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Original Article

Surgical outcomes and proposal for a treatment algorithm for urethral strictures in transgender men

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Objectives

To assess our results of surgical treatment for urethral strictures in transgender men, and to provide a surgical treatment algorithm.

Patients and methods

A single centre, retrospective cohort study was conducted of transgender men who underwent surgical correction of their urethral stricture(s) between January 2013 and March 2020. The medical charts of 72 transgender men with 147 urethral strictures were reviewed. The primary outcomes were the success and recurrence rates after surgical treatment for urethral strictures.

Results

The median (interquartile range [IQR]) follow-up was 61 (25–202) months. At last follow-up, 50/72 (69%) were able to void while standing (after one [60%], two [20%], three [6%], four [8%], five [4%], or seven [2%] procedures), 10/72 (14%) await further treatment, two of the 72 (3%) sat to void despite good urodynamic function, and 10/72 (14%) had a definitive urethrostomy. Of 104 surgical treatments included in separate success rate analysis, 65 (63%) were successful (43/75 [57%] after phalloplasty, 22/29 [76%] after metoidioplasty). The highest success rates in short urethral strictures were seen after a Heineke-Mikulicz procedure (six of seven cases), and in longer or more complicated urethral strictures after two-stage with graft (four of six), two-stage without graft (10/12), pedicled flap (11/15, 73%), and single-stage graft (seven of seven) urethroplasties. Grafts used were buccal mucosa or full-thickness skin grafts. Success rates improved over time, with success rates of 38% and 36% in 2013 and 2014, to 71% and 73% in 2018 and 2019, respectively. We concluded with a surgical treatment algorithm based on previous literature, stricture characteristics, and our surgical outcomes.

Conclusion

The highest success rates were seen after a Heineke-Mikulicz procedure in short urethral strictures; and after graft, pedicled flap, or two-stage urethroplasties in longer or more complicated urethral strictures. Finally, most of the transgender men were able to void while standing, although in some multiple surgical procedures were necessary to accomplish this.

Keywords

genital gender-affirming surgery, metoidioplasty, phalloplasty, surgical outcome, transgender men, treatment algorithm, urethral stricture

Introduction

For some transgender men, genital gender-affirming surgery (gGAS) is the last step in the complex and multidisciplinary treatment of gender dysphoria [1]. The gGAS typically offered to them is phalloplasty or metoidioplasty, both of which can be performed with or without urethral lengthening (UL). If the ability to void in standing position is desired, UL during gGAS

is mandatory [2, 3]. In our institution, between 2004 and 2018, 66% of transgender men underwent gGAS with UL [4].

After gGAS with UL, the neourethra consists of the native, fixed, and pendulous urethra, as shown in Figure S1. The anastomosis between the native and fixed urethra is the proximal urethral anastomosis (PUA), situated at the

perineal–scrotal junction. After phalloplasty, the additional anastomosis between the fixed and pendulous urethra is the distal urethral anastomosis (DUA), located at the peno–scrotal junction. These urethral anastomoses are generally the location of strictures or fistulae after gGAS with UL, with incidence rates of 22–75% and 25–58%, respectively [5]. These complications can cause physical and emotional burden due to required re-operations, prolonged indwelling transurethral or suprapubic catheters, and limitations in social activities [6].

To reduce the incidence of urological complications in our institution, changes have been made in the surgical algorithm of gGAS over recent years. Since 2009, a colpectomy has been mandatory in our institution before gGAS with UL [7]. Subsequently, a reduction in urethral fistulae was observed [7]. Additionally, during gGAS with UL, the PUA is covered with multiple layers of well-vascularised surrounding tissue, including the bulbospongiosus muscle [8]. Nevertheless, urethral strictures still occur frequently, especially at the DUA [5].

Urethral strictures occur due to a compromised vasculature at the urethral anastomosis or postoperative kinking of the neourethra at the peno–scrotal junction [9, 10]. Surgical modalities for urethral strictures in transgender men are derived from treatment options in cisgender men, and the choice of treatment is based on stricture characteristics and surgeon's expertise [9,10]. Complicated urethral strictures (e.g. more scarred, recurrent, infectious, or located in less vascularised periurethral tissue) may require more extensive surgical modalities [10]. The following surgical treatments, ordered by severity, are described in the literature:

- Transurethral treatment options: urethral dilatation or direct visual internal urethrotomy (DVIU) according to Sachse, used in short urethral strictures (mostly ≤1 cm), are rarely successful in the long term for transgender men [9,11]. However, these treatment options can be used as a temporary solution before definitive surgery [11].
- Heineke-Mikulicz procedure (HMP): after longitudinal incision over the ventral side of the urethral stricture, the incision is closed transversely causing the urethral diameter to enlarge without excising the urethral stricture and compromising the vasculature [10]. Recurrence rates described after a HMP, performed in short urethral strictures (<1.5 cm) are 42% after phalloplasty [10] and 33% after metoidioplasty [12].
- Excision and primary anastomosis (EPA): after excision of a urethral stricture up to 2.5 cm, the two urethral ends are mobilised and spatulated, and a urethral anastomosis is made [10,13]. Recurrence rates reported after phalloplasty are 43% [10,13].

- Single-stage full-thickness skin graft or buccal mucosa graft (BMG) urethroplasty: the urethra is incised ventrally and dorsally at the stricture site, and BMG or a full-thickness skin graft is harvested and sutured as a dorsal inlay into the incision [5]. Graft urethroplasties used in long (≥1.5 cm) or complicated strictures show recurrence rates after phalloplasty ranging from 0% to 50% [10,14–16].
- Pedicled flap urethroplasty: after opening the urethra at the stricture site with or without excision of the stricture, a local pedicled flap is harvested and sutured into the urethra [10,12]. This treatment option is used in long (≥1.5 cm) or complicated strictures [10]. After metoidioplasty, one successful pedicled flap urethroplasty is reported in the literature [12]; however, after phalloplasty a recurrence rate of 40% has been described [10].
- Staged urethroplasty: a two-stage technique is performed in long (≥1.5 cm) or complicated strictures according to one of the methods described above [10]. Generally in the first stage, a scrotostomy is created to provide the opportunity for the urethra to heal, and the urethra is tubularised after 3–6 months [6,10,11] Depending on the severity of the urethral stricture, the two-stage technique can be combined with a graft urethroplasty. In a two-stage urethroplasty without graft, an EPA is performed dorsally with creation of a scrotostomy in the first stage, and in the second stage the urethra is tubularised [6,10]. In patients with a local infection during two-stage urethroplasty, a temporary scrotostomy is constructed in the first stage, and in the second stage the stricture is treated, and the urethra is tubularised [6,10]. Recurrence rates in the literature after two-stage urethroplasty are 30% after phalloplasty and 33% after metoidioplasty [10, 12].

In some cases of refractory urethral strictures, the patient refrains from the ability to void in a standing position, and a definitive perineostomy is performed as a final solution [10]. It is possible to create a perineostomy through an incision on the ventral side of the urethra, after which the borders of the urethral incision are marsupialised, or to mobilise and excise the fixed urethra in which an end urethrostomy is created [10].

In 2011, the above-mentioned treatment options for urethral strictures in transgender men were discussed by Lumen *et al.* [10] and an overview showed recurrence rates ranging from 25% to 62%. Over the past decade, alterations in the surgical treatment of urethral strictures have occurred as a result of increased experience and insights, and therefore a more recent overview of success and recurrence rates is useful. The aim of the present study was to assess our results of surgical treatment for urethral strictures in transgender men after gGAS with UL, and to conclude with a treatment algorithm.

Patients and Methods

Study Design

A single centre, retrospective cohort study was conducted at the Center of Expertise on Gender Dysphoria at the Amsterdam University Medical Center, location VUmc, Amsterdam, the Netherlands. Transgender men after gGAS (phalloplasty and metoidioplasty) with UL, who were surgically treated for a urethral stricture or re-stricture between January 2013 and March 2020, were included. Patients were excluded if they had a meatal stenosis only, or were treated conservatively, in the outpatient clinic, or in other centres. The Medical Ethics Committee of the Amsterdam University Medical Center, location VUmc, approved the study protocol (FWA00017598). All the patients provided written informed consent.

Data Collection

The medical charts of the included transgender men were reviewed, and patient demographics (age at gGAS, body mass index, intoxications, medical history), type of flaps used for gGAS (shaft type, neourethra type), and stricture specific data (length, location, diagnostic tests, surgical technique) were collected. If the transgender men had their first stricture before 2013, the data from before 2013 was only used for stricture characteristics and the surgical flowchart and excluded from success rate analysis to avoid selection bias.

Urethral Lengthening

During gGAS, the fixed urethra was constructed by tabularising the inner lining of the labia minora and vulvar vestibular mucosa around an 18-F transurethral catheter. Before 2003, the fixed urethra was constructed using the anterior vaginal wall together with labia minora and vulvar vestibular mucosa. The pendulous urethra was created from a pedicled labia minora flap, a free radial forearm flap (FRFF), or a superficial circumflex iliac artery flap (SCIA), and also tubularised around an 18-F transurethral catheter.

Urethral Strictures

The primary outcomes were the success rates after surgical treatment for urethral strictures, with success defined as 'satisfactory micturition in standing position without obstructive voiding symptoms, no signs of urethral obstruction on retrograde urethrogram (RUG), urethroscopy, or uroflowmetry, or the need for further surgical treatment'. Diagnostic tests for urethral strictures (e.g. RUG, urethroscopy, or uroflowmetry with post-void residual volume) were conducted if transgender men had obstructive voiding symptoms such as hesitancy, poor urinary stream, or incomplete bladder emptying. A urethroscopy was performed to objectify the length and diameter of the stricture in case a RUG was inconclusive or unavailable. A maximum urinary flow rate (Q_{max}) during uroflowmetry of <15 mL/s was considered as obstructive. This threshold for BOO was derived from cisgender men, as no specific thresholds are known for transgender men [17]. A urethral stricture was defined as a narrowing of the urethra that required surgical treatment. The date of initial presentation with complaints was scored as the date of diagnosis. If obstructive voiding symptoms recurred after surgical treatment, diagnostic tests were conducted again. A re-stricture was defined as a stricture recurrence diagnosed at the same location in the urethra as a previously treated stricture requiring surgical treatment. Surgical modalities for urethral strictures were chosen based on stricture characteristics and surgeon's preference. A urethral dilatation, DVIU, and HMP were generally used in short (<1.5 cm) or initial strictures; and graft, pedicled flap, and staged urethroplasties in longer (≥1.5 cm) or complicated (e.g. more scarred, recurrent, infectious, or located in less vascularised periurethral tissue) strictures. An EPA was performed in strictures up to 2.5 cm.

Statistical Analysis

The IBM Statistical Package for the Social Sciences (SPSS®), version 26 (IBM Corp., Armonk, NY, USA) was used for data analysis. Continuous variables were presented as the mean ± standard deviation (SD) if normally distributed and as the median (interquartile range [IQR]) if the distribution was skewed. The Mann–Whitney U-test was used to analyse continuous variables. To compare dichotomous variables, the chi-square test was used in large-sized samples and the Fisher's exact test in small-sized samples. A $P \leq 0.05$ was considered as statistically significant.

Results

Patient and Stricture Characteristics

Of 86 eligible transgender men, 14 were excluded based on missing data due to treatment in other centres or refusal to participate in the research. In total, 72 transgender men with 147 urethral strictures were included in the study. Of 147 urethral strictures (78 [53%] initial strictures and 69 [47%] recurrent strictures), 10 (7%) occurred simultaneously to another stricture at a different location in the neourethra (six [4%] as an initial stricture and four [3%] as a recurrent stricture). The patient and gGAS characteristics are presented in Table 1, and an overview of stricture characteristics is provided in Table 2 [12]. Most of the urethral strictures were visualised on a RUG (108/147, 73%) and located at the DUA (96/147, 65%).

Table 1 Patients' characteristics.

Characteristic	Value
Total number of included patients	72
Age at gGAS, years, mean (SD)	31.3 (8.6)
BMI, kg/m^2, mean (SD)	24.1 (3.4)
Smoking status at gGAS, n (%)	
Yes	9 (12)
No	38 (53)
Quit	25 (35)
Comorbidities, n (%)	
Cardiovascular disease	8 (11)
Diabetes	1 (1)
Colpectomy before gGAS, n (%)	
Yes	61 (85)
Interval with gGAS, months, median (IQR)	12.9 (7.2–26.6)
Type of gGAS, n (%)	
Primary phalloplasty	44 (61)
Secondary phalloplasty	12 (17)
Metoidioplasty	16 (22)
Type of phallic reconstruction, n (%)	
Phalloplasty	56 (78)
FRFF	27 (38)
SCIA	19 (26)
ALT	9 (13)
Fibula flap	1 (1)
Metoidioplasty	16 (22)
Type of fixed urethra, n (%)	
Labia minora and vulvar vestibular mucosa	58 (81)
Anterior vaginal wall	8 (11)
Anterior vaginal wall and vulvar vestibular mucosa	1 (1)
Missing data	5 (7)
Type of pendulous urethra, n (%)	
Labial tissue	33 (46)
FRFF (tube-in-tube)	25 (35)
FRFF (free flap)	6 (9)
SCIA	5 (7)
Free groin flap	1 (1)
Buccal mucosa and labial tissue	1 (1)
Anterior vaginal wall and abdominal pedicled flap	1 (1)
Follow-up, months, median (IQR)	61.0 (24.5–201.8)
Interval between gGAS and first stricture, months, median (IQR)	3.4 (2.0–27.0)
Interval between stricture treatment and re-stricture, months, median (IQR)	4.6 (1.6–20.5)

ALT, anterolateral thigh flap; BMI, body mass index.

Table 2 Stricture characteristics (*n* = 147).

	After phalloplasty (%)	After metoidioplasty (%)
Number of urethral strictures	107	40
Stricture rate divided per type of gGAS		
Metoidioplasty	–	40 (100)
FRFF	58 (54)	–
SCIA	26 (24)	–
ALT	18 (17)	–
Fibula flap	5 (5)	–
Treatment before January 2013	12 (11)	8 (20)
Treatment after January 2013	83 (78)	32 (80)
Waiting for treatment	12 (11)	–
Diagnostic test used		
RUG	67 (62)	14 (34)
Urethroscopy	7 (7)	9 (23)
RUG and urethroscopy	18 (17)	9 (23)
Other*	15 (14)	8 (20)
Stricture location		
Native urethra	–	–
PUA	8 (8)	6 (15)
Fixed urethra	7 (7)	7 (18)
DUA	77 (71)	19 (47)†
Pendulous urethra	15 (14)	8 (20)
Stricture length, cm		
<0.5	43 (40)	17 (43)
0.5–1.4	27 (25)	10 (25)
1.5–2.4	13 (12)	3 (7)
≥2.5	24 (23)	10 (25)

*Multifocal strictures are scored separately. ALT, anterolateral thigh flap. *Inability to catheterise, clinical presentation, or uroflowmetry. †Urethral strictures visualised at the penoscrotal angle after metoidioplasty were scored as strictures at the DUA, in accordance with previous literature [12].*

Success Rates

From January 2013 to March 2020, 104 surgical treatments for urethral strictures were performed, with an overall success rate of 63% (57% after phalloplasty, 76% after metoidioplasty, Fig. 1). The success rate after treatment of initial urethral strictures was comparable with the success rate after subsequent interventions (38/56 [68%] vs 27/48 [56%]; *P* = 0.22). The surgical treatment options and corresponding success rates divided into four categories of stricture length are presented in Fig. S2.

For the treatment options generally used in short (<1.5 cm) or initial urethral strictures, the highest success rate was observed after a HMP (six of seven cases) compared to DVIU (seven of 19, 37%) and urethral dilatation (zero of one) (*P* = 0.03). After an EPA, used in urethral strictures up to 2.5 cm, a success rate of 20/37 (54%) was observed. For treatment options in long (≥1.5 cm) or complicated urethral strictures, a two-stage with graft was successful in four of six cases, two-stage without graft in 10 of 12, pedicled flap urethroplasties in 11 of 15 (73%), and single-stage graft urethroplasties in seven of seven. Furthermore, of all treatment options, the largest difference in success rates between the phalloplasty and metoidioplasty group was observed after an EPA (13/28 [46%] vs seven of nine; *P* = 0.14).

An interval analysis between consecutive operations was conducted to describe what time interval provided the highest success rate in patients with an interval up to 1 year. The median (IQR) follow-up time after a successful surgical treatment was 24 (13–45) months. The interval between gGAS and first stricture treatment was comparable for patients with a successful and unsuccessful treatment, at a median (IQR) of 200 (98–268) vs 195 (123–251) days

Fig. 1 Success rates of different surgical treatment options after phalloplasty and metoidioplasty, performed between January 2013 and March 2020 (n = 104) *Two full-thickness skin grafts from the groin (one successful) and two BMGs (one successful). †Eight EPAs dorsally, scrotostomy and tubularised in the second stage (six of eight successful), and four scrotostomies due to infection and tubularised in the second stage (all four successful). ‡One successful full-thickness skin graft from the groin. §12 scrotal flaps (10/12 successful) and three penile skin flaps from the neophallus (one of three successful). #Two successful two-stage BMG urethroplasties. ¶Six successful single-stage BMG urethroplasties.

Success Rates after Stricture Treatment in Phalloplasty

Success Rates after Stricture Treatment in Metoidioplasty
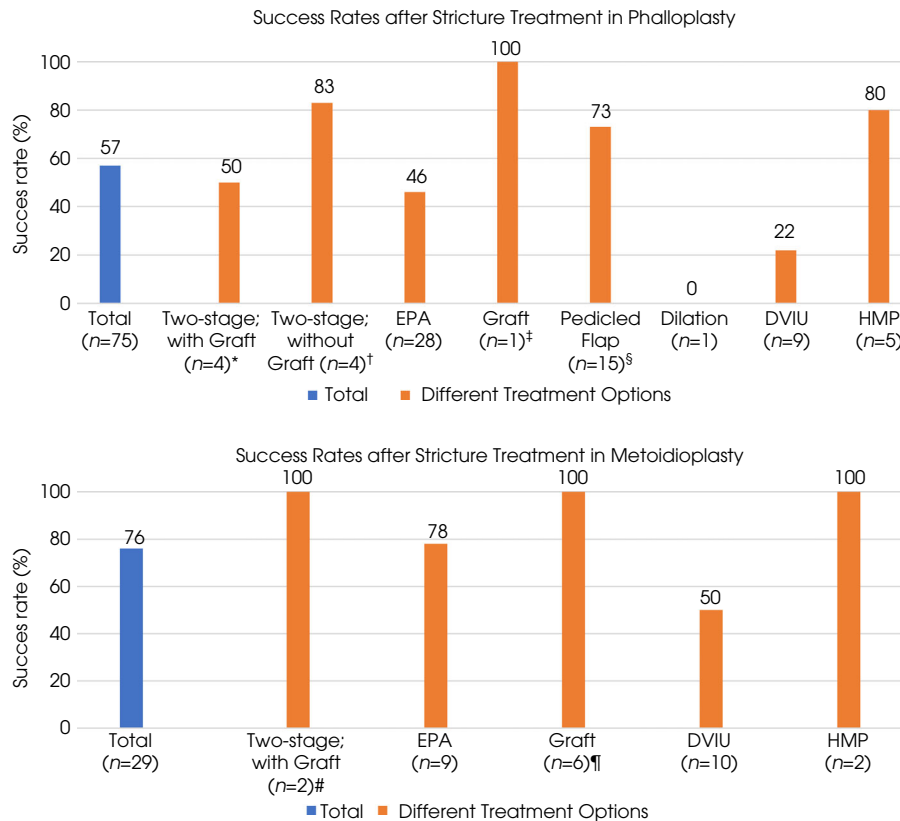
($P = 0.99$). The interval between the first and second stage of a two-stage urethroplasty was comparable as well, at a median (IQR) of 216 (149–287) vs 272 (233–323) days ($P = 0.24$). The interval between two consecutive stricture treatments was significantly longer for transgender men who had a successful stricture treatment compared to patients with a recurrence, at a median (IQR) of 260 (151–304) vs 124 (69–163) days ($P = 0.001$).

Treatment Over Time

Over the last 7 years, shifts have occurred in the choice of treatment, as shown in Fig. 2. The number of DVIU has decreased and there has been an increase in two-stage and graft urethroplasties. Furthermore, overall success rates per year have improved over time, with success rates of 38% and 36% in 2013 and 2014, to 71% and 73% in 2018 and 2019, respectively.
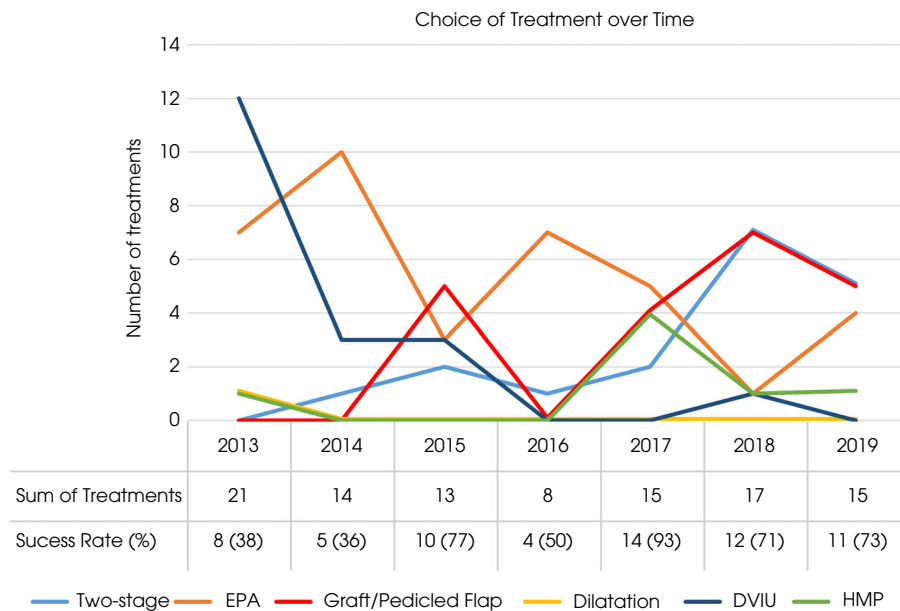
End-stage

Figure S3 provides the surgical flowchart of all transgender men included in the study ($n = 72$). At last follow-up, 50 of the 72

patients (69%) were able to void while standing, 35/56 (63%) after phalloplasty and 15/16 (94%) after metoidioplasty. Voiding while standing was achieved after one (60%), two (20%), three (6%), four (8%), five (4%), or seven (2%) procedures. Seven of these transgender men (10%) needed additional self-dilatation, ranging from once a day to once every 2 months.

Of the 22 patients (31%) unable to void while standing, 10 (14%) were waiting for surgical treatment, and so had not yet reached end-stage. Two patients (3%) sat to void despite good urodynamic function. In the last 10 patients (14%), a definitive urethrostomy was performed, eight (11%) after phalloplasty and two (3%) after metoidioplasty.

Treatment Algorithm

Based on previous literature, stricture characteristics, and the results of our study, we have provided a surgical treatment algorithm (Fig. 3). Treatment options were divided for patients after phalloplasty and metoidioplasty, and for shorter, relatively simple urethral strictures; and longer, more complicated (e.g. more scarred, recurrent, infectious, or

Fig. 2 The choice of treatment and success rates per year (2013–2019, *n* = 103).

Choice of Treatment over Time

	2013	2014	2015	2016	2017	2018	2019
Sum of Treatments	21	14	13	8	15	17	15
Sucess Rate (%)	8 (38)	5 (36)	10 (77)	4 (50)	14 (93)	12 (71)	11 (73)

Two-stage — EPA — Graft/Pedicled Flap — Dilatation — DVIU — HMP

located in less vascularised periurethral tissue) urethral strictures.

Discussion

In the present study, we assessed our results of surgical treatment for urethral strictures in 72 transgender men. Between January 2013 and March 2020, an overall success rate of 63% was observed (57% after phalloplasty, 76% after metoidioplasty), with success defined as voiding while standing after stricture treatment. Success rates after treatment of initial or recurrent strictures were comparable (68% vs 56%, *P* = 0.22), and therefore its feasible to perform surgical treatment for recurrent strictures. Over time, an increase was seen in overall success rates per year, with success rates of 38% and 36% in 2013 and 2014, to 71% and 73% in 2018 and 2019. This improvement is likely caused by increased surgical experience, change in treatment preferences, and a more tailored surgical approach based on stricture characteristics; however, this change may be overestimated due to a relatively short follow-up time. Based on our present surgical results and previous literature, we have provided a surgical treatment algorithm for treatment of initial and recurrent strictures. In the following sections, the different surgical modalities for urethral strictures in transgender men are discussed in order of treatment severity.

Urethral Dilatation

Surgical urethral dilatation was only performed once in the period of success rate analysis, and this treatment was unsuccessful. We suggest that surgical dilatation is an outdated technique and should not be used as treatment option in urethral strictures after gGAS in transgender men.

### Direct Visual Internal Urethrotomy (DVIU)

A low success rate was seen in patients after DVIU (37%), generally used in short (<1 cm) urethral strictures, with a comparable result described by Lumen *et al.* [18] (2009) in transgender men after phalloplasty (14/32, 44%). A recent comprehensive review in cisgender men also described a low long-term success rate (10–30%) after DVIU [19], and an even lower success rate in recurrent strictures [18,19]. As a result, DVIU is not advised as a treatment option for urethral strictures in transgender men.

Heineke–Mikulicz Procedure (HMP)

In our present cohort, a HMP was mainly performed in short urethral strictures (<1.5 cm), and the overall success rate was 86%. During a HMP, less mobilisation of urethral tissue is necessary compared to other techniques of urethroplasty, which ensures the preservation of blood perfusion. In addition, the urethra is not completely transected, which may result in less scar tissue, especially at the dorsal side of the urethra. Although a similar result was found by Lumen *et al.* [20] (2010) in cisgender men (nine of 10), success rates in transgender men were lower after phalloplasty (11/19, 58%) [10] and metoidioplasty (two of three) [12]. One possible explanation for this difference is that these transgender men had more complicated strictures preoperatively. We suggest in our treatment algorithm that, in accordance with the

Fig. 3 Urethral stricture treatment algorithm advised time interval between consecutive operations for urethral (re-)strictures of at least 6 months, also in case of a two-stage urethroplasty. *Hesitancy, poor urinary stream, or incomplete bladder emptying. †Maximum flow rate, thresholds for BOO derived from cisgender men. ‡Urethroscopy is performed in case a RUG is inconclusive or unavailable. §Recurrent, refractory, infectious, or more scarred urethral strictures, or located in less vascularised periurethral tissue. #Depending on the severity of a urethral stricture, the two-stage technique can be combined with a graft urethroplasty.
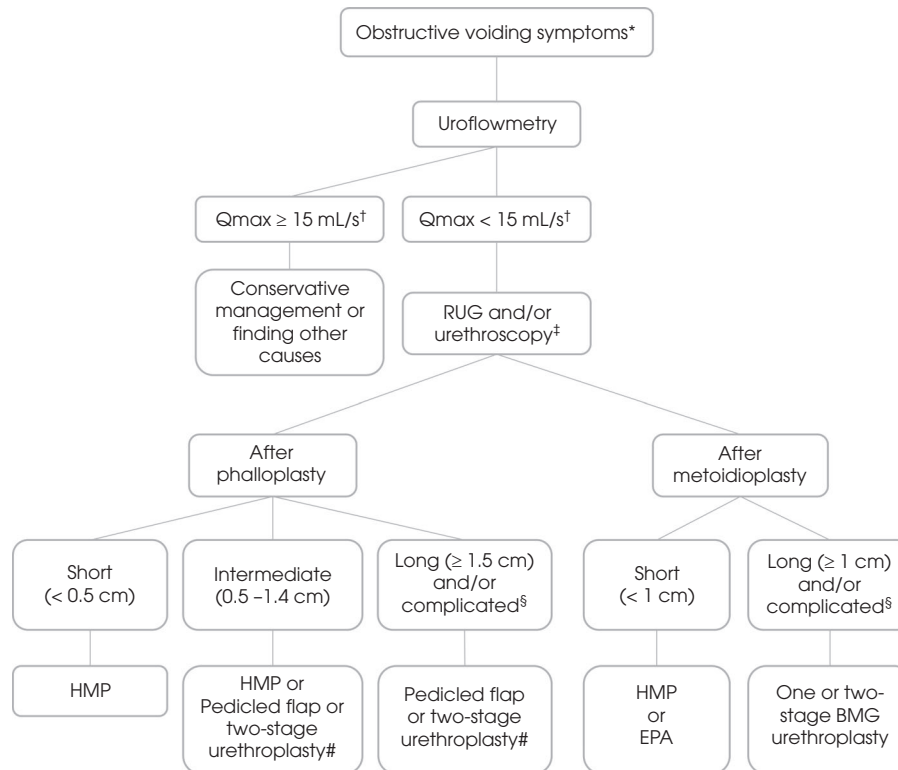
literature, a HMP should only be applied in short, relatively simple urethral strictures after phalloplasty and metoidioplasty [10,12].

Excision and Primary Anastomosis (EPA)

An EPA was most performed in our present study in short and longer urethral strictures (<2.5 cm), with an overall success rate of 54%. Compared to a HMP, which was mainly performed in short urethral strictures (<1.5 cm), the difference in success rates may also be biased due to the patency of urethral strictures. While pinpoint strictures can be treated with an EPA or other techniques of urethroplasty, there is a necessity for a partially patent urethra in a HMP. This clinical difference in severity of urethral strictures may influence the outcome of success rate analysis. A comparable success rate (57%) after an EPA was found in recent literature with patients following phalloplasty [10,13]. In our present study, there was a non-significant difference in success rates between patients after phalloplasty (46%) and metoidioplasty (78%). This difference may be caused by the inability to mobilise urethral ends during surgery (especially in the pendulous urethra) and the degree of blood perfusion in the periurethral tissue that affects the recovery [9,11]. In all patients, a slight decrease in performed EPA urethroplasties was noted over the years (Fig. 2), due to change in treatment preferences based on success rates. We recommend that an EPA is only performed in short (<1 cm) and relatively simple urethral strictures after metoidioplasty and is not used as a treatment option after phalloplasty.

Graft and Pedicled Flap Urethroplasty

In longer and more complicated (e.g. more scarred, recurrent, infectious, or located in less vascularised periurethral tissue) strictures, graft, pedicled flap or two-stage urethroplasties were performed. A BMG was performed more often in patients after metoidioplasty, with a success rate of six of six. After metoidioplasty, less local tissue is available for a pedicled flap, and the fixed and pendulous urethra are better vascularised for augmentation with a graft, which is sutured as a dorsal inlay on the well-vascularised tunica of the clitoral body [12]. Accordingly, BMG urethroplasty is recommended for longer and more complicated strictures after metoidioplasty. A pedicled flap was used more often in patients after phalloplasty, with a success rate of 11/15 (73%).

After phalloplasty, the periurethral tissue might be less vascularised, and due to the absence of corpus spongiosum, coverage after urethroplasty is difficult [9,10]. Therefore, a well-vascularised pedicled local flap is thought to improve the chance of success after phalloplasty and is advised as a treatment option for longer and more complicated strictures after phalloplasty [10].

Two-stage Urethroplasty

A two-stage urethroplasty was performed more frequently after phalloplasty compared to metoidioplasty. We consider that due to the degree of vascularisation, urethral rest (at least 6 months) after stricture treatment in phalloplasty can improve healing and reduce the recurrence rate. In patients after phalloplasty, a two-stage urethroplasty was done with (four cases, successful in two) or without (12 cases, successful in 10) a graft. This difference in success rate may be caused by the severity of strictures preoperatively. More complicated strictures (e.g. more scarred, recurrent, infectious, or located in less vascularised periurethral tissue) require the use of a graft more often. After metoidioplasty, two patients underwent a two-stage urethroplasty with graft, which was successful in both cases. As a considerable number of transgender men need more than one surgical treatment for longer or more complicated urethral strictures, a shift towards a two-stage treatment is preferable, especially after phalloplasty. Although voiding while sitting may be a temporary setback, an additional benefit is that during this period transgender men have a normal urodynamic function without prolonged indwelling catheters, self-dilatation or limitations in social activities. Relatively high success rates after two-stage urethroplasty were also reported in the literature after metoidioplasty (67%) [12] and phalloplasty (70%) [10]. Due to the high success rates, a subsequent increase in two-stage and graft urethroplasties was observed over time (Fig. 2). Therefore, a two-stage urethroplasty is recommended in the treatment of longer and more complicated strictures after phalloplasty. Furthermore, a BMG urethroplasty after metoidioplasty can be performed in two stages as well, depending on the severity of the stricture.

End-stage

In our present study, the number of patients able to void while standing at end-stage was higher after metoidioplasty than after phalloplasty (94% vs 63%). As stated above, a difference in vascularisation of the flaps used during gGAS and the periurethral tissue may result in higher success rates after stricture treatment in metoidioplasty compared to phalloplasty (76% vs 57%) [9, 10]. In addition, stricture characteristics (e.g. density of scar tissue and stricture length) probably differ between patients after phalloplasty or

metoidioplasty, as different surgical techniques and flaps are used during gGAS.

Treatment Interval

The interval between two consecutive stricture treatments was significantly longer for patients with a successful outcome, and therefore with the ability to void while standing (median [IQR] of 260 (151–304) vs 124 (69–163) days, $P = 0.001$). As opposed to our present results, a previous study by Lumen *et al.* [18] (2009) observed a higher success rate after a longer interval between gGAS and first stricture treatment. The patients benefit from a longer recovery time and subsequently less inflammatory tissue is present during a subsequent surgical treatment [11,18,21]. Therefore, in accordance with recent literature, it is suggested to wait at least 6 months after the previous surgery to perform a surgical treatment for a urethral stricture or re-stricture after gGAS in transgender men [11, 18, 21].

Strengths and Limitations

Strengths of the present study are the long-term follow-up, and that multiple treatment options are discussed, which gives a representative overview of different surgical treatment options available. One of the limitations is that further subgroup analyses are challenging due to the negative effect of the sample size. A useful sub-analysis would be to compare the location of urethral strictures for different treatment options with their success rates, which could be done in future studies. Additionally, certain information regarding stricture characteristics or the decision-making process could not be retrieved due to the retrospective nature of the study. In particular, the exact stricture length, which was often lacking in the imaging or operation report, would have provided additional information regarding the severity of urethral strictures. It should also be mentioned that some level of heterogeneity is present in our present study, which is something to keep in mind during comparison of groups. Finally, no patient-reported outcomes are scored, which would have added some perspective to the surgical data.

Conclusions

Shifts in treatment preferences for urethral strictures in transgender men have led to an improved success rate over the years. The highest success rates were seen after a HMP in short urethral strictures; and after graft, pedicled flap, or two-stage urethroplasties in longer or more complicated urethral strictures. Success rates were higher in patients after metoidioplasty compared to phalloplasty, and in patients with a longer interval between two consecutive stricture treatments. According to our present study, transurethral treatment options (e.g. DVIU and urethral dilatation) should no longer be performed for urethral strictures in transgender

men. We concluded with an advised surgical treatment algorithm based on previous literature, stricture characteristics, and our surgical outcomes. At end-stage, most transgender men were able to void while standing (69%), although in some multiple surgical procedures were necessary to accomplish this.

Disclosure of Interest

The authors report no conflicts of interest.

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Abbreviations: BMG, buccal mucosa graft; DUA, distal urethral anastomosis; DVIU, direct visual internal urethrotomy; EPA, excision and primary anastomosis; FRFF, free radial forearm flap; gGAS, genital gender-affirming surgery; HMP, Heineke–Mikulicz procedure; IQR, interquartile range; PUA, proximal urethral anastomosis; Q_{max}, maximum urinary flow rate; RUG, retrograde urethrogram; SCIA, superficial circumflex iliac artery flap; UL, urethral lengthening.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Fig. S1. Retrograde urethrogram in a transgender man after phalloplasty with a urethral stricture at the DUA. A, meatus; B, catheter; C, air bubbles; D, urethral stricture.
Fig. S2. Surgical treatment options and corresponding success rates in percentages, categorised by stricture length ($n = 104$). *Two-stage without graft. †Two-stage with graft.
Fig. S3. Surgical flowchart of all included transgender men ($n = 72$). Every step in the flowchart corresponds to a consecutive surgical treatment for urethral strictures. *Waiting for second-stage urethroplasty.