Validation of Robotic-assisted Ureteroplasty with Buccal Mucosa Graft for Stricture at the Proximal and Middle Ureters: The First Comparative Study

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Abstract

Although ureteroplasty with buccal mucosa graft for long-segmental ureteral stenosis has been developed long ago, evidence was still restricted to case series in published literature. This study aims to validate ureteroplasty with buccal mucosa graft (BMG) in long-segment stricture at the proximal and middle ureters under designed comparative methods. From April 2015 to January 2019, we performed robotic-assisted ureteroplasty with BMG with a two-phase design and compared ureteroplasty and BMG (phase 2 surgery) with endoscopic stenting (phase 1 surgery). Paired data of effective renal plasma flow (ERPF), glomerular filtration rate (GFR), hydronephrosis grade, and physical and psychological domains of the World Health Organization Quality of Life (WHOQOL)-BREF were compared. A total of 29 patients were enrolled, and only three (10%) patients had hydronephrosis resolution after treatment with endoscopic stenting ($p = 0.250$ to baseline). Compared to endoscopic ureteral stent, Hedges' g of ureteroplasty with BMG was 0.56 (95% CI: 0.43-0.69), 0.63 (95% CI: 0.46-0.80), 0.80 (95% CI: 0.56-1.04), and 1.06 (95% CI: 0.69-1.43) in EGFR, GFR, physical domain of WHOQOL-BREF, and psychological domain of WHOQOL-BREF, respectively (All significance; $p<0.001$). After 12-month follow-ups, no recurrence of stricture was reported. In conclusion, Robotic-assisted ureteroplasty with BMG onlay is efficient in reconstruction of long-segment stricture of the proximal and middle ureters.

1. Introduction

Ureteral stricture is always a challenge to a urologist, and no one unified management can be applied to various situations. Generally, urologists would choose managements based on the location and length of the diseased ureters. Most urologists will consider conservative treatments in the first place when managing the stricture, such as long-term indwelling of ureteral stents, balloon dilation, or endoscopic incision. However, conservative endoscopic treatments only provide limited improvement and require periodic clinical visits. For example, long-term indwelling of ureteral stent will gather biofilms, causing urinary tract infection, or constitute encrustations, forming calcifications or even stones requiring lithotripsy [1]. These complications are not infrequent and compromise patients' quality of life [2].

Unlike conservative treatments, meticulous surgery is considered the only method to resolve problems, especially for those with complicated conditions refractory to conservative treatments. Categorized by locations, reimplantation or Boari flap Psoas hitch will be considered firstly in the reconstruction at the distal end of the ureter [3], and pyeloplasty, ureteroureterostomy, ~~or~~ transureteroureterostomy or Boari flap [3] will be preferably selected in the reconstruction at the uerteropelvic, proximal, or middle part of the ureter, respectively. Regardless of the operations performed, the ultimate goals of reconstruction are to achieve a tension-free anastomosis and absence of leakage from the repaired sites. However, the situation will become complicated when long-segment reconstruction is needed at the proximal and middle parts, which might require bowel interposition or mobilization of the ureter or kidney. However, when there is adequate lumen in a diseased ureter, reconstruction might be carried out with a graft onlay on a simple incision or an augmented defect. This does not need interposition of the bowel or transposition of the kidney and might benefit patients with least morbidities [4]. Open reconstruction has been performed as a major surgery in this territory, but minimally invasive surgery has emerged and gains increasing interest, especially robotic-assisted reconstruction featuring three-dimensional augmented visual field and ease of suturing at any angle and position [5].

Among choices of graft reconstruction, the most discussed autologous ones originated from the oral cavity, preputial skin, bladder urothelium, ileal graft, and appendiceal graft. An ideal tissue graft has various features, and the most important feature is an adequate vascularity essential to its nourishment. In the oral cavity, the buccal mucosa renews on its own, with a quick cell turnover of approximately 25 days [6]. It has a thick non-keratinized epithelium and abundant vascularity, releasing an anastomosis loop into the papillae. These inherent characteristics make the buccal mucosa a potential alternative for grafting. In previous studies [7], which are predominantly case series, 12 of 20 studies adopted oral mucosa as an autologous graft, and 11 of them took the mucosa from the buccal region. Eight of them had a success rate of 100% under various observation periods [7]. However, none of these case series have compared conservative strategies with the use of buccal mucosa graft (BMG). Thus, in this study, we designed a two-phase comparison between endoscopic stenting and ureteroplasty with BMG to illustrate the difference between these two methods.

2. Materials And Methods

2.1 Patients

From April 2015 to January 2019, this study had enrolled patients experiencing non-malignant ureteral stricture at the proximal and middle portions. For the optimal quality of the buccal mucosa, specialists were consulted to ensure oral hygiene. Cigarette smokers consulted specialists to modify their habits during the perioperative period. Severity was categorized into smoking index (SI), which was obtained by multiplying the number of daily cigarettes smoked and years of smoking. Smokers were required to stop smoking from 4 weeks before surgery to 4 weeks after surgery. Tailored strategies were made to each patient, and carbon monoxide (CO) was monitored to be <5 parts per million (ppm) in the interval of 2 days at clinics or on admission.

The location of the stricture was initially assessed by retrograde pyelography and computed tomography urography (CTU), and a fixed two-phase protocol (Fig. 1) was applied to each patient. Hydronephrosis was assessed by sonography during the study period and monthly clinical visits after removal of the ureteral stent at phase 2. CTU was arranged every 6 months for 1 year after removal of the ureteral stent at phase 2.

2.2 Assessment

The Society of Fetal Urology (SFU) grading system was interpreted by a urologist in a single-blinded fashion, and hydronephrosis SFU grade <2 was defined as successful resolution [8]. Effective renal plasma flow (ERPF) and glomerular filtration rate (GFR) were used to assess renal function. As regards the quality of life (QoL), we used World Health Organization Quality of Life (WHOQOL)-BREF [9] Taiwan version for subjective assessment, and physical and psychological domains were extracted for analysis across different phases. Baseline data were measured before the patients entered phase 1 of endoscopic stenting.

2.3 Surgical techniques and postoperative care

In the phase 1 of endoscopic treatment, a 6-French (Fr) stent of 24–26 cm long was indwelled for 6 months. During the stent-free period between phase 1 and phase 2, oral analgesics were prescribed for symptomatic treatment. Percutaneous drainage was only considered when flank pain was refractory to medication or kidney injury warranting diversion. During reconstruction, patients were placed in the lateral modified lithotomy position, allowing simultaneous cystoscopy or ureteroscopy. Reconstruction by robotic-assisted ureteroplasty was performed using the da Vinci system (Intuitive Surgical, Sunnyvale, CA, USA), either Si or Xi. Port placement resembled that of pyeloplasty, and a total of three arms, including one camera port, were docked. In addition, one 12-mm trocar was inserted as the assistant port (Supplement 1).

The overall surgical steps were modified from the previously published literature [10], and the surgical approach in this study is demonstrated in Fig. 2. However, not all procedures were modified and unified. Methods on identifying the stricture were fully dependent on the preference of the attending urologists. Some urologists preferred intraoperative ureteroscopy with near-infrared light identified by robotic system, while others preferred intra-ureteral injection of indocyanine green (ICG, 10 ml and 2.5 mg/ml). Some would place a ureteral stent to the stricture part right before the reconstruction, but others would not. The actual length of the stricture was measured by an intra-abdominal ruler introduced by the assistant port, and BMG was harvested by an oral and maxillofacial surgeon. The harvested BMG was matched with the length of the diseased ureter and of approximately 1.5 cm in width. Ideally, intravenous administration of ICG was used to assess viable tissues wrapping the BMG, but this was also dependent on the preference of the attending urologists.

A 6-Fr ureteral stent was placed across the reconstruction, and drainage was placed around the reconstruction at completion of the procedure. Ureteral stent can be placed through either retrograde or antegrade fashion and was freely decided by the attending urologists. Urethral catheters were also placed after the procedures. Postoperatively, the amount of fluid and creatinine from the drainage bags were monitored for 3 days. After confirming no suspicious of leakage from reconstructed ureter, drainage tubes and urethral catheter were removed, and patient discharge was arranged.

2.4 Statistical methods

Nonparametric methods and standardized mean difference were performed by using the STATA 17.0 (StataCorp. 2021. College Station, TX: StataCorp LLC.). The acceptable rate of type 1 error was 5%, and significance was corrected using the Holm–Sidak method.

3. Results

3.1 Descriptive data of all patients

There were four patients choosing ureteral stents only and refusing to proceed with reconstruction, and thus they were counted as drop-outs in this study. The general background of included patients are listed in Table 1. Seven smokers were enrolled, and they had SI < 400. All of them were able to maintain CO < 5 ppm in 4 weeks before and after the surgery. In the stent-free period between phase 1 and phase 2, no percutaneous drainage was performed to alleviate the hydronephrosis.

Table 1

Descriptive results for all participants. [a] Standard deviation [b] Interquartile range [c]American Society of Anesthesiology [d] Indocyanine green

	n=29
Gender (n; %)	
Male	16 (55%)
female	13 (45%)
Age (years old; mean ± SD[a])	50.6 ± 9.6
	(median:49.0; IQR[b]: 12.0)
BMI (kg/m^2; mean ± SD[a])	24.8 ± 4.1
	(median:25.0; IQR[b]: 4.5)
Smoker(n; %)	7 (24%)
Smoking Index (mean ± SD[a])	178.57 ± 74.26
	(median:150.00; IQR[b]: 130.00)
Carbon monoxide concentration in perioperative periods (ppm; mean ± SD[a])	2.74 ± 1.28
	(median:3.50; IQR[b]: 2.60)
Type-2 diabetes mellitus (n; %)	3 (10%)
Glycated hemoglobin (%;mean ± SD[a])	7.10 ± 0.20
	(median:7.10; IQR[b]: 0.20)
Reasons of stricture	
Previous laparoscopic surgery	9 (31%)
Previous endoscopic surgery	15 (52%)
Previous anastomosis for traumatic injury	2 (7%)
Inborn defects	1 (3%)
Previous radiation therapy	2 (7%)
ASA[c] grade (n; %)	
1	1 (3%)
2	25 (87%)
3	3 (10%)
Side of diseased ureter (n; %)	
Right	13 (45%)

Left	16 (55%)
Site of disease ureter (n; %)	
Ureteropelvic Junction	4 (14%)
Proximal	13 (45%)
Middle	12 (41%)
Previous reconstruction (n; %)	
No	26 (90%)
Ureteroureterostomy	
Right	2 (7%)
Left	1 (3%)
Length of reconstructed ureter (cm; mean ± SD[a])	3.7 ± 1.4 (median: 3.1; IQR[b]: 1.6; range: 2.0-7.0)
ICG[d] (n; %)	
Intravenous	23 (79%)
intraureteral	6 (21%)
Surgical techniques (n; %)	
Incision with BMG onlay	
Dorsal	3(10%)
Ventral	20 (69%)
Augmented reconstruction with BMG onlay	
Dorsal	0 (0%)
Ventral	6 (21%)
Blood supply (n; %)	
Omentum	26 (86%)
Perirenal fat	4 (14%)
Console time (minutes; mean ± SD[a])	162.3 ± 53.8 (median: 161.0; IQR[b]: 56.0)
Blood loss (ml; mean ± SD[a])	23.6 ± 20.2 (median: 20.0; IQR[b]: 20.0)

Intraoperative conversion (n; %)	0 (0%)
Perioperative adverse effects (n; %)	0 (0%)

A median length of 3.1 cm was repaired. Most of the procedures were performed with incision with BMG onlay, and only six were performed with augmentation. Most of the attending urologists chose omental tissue to wrap the BMG after intravenous assessment of the vasculature. In four cases, perirenal fat wrapping was chosen for the diseased ureters at the ureteropelvic junction. Neither intraoperative conversion nor perioperative adverse effects occurred.

3.2 Primary Outcomes

Hydronephrosis grade, ERPF, GFR, and physical and psychological domains of WHOQOL-BREF are shown in Table 2. Comparisons of data with Holm–Sidak method are presented Table 3. Only one (3%) case was unable to achieve grade < 2 hydronephrosis by sonography 6 weeks after ureteral stent removal in phase 2. This patient had an SI of 300 and glycated hemoglobin of 7.1% before the surgery. Additional intravenous pyelography and ureteroscopy were carried out, and moderate tissue swelling at the repaired site was noted. A 6-Fr width and 26-cm length ureteral stent was indwelled after ureteroscopy for 1 month, and the hydronephrosis disappeared after the ureteral stent was removed. There was gradual resolution of hydronephrosis as shown in the CTU performed every 6 months for 1 year. The other 28 (97%) patients achieved hydronephrosis grade < 2 based on sonographic examination performed 6 weeks after the ureteral stent was removed and were assessed to maintain resolution of hydronephrosis by CTU performed every 6 months for 1 year.

In the analysis of ERPF, GFR, and physical and psychological domains of WHOQOL-BREF, although both endoscopic stenting and ureteroplasty with BMG could offer significant benefits to our patients, the latter could improve the conditions of the patients more significantly. The effective sizes of ureteroplasty with buccal mucosa graft were demonstrated in the Figure 3, and a similar trend was observed in these two comparisons. Although there were the greatest values in psychological domain of WHOQOL-BREF, the precisions were the worst. In contrary, although there were the least improvements in ERPF, the precisions were the best.

Table 2

Comparison of variables across two therapeutic phases. [a] Cochran's Q test [b] Effective renal plasma flow [c] Standard deviation [d] Interquartile range [e] Friedman test [f] Glomerular Filtration Rate **p<0.001

	Baseline	After phase-1 treatment	After phase-2 treatment	p-value
Hydronephrosis				-
(n; %)				
Grade 1	0 (0%)	0 (0%)	13 (45%)	
Grade 2	0 (0%)	3 (10%)	15 (52%)	
Grade 3	16 (55%)	20 (70%)	1 (3%)	
Grade 4	13 (45%)	6 (20%)	0 (0%)	
Cumulative successful resolution of hydronephrosis in sonography (n; %)	0 (0%)	3 (10%)	28 (97%)	<0.001[a]**
ERPF[b] (Mean ± SD[c]; ml/min/1.73 m^2)	144.6±56.4 (median: 154.0; IQR[d]:106.6)	159.1±55.6 (median: 168.0; IQR[d]:90.15)	191.0±49.2 (median: 198.6; IQR[d]:71.5)	<0.001[e]**
GFR[f] (Mean ± SD[c]; ml/min/1.73 m^2)	40.78±10.90 (median: 43.21; IQR[d]:13.63)	45.53±9.42 (median: 45.67; IQR[d]:14.15)	51.81±9.87 (median: 51.22; IQR[d]:14.89)	<0.001[e]**
Physical domain score of quality of life (Mean ± SD[c])	10.10±1.00	10.60±1.30	13.00±2.60	<0.001[e]**
Psychological domain score of quality of life (Mean ± SD[c])	9.20±1.00	11.10±1.20	12.70±1.60	<0.001[e]**

Table 3

Significance with Holm-Sidak correction in each variable. [a] McNemar's test [b] Effective renal plasma flow [c] Wilcoxon signed-rank test [d] Glomerular Filtration Rate *p<0.05 ** p<0.001

	p-value
Successful resolution of hydronephrosis in sonography	
Baseline vs After phase-2 treatment	<0.001[a**]
After phase-1 treatment vs After phase-2 treatment	<0.001[a**]
Baseline vs After phase-1 treatment	0.250[a]
ERPF [b]	
Baseline vs After phase-2 treatment	<0.001[c**]
After phase-1 treatment vs After phase-2 treatment	<0.001[c**]
Baseline vs After phase-1 treatment	<0.001[c**]
GFR[d]	
Baseline vs After phase-2 treatment	<0.001[c**]
After phase-1 treatment vs After phase-2 treatment	<0.001[c**]
Baseline vs After phase-1 treatment	<0.001[c**]
Physical domain score of quality of life	
Baseline vs After phase-2 treatment	<0.001[c**]
After phase-1 treatment vs After phase-2 treatment	<0.001[c**]
Baseline vs After phase-1 treatment	0.001 [c*]
Psychological domain score of quality of life	
Baseline vs After phase-2 treatment	<0.001[c**]
After phase-1 treatment vs After phase-2 treatment	<0.001[c**]
Baseline vs After phase-1 treatment	<0.001[c**]

3.3 Postoperative outcomes

All patients had not experienced adverse effects during the admission and treatment periods, and no complications at the donor site were reported.

4. Discussion

Ureteral stricture could have various causes, including iatrogenic origins, such as laparoscopic or endoscopic surgery, and congenital diseases. Although it is not uncommon, the optimal management still depends on the condition of each patient and practice of each urologist. Many urologists will consider conservative treatments, such as long-term ureteral stenting or balloon dilation, but the stricture might recur [11] and require frequent clinical visits, compromising the QoL of the patients. As regards surgery, a stricture length >2 cm may render it difficult to perform a tension-free end-to-end ureteroureterostomy anastomosis, but ureteroplasty with graft onlay might alleviate this concern. The practice of BMG onlay in the reconstruction by ureteroplasty has evolved since more than 20 years ago. However, contemporary literature is still limited to evidence level of case series and no comparative studies were available. These case series included 3–19 cases, and the repaired length ranged from 1.5 to 11 cm [7]. After omitting duplicates, a total of 55 cases have been published since 1999 [7], and four (7%) of them experienced restenosis within 6 weeks to 39 months after surgery. Of these patients, one female patient having visible recurrence 6 weeks after surgery had a history of failed pyeloplasty and the area of narrowing was uncertain during repair, but she achieved stent-free condition after adjunctive balloon dilation [12]. Another recurrence cases included long-segment ureteral stricture, 8 and 11 cm, at the middle-lower site and was treated with pelvic extirpative surgery and adjuvant radiotherapy [12]. In our study, only one (3%) patient was unable to achieve resolution of hydronephrosis 6 weeks after ureteral stent was removed. The stricture length was 2.5 cm and was caused by a previous lithotripsy via ureteroscopy at the middle site of the ureter. However, additional intravenous pyelography and ureteroscopy were carried out to rule out restenosis and the hydronephrosis subsided 1 month after ureteral stenting and did not recur during the follow-up period. Regarding the hydronephrosis after reconstruction with buccal mucosa onlay, since it is an anatomical finding not only specific to obstruction alone but also reflects reflux or persistent chronically dilated collecting system, a hydronephrosis may persist after removing ureteral stents despite no evidence of functional obstruction. To identify the nature of hydronephrosis, CTU or fluoroscopy could be considered first. However, a ureteroscopy to rule out failure of operation is essential. Another important consideration is that hydronephrosis, an anatomical finding, is not always relevant to functional obstruction. Herein, in this study we incorporate ERPF and GFR into analysis, and we suggested other urologists should take anatomical and functional information into account when evaluating restenosis after reconstruction.

Onlay graft used in reconstruction could have other autologous components, such as ileal and appendiceal origins. In 48 cases from published literature of reconstruction with autologous graft other than BMG [7], restenosis occurred in two (4%) cases. However, compared with BMG, complications were difficult to manage, such as ureteral fistula requiring surgical intervention [14]. However, a large-scale comparative study regarding different reconstruction onlay materials is still unavailable, and it is still unclear whether BMG could reduce complications requiring surgical interventions. BMG can be easily harvested from the donor site, and no complications have been reported, except for restenosis at the recipient site. To date, only one patient complained of difficulty in whistling [15].

Correct identification of the narrowing site to be repaired is critical to reconstruction, as failure to do so may lead to postoperative restenosis. Theoretically, the length of the incision, or augmentation, with onlay covering better substitutes for the originally unhealthy length of diseased stricture, or the remaining unhealthy tissue might result in restenosis. A study reported restenosis regarding this reason [12]. A retrospective case–control study [16] found that a stent-free period over 4 weeks could significantly promote successful reconstruction by allowing stricture maturation. In that study, the authors hypothesized that improvement was attributed to the wound healing process and that a hard wire could possibly jeopardize the microvascular environment and consequently impede the inflammatory phase. Clinically, this might obscure the true narrowing segment with the swollen appearance of the diseased ureter when performing reconstruction and subsequently leave unhealthy tissues in place, causing successive restenosis. This theory is applicable to strictures caused by injuries, such as laparoscopic surgery, endoscopic surgery, or radiotherapy. However, some patients might have congenital strictures, and the role of this stent-free period remains unknown. In our study protocol, the stent-free period between two phases was 6 weeks, and the resolution rate of hydronephrosis on sonography was as high as 97%. In this study, majority of the patients experienced secondary injuries, rather than congenital disorders; thus, this stent-free period might contribute to our high successful rate to some extent.

In the assessment of the hydronephrosis grade, we deem SFU grade 2 hydronephrosis as a successful goal. In normal occasions, most nephrons are present in the cortical area, and some parts of the ascending and descending Henle's loop might travel down to the medullary area. As a result, medullary thinning, SFU grade 3 hydronephrosis, might endanger the functions of the nephron. Based on experimental evidences and fluid mechanics, we postulated that the increased pressure resulting from the obstruction would be transported through the renal tubule and finally to Bowman's capsule and glomerular capillary beds, and this process would reduce the GFR [17]. Afterwards, the elevated glomerular capillary pressure further stimulates the release of angiotensin 2, which eventually affects arteriole blood flow [18]. In our participants, although most of our patients initially presented with GFR <60 ml/min, some of their renal blood flow did not drop dramatically. This phenomenon might indicate that although they have grade 3 or grade 4 hydronephrosis anatomically, the microscopic etiology might be still in the early change process. Moreover, experiences demonstrated that SFU grade 1 and grade 2 hydronephrosis have extremely high chance of spontaneous resolution [19].

For an obstructive uropathy, one urgent concern is to judge the necessity to decompress the dilated collecting system. Before one is operated with reconstruction successfully, ureteral stent and percutaneous nephrostomy tube are two options for him/her. Experiences in managing obstructive urolithiasis with acute illness, these two method are both effective and similar to each other [20,21]. However, indwelling a ureteral stent will remarkably decrease the QoL of patients but placing percutaneous nephrostomy tube will not [22]. This implies another issue when choosing ureteral stent other than reconstruction in long-segmental stenosis. For this type of stenosis will anticipate a longer indwelling periods, the impact of QoL of a patient will be considerably huge. In this study, we demonstrate that QoL after reconstruction is more improved than that after indwelling ureteral stents.

To the best of our knowledge, this is the largest validation study of BMG in reconstruction by ureteroplasty. In our experience, reconstruction with BMG could provide better improvements in renal function and image resolution of hydronephrosis than with endoscopic stenting. As regards QoL, ureteroplasty with BMG is associated with subjective improvements than with endoscopic stenting. Although our study was limited by the small sample size, it not only provides comparative results to common clinical practice, but paired data from a two-phase design reveal that our technique could lower the error term from different individuals. By accumulating published literature and results of our study, the overall successful rate is >90%. Cases with inferior outcomes may have other causes and thus should be further evaluated. Moreover, second endoscopic stenting is sufficient for restenosis and no second reconstructions are required. However, a case–control study for comparison with other autologous materials of onlay graft is warranted.

5. Conclusion

Robotic-assisted ureteroplasty with BMG onlay is efficient in reconstruction of long-segment stricture of the proximal and middle ureters. Compared with indwelling ureteral stents, the anatomical parameter, functional parameter and QoL are more improved after operation.

Declarations

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Conflict of interest statement:

The authors declare that there is no conflict of interest.

Availability of data and material:

The authors confirm that the data supporting the findings of this study is available within the article or its supplementary materials.

Author contributions:

Che Hsueh Yang: conceptualization, writing, formal analysis, review, and editing

Yi Sheng Lin: data acquisition

Wei Chung Weng: data acquisition

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Yen Chuan Ou: conceptualization, data acquisition, data curation, review and editing, and project administration

Ethics approval:

The study protocol complied with the Declaration of Helsinki and the corresponding regulations. This study was approved by the local institutional human research committee of Tungs' Taichung MetroHarbor Hospital (IRB No.110021).

Consent for participation:

Verbal informed consents were conducted by project administrator, and written informed consents were signed by the patients if they accepted the contents.

Consent for publication:

I, representing all co-author, give our consent for the publication of identifiable details, which can include figures/tables and any information in the text.

Consent statements

The study protocol complied with the Declaration of Helsinki and the corresponding regulations. This study was approved by the local institutional human research committee of Tungs' Taichung MetroHarbor Hospital (IRB No.110021). Verbal informed consents were conducted by project administrator, and written informed consents were signed by the patients if they accepted the contents.

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Figures

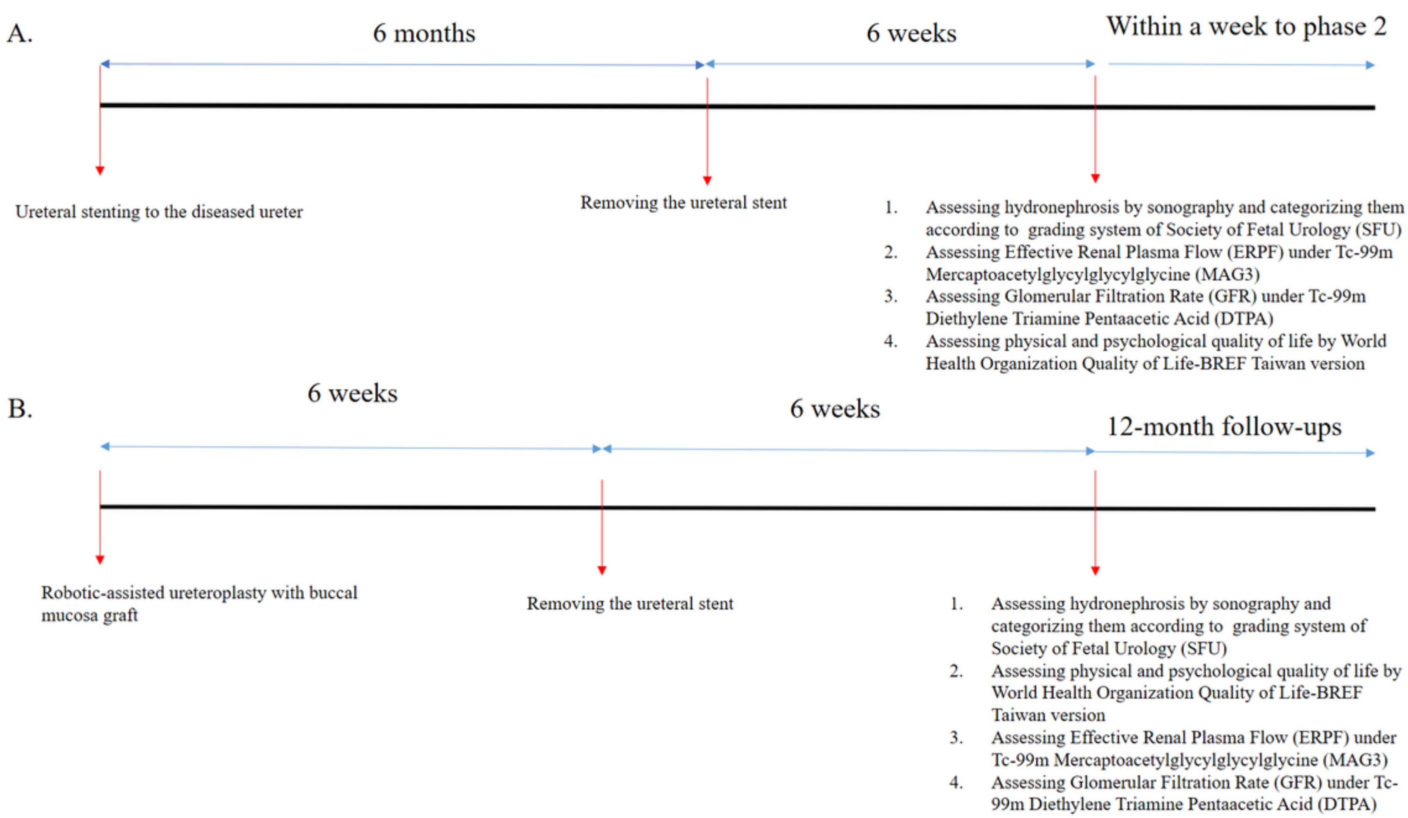

Figure 1

(A)Phase 1 therapeutic course of ureteral stent. (B) Phase 2 therapeutic course of reconstruction with buccal mucosa graft.

Figure 2

Surgical steps of ureteroplasty with buccal mucosa onlay. (A) Diseased ureter was sourced underneath the gonadal vessel. (B) Performing ureterolysis around the diseased ureter. (C) Incising the diseased ureter and measuring the reconstructed length for harvesting buccal mucosa. (D) Indwelling a ureteral stent before onlay covering. (E) After indwelling ureteral stent, buccal mucosa onlay was applied to the incised defect. (F) A continuous watertight suturing was performed to anchor the buccal mucosa onlay.

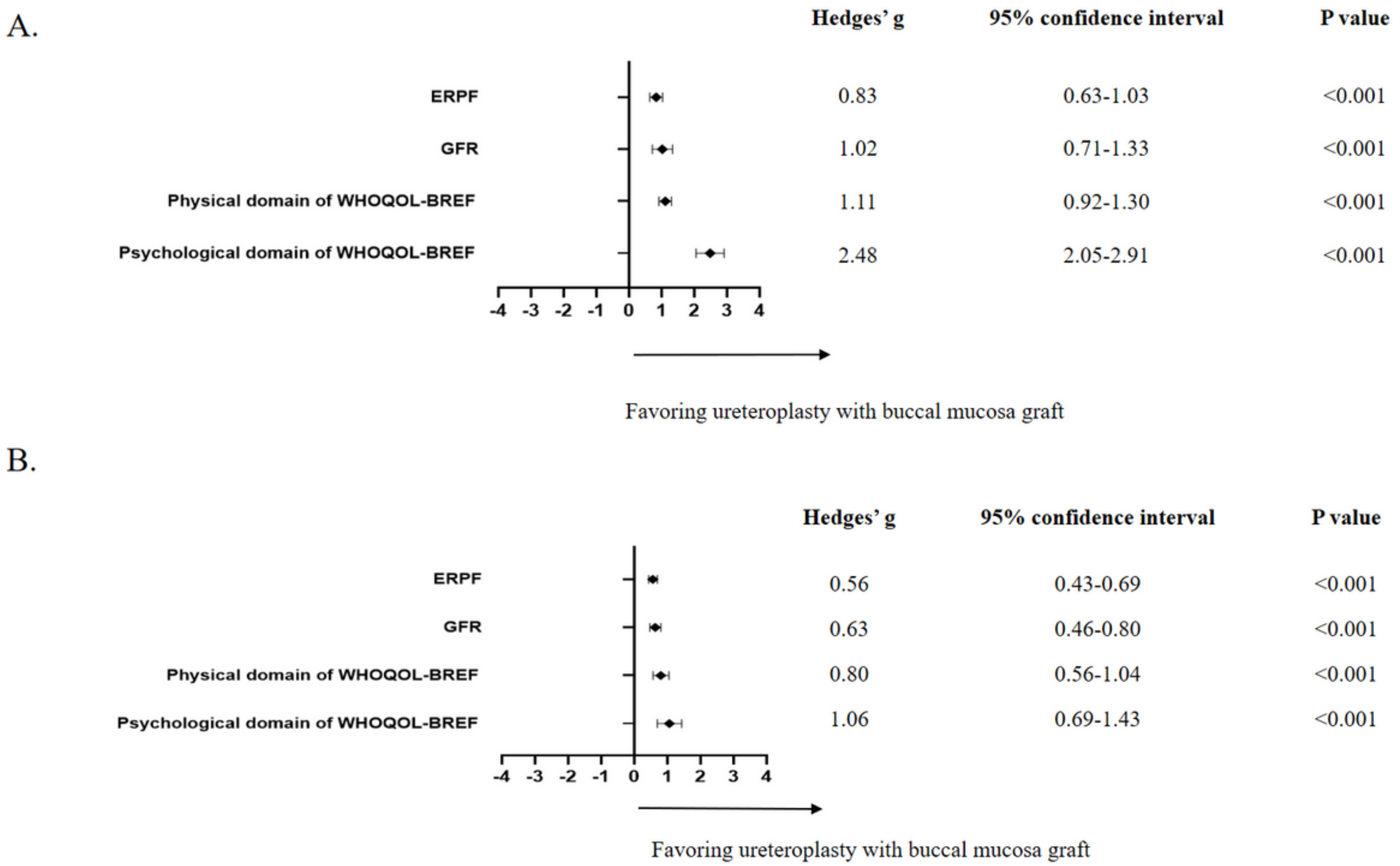

Figure 3

(A) Effective size of ureteroplasty with buccal mucosa graft to baseline. (B) . Effective size of ureteroplasty with buccal mucosa graft to endoscopic ureteral stent indwelling.

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