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Prospective Analysis of Uroflowmetric Changes after Transurethral Resection of the Prostate (TURP)

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Abstract | **Original Research Article**

Introduction: Benign Prostatic Hyperplasia (BPH) is a common condition in aging men, often causing Lower Urinary Tract Symptoms (LUTS) that negatively impact quality of life. Transurethral Resection of the Prostate (TURP) is the gold-standard surgical treatment for patients who fail medical therapy. This study aimed to assess changes in uroflowmetric parameters and correlate them with symptomatic improvement following TURP. ***Methods:*** This hospital-based, prospective, observational study included 80 male patients over 50 years with LUTS due to BPH, who underwent TURP at a tertiary care center in Pokhara, Nepal, between September 2022 and January 2024. Objective parameters, including Maximum Flow Rate (Qmax) and Average Flow Rate (Qaverage), and subjective parameters, comprising International Prostate Symptom Score (IPSS), Quality of Life (QoL), and Post-Void Residual Urine (PVRU), were assessed preoperatively and at one and three months postoperatively. Data were analyzed using repeated measures Analysis of Variance (ANOVA), with $p < 0.05$ considered statistically significant. ***Results:*** The mean age of participants was 69.81 ± 8.25 years. Preoperative Qmax (11.51 ± 2.73 mL/sec) improved to 16.89 ± 3.12 mL/sec at one month and 16.91 ± 2.71 mL/sec at three months ($p < 0.05$). Qaverage increased from 6.93 ± 1.99 mL/sec preoperatively to 10.44 ± 1.99 mL/sec and 11.01 ± 2.05 mL/sec postoperatively ($p < 0.05$). Significant improvements were also observed in IPSS, QoL, and PVRU. ***Conclusion:*** TURP significantly improves both objective (Qmax, Qaverage) and subjective (IPSS, QoL) outcomes in patients with BPH. Uroflowmetry is a simple, noninvasive, and reliable tool for evaluating functional recovery after TURP.

Keywords: Benign prostatic hyperplasia, bladder outlet obstruction, international prostatic symptomatic scores, lower urinary tract symptoms, transurethral resection of prostate, uroflowmetry.

INTRODUCTION

Benign prostatic hyperplasia (BPH) is one of the most prevalent urological conditions affecting aging men, characterized by nonmalignant enlargement of the prostate gland that leads to lower urinary tract symptoms (LUTS). The condition significantly impacts patients' quality of life (QoL), manifesting as both storage symptoms, such as urinary frequency, urgency, and nocturia, and voiding symptoms, including weak urinary stream, hesitancy, intermittency, and incomplete bladder emptying [1]. The incidence of BPH increases steadily with age, with up to 70% of men over 60 years experiencing some degree of LUTS [2].

The primary mechanism underlying LUTS in BPH is bladder outlet obstruction (BOO), caused by progressive prostatic enlargement and increased smooth muscle tone in the prostatic stroma. Although medical therapy with α-blockers and 5α-reductase inhibitors is the first-line approach, many patients eventually require surgical intervention when symptoms persist or complications such as urinary retention, recurrent infection, or bladder stones occur [3,4].

Transurethral resection of the prostate (TURP) remains the gold standard surgical procedure for relieving BOO due to BPH, offering durable symptomatic relief and improvement in urinary flow [5].

Objective assessment of surgical efficacy can be achieved through uroflowmetry, a simple and noninvasive diagnostic test that measures parameters such as maximum flow rate (Qmax) and average flow rate (Qaverage). These quantitative indicators reflect the improvement in urinary flow dynamics following surgical decompression of the bladder outlet [6].

The International Prostate Symptom Score (IPSS) and QoL index serve as validated subjective tools to assess symptom severity and treatment response [7]. Correlating uroflowmetric parameters with these subjective measures provides a comprehensive evaluation of functional outcomes after TURP.

This study aims to assess the changes in uroflowmetric parameters (Qmax, Qaverage) and correlate them with subjective improvements in IPSS and QoL at one and three months following TURP in patients with BPH.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based, prospective, observational study conducted in the Department of General Surgery of tertiary center in Pokhara, Nepal. The study period extended from September 2022 to January 2024.

Ethical approval was obtained from the Institutional Review Committee (IRC), prior to initiation. Written informed consent was obtained from all participants or from family members where necessary. All data were kept confidential, and patient identities were anonymized throughout the study.

Study Population

A total of 80 male patients aged above 50 years who presented with LUTS due to BPH and had inadequate response to medical management were included. All participants underwent TURP and fulfilled the inclusion criteria.

Inclusion and Exclusion Criteria

The study included male patients aged above fifty years who were diagnosed with BPH and experienced persistent LUTS despite adequate medical management. Only those who provided written informed consent for participation and surgery were enrolled in the study. All participants underwent TURP after fulfilling the eligibility criteria and completing baseline clinical and radiological evaluations.

Patients were excluded from the study if they were medically unfit for anesthesia or surgery, or if they declined to participate. Individuals with a history of gross hematuria, melena, or prior urethral catheterization were not included. Patients with a clinical suspicion or histological diagnosis of prostate malignancy were also excluded from the study.

Sample Size Calculation

Based on the prevalence rate of BPH reported by Lim (2017) as 8% among men above 40 years, the sample size was calculated using the formula as below [8].

$N = (Z^2 \text{ X } P \text{ X } Q) / E^2$

Were,
N = Sample size
Z = Reliability coefficient = 1.96 (at 95% confidence interval)
P = Prevalence = 8% = 0.08
Q = 1-P = 1-0.08 = 0.92
E = Margin of error = 6% = 0.06 N = 78.539

The calculated sample size was 78.539, rounded to 80 patients.

Study Procedure

After obtaining informed consent, each patient underwent detailed history taking, physical examination including digital rectal examination, and baseline investigations such as serum prostate-specific antigen (PSA) and urinalysis. Ultrasonography was performed to assess prostate size and post-void residual urine (PVRU).

All patients underwent standard monopolar TURP under spinal anesthesia. Uroflowmetry was performed preoperatively and repeated at the end of the first and third postoperative months. Parameters recorded included Qmax, Qaverage, voided volume (VV), and voiding time. Simultaneously, subjective assessments were made using the IPSS and QoL index.

Tools and Instruments

Uroflowmetry*:*

Conducted using a digital uroflowmeter, where the patient voided into a calibrated funnel connected to a collection jar and flow sensor. The system recorded urinary flow rate, volume, and voiding duration automatically.

International Prostate Symptom Score (IPSS):

IPSS is an eight-question written screening tool used to screen, rapidly diagnose, track the symptoms of, and suggest management of the lower urinary tract symptoms of BPH. It contains seven questions related to symptoms related to BPH and one question related to the patient's perceived quality of life (Table 1*)*.

Table 1: Adapted Summary of the International Prostate Symptom Score (IPSS)

Symptom Category	Description of Symptom Assessed	Response Frequency or Severity Scale	Score Range
Frequency	How often the patient feels the need to urinate again shortly after voiding	From "never" to "almost always"	0–5
Urgency	How difficult it is for the patient to delay urination	From "never" to "almost always"	0–5
Weak Urinary Stream	How often the urinary stream is perceived as weak	From "never" to "almost always"	0–5
Intermittency	How often urination stops and starts repeatedly	From "never" to "almost always"	0–5
Straining	How often the patient must exert effort to initiate urination	From "never" to "almost always"	0–5
Incomplete Emptying	How often the patient feels the bladder has not completely emptied	From "never" to "almost always"	0–5
Nocturia	Number of times the patient awakens at night to urinate	From "none" to "five or more times"	0–5
Quality of Life	Patient's satisfaction with current urinary condition	from "delighted" to "very unhappy"	0–5

Mild = 1-7; Moderate = 8-19; Severe = 20-35

This table provides a descriptive adaptation of the symptom categories and scoring system of the IPSS. The original questionnaire is copyrighted by the American Urological Association and is not reproduced here [9].

Post-Void Residual Urine (PVRU): Measured by transabdominal ultrasonography immediately after voiding.

Data Management and Statistical Analysis

All data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD). Repeated measures analysis of variance (ANOVA) was applied to compare uroflowmetric parameters (Qmax and Qaverage) across the three time points (preoperative, one month, and three months postoperative). A p-value <0.05 was considered statistically significant. Correlations between uroflowmetric parameters, IPSS, and QoL were also analyzed.

RESULTS

A total of 80 male patients who matched the inclusion criteria were included in the study. The age distribution of the study population ranged from 51 to 87 years, with mean age (+/-SD) being 69.81 (+/- 8.249) years. The highest incidence of the BPH was found in the age group of 70-80 years with 32 (40%) patients followed by 31 (38.75%) patients having age 60-70 years as shown in Table *2*.

Table 2: Age distribution of patients with Symptomatic BPH undergoing TURP

Age in Years	Number of Patients (N)	Percentage (%)
<60	10	12.5
60-70	31	38.75
70-80	32	40
>80	7	8.75
Total	N = 80	100

BPH: Benign prostate enlargement; TURP: Transurethral Resection of the Prostate

As BPH is disease only encountered in male patients. So, all the study populations were males in this study. The mean prostatic size was 65 gm with a range of 36-121 gm and standard deviation of 21 gm.

The Uroflowmetry was conducted in all patients before the surgery and at the end of 1st and 3rd month following TURP. Preoperatively almost all patients had a maximum flow rate of less than 15 ml/sec. The Qmax preoperatively was 11.51. Post-Operative Qmax at the end of 1st month and 3rd month were 16.89 and 16.91 respectively. Out of 80 patients, only 3 of them had no significant improvement in Qmax. However, the rest of all the patients had improvement in Qmax. Post Operatively at the end of the 3rd month significant improvement was noted in Qmax values with none of the patient value <10/sec and most of the patient 56 (70%) having maximum flow more than 15 ml/sec. In our research, the mean Qmax preoperatively was 11.51 ml/sec. After TURP, the mean Qmax increased to 16.89 and 16.91 ml/sec respectively.

In our research, the mean Qaverage preoperatively was 6.93. After TURP, the mean Qaverage posts operatively at the end 1st and 3rd months were 10.44 and 11.01 respectively. About 61 (76%) of the patients showed Qaverage between 10-15 ml/sec post operatively at 3rd month followed by 2 (2.5%) of the

patients having Qaverage more than >15 ml/sec. So, there was a significant improvement in Qaverage in patients undergoing TURP.

The IPSS were evaluated in all the patients at the time of initial evaluation prior to TURP and at the end of 1st and 3rd month of follow-up visit as shown in Table 3.

Table 3: Pre-Operative and Post-Operative IPSS Values

IPSS Scoring	No. of Patients Pre- Operatively	No. of Patients Post Operatively at the end of 1st month	No. of Patients Post Operatively at the end of 3rd month
Mild (0-7)	0	2	5
Moderate (8-19)	8	69	71
Severe (20-35)	72	9	4

IPSS: International Prostate Symptom Score

Table 4 shows the comparison of means of uroflowmetry parameters and IPSS/QoL.

Table 4: Comparison of means of Uroflowmetry parameters and IPSS/QoL taken pre- operatively and post-operatively at 1st month and 3rd months following TURP.

Measurement	Pre-Operatively	Post Operatively at the end of 1st month	Post Operatively at the end of 3rd month
Qmax (Mean) (ml/sec)	11.51 +/- 2.733	16.89 +/- 3.118	16.91 +/- 2.71
Qaverage (Mean) (ml/sec)	6.93 +/- 1.992	10.44 +/-1.986	11.01+/- 2.053
IPSS Score	22.89 +/- 4.54	15.47 +/- 3.68	15.21 +/- 3.98
QoL	5.26 +/- 0.98	3.39 +/- 0.89	2.72 +/- 0.71

IPSS: International Prostate Symptom Score; QoL: Quality of Life; TURP: Transurethral Resection of the Prostate

Given that the data encompassed more than two related measurements, a repeated measures ANOVA was conducted to assess the changes in Qmax across three distinct time points, as shown in Table 5. The time points evaluated included preoperative Qmax, postoperative Qmax at one month, and postoperative Qmax at three months.

Table 5: Repeated measure anova test comparison of Qmax over three different time period showing results of Within Subjects Effects i.e. Qmax preoperatively, Qmax post operatively at the end of 1st month and Qmax post operatively at the end of 3rd month

Source		Type III Sum of Squares	Df	Mean Square	F	Sig. (p-value)	Partial Eta Squared
Time	Sphericity Assumed	2068.30	2	1034.15	179.35	2.2274E-41	0.69
	Greenhous e-Geisser	2068.30	1.195	1731.06	179.35	8.4467E-26	0.69
	Huynh-Feldt	2068.30	1.20	1719.55	179.35	5.9118E-26	0.69
	Lower-bound	2068.30	1	2068.30	179.35	5.0417E-22	0.69

Sig. (p-value): Significant p-value; Df: degree of freedom; F value: the ratio of variance explained by the time factor to the unexplained variance

Hence, there was significant change in Qmax preoperatively and postoperatively following TURP ($F=179.35$, $p<0.05$). Similarly, Table 6 illustrates the key components of the Pairwise Comparison of Qmax over time periods.

Table 6: Key Components of the Pairwise Comparison, Mean Difference, Standard Error, p- value and Confidence Interval of Qmax over time periods.

(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig. (p-value)	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Pre Op Qmax	Post Op 1st month Q_{max}	-6.12*	0.43	7.4564E-23	-7.18	-5.06
	Post Op 3rd month Q_{max}	-6.32*	0.46	7.3672E-22	-7.46	-5.18
Post Op 1st month Qmax	Pre Op Qmax	6.12*	0.43	7.7242E-23	5.06	7.18
	Post Op 3rd month Q_{max}	-0.20	0.16	0.682147	-0.60	0.20
Post Op 3rd month Qmax	Pre Op Qmax	6.32*	0.46	7.3672E-22	5.18	7.46
	Post Op 1st month Q_{max}	0.20	0.16	0.682147	-0.20	0.60

Based on estimated marginal means.
*: The mean difference is significant at the 0.05 level; Adjustment for multiple comparisons: Bonferroni

Hence, there was a significant increase in Qmax from pre-op to 1st month and pre-op to 3rd month. However, there was no significant increase in Qmax from Post-op 1st month to 3rd month. Similarly, as the dataset for Qaverage included more than two related measurements, a repeated measures ANOVA was performed to evaluate changes in Qaverage across three time points, as presented in Table *7*. The time points assessed were preoperative Qaverage, postoperative Qaverage at one month, and postoperative Qaverage at three months.

TABLE 7: Repeated measure anova test comparison of Qaverage over three different time period showing results of Within Subjects Effects i.e. Qaverage preoperatively, Qaverage post operatively at the end of 1st month and Qaverage post operatively at the end of 3rd month

Source		Type III Sum of Squares	Df	Mean Square	F	Sig. (p-value)	Partial Eta Squared
Time	Sphericity Assumed	885.05	2	442.52	166.89	1.1046E-39	0.67
	Greenhous e-Geisser	885.05	1.66	531.74	166.89	1.7725E-33	0.67
	Huynh-Feldt	885.05	1.69	521.87	166.89	4.636E-34	0.67
	Lower-bound	885.05	1	885.05	166.89	3.5892E-21	0.67

Sig. (p- value): Significant p-value; Df: degree of freedom; F value: the ratio of variance explained by the time factor to the unexplained variance

Hence, there was a significant change in Qaverage preoperatively and postoperatively following TURP ($F=166.89$, $p<0.05$). Similarly, Table *8* illustrates the key components of the Pairwise Comparison of Qaverage over time periods.

TABLE 8: Key Components of the Pairwise Comparison, Mean Difference, Standard Error, p- value and Confidence Interval of Qaverage over time periods

(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig. (p-value)	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Pre Op Qaverage	Post Op Qaverage at 1st month	-3.66*	0.26	1.2152E-22	-4.30	-3.02
	Post Op Qaverage at 3rd month	-4.38*	0.30	1.4208E-23	-5.12	-3.65
Post Op Qaverage at 1st month	Pre Op Qaverage	3.66*	0.26	1.2152E-22	3.02	4.30
	Post Op Qaverage at 3rd month	-0.72*	0.19	0.001428	-1.21	-0.23
Post Op Qaverage at 3rd month	Pre Op Qaverage	4.38*	0.30	1.4208E-23	3.65	5.12
	Post Op Qaverage at 1st month	0.72*	0.19	0.001428	0.239	1.21

Based on estimated marginal means.
*: The mean difference is significant at the 0.05 level; Adjustment for multiple comparisons: Bonferroni

Hence there was a significant increase in Qaverage from pre-op to 1st month, pre-op to 3rd month and post-op 1st month to 3rd month.

DISCUSSION

BPH remains one of the most prevalent urological conditions affecting aging men and continues to have a profound impact on QoL. The primary pathophysiological mechanism in BPH is BOO, which leads to LUTS and a decline in urinary flow parameters. TURP has long been considered the gold standard for the surgical management of BPH, offering substantial symptomatic and functional relief when conservative measures fail [10]. The present study aimed to evaluate changes in objective uroflowmetric parameters and their correlation with subjective symptom improvement following TURP among patients with BPH.

In this prospective hospital-based study of 80 patients, the mean age was 69.81 ± 8.25 years, reflecting the typical demographic distribution of BPH reported in global literature. Most patients were in their seventh decade of life, supporting the notion that the prevalence of BPH increases with advancing age [11]. In the present series, significant improvement was observed in both objective parameters such as Qmax and Qaverage, as well as in subjective parameters including IPSS and QoL scores at one and three months postoperatively. The mean Qmax improved from 11.51 mL/sec preoperatively to 16.91 mL/sec at three months, while Qaverage increased from 6.93 mL/sec to 11.01 mL/sec during the same period. These findings indicate that TURP effectively relieves bladder outlet obstruction, thereby enhancing detrusor contractility and urinary flow.

The findings of this study are consistent with those of Narendra *et al.*, who reported significant postoperative improvement in Qmax, Qaverage, and

IPSS following TURP, demonstrating the strong correlation between objective and subjective outcomes [12]. Similarly, Milonas *et al.,* found that uroflowmetry values significantly improved postoperatively, mirroring the decrease in IPSS scores and improvement in QoL, indicating that uroflowmetry can serve as a reliable, noninvasive measure of treatment efficacy [13].

The correlation between uroflowmetric improvement and symptom relief is of particular clinical relevance. In our study, both Qmax and Qaverage showed significant postoperative increases, which were directly associated with reduced symptom severity and improved QoL. Darius Trumbeckas *et al.,* emphasized that peak and average flow rates are the most important predictors of bladder outlet obstruction, and their postoperative improvement strongly predicts successful surgical outcomes [14]. Likewise, Slawin *et al.,* demonstrated that combining parameters such as IPSS, PSA, peak flow rate, and prostate volume could predict the necessity for surgical intervention in BPH with high accuracy [15]. The present findings reinforce the role of uroflowmetry as a simple, reproducible, and clinically valuable test for monitoring postoperative progress and predicting outcomes after TURP.

PVRU and symptom scores also showed marked improvement in our study. The mean IPSS score declined significantly from 22.89 to 15.21, while QoL scores improved from 5.26 to 2.72, confirming the high efficacy of TURP in symptomatic relief. Similar results were obtained by Reddy and Shaik, who reported that Qmax and IPSS were reliable indicators of bladder outlet obstruction severity, and both improved markedly following surgical treatment [16]. Our results further support these findings, highlighting that the objective and subjective outcomes align in nearly all patients after TURP, underscoring the surgery's reliability in achieving durable functional improvement.

Histopathological variations in BPH have also been shown to influence surgical outcomes. Dorflinger *et al.,* demonstrated that patients with predominantly glandular or mixed hyperplasia exhibit greater postoperative improvement in uroflowmetry parameters compared to those with stromal hyperplasia [17]. Although histological analysis was not part of this study, it is plausible that similar differences may contribute to variable responses among individual patients.

The present study also aligns with the long-term findings of Nielsen *et al.,* who reported that postoperative improvement in urine flow rates and symptom relief remained stable for several years following TURP [18]. Our three-month follow-up period showed sustained improvement in Qmax and Qaverage between the first and third postoperative months, suggesting early stabilization of the surgical benefit. While longer follow- up is necessary to confirm long-term durability, these short-term outcomes are highly encouraging and reflect the expected trajectory of postoperative recovery.

Another important observation was that elderly patients, especially those above 80 years, were less likely to undergo surgical intervention due to comorbidities or social hesitation. This highlights the ongoing need for patient education and the promotion of safe surgical access in older age groups. The fear of operative complications or misconceptions about surgical risks often delays definitive management, leading to prolonged catheter dependence or chronic urinary retention, as observed in other South Asian populations [19].

In addition, the significant correlation between objective and subjective parameters underscores the value of using uroflowmetry and IPSS together for comprehensive postoperative assessment. Barry *et al.,* noted that variations in flow rate and symptom scores can occur by chance, and repeated measurements improve accuracy [20]. The present study also utilized repeated postoperative assessments at one and three months, which enhanced the reliability of results and minimized random variability.

Overall, the present findings reaffirm the efficacy of TURP as a gold standard surgical procedure for BPH. The improvement in Qmax, Qaverage, IPSS, and QoL observed in nearly all patients demonstrates that TURP provides significant functional and symptomatic relief in the early postoperative period. Uroflowmetry, being an objective and noninvasive tool, correlates well with subjective outcomes and can serve as a dependable follow-up modality to assess postoperative improvement. Future studies with longer follow-up durations and larger multicentric cohorts are warranted to evaluate long-term stability of outcomes and to explore the influence of factors such as prostate volume, detrusor function, and histological subtype on surgical success.

LIMITATIONS

This study was conducted at a single center, which may limit the generalizability of the findings. The follow- up period was restricted to three months, preventing assessment of long-term outcomes. Additionally, the sample size was relatively small, reducing the statistical power, and only unipolar TURP was performed, without comparison to bipolar or newer laser techniques such as Holmium, Yttrium-Aluminum-Garnet (YAG), or Thulium lasers.

CONCLUSIONS

This prospective study evaluating eighty patients undergoing TURP demonstrated significant improvement in both objective and subjective parameters of bladder function. The incidence of BPH was found to

increase notably after the age of 60 years, reflecting the global trend of rising prevalence with advancing age.

Following TURP, marked enhancement was observed in Qmax and Qaverage at the end of the first and third postoperative months. In contrast, PVRU decreased substantially after surgery, indicating effective relief of bladder outlet obstruction.

The IPSS and QoL scores also showed statistically significant improvement, confirming that subjective symptom relief correlated closely with the objective findings of uroflowmetry. These results collectively affirm that TURP provides substantial functional and symptomatic benefits, restoring normal voiding dynamics and improving patients' quality of life.

In conclusion, TURP remains the gold standard treatment for benign prostatic hyperplasia. It effectively enhances urinary flow parameters such as Qmax and Qaverage, reduces post-void residual urine, and leads to consistent improvement in IPSS and QoL outcomes. The strong correlation between uroflowmetric parameters and patient-reported symptom improvement further underscores the value of combining both objective and subjective assessments in the postoperative evaluation of TURP patients.

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

DISCLOSURES

Human subjects:

Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Manipal College of Medical Sciences (MCOMS) IRC issued approval MTH/IRC/2022/07.

Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue.

Conflicts of interest:

In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Payment/services info:

All authors have declared that no financial support was received from any organization for the submitted work.

Financial relationships:

All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other relationships:

All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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