2025	RCTs	MDP	64	7.01 \pm 1.60	1.90 \pm 0.31
			TDP	64	7.05 \pm 1.62	1.93 \pm 0.32
Zhang and Cai ²⁵	2025	RCTs	MDP	30	8.63 \pm 1.02	4
			TDP	30	8.53 \pm 1.29	1.6428
Li et al. ²⁶	2023	RCTs	MDP	53	8.28 \pm 1.06	1.45 \pm 0.23
			TDP	53	8.19 \pm 1.02	1.42 \pm 0.24
Zhao et al. ¹³	2023	retrospective	MDP	27	10.19 \pm 2.04	1.90 \pm 0.53
			TDP	27	10.07 \pm 2.29	1.94 \pm 0.52
Zhou et al. ¹⁴	2022	RCTs	MDP	43	4.21 \pm 0.33	1.21 \pm 0.21
			TDP	43	4.22 \pm 0.24	1.22 \pm 0.23
Wang et al. ²³	2021	Retrospective	MDP	26	8.02 \pm 2.39	1.56 \pm 0.97
			TDP	26	8.34 \pm 2.15	1.67 \pm 1.02
Huang et al. ²⁷	2021	RCTs	MDP	38	9.13 \pm 2.17	1.42 \pm 0.05
			TDP	37	9.32 \pm 2.46	1.41 \pm 0.04
Zhang et al. ⁷	2021	RCTs	MDP	30	6.63 \pm 1.02	1.43 \pm 0.53
			TDP	30	6.53 \pm 1.29	1.45 \pm 0.48
Wang et al. ¹²	2020	Retrospective	MDP	16	8.5	NA
			TDP	14	8.5	NA
Zhang ²⁸	2020	RCTs	MDP	52	8.12 \pm 0.19	4.52 \pm 0.34
			TDP	52	8.85 \pm 0.05	4.45 \pm 0.36
Luo et al. ²	2019	RCTs	MDP	50	7.18 \pm 1.9	1.96 \pm 0.55
			TDP	50	6.28 \pm 2.94	1.93 \pm 0.73
Li ³⁰	2019	RCTs	MDP	20	10.21 \pm 1.02	NA
			TDP	20	10.11 \pm 1.17	NA
He and Zhang ²⁹	2019	RCTs	MDP	30	9.7 \pm 4.1	1.8 \pm 0.3
			TDP	30	9.6 \pm 4.1	1.8 \pm 0.2

(Continued)

TABLE 1. (Continued)

Author	Year	Type	Procedure	Sample (n)	Age (mean \pm SD)	Preoperative penis length (mean \pm SD)
Jiang ⁸	2019	RCTs	MDP	30	9.5 \pm 1.4	1.5 \pm 0.3
			TDP	30	9.2 \pm 1.3	1.6 \pm 0.4
Zeng ²²	2018	Retrospective	MDP	45	3.58 \pm 0.42	2.38 \pm 1.03
			TDP	45	3.52 \pm 0.46	2.41 \pm 1.01
Shen and Wang ²⁴	2018	RCTs	MDP	42	4.91 \pm 0.64	NA
			TDP	45	4.80 \pm 0.75	NA
Ji et al. ³¹	2018	RCTs	MDP	30	9.98 \pm 1.84	1.89 \pm 0.35
			TDP	30	10.32 \pm 1.76	1.91 \pm 0.40
Zhang ³²	2016	RCTs	MDP	20	4.2 \pm 0.7	NA
			TDP	20	3.9 \pm 0.5	NA
Fang et al. ³³	2016	RCTs	MDP	34	7.4 \pm 1.6	2.38 \pm 0.35
			TDP	34	7.4 \pm 1.6	2.43 \pm 0.42
Yang ³⁴	2015	RCTs	MDP	25	NA	2.6 \pm 0.85
			TDP	25	NA	2.7 \pm 0.90
Che et al. ²¹	2011	Retrospective	MDP	29	6.5	NA
			TDP	23	6.5	NA
Wang et al. ³⁵	2011	RCTs	MDP	25	6.9 \pm 2.5	NA
			TDP	25	6.9 \pm 2.5	NA

Note: RCTs, Randomised controlled trial studies; MDP, Modified Devine procedure; TDP, Traditional Devine procedure; NA, Not available.

size, patient age, preoperative penile length, and related variables.

Quality assessment

Using the ROBINS-I tool, the overall risk of bias varied across the included studies. Specifically, four studies^{13,21–23} were rated as having a moderate risk of bias, while one study¹² was rated as having a high risk of bias. No study was assessed as having a critical risk of bias. The overall risk-of-bias judgments are summarized in Table 2, while detailed domain-level assessments are also provided.

The quality of the 17 included RCTs^{2,7–9,14,24–35} was assessed using the Cochrane Risk of Bias Assessment Tool, and the results are shown in Figure 2. Two studies^{3,24} were rated as 'high risk' for random sequence generation and the rest as 'low risk'; All studies were rated 'unclear' for allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), and other biases; All studies were rated as 'low risk' for selective reporting (reporting bias).

Perioperative outcomes

Main outcomes: postoperative penis length (PPL), postoperative penis extension length (PPEL), satisfaction, effectiveness

Postoperative penis length (PPL)

Twelve studies, including 875 patients, reported PPL.^{2,8,22,23,26–29,31,33–35} There was high heterogeneity between studies ($I^2 = 96.3\%$, $p < 0.001$). The MDP group had more PPL than the TDP group (WMD = 0.52, 95% CI [0.25, 0.80], $p < 0.01$) (Figure 3). Postoperative penis extension length (PPEL)

Five studies, including 318 patients, reported PPEL.^{8,21,26,31,32} There was high heterogeneity between studies ($I^2 = 94.1\%$, $p < 0.001$). The MDP group had more PPEL than the TDP group (WMD = 0.90, 95% CI [0.58, 1.22], $p < 0.01$) (Figure 4).

Satisfaction

Four studies reported satisfaction and included 300 patients.^{2,13,14,29} There was low heterogeneity among the studies ($I^2 = 0.0\%$, $p = 0.982$). The MDP group had more satisfaction than the TDP group (OR = 8.35, 95% CI [2.42, 28.78], $p < 0.01$) (Figure 5). Effectiveness

Eleven studies reported effectiveness and included 732 patients.^{7,14,23–25,27–30,32,33} There was

TABLE 2. Risk of bias assessment using the ROBINS-I tool

Authors	Year	Confounding	Selection of participants	Classification of interventions	Deviations from intended interventions	Missing data	Measurement of outcomes	Selection of reported result	Overall risk of bias
Zhao et al. ¹³	2023	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Low risk	Moderate risk
Wang et al. ²³	2021	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Low risk	Moderate risk
Wang et al. ¹²	2020	Low risk	Low risk	Low risk	Low risk	Serious risk	Low risk	Low risk	Serious risk
Zeng et al. ²²	2018	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Low risk	Moderate risk
Che et al. ²¹	2011	Low risk	Low risk	Low risk	Low risk	Moderate risk	Low risk	Low risk	Moderate risk

Note: Confounding: Bias due to uncontrolled confounders; Selection of participants: Bias in selection into the study; Classification of interventions: Bias in defining /assigning interventions; Deviations from intended interventions: Bias from deviations from planned interventions; Missing data: Bias due to incomplete outcome data; Measurement of outcomes: Bias in assessing outcomes; Selection of reported result: Bias due to selective reporting of outcomes; Overall risk of bias: Determined by the highest domain-level judgment for each study; Judgment categories: Low risk, Moderate risk, Serious risk, Critical risk, No information.

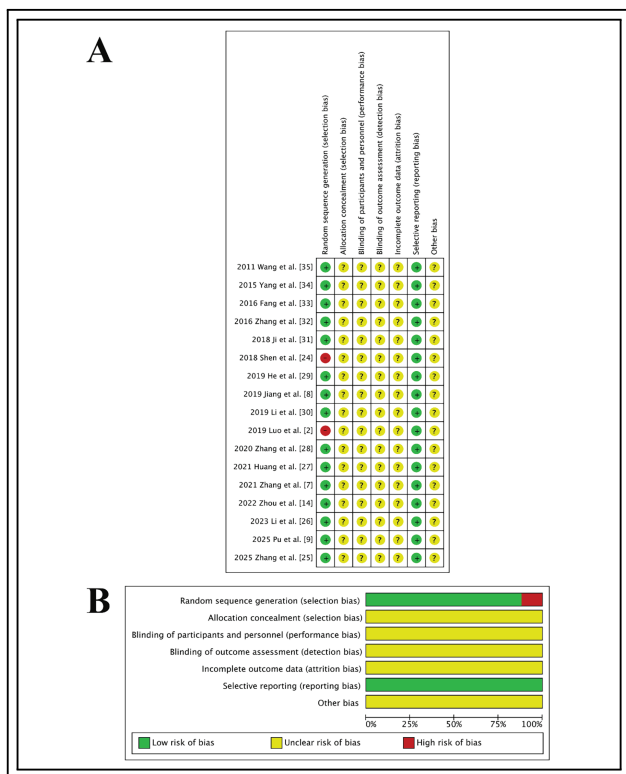


FIGURE 2. Risk of bias map for randomized controlled trial studies. (A) Risk of bias summary; (B) Risk of bias graph^{2,7-9,14,24-35}

low heterogeneity among the studies ($I^2 = 0.0\%$, $p = 0.890$). The MDP group had more effectiveness than the TDP group (OR = 4.64, 95% CI [2.61, 8.26], $p < 0.01$) (Figure 6).

Perioperative outcomes: operative time (OT), length of stay (LOS), estimated blood loss (EBL), prepuce oedema time (POT)

Operative time (OT)

Fourteen studies reported OT, including 988 patients.^{2,7-9,12,13,24,26,27,29,31,33-35} There was high heterogeneity among studies ($I^2 = 99.0\%$, $p < 0.001$). The results of the meta-analysis showed that the OT between MDP and TDP was comparable (WMD = -3.76, 95% CI [-7.81, 0.30], $p = 0.07$) (Figure 7).

Length of stay (LOS)

Five studies reported LOS, including 348 patients.^{8,9,29-31} There was high heterogeneity among studies ($I^2 = 92.1\%$, $p < 0.001$). The MDP group had a shorter LOS than the TDP group (WMD = -1.19, 95% CI [-1.03, -0.15], $p < 0.01$) (Figure 8).

Estimated blood loss (EBL)

Nine studies, including 665 patients, reported EBL.^{2,7,9,12,13,24,26,29,30} There was high heterogeneity between studies ($I^2 = 99.0\%$, $p < 0.001$). The MDP group had less EBL than the TDP group

Modified versus traditional Devine procedure

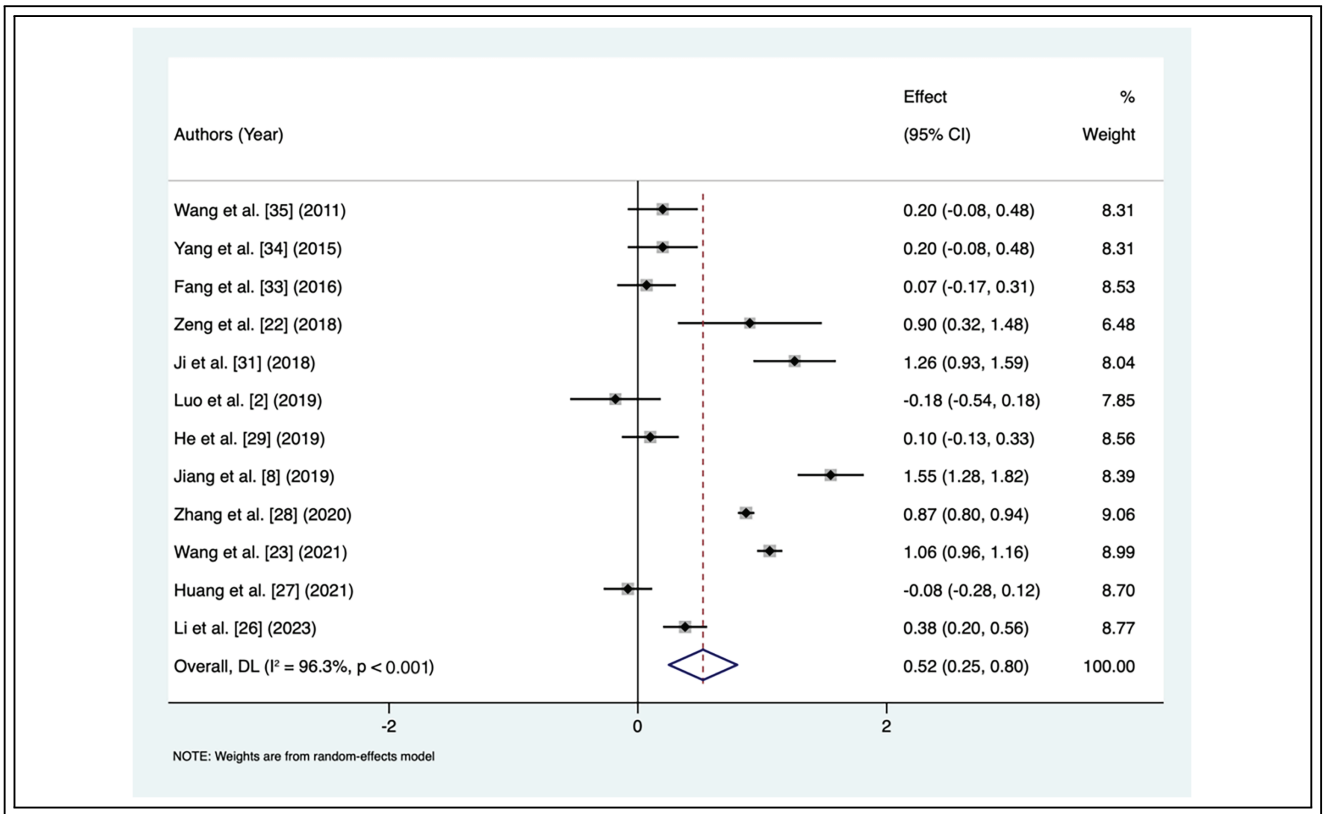


FIGURE 3. Forest plot and meta-analysis of the postoperative penis length between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{3,8,22,23,26-29,31,33-35}

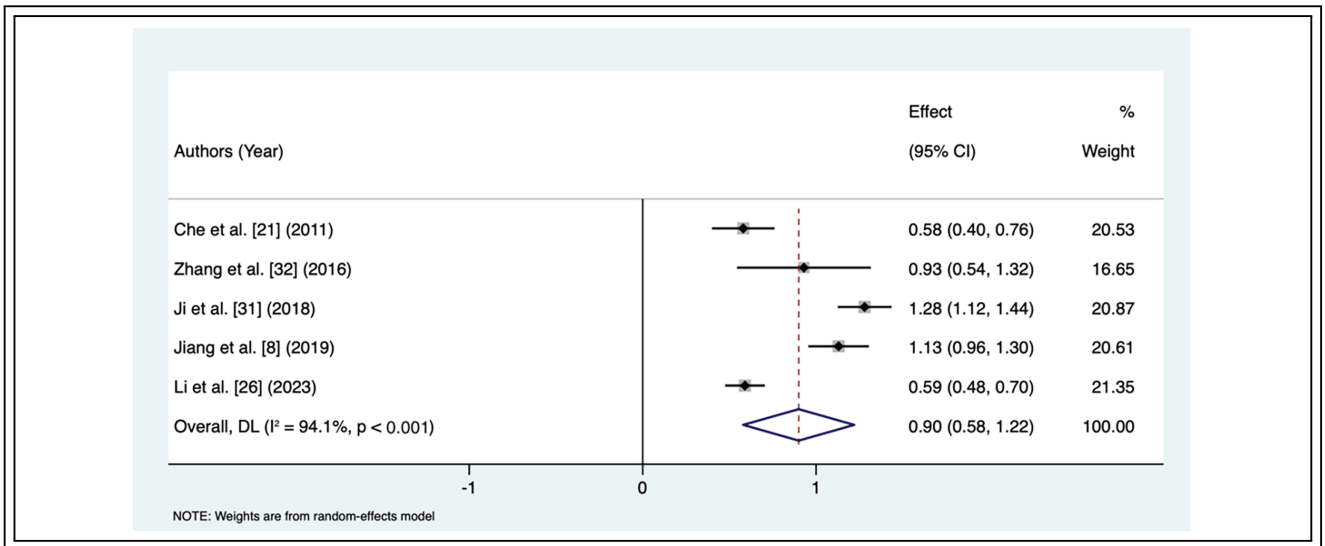


FIGURE 4. Forest plot and meta-analysis of the postoperative penis extension length between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{8,21,26,31,32}

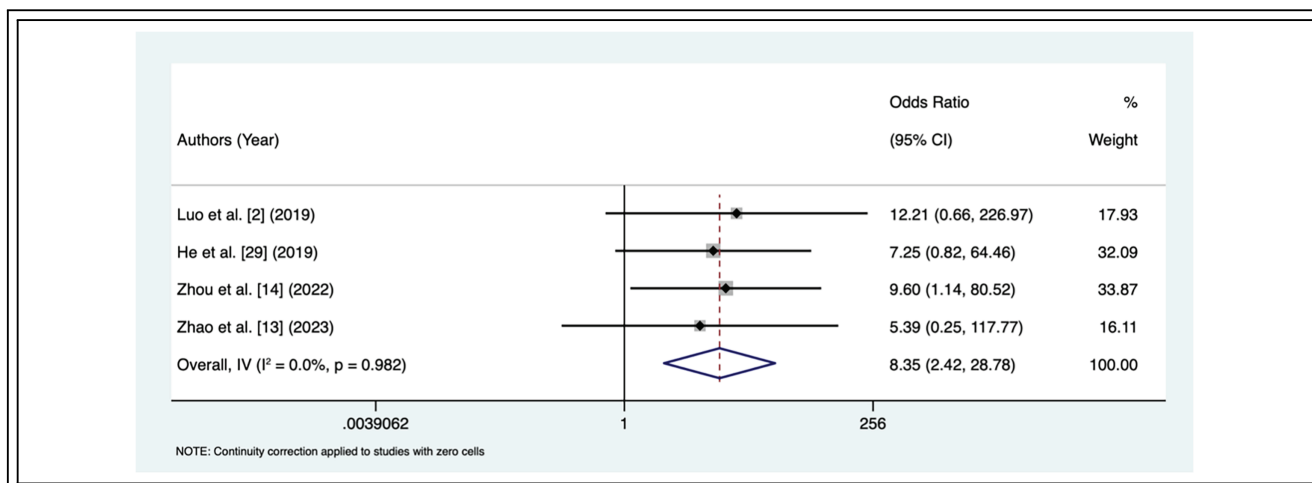


FIGURE 5. Forest plot and meta-analysis of the satisfaction between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{2,13,14,29}

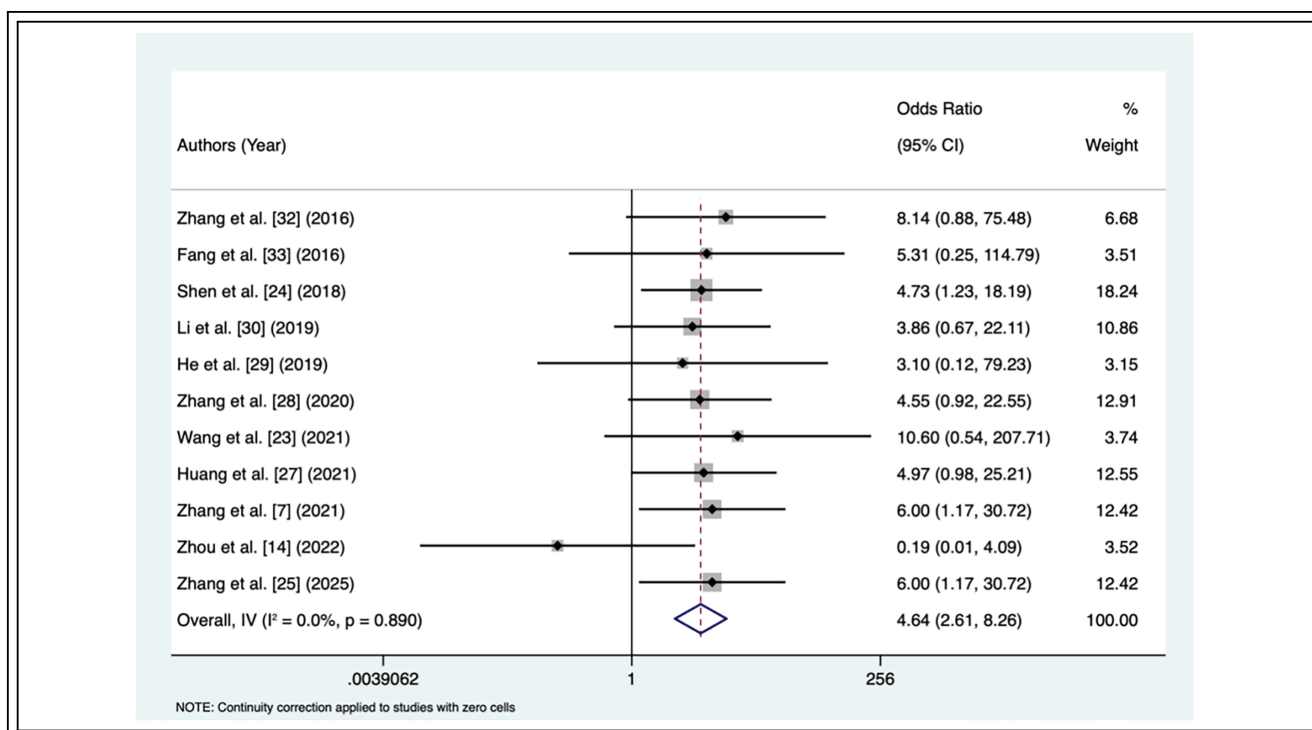


FIGURE 6. Forest plot and meta-analysis of the effectiveness between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{7,14,23-25,27-30,32,33}

(WMD = -4.32, 95% CI [-7.64, -1.01], $p < 0.05$) (Figure 9).

Prepuce oedema time (POT)

Five studies, including 423 patients, reported POT.^{9,13,26,27,31} There was high heterogeneity between studies ($I^2 = 96.7%$, $p < 0.001$). The MDP group had

less POT than the TDP group (WMD = -1.37, 95% CI [-2.49, -0.25], $p < 0.05$) (Figure 10).

Complications: overall, preputial edema, postoperative pain

Overall complications

Modified versus traditional Devine procedure

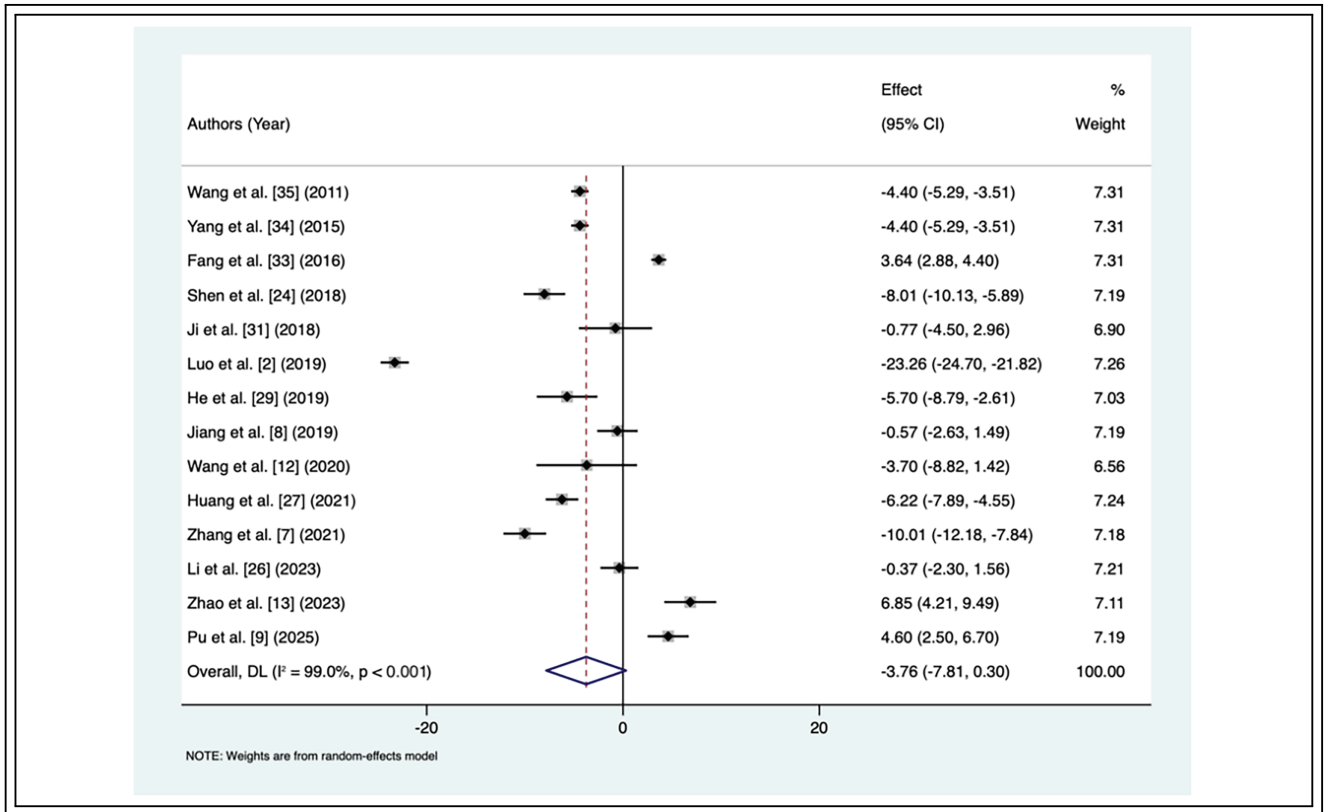


FIGURE 7. Forest plot and meta-analysis of the operative time between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{2,7-9,12,13,24,26,27,29,31,33-35}

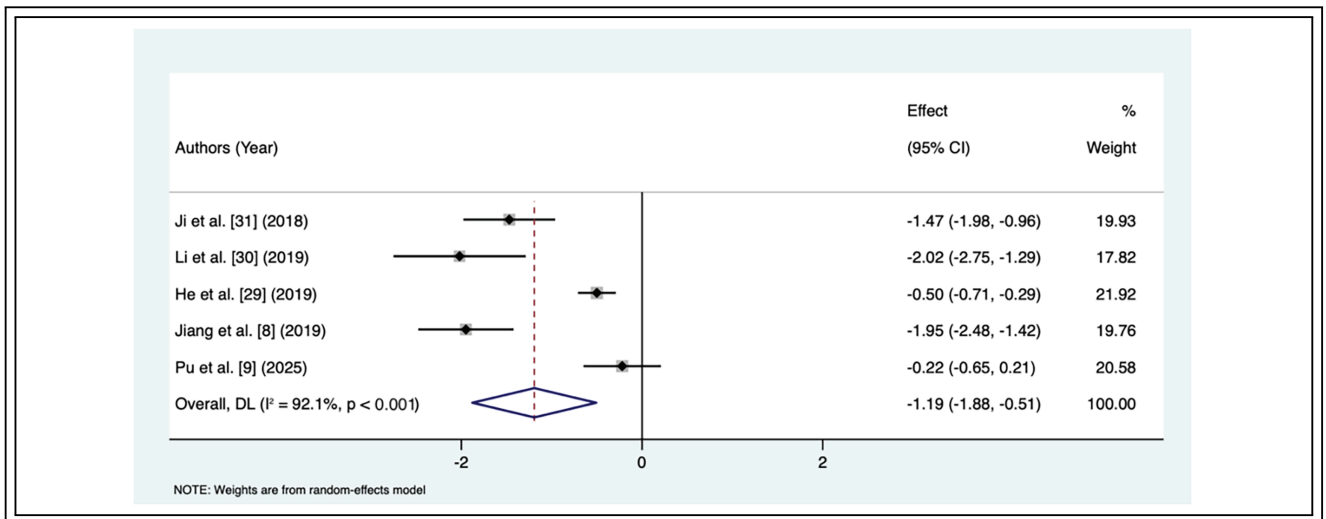


FIGURE 8. Forest plot and meta-analysis of the length of stay between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{8,9,29-31}

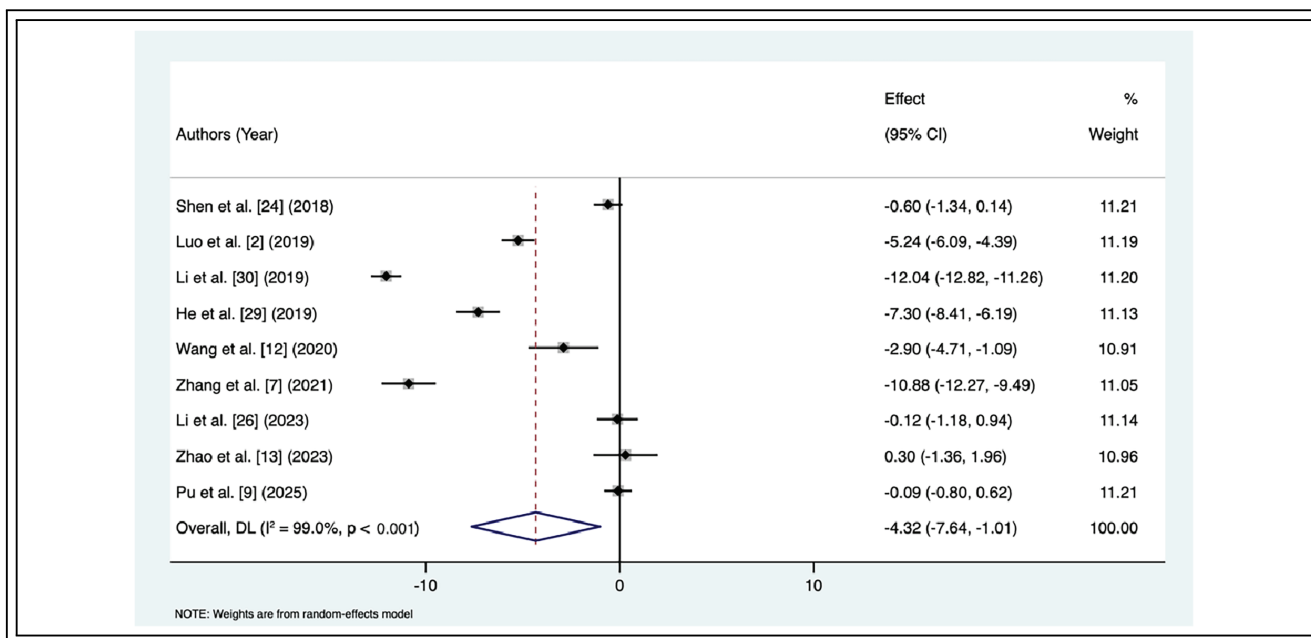


FIGURE 9. Forest plot and meta-analysis of the estimated blood loss between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{2,7,9,12,13,24,26,29,30}

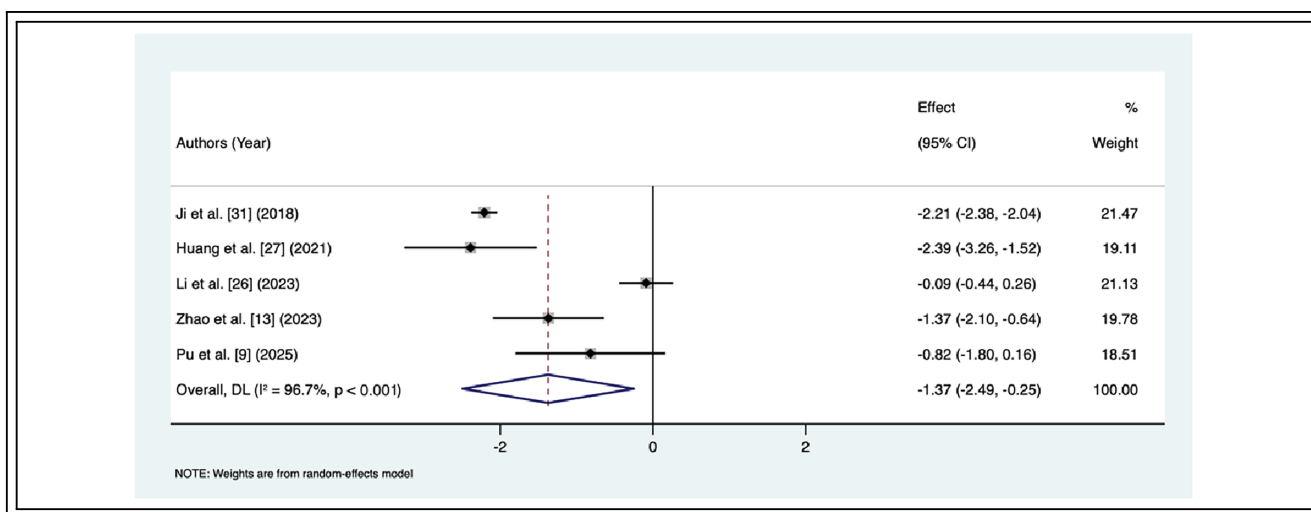


FIGURE 10. Forest plot and meta-analysis of the prepuce oedema time between MDP and traditional Devine procedure (TDP)^{9,13,26,27,31}

Sixteen studies reported overall complications and included 1048 patients.^{2,7-9,12,13,21,22,26,29-35} There was low heterogeneity among the studies ($I^2 = 0.0\%$, $p = 0.583$). The MDP group had fewer overall complications than the TDP group (OR = 0.15, 95% CI [0.10, 0.24], $p < 0.01$) (Figure 11).

Prepuce oedema

Fifteen studies reported prepuce oedema and included 952 patients.^{2,7,8,12,14,21,22,26,29-35} There was low heterogeneity among the studies ($I^2 = 0.0\%$, $p = 0.992$). The MDP group had less prepuce oedema than the TDP group (OR = 0.21, 95% CI [0.13, 0.34], $p < 0.01$) (Figure 12).

Penile retraction

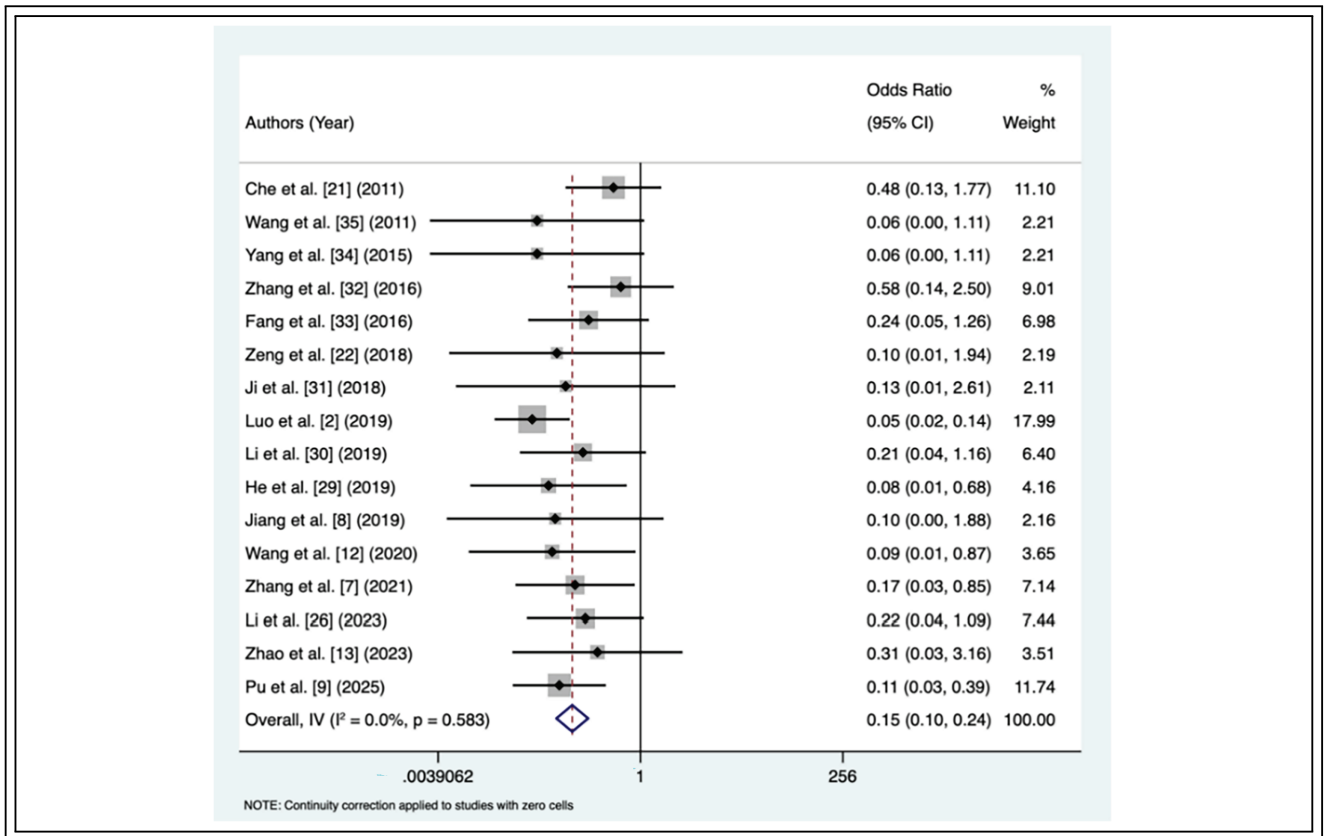


FIGURE 11. Forest plot and meta-analysis of the complications between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{2,7-9,12,13,21,22,26,29-35}

Five studies reported penile retraction and included 374 patients.^{2,9,13,21,32} There was low heterogeneity among the studies ($I^2 = 0.0\%$, $p = 0.918$). The MDP group had less penile retraction than the TDP group (OR = 0.21, 95% CI [0.06, 0.79], $p < 0.05$) (Figure 13).

Postoperative pain

Four studies reported postoperative pain and included 358 patients.^{2,9,22,30} There was low heterogeneity among the studies ($I^2 = 0.0\%$, $p = 0.806$). The MDP group had less postoperative pain than the TDP group (OR = 0.18, 95% CI [0.05, 0.64], $p < 0.01$) (Figure 14).

Publication bias analysis

Publication bias was assessed for the outcome with the largest number of included studies (overall complications) using a funnel plot. As shown in Figure 15, the funnel plot appeared largely symmetrical, suggesting no obvious publication bias. Begg’s test yielded $p = 0.471$ (Figure 16), and Egger’s test yielded $p = 0.860$ (Figure 17), both indicating the absence of publication bias in this study.

Sensitivity analysis

Although all included studies were of high quality (≥ 6 stars), significant heterogeneity existed among them. Sensitivity analyses were performed by omitting each study in turn to identify the source of heterogeneity. The results indicated that only OT was unstable, while other outcomes were stable.

Discussion

CP is one of the most common congenital anomalies encountered in pediatric urology, and it can significantly impact both the physical and psychological health of affected children. Left untreated, CP may lead to functional difficulties such as abnormal urination, penile pain during erections, and, in later life, it may even interfere with sexual function and reproductive health. Therefore, timely surgical intervention is considered the standard of care. The main objectives of surgical treatment include not only restoring the normal anatomical appearance of the penis but also ensuring functional recovery,

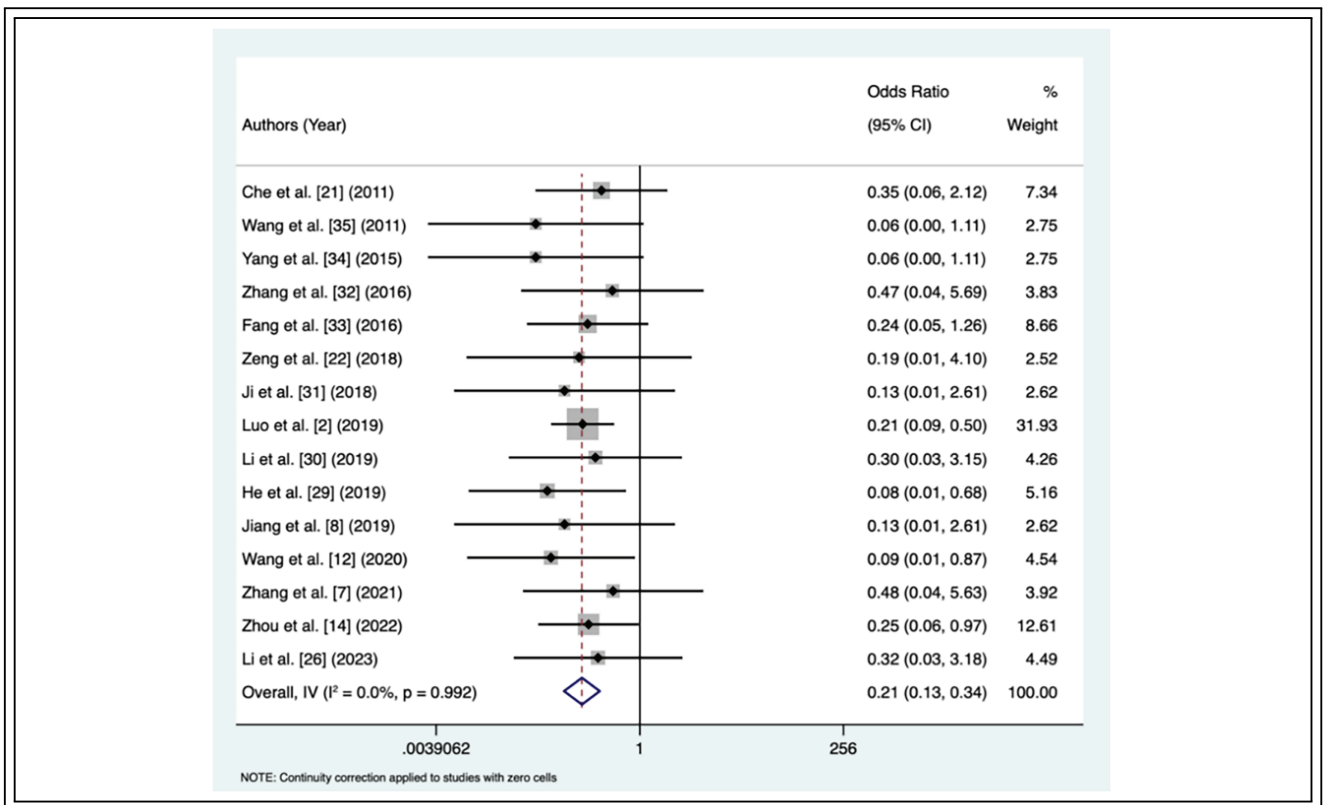


FIGURE 12. Forest plot and meta-analysis of the prepuce oedema between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{2,7,8,12,14,21,22,26,29-35}

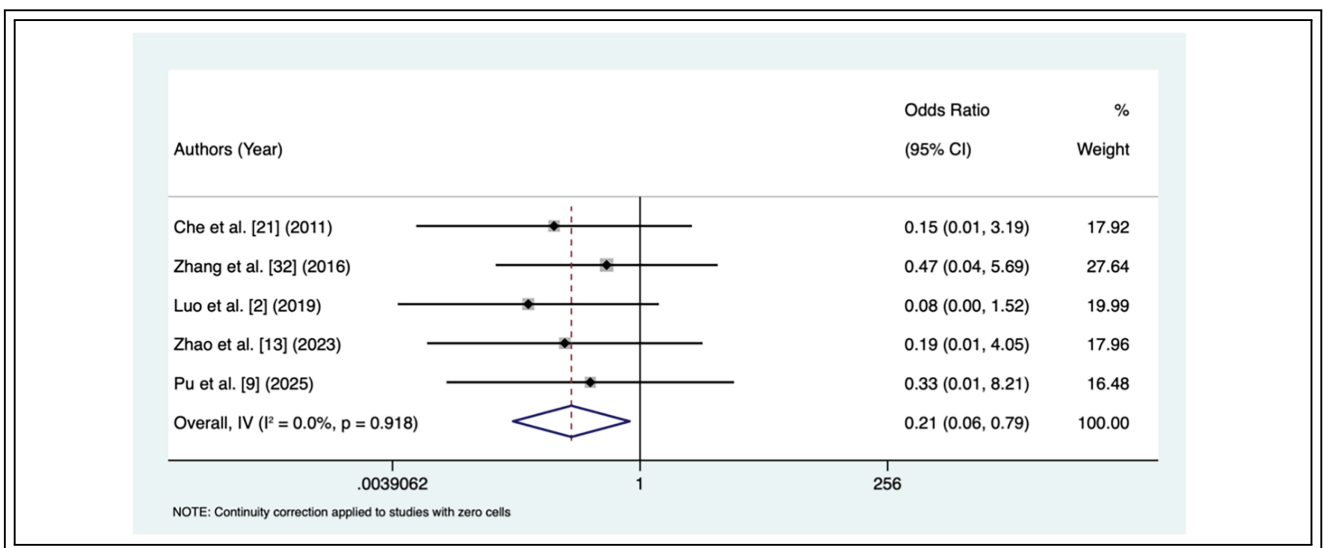


FIGURE 13. Forest plot and meta-analysis of the penile retraction between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{2,9,13,21,32}

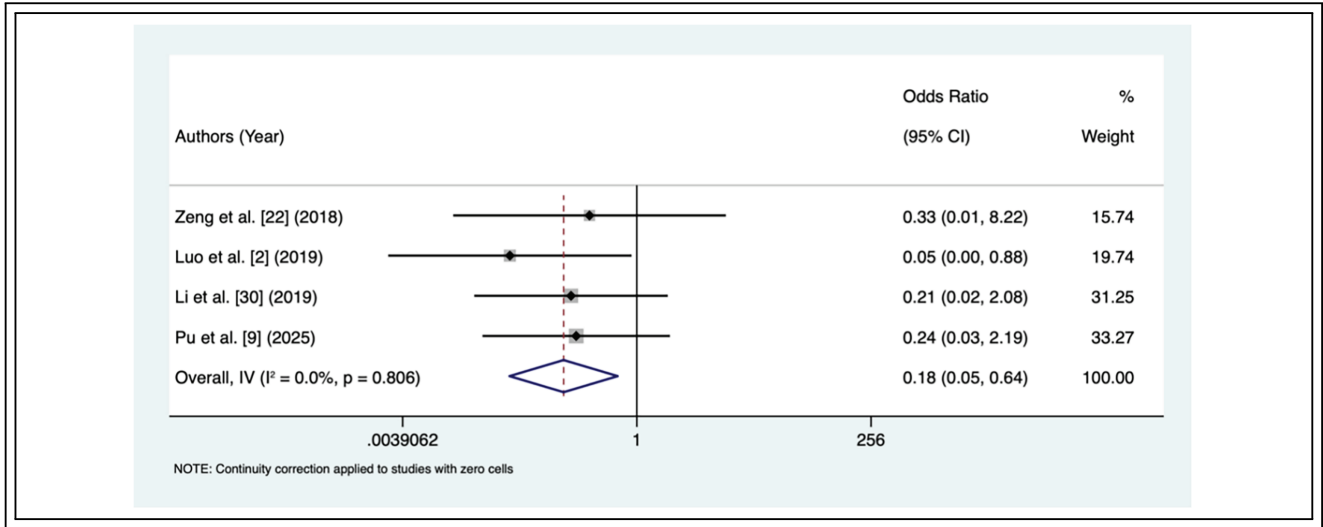


FIGURE 14. Forest plot and meta-analysis of the postoperative pain between modified Devine procedure (MDP) and traditional Devine procedure (TDP)^{3,9,22,30}

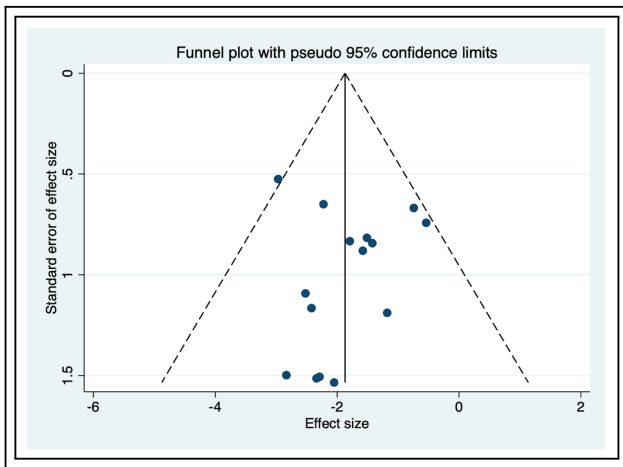


FIGURE 15. Funnel plot of overall complications

minimizing the risk of complications, and reducing recurrence rates after surgery. In recent years, with the deeper understanding of the pathophysiological mechanisms of CP and the continuous advancement of surgical techniques, the MDP has gradually gained the attention of clinicians.³³ The present study of perioperative clinical indicators aims to evaluate the advantages and shortcomings of the MDP compared with the TDP, and to provide a more scientific and precise basis for the selection of surgery in clinical practice. The results of this study showed that MDP was more advantageous in LOS, EBL, POT, PPL, PPEL, complications, prepuce oedema, penile

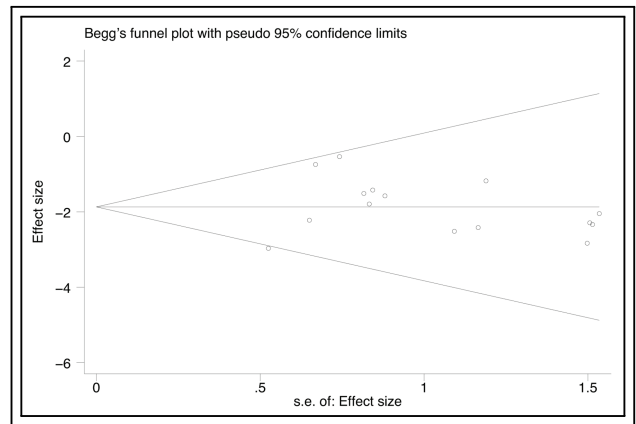


FIGURE 16. Begg's test

retraction, postoperative pain, satisfaction, and effectiveness compared to TDP. The two surgical groups were comparable in terms of OT.

Fourteen studies reported OT,^{2,7-9,12,13,24,26,27,29,31,33-35} and the difference between the two surgical groups in this area was not statistically significant. There was a high degree of heterogeneity among the studies ($I^2 = 99.0\%$, $p < 0.001$), the source of which may be related to the different surgeons' proficiency in the procedure, their improved protocols for the procedure, and the differences in the patients' own medical conditions. For example, some surgeons with extensive experience in TDP may perform the traditional procedure more efficiently than less experienced surgeons attempting MDP, which could

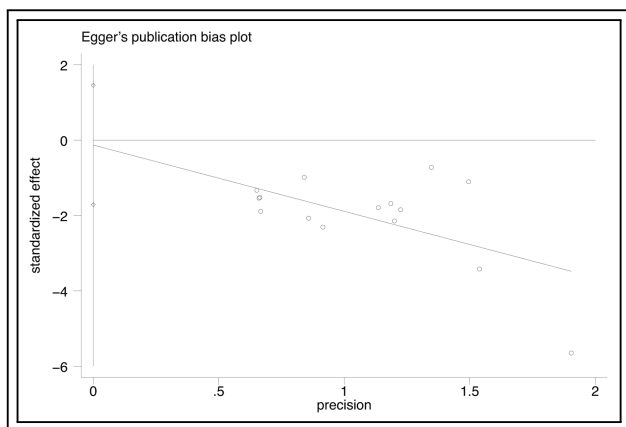


FIGURE 17. Egger's test

offset the expected time-saving benefits of the modified method. Additionally, patient-specific factors such as age, penile anatomy, and comorbidities may further contribute to heterogeneity, making cross-study comparison more complex. However, some researchers^{2,7,24,29} have found that the operative time of the MDP is significantly shorter than that of the conventional procedure. This streamlining effect arises because MDP eliminates redundant tissue handling, avoids repeated suturing steps, and introduces a more direct approach to correcting curvature. As a result, surgeons can achieve the same or better correction with fewer maneuvers, thereby reducing fatigue, anesthesia exposure time, and intraoperative risks associated with prolonged procedures. It is worth noting that due to the high heterogeneity of this outcome metric, we performed a sensitivity analysis to determine its stability, and the results showed that it was not stable. This suggests that while MDP has potential advantages in operative efficiency, the variability between studies limits the strength of evidence, and future multicenter randomized trials with standardized surgical protocols are necessary to draw more definitive conclusions.

Intraoperative bleeding is an important indicator for assessing the safety of surgery. MDP has shown significant advantages in reducing EBL.^{2,7,9,12,13,24,26,29,30} The modified procedure is more delicate in separating the fibrous tissue, which reduces the damage to the surrounding tissues;² by circumcising the foreskin, it reduces the damage to the foreskin, and at the same time, the OT is shorter, which further reduces the risk of bleeding.^{7,12} In addition, the improved procedure avoids suturing of the tunica albuginea when fixing the tissue at the root of the penis, reducing the possibility of postoperative bleeding.^{2,29} This reduced

bleeding translates to fewer intraoperative hemodynamic fluctuations, lower transfusion requirements, and decreased risk of postoperative hematoma formation. For pediatric patients, who have smaller blood volumes and lower tolerance for blood loss, this advantage is particularly critical, as it directly affects both surgical safety and recovery. The LOS not only affects the financial burden on the patient but also reflects the speed of recovery after surgery. The LOS for the MDP is significantly shorter than that for the conventional procedure.^{8,9,29-31} The reason for this is that the MDP is a simpler procedure, with a shorter OT and less intraoperative trauma and bleeding, which together facilitate the child's postoperative recovery, resulting in a shorter LOS.²⁹ A shorter LOS also reduces the risk of hospital-acquired infections, lowers healthcare costs, and decreases psychological stress for both the child and family members. From a healthcare system perspective, reduced LOS allows for more efficient use of medical resources, which is particularly beneficial in high-volume pediatric urology centers.

The MDP has demonstrated significant advantages in increasing PPL^{2,8,22,23,26-29,31,33-35} and PPEL.^{8,21,26,31,32} The MDP relieves penile tugging more effectively by completely removing the fibrous cords in the superficial fascial layer of the penis, promoting penile exposure and lengthening.^{8,21,26} This is of particular importance in pediatric patients, as improved penile length not only has immediate cosmetic benefits but also long-term implications for sexual function, body image, and psychological well-being during adolescence and adulthood. At the same time, this procedure further optimizes the surgical results by finely trimming the inner and outer prepuce plates and fixing the white membrane, resulting in a better postoperative penile extension length than that of the traditional procedure.³¹ Such meticulous tissue handling ensures symmetrical penile appearance, minimizes postoperative scarring, and reduces the likelihood of recurrent tethering, thereby enhancing both functional and aesthetic outcomes. The incidence of postoperative complications,^{2,7-9,12,13,21,22,26,29-35} including prepuce oedema,^{2,7,8,12,14,21,22,26,29-35} penile retraction,^{2,9,13,21,32} and postoperative pain,^{2,9,22,30} was significantly reduced in the MDP, mainly due to the reduction of tissue damage by the modified surgical approach and the optimization of the postoperative recovery environment.

Lower complication rates directly translate into higher patient safety, fewer readmissions, and reduced need for secondary corrective surgeries. This is especially valuable in pediatrics, where

repeated anesthesia and interventions may pose additional developmental and psychological risks. The modified procedure avoids direct suturing of the glans for traction, which reduces damage and bleeding to the glans, and eliminates the subcutaneous fascia at the inner plate of the prepuce, which reduces the risk of postoperative prepuce oedema.¹² In addition, the modified procedure reduces the possibility of postoperative penile retraction by preserving the pubic fat pad, which reduces pathological straining.⁷ By maintaining the integrity of these supportive structures, MDP achieves a more stable and natural penile positioning, thereby preventing relapse of curvature and ensuring sustained functional improvement over time. At the same time, the modified surgery reduces the incidence of postoperative pain by optimizing the operation steps and reducing the pulling and damage to the surrounding tissues.²

Lower postoperative pain not only improves the immediate comfort of pediatric patients but also facilitates early mobilization, reduces the need for analgesics, and accelerates overall recovery, which contributes to the shorter LOS observed in MDP cases. The MDP also showed significant advantages in terms of family satisfaction^{2,13,14,29} and effectiveness.^{7,14,23–25,27–30,32,33} The increase in family satisfaction was mainly attributed to better cosmetic recovery, resulting in more satisfied patients with their postoperative outcome. In pediatric populations, family perspectives are particularly critical, as parents or guardians are the primary decision-makers for surgical intervention. Improved cosmetic outcomes and smoother recovery processes enhance parental confidence in the procedure and reduce anxiety about long-term complications.

In addition, the modified procedure resulted in better surgical outcomes, such as a more pronounced increase in penile length, which further improved patient and family satisfaction.¹⁴ These improvements not only address physical abnormalities but also play a key role in supporting the child's psychological development, as a more natural penile appearance helps prevent social embarrassment and self-esteem issues later in life. The improvement in effectiveness is largely attributed to more complete release of penile constriction, resulting in better postoperative outcomes and higher overall effectiveness rates. Improvements in surgical techniques, such as more precise incision design and tissue management, have further improved the effectiveness of the procedure.^{7,25} This highlights how continuous innovation and refinement of surgical methods can

produce tangible benefits in patient care. The consistently higher effectiveness rates associated with MDP suggest that it may gradually replace TDP as the preferred standard for managing pediatric CP.

We performed this meta-analysis using the PRISMA guidelines.¹⁵ However, there are still many limitations. Firstly, the number or sample size of included studies for some of the outcome indicators was small, with high heterogeneity and unstable results of the sensitivity analyses, which reduced the reliability of the results; secondly, the number of included studies and patients was small; thirdly, the quality scores of some of the randomized controlled trials were not high, which also reduced the reliability of the results to some extent; fourthly, potential publication bias cannot be ruled out. While the bias assessment figure provides supportive evidence, the presence of small-study effects should be interpreted with caution. fifthly, EMBASE was not searched due to institutional access restrictions. Although other major databases (PubMed, Web of Science, Cochrane Library, Medline, and China National Knowledge Infrastructure) were included, the absence of EMBASE may have led to omission of some relevant studies; and finally, some cited Chinese references were obtained from CNKI, which may not be directly accessible to international readers. This might introduce potential limitations. Future studies with larger sample sizes and standardized outcome measures are needed to confirm these findings.

Conclusions

In conclusion, for pediatric CP, our findings suggest that MDP tends to show advantages over TDP in terms of LOS, EBL, POT, PPL, PPEL, complications, prepuce oedema, penile retraction, postoperative pain, satisfaction, and effectiveness. The two surgical groups appeared comparable regarding OT. However, these results should be interpreted as preliminary trends, and further randomized controlled trials with larger sample sizes are needed to validate and strengthen these observations.

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Author Contributions

Jinwei Mao was responsible for the conceptualization, study design, data analysis, and manuscript writing; Jinwei Mao, Jie Deng, and Xiqi Peng contributed to data collection, analysis, interpretation, and manuscript revision; Jinwei Mao, Jie Deng, Xiqi Peng, and Xunbao Wang assisted with data analysis, result interpretation, and manuscript editing; Song Wu oversaw the overall project conceptualization, provided supervision, contributed to manuscript writing, and served as the corresponding author. All authors reviewed the results and approved the final version of the manuscript.

Availability of Data and Materials

The corresponding author's dataset during the current study are available upon reasonable request.

Ethics Approval

Ethical approval was not needed because data were extracted from primary published studies in which informed consent was obtained by investigators.

Conflicts of Interest

The authors declare no conflicts of interest to report regarding the present study.

Supplementary Materials

The supplementary material is available online at <https://www.techscience.com/doi/10.32604/cju.2025.072113/s1>.

References

1. Al-Qaisi MA, Tian HF, Feng JJ et al. Observation on the therapeutic effect of a modified Devine procedure with subcutaneous sliding fixation method for concealed penis. *Asian J Androl* 2025;27(4):470–474. doi:10.4103/aja20251.
2. Luo W, Wang SJ, Fang KW et al. Efficacy and safety of a modified surgery for concealed penis. *J Kunming Med Univ* 2019;40(12):130–135. (In Chinese).
3. Pan R, Li J, Zhou Z, Liang K, Li Z, Xiao Z. Comparative efficacy of modified Shiraki procedure and pedicled Island preputial flap in the treatment of severe concealed penis in children. *Sci Rep* 2025;15(1):14428. doi:10.1038/s41598-025-99589-2.
4. Ge W, Zhu X, Xu Y, Chen Y, Wang J. Therapeutic effects of modified Devine surgery for concealed penis in children. *Asian J Surg* 2019;42(1):356–361. doi:10.1016/j.asjsur.2018.06.007.
5. Yener S, Ayyıldız HNK, Güvenç FT, Yıldız ZA, İlçe Z. Surgical technique experience and results for concealed penis. *Pediatr Surg Int* 2025;41(1):113. doi:10.1007/s00383-025-06013-x.
6. Xiang BY, Peng JX, Shang XJ, Zu XB, Li DJ. Concealed penis: a review of multilevel classification and surgical reconstruction techniques. *BJUI Compass* 2025;6(1):e470. doi:10.1002/bco2.470.
7. Zhang JM, Wu QK, Xia LF. Application of penile lengthening and fixation surgery with skin flap release in the treatment of concealed penis patients. *Zhejiang J Traumat Surg* 2021;26(1):47–48. (In Chinese).
8. Jiang YP. Clinical study on the revision and correction of concealed penis in children following failed circumcision surgery. *World Latest Med Inf* 2019;19(92):235–244. (In Chinese). doi:10.19613/j.cnki.1671-3141.2019.92.135.
9. Pu X, Xuan XQ, Yang JL, Yang Y, Li GG. The impact of modified Devine technique combined with penile scrotal angle formation surgery on the rehabilitation process and complications in children with hidden penis. *Compr Collect Typ Cases China* 2025;19(1):238–241. (In Chinese). doi:10.20256/j.cnki.zgdxbl.20250307.003.
10. Zhang Z, Wu H, Mao W, Gao SL, Zuo L, Zhang LF. Clinical study of modified Devine's surgical technique in the treatment of concealed penis. *Urol J* 2023;20(4):229–233. doi:10.22037/uj.v20i.6900.
11. Chen HK, Chu YS, Hu YF. The modified Devine's procedure for the management of concealed penis in children: an experience of 131 cases. *Eur Rev Med Pharmacol Sci* 2022;26(13):4592–4596. doi:10.26355/eurrev_202207_29180.
12. Wang C, Qian XQ, Zhou SM et al. Treatment of concealed penis by modified Devine procedure of traction without glans suture combined with removal of inner plate fascia. *J Clin Urol* 2020;35(8):648–650. (In Chinese). doi:10.13201/j.issn.1001-1420.2020.08.013.
13. Zhao JY, Nie H, Gao QL. A comparative study on the clinical efficacy of modified Devine surgery combined with serotal flap transfer and traditional Devine surgery in the treatment of concealed penis in children. *J Mod Urol* 2024;29(2):46–50. (In Chinese). doi:10.3389/fsurg.2025.1654258.
14. Zhou HJ, Wang LJ, Cui GH, Chen FS. Clinical study of modified Devine operation in the treatment of concealed penis in children. *Heilongjiang Med J* 2022;46(01):39–41. (In Chinese).
15. Page MJ, McKenzie JE, Bossuyt PM et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi:10.1136/bmj.n71.
16. Shea BJ, Reeves BC, Wells G et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ* 2017;358:j4008. doi:10.1136/bmj.j4008.
17. Sterne JA, Hernán MA, Reeves BC et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* 2016;355:i4919. doi:10.1136/bmj.i4919.

Modified versus traditional Devine procedure

18. Higgins JPT, Altman DG, Gøtzsche PC et al. The Cochrane collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011;343:d5928. doi:10.1136/bmj.d5928.
19. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ* 2003;327(7414):557–560. doi:10.1136/bmj.327.7414.557.
20. Patsopoulos NA, Evangelou E, Ioannidis JPA. Sensitivity of between-study heterogeneity in meta-analysis: proposed metrics and empirical evaluation. *Int J Epidemiol* 2008;37(5):1148–1157. doi:10.1093/ije/dyn065.
21. Che XP, Yan YJ, Wang LQ, Jiao ZL, Xu GL, Bu HM. Comparison of the efficacy of two commonly used surgical procedures for concealed penis in children. *China Foreign Med Treat Mag* 2011;30(24):37–38. (In Chinese). doi:10.16662/j.cnki.1674-0742.2011.24.130.
22. Zeng LS. Analysis of the value of Devine procedure combined with scrotal flap transfer in the treatment of hidden penis in children. *World Latest Med Inf* 2018;18(85):16–17. (In Chinese). doi:10.19613/j.cnki.1671-3141.2018.85.005.
23. Wang Q, Fan YJ, Wang YW. Effect of modified penile release on hidden penis. *Chin J Mod Drug Appl* 2021;15(15):78–80. (In Chinese). doi:10.14164/j.cnki.cn11-5581/r.2021.15.026.
24. Shen ZY, Wang CY. Comparison of the efficacy of the modified Devine procedure with double circular incisions and the traditional Devine procedure in the treatment of concealed penis in children. *Fujian Med J*. 2018;40(6):90–93. (In Chinese).
25. Zhang GJ, Cai L. Clinical application of foreskin detachment release and penile elongation fixation in concealed penis. In: Academic Symposium on Health in Clinical Medicine and Communication; 2025 Jan 5; Chongqing, China. p. 633–636. (In Chinese). doi:10.26914/c.cnkihy.2025.000673.
26. Li ZX, Shi C, Yang XJ, Tan HY. Effect analysis of modified Devine procedure in treatment of concealed penis in children. *Chin Community Dr* 2023;40(34):20–22. (In Chinese).
27. Huang ZG, Shi JM, Li YP et al. Efficacy of penile body fixation to the pubic fascia in the modified Devine procedure for concealed penis. *Shenzhen J Integr Tradit Chin West Med* 2021;31(7):144–145. (In Chinese). doi:10.16458/j.cnki.1007-0893.2021.07.068.
28. Zhang YT. Clinical effects of modified penile release on children with concealed penis. *Med J Chin People's Health* 2020;32(18):19–20. (In Chinese).
29. He HB, Zhang JX. Effect of modified Devine operation in the treatment of concealed penis. *Clin Res Pract* 2019;4(3):83–85. (In Chinese). doi:10.19347/j.cnki.2096-1413.2019.03034.
30. Li H. Surgical treatment for concealed penis in children. *Chin Manip Rehabil Med* 2019;10(9):22–23. (In Chinese). doi:10.19787/j.issn.1008-1879.2019.09.009.
31. Ji FL, Shi PY, Kong YX, Li ZH, Liang YJ. Clinical study on the plastic surgery of concealed penis in children after circumcision failure. *Chin J Hum Sex* 2018;27(6):42–44. (In Chinese).
32. Zhang LM. Application of modified penile release surgery in the treatment of concealed penis: a study of clinical efficacy. *J Clin Med* 2016;3(28):75–76. (In Chinese). doi:10.16281/j.cnki.jocml.2016.28.043.
33. Fang YG, Gao SY, Ma XJ, Ye K, Zhao Y. Clinical study of modified Devine procedure for concealed penis. *Jilin Med J* 2016;37(12):121–122. (In Chinese).
34. Yang BF. Clinical observation of modified Devine procedure for complete concealed penis in children. *China Pract Med* 2015;10(10):127–128. (In Chinese). doi:10.14163/j.cnki.11-5547/r.2015.10.082.
35. Wang XJ. Therapeutic effect observation of modified Devine procedure for concealed penis in children. *Shandong Med J* 2011;51(46):56–57. (In Chinese). doi:10.3969/j.issn.1002-266X.2011.46.030.