A Thorough Analysis of The Effects and Complications of Two Different Suturing Techniques in Hypospadias Repair Using Tubularized-Incised Plate Urethroplasty: a Meta-Analysis

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ABSTRACT

Background: Hypospadias is a male congenital anomaly that requires urethroplasty via the tubularized-incised plate (TIP) technique. This technique is simple, and the results are promising, although it has few postoperative complications, including the associated suture technique. Objective: Comparing the continuous and interrupted suturing techniques on the TIP procedure for hypospadias repair. Methods: This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The authors thoroughly searched electronic databases of PubMed, Scopus, ScienceDirect, and Web of Science. The compared endpoints were the total complication, wound infection, meatal stenosis, glans dehiscence, and urethral stricture presented as risk ratio (RR), with average operating time as mean difference (MD), in 95% confidence intervals (CIs). All statistical analyses were performed using Revman 5.4. Results: Ten eligible studies were included, totalling 1,894 patients. Pooled RR showed no significant difference in overall complication, surgical site infection, meatal stenosis, glans dehiscence, and urethral stricture between continuous and interrupted sutures. In subgroup analysis, the interrupted suture had fewer complications when using polyglactin material (RR: 1.51, 95% CI 1.07 to 2.14; p = 0.02). The continuous suture showed lesser operative time than the interrupted suture (MD: -6.67, 95% CI -12.52 to -0.82; p = 0.03). Discussion and Conclusion: No significant complication difference existed between continuous and interrupted suturing techniques. Fewer complications were obtained when using interrupted sutures with polyglactin material. However, continuous suture required less operative time.

Keywords: Meta-analysis, continuous suture, interrupted suture, suture technique, tubularized-incised plate.

1. BACKGROUND

Hypospadias is a male congenital anomaly that occurs in 20.9 per 10,000 live births (1, 2). Only reconstructive surgery is amenable for hypospadias. Urethroplasty is intended to create an anatomical-orthotopic meatus, straighten the chordee, and achieve an excellent appearance, including the glans penis (3). Snodgrass’ introduction of the tubularized-incised plate (TIP) technique in 1994 gained worldwide acknowledgment as a versatile repair option for hypospadias. TIP is popular mainly because it is simple, produces good cosmesis, and has few postoperative complications. Several identifiable factors may affect the development of postoperative complications, and their association with the suturing technique is currently not yet present in any consensus or guidelines (4).

TIP procedures can be performed using two suturing technique alternatives: continuous and interrupted sutures. Ulman et al. reported the first study to link the subcuticular continuous suture approach to a decreased urethrocuteaneous fistula (UCF) incidence in Mathieu repair (5). Nevertheless, Snodgrass et al. previously found no significant difference in complication...
rates between the suturing techniques for TIP (6). With growing evidence, there is still some debate on whether TIP treatment complications are best avoided with continuous or interrupted suturing techniques.

2. OBJECTIVE
This systematic review and meta-analysis compares the continuous and interrupted suturing techniques on the TIP procedure for hypospadias repair.

3. MATERIAL AND METHODS
Materials/Patients and Methods
This study is a systematic review and meta-analysis of hypospadias repair outcomes with the TIP technique using continuous sutures compared with interrupted sutures in terms of complications.

Literature Search Strategy
The search was performed on PubMed, Scopus, ScienceDirect, and Web of Science databases using the combination of pre-specified keywords and their associative terms, including “hypospadias,” “tubularized-incised plate,” “TIP,” “Snodgrass,” “continuous suture,” “interrupted suture,” and “suturing technique.”

Data Extractions and Eligibility Criteria
After the literature search completion, the extraction process involved two authors who evaluated the article’s relevance based on titles and abstracts. Further inclusion was screened-in-depth from the full texts, with any disagreements resolved by the third author. The PRISMA flow diagram was implemented during the study selection process. The inclusion criteria for complete review were: The study must investigate hypospadias patients who underwent TIP urethroplasty, continuous and interrupted sutures were compared, and postoperative complications were reported as the study endpoint. The exclusions were made for articles not published in English, unavailable in full text, and lacking both suturing techniques.

Analysis Technique
Risk ratio (RR) and mean difference (MD) was utilized when analyzing dichotomous and continuous variables, respectively. A p-value of <0.05 was set to define statistical significance. The chi-square and I2 statistics were carried out to define statistical heterogeneity between studies. An I2 of less than 50% was interpreted as minimal to moderate heterogeneity, with the fixed-effect model used for the meta-analysis estimates. Otherwise, the pooled data will be valued as having substantial heterogeneity, accounting for the random-effect model. Complete analyses and forest plots were generated using Review Manager 5.4. The Cochrane Risk of Bias 2 and the Newcastle-Ottawa Scale assessment was performed to identify the risk of bias in each included study.

4. RESULTS
Search Results and Study Characteristics
An initial 851 online articles were retrieved. After duplicate removal, the obtained articles were screened through titles and abstracts. A subsequent 688 articles that did not meet the inclusion criteria were excluded. A thorough review of the remaining 26 articles yielded ten eligible articles included in qualitative and quantitative analysis. The entire phase of the systematic search result is outlined in Figure 1.

The average age among the study population ranged from 12.8-73.68 months (1.07-6.14 years). The average operating time required was 58-132.4 minutes for the continuous suture group and 60.5-139 minutes for the interrupted suture group. The follow-up period was between 4 weeks and three years. The thread materials for the suture used in the included study were mainly polyglactin, while polydioxanone was used in only two studies. The reported endpoints were the occurrences of urethrocutaneous fistula, meatal stenosis, urethral stricture, glans dehiscence, and surgical site infection. The summary of characteristics and outcomes from each study are listed in Table 1 and Table 2.

Risk of Bias Assessment
All RCTs included were assessed using the Risk of Bias 2 valuation by the Cochrane Collaboration. The bias assessment results showed that two of the six studies showed a low overall risk of bias. However, the other
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Table 1. Characteristics of included studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Research Location</th>
<th>Study Design</th>
<th>Suturing Technique</th>
<th>N</th>
<th>Hypospadias type (n, %)</th>
<th>Age</th>
<th>Follow-up</th>
<th>Suture Material</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samir</td>
<td>Egypt</td>
<td>RCT</td>
<td>Interrupted</td>
<td>40</td>
<td>Anterior penis (64; 60%) Midpenile (16; 20%)</td>
<td>Mean (range)</td>
<td>4.5 Years (3-7)</td>
<td>Mean (range)</td>
<td>3 Years (2-4.5) Polydioxanone</td>
</tr>
<tr>
<td>Gafar</td>
<td>Egypt</td>
<td>RCT</td>
<td>Interrupted</td>
<td>40</td>
<td>Subcorona (11; 13.7%) Distal penis (29; 36.3%)</td>
<td>Mean (range)</td>
<td>12.8 ± 7.1 month</td>
<td>Range (9-12 month)</td>
<td>Polydioxanone Surgical wound infection</td>
</tr>
<tr>
<td>Gupta</td>
<td>India</td>
<td>RCT</td>
<td>Interrupted</td>
<td>50</td>
<td>Subcorona (30; 30%) Distal penis (12; 12%) Midpenile (8; 8%)</td>
<td>Mean (range)</td>
<td>26.2 month (12-66)</td>
<td>Mean (range)</td>
<td>23.5 month (9-36) Polydioxanone</td>
</tr>
<tr>
<td>Samir</td>
<td>Egypt</td>
<td>RCT</td>
<td>Interrupted</td>
<td>130</td>
<td>Subcorona (79; 30.4%) Distal penis (21; 8%) Midpenile (17; 6.5%)</td>
<td>Median (IQR)</td>
<td>27 month (22-31)</td>
<td>TD</td>
<td>Six months initially, then every three months for a year</td>
</tr>
<tr>
<td>Mahmud</td>
<td>Bangladesh</td>
<td>RCT</td>
<td>Interrupted</td>
<td>33</td>
<td>Anterior Penis (76; 100%)</td>
<td>Mean (range)</td>
<td>43.45 ± 34.06 month</td>
<td>TD</td>
<td>Six months</td>
</tr>
<tr>
<td>Eassa</td>
<td>Canada</td>
<td>Observational</td>
<td>Interrupted</td>
<td>66</td>
<td>Penoscrotal and proximal (33845%) Distal and mid penile (57.15%)</td>
<td>Median (range)</td>
<td>2 (0.5-16) years</td>
<td>Median (range)</td>
<td>11 (3-96) months Polydioxanone (215; 55%) Polydioxanone (174; 45%)</td>
</tr>
<tr>
<td>El-Sherbiny</td>
<td>Canada</td>
<td>Observational</td>
<td>Interrupted</td>
<td>76</td>
<td>Distal + Midshaft (106; 79.7%) Posterior (27; 20.3%)</td>
<td>Mean (SD, range)</td>
<td>7 (4, 1-22) years</td>
<td>Mean (SD, range)</td>
<td>10 (5, 3-36) months Polydioxanone</td>
</tr>
<tr>
<td>Ismail</td>
<td>N/A</td>
<td>Observational</td>
<td>Interrupted</td>
<td>50</td>
<td>Distal penis (250; 100%)</td>
<td>Dichotomous</td>
<td>&lt;2 and &gt;2 years</td>
<td>N/A</td>
<td>Few days</td>
</tr>
<tr>
<td>Sahan</td>
<td>Egypt</td>
<td>Observational</td>
<td>Interrupted</td>
<td>92</td>
<td>Coronal (110; 22%) Distal penis (261; 52.5%) Midpenile (78; 15.6%) Posterior penile (21; 4.2%) Penoscrotal (30; 6.5%)</td>
<td>Mean (SD, range)</td>
<td>6 (3.6-1-8) years</td>
<td>Mean (SD, range)</td>
<td>34 (18, 7-77) months Polydioxanone</td>
</tr>
</tbody>
</table>

Table 1. Characteristics of included studies

four studies were considered to have an overall moderate risk of bias. Studies by Mahmud et al. and Shibli et al. indicated some concerns in three of the five domains. Each valuation of the included RCTs is summarized in Figure 2.

Overall Complications

Meta-analysis of overall complications involving all reported postoperative incidence showed no significant difference between continuous and interrupted sutures (RR: 0.84, 95% CI 0.50-1.41; p = 0.51), as shown in Figure 3. The random-effect model was used for the pooled estimates, as the heterogeneity between studies was considered high (I2 = 72%; p = 0.001). A sensitivity analysis with the leave-one-out method was performed, where exclusion from the Gafar et al. study affected the significance of the meta-analysis (RR: 1.51 95% CI 1.07-2.14; I2 = 0%; p = 0.02).

Urethrocutaneous Fistula

Meta-analysis of the incidence of urethrocutaneous fistula showed no significant difference between the two
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groups (RR: 1.40, 95% CI 0.86-2.28; p = 0.18), as shown in Figure 4. The fixed-effect model was used in this analysis due to low heterogeneity between studies (I2: 47%; p = 0.11).

Surgical Site Infection
Meta-analysis showed that surgical site infection incidence with continuous and interrupted suturing techniques was not statistically different (RR: 0.93, 95% CI 0.34-2.54; p = 0.89), as shown in the forest plot in Figure 5. The fixed-effect model was used in this analysis because the heterogeneity between studies was low (I2: 0%; p = 0.64).

Glans Dehiscence
Meta-analysis showed that the incidence of glans dehiscence was similar among the continuous and interrupted suture groups, as the comparative risk was not statistically significant (RR: 1.89, 95% CI 0.59-6.06; p = 0.28). The fixed-effect model was applied, giving the low heterogeneity between studies (I2: 0%; p = 0.81). The forest plot of the glans dehiscence outcome is shown in Figure 6.

Meatal Stenosis
Meta-analysis showed that the incidence of meatal stenosis was also similar among the continuous and interrupted suture groups (RR: 1.35, 95% CI 0.54-3.35; p = 0.52), as shown in Figure 7. The fixed-effect model was used for analysis, as the heterogeneity between studies was low (I2: 0%; p = 0.66).

Urethral Stricture
Meta-analysis showed that the incidence of urethral stricture was not significantly different between the continuous and interrupted suturing techniques (RR: 1.54, 95% CI 0.26–9.05; p = 0.63). The fixed-effect model was applied for outcome estimates considering low hetero-

Table 2. Summary of outcomes. UCF, urethrocutaneous fistula; NUD, neourethral disruption; MS, meatal stenosis; POI, post-operative infection *Mean (± Standard Deviation), †Median (Range)
A thorough analysis of the effects and complications of two different suturing techniques in hypospadias repair

Geneity between studies (I²: 0%; p = 0.69). The pooled analysis is shown in Figure 8.

Overall complication in subgroup of thread material
Subgroup analysis showed that the overall complication when using polyglactin was significantly higher in the continuous suture group compared to the interrupted suture group (RR: 1.51, 95% CI 1.07–2.14; p = 0.02). The fixed-effect model was used for the outcome, attributed to a low level of heterogeneity (I² = 0%; p = 0.41). The outcome of polyglactin use is presented in Figure 5.9.

Average operating time
Meta-analysis showed that the average operating time was significantly shorter in the continuous suture group than the interrupted one (MD: -6.67, 95% CI -12.52 to -0.82; p = 0.03), as shown in Figure 10. A random-effect model was used due to substantial heterogeneity between studies (I² = 85%; p < 0.001). A leave-one-out sensitivity analysis revealed that the exclusion of the study by Gafar et al. affected the significance and the degree of heterogeneity between studies (I² = 0%; p < 0.00001).

5. Discussion
Hypospadias is the most common congenital disorder of the male genitalia, and the prevalence is 20.9 per 10,000 births, where reconstructive surgery is the only treatment (1, 2). Variations in surgical technique and many other factors can affect urethroplasty’s cosmetic and functional outcome. The use of absorbable sutures for urethroplasty is commonly accepted, but until now, there has been no consensus for using suture techniques (continuous or interrupted) in TIP urethroplasty. The choice of suture technique is still based on the preference of the surgical operator (7). In theory, continuous sutures require less operating time than interrupted sutures. However, they may have a greater risk of complications due to tissue strangulation and ischemia due to too tight attachment between the sutures (4).

This meta-analytic study is the first to comprehensively compare continuous and interrupted sutures in neo-urethral creation in TIP urethroplasty. Six RCTs met the inclusion criteria for the meta-analysis, comprising 620 total patients. After analyzing all the studies that met the criteria, the total complications were higher in the group with continuous sutures. However, the difference compared to interrupted sutures was not statistically significant. Several other studies have stated that TIP with continuous sutures has a greater risk of complications. The authors explained that the high rate of complications with interrupted sutures is due to the subcuticular suture method used and the urethral plate edges being closer together in continuous than interrupted sutures (4, 7–11). Previous meta-analysis studies by Wahyudi et al., and Borkar et al. found that neither suturing technique was significantly associated with complications...
especially in prepubertal patients. As long as tissue via-
ticance.

tended to be higher in the group with continuous su-
number of postoperative hypospadias wound infections
is consistent with previous meta-analyses (12, 13). The
between continuous and interrupted suture groups in
results. However, there is still a risk of complications such
as bleeding, infection, and the formation of fibrotic tis-
tures, which was statistically significant, could be in-
fluenced by various factors, including the continuous
suture effect on tissue ischemia due to too tight knot
or because the edges of the wound are unable to close
correctly. The lack of blood supply to the wound edges
could also cause fistulas. The exact cause of urethrocu-
taneous fistula itself is still not fully understood. Choice
of surgical technique, age at urethroplasty, use of cystos-
tomy, length of neourethra, and size of split catheter
have been studied by Duarsa et al. as factors that can
form urethrocutaneous fistula, where age and split size
are significant. Identification of various factors that can
cause fistulas must be studied and evaluated to prevent
the high risk of complications in hypospadias patients
(4, 9, 14, 15).

Comparison of the risk of surgical site infection
In general, the success of surgery for hypospadias is
relatively high, with some patients achieving good re-
results. However, there is still a risk of complications such
as bleeding, infection, and the formation of fibrotic tis-
tue (11). There was no statistically significant difference
between continuous and interrupted suture groups in
the surgical site infection outcome analysis. This finding
is consistent with previous meta-analyses (12, 13). The
number of postoperative hypospadias wound infections
tended to be higher in the group with continuous su-
tures, but this difference did not reach statistical signif-
icance.

Surgical site infection is rare after hypospadias repair,
especially in prepubertal patients. As long as tissue vi-
ability is good, infection is a minor problem. Prophylactic
antibiotics have a small role in preventing post-urethro-
plasty wound infection. Severe sepsis is rare, but local
infection can occur due to impaired vascularization, hu-
midity, high temperatures, or proximity to contaminat-
ed areas. Infection can be prevented by administering
preoperative povidone-iodine, prophylactic and postop-
ervative antibiotics, and preventing edema/hematoma (9,
16).

Comparison of the risk of glans dehiscence
Glans dehiscence occurs due to failure of approxima-
tion of the glans wings after hypospadias surgery. Com-
plications of glans dehiscence are early complications
that often occur in postoperative hypospadias patients.
In this study, there was no significant difference in the
incidence of glans dehiscence in the group with inter-
rupted and continuous sutures. Accordingly, the find-
ings reported by previous studies reported no difference
in the incidence of glans dehiscence between groups
with interrupted and continuous sutures (10, 11). The
formation of the glans dehiscence itself is related to
many factors, including poor surgical technique, stress
on glans closure, pressure due to the catheter used, or
changes in glans vascularization. Research by Karabulut
et al. stated that glans dehiscence was significantly high-
er in proximal than distal hypospadias (5%). A differ-
ent perspective in other studies suggests that increased
glans dehiscence is more likely due to small glans size
and testosterone use rather than the type of hypospadias
(17, 18).

Comparison of the risk for glans dehiscence

Comparison of the risk of developing meatal ste-
nosis
The most common complications found in postop-
erative hypospadias patients are the formation of fis-
tulas and meatal stenosis. In this study, it can be seen
that complications of meatal stenosis were higher in
the group with continuous suture technique than in the
group with interrupted sutures, but there was no statis-
tically significant difference. These findings are similar
to previous studies, which reported that the incidence of
meatal stenosis was higher in the group with continuous
sutures than interrupted sutures, but this difference was
insignificant (15). This outcome analysis confirms the
findings of Wahyudi et al. and Borkar et al., who con-
cluded that there was no statistically significant differ-
ence between the two groups (12, 13). The definition of
meatal stenosis varies in the literature, but recent stud-
ies state that the width of the urethral meatus must be
calibrated > 8 Fr after urethroplasty and increases with
age. The routine use of meatal dilatation is considered to
have a good effect on preventing meatal stenosis. Dilata-
tion is routinely thought to be capable of causing re-
epithelialization of the urethral lumen, thereby providing
improvement of meatal stenosis. The incidence of re-op-
eration is higher in patients who do not have urethral
dilation (19).

Comparison of the risk of urethral stricture
Narrowing of the urethra that extends proximally
from the meatus is a complication frequently reported
after urethroplasty surgery. This study showed no signif-
icant difference between the continuous and interrupted
suture groups. This result is consistent with the findings of Wahyudi et al. and Borkar et al., who found no significant difference in the incidence of post-TIP urethral stricture between the two suturing groups (12, 13). This may be since the occurrence of urethral strictures is more related to the quality of the depth and width of the urethral plate (4, 10).

Urethral stricture has been reported to occur in 10% of post-urethroplasty patients. Although the exact incidence remains unclear, postoperative hypospadias urethral narrowing is associated with using foreskin flaps, tubularized tissue, or in complex cases of proximal hypospadias. Urethral stricture appears to result from poor reconstructive technique resulting in infection, hematoma, extravasation, and tissue ischemia. If it has been identified clinically, the next step is to establish the type of stricture through cystoscopy to see its length, diameter, and location. Initial management depends on the severity of the stricture. In short, strictures that cause minimal symptoms, urethral dilatation, or incision can be performed endoscopically. If it fails or the stricture is more severe when diagnosed, it requires revision of urethroplasty (20, 21).

Comparison of complications by sub-group of Poliglactin suture types

Regarding hypospadias surgery, several studies contradict the relationship between thread material and the occurrence of complications. Depending on the surgeon’s preference, each absorbable suture provides sufficient tensile strength for use in urethroplasty. This meta-analysis showed that a subgroup analysis of the type of suture used in the five previous studies showed a higher complication rate for poliglactin suture strictures in the continuous suture technique than the interrupted technique and was statistically significant. These results align with previous studies, which showed that TIP urethroplasty using interrupted poliglactin sutures had a lower complication rate than continuous sutures (4, 7, 10, 11).

Several studies reported different results. A study by Shirazi et al. showed that poliglactin sutures were associated with increased complications compared with polydioxanone sutures (15.1% vs 5.3%). Guarino et al. found no significant difference in the risk of complications between the two types of thread (poliglytone vs. polydioxanone) in TIP urethroplasty (22, 23).

Comparison of average operating times

The average operating time in this meta-analysis showed a statistically significant difference. The continuous suture technique had a shorter operating time than interrupted sutures. Previous studies also stated that TIP with continuous suture techniques statistically had less operating time than interrupted suture TIP. Generally, this result is expected since continuous sutures are more straightforward and do not require ties at each suture, thus making the urethroplasty operation process faster (4, 9).

Strengths and Limitations

This systematic review and meta-analysis study is the first to include data on every complication and surgical time from randomized and non-randomized studies. Observational studies have given additional data for decision-making when comparing continuous and interrupted sutures for TIP urethroplasty, though their evidence level is lower than that of RCTs.

However, this current review only included a few available RCTs and only a few studies with large sample populations. The standardization of the assessment of complications in most of the studies has not been clearly described, which can lead to bias. It is necessary to clarify each of the existing complications to more accurately determine the effect and safety of the compared suturing technique. Several risk factors that can affect the outcome of hypospadias repairs, such as age, operator experience, urethral plate characteristics, thread size, antibiotic use, wound dressings, and catheterization, are other factors that have not been thoroughly evaluated in meta-studies.

The study quality assessment indicated an overall moderate risk of bias, which is also a limitation of this study. Future update on this topic needs to involve high-quality RCTs, have a larger, homogeneous population, and incorporate multicenter studies to obtain more robust analysis and minimize the overall risk of bias.

6. CONCLUSION

The incidence of complications after TIP urethroplasty using continuous poliglactin sutures is significantly higher than the interrupted one. However, the continuous suture technique had a significantly shorter operating time than the interrupted suture. No significant difference was obtained between the two methods on overall complications, urethrotunaneous fistula, surgical site infection, glans dehiscence, meatal stenosis, and urethral stricture.

It is recommended for the urethroplasty surgeon who performs the TIP repair, particularly with poliglactin threads, to use interrupted sutures for favourable complication outcomes. For further study, additional analysis is needed on other factors that can influence the effect of suturing techniques on the outcome of hypospadias repair. It is necessary to involve multicenter studies in countries other than Asia and Africa to generalize the insights of the current study.

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