The effectiveness of Barbagli technique compared to Kulkarni technique for urethral strictures: a systematic review and meta-analysis

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ABSTRACT

Introduction: Urethroplasty is one of the management of urethral stricture. Various studies reported that urethroplasty procedures have a higher long-term success rate than urethrotomy for treating urethral stricture. We aim to compare the efficacy and safety of urethroplasty using the Barbagli and Kulkarni approaches.

Materials and Methods: This systematic review and meta-analysis were performed in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. We systematically searched for relevant articles through several databases. The outcomes evaluated in this study were success rate, mean operative time, and complication rate. Outcomes with dichotomous data were analyzed using odds ratio (OR). Continuous data will be analyzed using mean difference (MD) and standard deviation (SD). Statistical analysis using RevMan 5.4 for Windows.

Results: Three studies were evaluated involving 272 urethral stricture patients. Urethroplasty procedure using the Barbagli technique had a success rate that was not significantly different from that of the Kulkarni technique (OR 0.55, 95% CI 0.28-1.08, p = 0.08). The Barbagli technique had a significantly longer duration of operation (MD 10.34, 95% CI 3.83-16.85, p = 0.002). The incidence of surgical wound infection was not significantly different in both groups (OR 2.13, 95% CI 0.46-9.83, p = 0.33). There was no significant difference in overall complication rates between patients undergoing urethroplasty using the Barbagli and Kulkarni technique (OR 1.52, 95% CI 0.42-5.55, p = 0.52).

Conclusion: This SRMA found that the success rate in the Barbagli technique urethroplasty procedure was not significantly different from the Kulkarni technique. However, the operation duration was significantly longer in the Barbagli technique. Complication rates were minimal in both groups.

Keywords: urethral strictures, anterior urethral strictures, urethroplasty, Barbagli technique, Kulkarni technique.


INTRODUCTION

The etiology of urethral stricture consists of idiopathic, iatrogenic, external trauma, infection and lichen sclerosis. A study in 2013 showed that urethral strictures in India were primarily due to external trauma, to a lesser extent, iatrogenic.3 In Western countries, most etiological strictures are iatrogenic and developing countries mostly acquire infection-induced strictures after non-specific urethritis.¹³ Urethroplasty is one of the management of urethral stricture. Various studies reported that urethroplasty procedures have a higher long-term success rate than urethrotomy for treating urethral stricture (85-90% vs. 20-30%).⁴

Grafts used for urethroplasty procedures include penile skin, extragenital skin, oral mucosa, and bladder mucosa.⁵ There are several locations where urethroplasty procedures can be performed, namely ventral, dorsal, and lateral. However, there is no data regarding the optimal location of buccal mucosal graft (BMG) in urethroplasty. There is also no clear consensus on the best location for grafting. The most commonly used urethroplasty is dorsal graft urethroplasty or the Barbagli technique. On the other hand, the one-sided dorsolateral onlay BMG urethroplasty as described by Kulkarni et al., is also used to preserve neurovascular outflow from the urethra.⁶

It is possible that different graft locations can lead to different success rates and complications between the two procedures. Several studies have compared the outcomes of patients undergoing urethroplasty using the Barbagli and Kulkarni approach. Therefore in this meta-analysis, we aim to compare the efficacy and safety of urethroplasty using the Barbagli and Kulkarni approaches.

METHODS

Study design and protocol registration

This systematic review and meta-analysis were performed in accordance with the Cochrane Handbook for Systematic Reviews and Intervention, in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The protocol is registered in the International Prospective Register...
of Systematic Reviews (PROSPERO CRD42022342416).

Literature search strategy and eligibility criteria
Two independent reviewers systematically searched for relevant articles through PubMed, Scopus, and ScienceDirect databases from their inception up to July 2022 using MeSH® related to “urethral strictures”, “anterior urethral strictures”, “urethroplasty”, “dorsal onlay”, “Barbagli technique”, “dorsolateral onlay”, and “Kulkarni technique”. The titles and abstracts were screened using pre-specified eligibility criteria. All randomized controlled trials (RCTs) and other observational studies (cohort, case-control, case series, and cross-sectional) which evaluated patients with urethroplasty with the Kulkarni technique and Barbagli technique and reported the outcome of success rate, mean operative time, complication rate were eligible for inclusion in this meta-analysis. Animal studies and unpublished articles were excluded.

Data collection and quality assessment
Two independent reviewers performed data collection using a standardized data collection form. The senior authors solved any disputes between the reviewers. The piloted form comprised of the first author’s name, study design, description of the urethra stricture characteristics, participant’s age, intervention protocol, and the outcomes included in the meta-analysis. The primary outcome of this study was the success rate. Secondary outcomes of this study were the mean operative time and the overall complication rate (the incidence of complications that occur during or after surgery, such as bleeding, surgical site infections, urinary tract infections, fistulas, erectile dysfunction, penile curvature, and recurrence of strictures). The bias was evaluated by using Newcastle-Ottawa Scale (NOS).

Data synthesis
Outcomes with dichotomous data were analyzed using odds ratio (OR) with Confidence interval (CI) at 95% and p-value below 0.05 was considered statistically significant. Continuous data will be analyzed using mean difference (MD) and standard deviation (SD). Heterogeneity between studies was calculated using I², if I²>50% it was considered statistically high heterogeneity and a random-effect effects model was applied. If I²<50%, then the fixed-effects model will be applied to this meta-analysis. Statistical analysis will use RevMan 5.4 for Windows software which will be presented in the form of forest plots and descriptive narratives.

RESULTS
Search results and study characteristics
The initial search results through the PubMed, Scopus, and ScienceDirect databases identified a total of 675 articles. Six hundred fifty-four titles and abstracts were screened after going through the process of removing duplicate articles. Based on the previously determined eligibility criteria, 647 articles were excluded by screening the title and abstract (Figure 1). Based on the results of further studies by screening the full text, the researchers included 3 studies that met the eligibility criteria to be included (Table 1).

The included studies were all retrospective cohort studies from Turkey and India. A total of 3 studies evaluated the comparative effectiveness of the Barbagli and Kulkarni urethroplasty techniques and included a total of 272 urethral stricture patients. The mean age of the included patients was 40.1 years, with a mean urethral stricture length of 8.47 cm to 10.5 cm. Success rates for each procedure vary, with the Barbagli technique having a 70% to 89% success rate, while the Kulkarni technique has a 79% to 91% success rate. Complications are reported in 20-37% of patients undergoing urethroplasty using the Barbagli technique and 16-21% of patients undergoing urethroplasty using the Kulkarni technique. The most common location of strictures is reported to be penobulbar, accounting for 51-57% of patients.

Studies’ Risk of Bias
Assessment of study quality was carried out using the Newcastle-Ottawa Scale (NOS) parameter because all the included studies had an observational study design. In the selection aspect, all of the included studies reported a good selection process because the included participants were representative of urethral stricture cases, and data were collected using medical records. In addition, the included studies also have good comparative aspects and good exposure aspects because they have adequate follow-up duration and low dropout rates. Based on the final assessment, the included studies had NOS scores between 7 to 8, which could be interpreted as good quality (Table 2).

Comparison on Success Rates
We included a total of three articles with a total of 272 urethral stricture patients to evaluate the success rate parameters. Based on the results of the meta-analysis, urethral stricture patients who underwent a urethroplasty procedure using the Barbagli technique had a success rate that was not significantly different from that of the Kulkarni technique (OR 0.55, 95% CI 0.28-1.08, p = 0.08). The results of the heterogeneity analysis between studies using the chi-square and I² test showed that there was low heterogeneity between the studies included in the analysis (I²=0%) (Figure 2).

Comparison on Operation Duration
A meta-analysis was done to evaluate the surgical duration between the Barbagli and Kulkarni techniques, which included 204 urethral stricture patients. Based on the results of the meta-analysis using forest plots, the Barbagli technique had a significantly longer duration of operation than the Kulkarni technique (MD 10.34, 95% CI 3.83-16.85, p = 0.002). The analysis results also show that the included studies have a low level of heterogeneity (I²=0%), so the analytical method used is the fixed-effects model (Figure 3).

Comparison of Complication Rates for Surgical Wound Infections
Complication rate parameters were analyzed by including two studies. Based on the analysis of 204 urethral stricture patients who underwent urethroplasty, the Barbagli technique had no significant difference in the incidence of surgical
wound infection compared to the Kulkarni technique (OR 2.13, 95% CI 0.46-9.83, p = 0.33). The heterogeneity analysis using I² showed that the heterogeneity level between studies was low (I²=0%) (Figure 4).

Comparison of Overall Complication Rate
In this meta-analysis, we also examined the overall complication rate by enrolling 204 urethral stricture patients from 2 studies. The following is the complication rate found in each study (Table 3, 4). Based on the analysis using a random-effects model, there was no difference in overall complication rates between patients undergoing urethroplasty using the Barbagli and Kulkarni technique (OR 1.52, 95% CI 0.42-5.55, p = 0.52) (Figure 5).

DISCUSSION
Minimally-invasive modalities have been widely used in the treatment of urological cases, but the reconstructive approach is reported to be preferred by urologists because it has a better outcome in cases of urethral stricture. It is known that male urethral stricture disease has an incidence of 0.6% in some vulnerable populations. Management of long-segment urethral strictures is a challenge in urological reconstruction. A number of studies have reported that the urethral reconstruction procedure is the most effective method of definitive management of urethral strictures and this approach is considered the gold standard of treatment for urethral strictures. Single or multiple-stage urethroplasty has been recommended as the surgical treatment for long anterior urethral strictures. Various substitute materials such as skin flaps, penile flaps, bladder, and colon mucosa can be used in this procedure. Substitution material using a Buccal-mucosal graft (BMG) is now widely accepted by urologists worldwide as a standard substitute for urethroplasty procedures.

In the case of bulbar urethral stricture, urethroplasty procedures often involve extensive dissection of the bulbospongious muscle and cutting of the central perineal tendon, because the previous urethroplasty procedure often causes side effects in the form of postvoid dribbling and impaired semen emission. Barbagli et al. first introduced the dorsal onlay BMG urethroplasty strategy in 1996; which minimized the disadvantages of ventral graft arrangement. In the latest procedure described by Barbagli et al., the structure of the bulbospongious muscle, central perineal tendon, and perineal nerve is preserved so that complications can be reduced.

Another urethroplasty technique used for the management of urethral stricture is the Kulkarni technique, a new technique discovered by Kulkarni et al. in 2009 by combining nerve-sparing and muscle-sparing bulbar urethroplasty techniques previously proposed by Barbagli et al. and by using the full-length dorsal urethral opening technique. Kulkarni’s technique is used to manage anterior urethral strictures with the advantage of maintaining lateral vascularization to the urethra, central tendon of the perineum, bulbospongious muscles, and perineum.

A similar study was conducted by Pathak et al. in the male population with anterior urethral stricture disease by enrolling 204 urethral stricture patients from 2 studies. The following is the complication rate found in each study (Table 3, 4). Based on the analysis using a random-effects model, there was no difference in overall complication rates between patients undergoing urethroplasty using the Barbagli and Kulkarni technique (OR 1.52, 95% CI 0.42-5.55, p = 0.52) (Figure 5).
urethral stricture in India. The authors reported that the Kulkarni urethroplasty procedure has a higher success rate than the Kulkarni urethroplasty (79% and 70%, respectively).\(^{17}\) A recent study was conducted by Kartal et al. on a male population with anterior urethral stricture in Turkey. The authors reported that Kulkarni urethroplasty also had a higher success rate (87.1%) compared to Barbagli urethroplasty (70.3%); however, the results of the analysis showed that the difference was not statistically significant (\(p = 0.08\)).\(^{17}\) Previously, Kulkarni et al. reported the success rate of Kulkarni urethroplasty techniques, a study by Sanjay Kulkarni et al., which is a new technique developed as in the Barbagli technique. The Kulkarni technique is a new technique developed by Sanjay Kulkarni et al., which is a combination of nerve-sparing and muscle-sparing bulbar urethroplasty and a full-length dorsal urethral opening technique.\(^{6,14,15}\)

Based on the results of our review, the authors report several different definitions of the success rate parameter. Research by Prakash et al. established the definition of success rate, namely maximum flow rate >15 ml/second, urethral caliber >12 Fr, no obstructive symptoms, no stricture found on urethrographic examination, and no need for further action at the last follow-up.\(^{18}\) In a study conducted by Pathak et al., the authors defined the success rate as a maximum flow rate >15 ml/second, no urethrography abnormalities were found, no voiding symptoms, and no need for further action.\(^{17}\)

Regarding the duration of surgery between Barbagli and Kulkarni urethroplasty techniques, a study by Prakash et al., stated that Barbagli procedure requires a more extended operation duration than Kulkarni (152.1 minutes and 143.3 minutes, respectively). However, the difference was not significantly different (\(p = 0.34\)).\(^{16}\) Kartal et al. also reported similar results; the conventional Barbagli technique had a longer operating duration of about 16 minutes compared to the Kulkarni technique.\(^{16}\) Based on the combined analysis using forest plots, we found that urethroplasty with the Barbagli technique had a significantly longer mean duration of surgery than the Kulkarni technique (MD 10.34, 95% CI 3.83-16.85, \(p = 0.002\)). Theoretically, these two techniques have different steps and approaches, thus, the average duration between these surgeries may also differ. The required operation duration in the Kulkarni urethroplasty procedure is shorter because it does not require a circumferential penile incision as in the Barbagli technique. The Kulkarni technique is a new technique developed by Sanjay Kulkarni et al., which is a combination of nerve-sparing and muscle-sparing bulbar urethroplasty and a full-length dorsal urethral opening technique.\(^{6,14,15}\)

In terms of safety, several studies have reported that both urethroplasty techniques had similar complication rates. Research by Prakash et al. reported that there were complications in the form of surgical wound infections in 4.4% of patients undergoing Barbagli urethroplasty procedures and 2.9% of patients undergoing Kulkarni urethroplasty procedures.\(^{16}\) A recent study by Kartal et al. reported that the incidence

<table>
<thead>
<tr>
<th>Author’s name</th>
<th>Study design</th>
<th>Intervention</th>
<th>Sample size (n)</th>
<th>Mean age (years)</th>
<th>Follow-up duration</th>
<th>Subjective symptom</th>
<th>Mean stricture length (cm)</th>
<th>Success rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prakash et al. 2018</td>
<td>Retrospective cohort</td>
<td>Barbagli Technique Urethroplasty</td>
<td>68</td>
<td>33.16 ±12.36</td>
<td>3, 6, 12 months</td>
<td>LUTS 10.62±4.9</td>
<td>8.47 ± 1.65</td>
<td>89%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kulkarni Technique Urethroplasty</td>
<td>68</td>
<td>28.16 ±14.12</td>
<td>3, 6, 12 months</td>
<td>LUTS 11.91±3.4</td>
<td>9.25 ± 2.11</td>
<td>91%</td>
</tr>
<tr>
<td>Pathak et al. 2017</td>
<td>Retrospective cohort</td>
<td>Barbagli Technique Urethroplasty</td>
<td>20</td>
<td>NR</td>
<td>1-5 years</td>
<td>NR</td>
<td>NR</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kulkarni Technique Urethroplasty</td>
<td>48</td>
<td>NR</td>
<td>1-5 years</td>
<td>NR</td>
<td>NR</td>
<td>79%</td>
</tr>
<tr>
<td>Kartal et al. 2020</td>
<td>Retrospective cohort</td>
<td>Barbagli Technique Urethroplasty</td>
<td>37</td>
<td>58.5 ±14.4</td>
<td>63.5 ± 26.8 months</td>
<td>NR</td>
<td>10.5 ± 2 cm</td>
<td>70.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kulkarni Technique Urethroplasty</td>
<td>31</td>
<td>59.8 ± 10.9</td>
<td>59.8 ± 24.7 months</td>
<td>NR</td>
<td>9.7 ± 1.5 cm</td>
<td>87.1%</td>
</tr>
</tbody>
</table>
The incidence of surgical wound infections was more common in Barbagli urethroplasty procedures compared to Kulkarni urethroplasty procedures (5.4% and 0%, respectively). The combined analysis results using a meta-analysis reported no significant difference in the incidence of surgical wound infection between patients undergoing Barbagli and Kulkarni urethroplasty procedures ($p = 0.33$).

A recent study by Kartal et al. reported that the overall complication rate was higher with Barbagli's urethroplasty procedure than Kulkarni's (37.8% vs. 16.1%, $p = 0.046$). Based on the combined analysis, we found that there was no significant difference in the overall complication rate between patients undergoing Barbagli and Kulkarni urethroplasty procedures ($p = 0.52$). They also reported that the incidence of erectile dysfunction was the most common complication found in both urethroplasty techniques. The incidence of erectile dysfunction was reported in 13.5% of patients undergoing Barbagli urethroplasty and 6.5% of patients undergoing Kulkarni.
Table 3. Complication rate on study by Prakash et al. 2018.

<table>
<thead>
<tr>
<th>Complication</th>
<th>Group 1 (n)</th>
<th>Group 2 (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial wound infection</td>
<td>3 (4.41%)</td>
<td>2 (2.94%)</td>
</tr>
<tr>
<td>Post-void dribbling</td>
<td>Nil</td>
<td>2 (2.94%)</td>
</tr>
<tr>
<td>Penile curvature</td>
<td>1 (1.47%)</td>
<td>2 (2.94%)</td>
</tr>
<tr>
<td>Decreased genitalia sensation</td>
<td>3 (4.41%)</td>
<td>4 (5.88%)</td>
</tr>
<tr>
<td>Urethra stricture recurrence</td>
<td>7 (10.2%)</td>
<td>6 (8.82%)</td>
</tr>
</tbody>
</table>

Table 4. Complication rate on study by Kartal et al., 2020.

<table>
<thead>
<tr>
<th>Complication</th>
<th>Group 1 (n)</th>
<th>Group 2 (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prolonged extravasation</td>
<td>2 (5.4%)</td>
<td>1 (3.2%)</td>
</tr>
<tr>
<td>Bleeding</td>
<td>3 (8.1%)</td>
<td>1 (3.2%)</td>
</tr>
<tr>
<td>Wound infection</td>
<td>2 (5.4%)</td>
<td>0</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>1 (2.7%)</td>
<td>0</td>
</tr>
<tr>
<td>Epididymo-orchitis</td>
<td>1 (2.7%)</td>
<td>0</td>
</tr>
<tr>
<td>Urethra fistula</td>
<td>-</td>
<td>1 (3.2%)</td>
</tr>
<tr>
<td>Erectile dysfunction</td>
<td>5 (13.5%)</td>
<td>2 (6.5%)</td>
</tr>
</tbody>
</table>

Several limitations of this meta-analysis should be considered. First, due to only a small number of studies available, only three were included, and all had an observational design. Second, the number of samples in each study is limited, so the conclusion might not be strong enough. Third, the included studies used in this study have different definitions of the outcome of the success rate, which may lead to bias in this study. Fourth, all of the included studies were conducted in the Asia region; this may lead this study less generalizable. We suggest a similar study conducted in the future, including studies with a multicenter clinical trial design and a larger sample size, with comparable outcome definitions.

CONCLUSION

The success rate of the Barbagli technique was not significantly different from the Kulkarni technique. However, the operation duration was significantly longer in the Barbagli technique. Complication rates were minimal in both groups. Based on the results of this meta-analysis, it is advisable to conduct a similar study, including studies with a multicenter clinical trial design and a larger sample size.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

FUNDING SOURCE

None.

ETHICS COMMITTEE APPROVAL

This systematic review and meta-analysis do not require ethical approval.

AUTHOR CONTRIBUTION

- Muhammad Rozaqy Ishaq (M.R.I.) is involved in the concept and project design, materials, literature search, data collection and/or processing, analysis and/or interpretation, writing the manuscript, and final approval of the version to be submitted.
- Niwanda Yogiswara (N.Y.) is involved in the materials, literature search, data collection and/or processing, analysis and/or interpretation, writing the manuscript, and final approval of the version to be submitted.
- Ilham Akbar Rahman (I.A.R) is involved in the materials, literature search, data collection and/or processing, analysis and/or interpretation, writing the manuscript, and final approval of the version to be submitted.
- Nafis Audrey Febriansyah (N.A.F) is involved in the materials, literature search, data collection and/or processing, analysis and/or interpretation, writing the manuscript, and final approval of the version to be submitted.
- Johan Renaldo (J.R.) is involved in the concept and project design, supervision, resources, materials, literature search, data collection and/or processing, analysis and/or interpretation, writing the manuscript, and final approval of the version to be submitted.
- Soetojo Wirjopranoto (S.W.) is involved in the concept and project design, supervision, resources, materials, literature search, data collection and/or processing, analysis and/or interpretation, writing the manuscript, and final approval of the version to be submitted.

REGISTRATION OF RESEARCH STUDY

- Name of the registry: PROSPERO
- The unique identifying number or registration ID: CRD42022342416
- Hyperlink to registration: https://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42022342416

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