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ORIGINAL RESEARCH

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The efficacy of transurethral holmium laser enucleation of the prostate (HoLEP) in the preservation of the urethral ridge in the treatment of prostatic hyperplasia in patients aged 75 years or less

Rongjin Fang[1], Qinglong Wu[1,*], Chao Li[1], Nanhua Li[2], Yiliang Huang[1], Songtao Zhao[1]

[1]Department of Urology, Xiamen Haicang Hospital, 361000 Xiamen, Fujian, China
[2]Department of Rehabilitation Medicine, Xiamen Third Hospital, 361000 Xiamen, Fujian, China

***Correspondence**
gohking15@163.com
(Qinglong Wu)

Abstract

To evaluate the efficacy of Transurethral holmium laser enucleation of the prostate (HoLEP) with preservation of the urethral ridge in the treatment of benign prostatic hyperplasia (BPH) in patients aged 75 years or less. We conducted retrospective analysis of clinical data acquired from 80 patients aged 75 years or less with BPH. We also included 30 cases of HoLEP with preservation of the "urethral ridge" (the modified group) and 50 cases of HoLEP (the control group). Analysis showed that there were no significant differences in operation time (59.5 (55.0, 66.0) min *vs.* 57.0 (52.5, 64.3) min), the weight of prostate tissue removed (45.4 $\pm$ 13.5 *vs.* 47.7 $\pm$ 15.2 grams), hemoglobin drop (1.5 $\pm$ 0.4 grams per liter *vs.* 1.4 $\pm$ 0.3 grams per liter), the time of postoperative bladder irrigation (21.0 (19.8, 23.3) h *vs.* 21.0 (19.0, 23.2) h), postoperative indwelling catheter time (4.0 (3.0, 4.0) d *vs.* 4.0 (3.0, 4.0) d) and postoperative hospitalization time (5.0 (4.0, 5.0) d *vs.* 5.0 (4.0, 5.0) d) between the two groups (all $p > 0.05$). However, there was a significant difference in the immediate postoperative urinary control rate (93.3% (28/30) *vs.* 76% (38/50), $p < 0.05$) and the incidence of retrograde ejaculation (5 cases (16.7%) *vs.* 19 cases (38%), $p < 0.05$) between the two groups. In addition, we identified significant differences in the International Prostate Symptom Score (IPSS), quality-of-life score (QoL), maximum urinary flow rate (Qmax), International Index of Erectile Function score (IIEF-5), and postvoid residual volume (PVR) intragroup comparison (all $p < 0.05$). The efficacy of HoLEP with preservation of the "urethral ridge" in the treatment of BPH was found to be comparable to that of conventional two-lobe HoLEP but can improve the rate of immediate urinary control and reduce the incidence of retrograde ejaculation.

Keywords

Holmium laser enucleation of the transurethral prostate; Benign prostatic hyperplasia (BPH); Urethral ridge; Immediate urinary control; Retrograde ejaculation

1. Introduction

Benign prostatic hyperplasia (BPH) is the most prevalent lower urinary tract symptom (LUTS) in men, affecting up to 60% of all males over the age of 60 years and approximately 30% of patients with BPH require surgical treatment [1]. Transurethral holmium laser enucleation of the prostate (HoLEP) has been widely used in the treatment of BPH because of its efficient ability to remove the prostate gland and achieve good hemostasis; moreover, HoLEP could potentially replace transurethral resection of the prostate (TURP) as the new "gold standard" procedure for the treatment of BPH [2, 3]. However, due to the high incidence of complications following HoLEP, such as transient urinary incontinence and retrograde ejaculation, there is an urgent need for this technique to be optimized further [4–6]. In order to improve postoperative outcomes, we modified the conventional two-lobe HoLEP by utilizing the advantages of precise laser cutting and preserving the structure of the "urethral ridge". Our aim was to improve postoperative urinary control and reduce the incidence of retrograde ejaculation.

2. Materials and methods

2.1 Materials

We conducted a retrospective analysis of clinical data acquired from 80 patients with BPH who were admitted into our hospital between January 2019 and March 2023. The inclusion criteria were a diagnosis of BPH and indication for surgery, no serious cardiovascular or cerebrovascular diseases, no obvious systemic bleeding disorders, and the ability to tolerate surgery.

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Other inclusion criteria included a patient age $\leq$75 years, a stable sexual partner and regular sexual activities, and no evidence of retrograde ejaculation. Patients were excluded if they had a neurogenic bladder, bladder stones, malignant tumors of the prostate, and overactive bladder disease. The patients were divided into two groups according to the surgical methods used, including 30 cases in the modified group and 50 cases in the control group.

2.2 Surgical technique

2.2.1 Instruments and equipment

Endoscopic enucleation instruments were provided by STORZ (Resectoscope Sheath, 26 Fr/HOPKINS Telescope 30°, KARL STORZ, Tuttlingen, Germany). The Holmium Nd:YAG laser surgical treatment system was provided by Komedian Gemini (VersaPulse PowerSuite 80W/100W, Lumenis, Salt Lake City, UT, USA).

2.2.2 Methods

Both groups of patients received surgery by the same physician who had completed over 200 similar cases. General anesthesia or epidural anesthesia was applied and each patient was asked to adopt a truncated position. The bladder irrigation fluid was 0.9% sodium chloride solution, and the laser parameters were set as follows: a holmium laser energy of 2.0 J; a frequency of 40 Hz; a Nd-YAG laser energy of 60 s, and a power of 80 watts.

With regards to surgery, we used a Holmium laser to create a longitudinal incision at the 5 o'clock position of the left paramedian groove in the seminal colliculus to identify the level of the "surgical capsule" and moderately expand the scope. We used this level as a basis for making an incision of the left paramedian groove in the urethral ridge at the 5 o'clock position of the bladder neck. Next, we incised the mucosa of the external urethral sphincter on the side of the bladder neck. Starting from the incised level of the perineum at the 5 o'clock position of the tip, the laser was used to expand the level counterclockwise up to the 12 o'clock level, leaving the external urethral sphincter intact. The mucosa at the 12 o'clock groove of the posterior urethra was preserved for approximately half a centimeter in length.

Next, the perineal plane was used to gradually dissect off the left lobe towards the bladder neck until we reached the bladder neck, thus preserving the bladder neck internal urethral sphincter. Next, we completely separated the left lobe of the prostate from the surgical capsule. The left lobe was then pushed into the bladder and the bleeding was stopped using the Nd-YAG laser.

For the control group, the left lobe was enucleated using the same methodology described above. We also performed the enucleation of both the right lobe and middle lobe was performed without preservation of the urethral crest. For the modified group, the left lobe was enucleated using the same method described above. After removing the right lobe, a laser lens was inserted from the paracolic groove of the urethral crest, and the middle lobe of the prostate was completely dissected away from under the urethral crest. This was followed by complete resection from under the surgical perimembranous layer.

All enucleated prostate tissue was collected in the bladder and completely aspirated using a tissue grinder. Finally, a F20 three-lumen catheter was inserted and continuous bladder irrigation was performed.

2.3 Study outcomes

Perioperative indicators included the operation time, the weight of the resected prostate, hemoglobin (Hb) drop, the duration of postoperative continuous bladder irrigation, the duration of postoperative indwelling urinary catheterization, the duration of postoperative hospitalization, and the rate of immediate urinary control (the proportion of patients who did not experience temporary urinary incontinence following removal of the catheter).

Preoperative and postoperative follow-up results were compared and evaluated using several objective indicators, including IIEF-5 scores, International Prostate Symptom Score-Quality of Life Score (IPSS-QoL), residual urine volume (PVR), and maximum urinary flow rate (Qmax). A total IIEF-5 score of 24 was considered as normal erectile function, while scores of 12–21 were classified as mild erectile dysfunction. Higher IPSS and QoL scores were suggestive of more severe voiding symptoms while lower postoperative PVR and higher Qmax values were indicators of better postoperative outcomes. Postoperative complications, including micturition, retrograde ejaculation, reduced ejaculation volume, and ejaculation pain were monitored and recorded during the 6-month postoperative follow-up period.

2.4 Statistical analysis

Statistical analysis was carried out with IBM SPSS (Chicago, IL, USA) Statistics version 27 software. Numerical data are described as n (%) and evaluated by the Chi-squared. We applied continuity correction if the count within a cell was between 1 and 5. Measurement data that followed a normal distribution are described as $\bar{x} \pm s$ and evaluated by the *t*-test. Measurement data that did not follow the normal distribution are described as medians with inter-quartile range (IQR) and evaluated by the Mann-Whitney U test. $p < 0.05$ was considered statistically significant.

3. Results

3.1 Preoperative analysis

There were no significant differences ($p > 0.05$) between the two groups in terms of patient age, prostate volume, the number of patients with diabetes, and the ASA (American Society of Anesthesiologists) Physical Status Classification System (ASA grading), as shown in Table 1.

3.2 Perioperative analysis

There were no significant differences between the two groups with regards to operation time, the weight of resected prostate, hemoglobin (Hb) drop, postoperative bladder irrigation time, postoperative indwelling catheter time, and postoperative hospitalization time ($p > 0.05$). The immediate postoperative

urinary control rate in the modified group and the control group was 93.3% (28/30) and 76% (38/50), respectively; these differences were significant ($p < 0.05$). In the modified group, one patient experienced urinary retention following removal of the catheter but could urinate normally after removing the catheter after 1 week of indwelling catheterization. None of the patients, in either of the two groups, experienced true incontinence at the 6-month postoperative follow-up (as shown in Table 2).

3.3 Postoperative follow-up

Postoperative IPSS score and QoL score were lower than the preoperative score, postoperative Qmax was larger than preoperative Qmax, and postoperative PVR was lower than the preoperative PVR when tested 6 months post-surgery; these differences were all statistically significant ($p < 0.05$). There was no significant difference between the two groups with regards to the lateral comparison of each index ($p > 0.05$) (Table 3). There was no significant difference in the IIEF-5 scores when compared between the two groups at 6 months post-surgery. There were 5 cases (16.7%) of retrograde ejaculation in the modified group and 19 cases (38%) in the control group; this represented a significant difference ($p < 0.05$). The incidence of decreased ejaculation volume and painful ejaculation was reduced post-surgery although this was not significantly different ($p > 0.05$) (Table 4).

4. Discussion

Over recent years, there has been a notable increase in the number of studies related to HoLEP; collectively, these studies indicate indicating that the efficacy of this technique is equal to or even superior to that of TURP. The holmium laser is a new type of pulsed laser with minimal penetration in human tissues, a low local thermal effect, and no electric field effect. Therefore, this laser rarely causes damage to damages surrounding tissues, reduces intraoperative and postoperative bleeding, clears the operative field, improves surgical efficacy, and has a high degree of safety [7]. The results of this study showed that none of our postoperative cases experienced serious complications and the level of surgical safety was high. Intergroup comparisons, performed for each study group, showed that the IPSS-QoL score at 6 months after surgery was lower than that before surgery, the Qmax was larger than before surgery, and the PVR was lower than before surgery; these differences were all statistically significant, thus indicating that the surgical efficacy was excellent.

The HoLEP procedure has numerous advantages for treating BPH, although postoperative complications such as urinary incontinence and retrograde ejaculation can still occur at a significant rate, thus impacting a patient's quality-of-life post-surgery. Recent studies have reported that the incidence of postoperative urinary incontinence following HoLEP ranges from 10.7% to 44% [6, 8–10]. On the other hand, the incidence

TABLE 1. Baseline characteristics according to grouping.

Characteristics	Modified group (n = 30)	Control group (n = 50)	Z/χ^2	p-value
Age (yr)	66.5 (63.8, 69.0)	67.0 (65.0, 69.3)	−0.738	0.461‡
Prostate volume (mL)	66.5 (55.9, 79.2)	68.7 (60.5, 76.9)	−0.651	0.515‡
Combined diabetes (cases (%))	5 (16.7)	9 (18.0)	0.023	0.879*
ASA grading				
ASA I	6	9	0.049	0.824*
ASA II	17	30	0.086	0.769*
ASA III	7	11	0.091	0.763*

Values are presented as median and interquartile range or as numbers and percentages.
*‡Analyzed by the Mann-Whitney U test; *Analyzed by the Chi-squared test. ASA: American Society of Anesthesiologists.*

TABLE 2. Perioperative analysis in the two groups.

	Modified group (n = 30)	Control group (n = 50)	Z or t or χ^2	p-value
Surgical time (min)	59.5 (55.0, 66.0)	57.0 (52.5, 64.3)	−1.199	0.231‡
Weight of prostate removed (g)	45.4 ± 13.5	47.7 ± 15.2	−0.676	0.500†
Hb decrease (g/L)	1.5 ± 0.4	1.4 ± 0.3	1.484	0.142†
Bladder flushing time (h)	21.0 (19.8, 23.3)	21.0 (19.0, 23.2)	−0.020	0.984‡
Duration of indwelling urinary catheter (d)	4.0 (3.0, 4.0)	4.0 (3.0, 4.0)	−0.895	0.371‡
Length of postoperative hospitalization (d)	5.0 (4.0, 5.0)	5.0 (4.0, 5.0)	−0.850	0.396‡
Immediate urinary control rate (% (cases))	93.3 (28/30)	76.0 (38/50)	3.902	0.048*

Values are presented as median and interquartile range (IQR) or mean ± standard deviation.
*‡Analyzed by the Mann-Whitney U test; †Variables that were normally distributed and analyzed by the student's t test; *Analyzed by the Chi-squared test. $p < 0.05$ (statistically significant difference).*

TABLE 3. Comparison of IPSS and QoL scores, Qmax, PVR and IIEF-5 score between the two groups.

Variables/Group	Pre-op	6 months post-op	*Z* or *t*	*p*-values
IPSS				
Modified group	25.0 (22.8, 28.0)	5.0 (5.0, 6.0)	−6.702	<0.001‡
Control group	24.5 (23.0, 26.0)	5.0 (4.8, 7.0)	−8.653	<0.001‡
t/*Z*	−0.478	−0.603		
p-values	0.481	0.421		
QoL score				
Modified group	5.0 (4.0, 5.3)	2.0 (1.0, 2.0)	−6.764	<0.001‡
Control group	5.0 (4.0, 5.3)	2.0 (1.0, 2.0)	−8.778	<0.001‡
t/*Z*	−0.478	−0.603		
p-values	0.633	0.546		
Qmax (mL/s)				
Modified group	7.7 ± 1.9	20.1 ± 3.8	−16.113	<0.001†
Control group	7.8 ± 2.0	19.2 ± 4.0	−17.906	<0.001
t/*Z*	−0.330	1.045		
p-values	0.742	0.299		
PVR (mL)				
Modified group	110.5 (67.0, 159.5)	17.5 (10.0, 25.3)	−6.499	<0.001‡
Control group	130.0 (74.0, 159.5)	15.5 (8.8, 27.3)	−8.471	<0.001‡
t/*Z*	−0.089	−0.632		
p-values	0.929	0.528		
IIEF-5				
Modified group	22.5 (21.8, 23.0)	20.0 (18.0, 22.0)	−3.941	<0.001‡
Control group	23.0 (22.0, 23.0)	20.0 (18.0, 21.0)	−5.908	<0.001‡
t/*Z*	−0.448	−0.466		
p-values	0.654‡	0.641‡		

Pre-op, preoperative; post-op, postoperative.
Values are presented as median and interquartile range or mean ± standard deviation.
†*Variables that were normally distributed and analyzed by the T-Student;* ‡*Analyzed by the Mann-Whitney U test.*

TABLE 4. Comparison of postoperative complications.

	Modified group (n = 30)	Control group (n = 50)	t/χ^2	*p*-value
Retrograde ejaculation (n (%))	5 (16.7)	19 (38)	4.063	0.044
Decrease in ejaculate volume (n (%))	3 (10.0)	7 (14)	0.030	0.861
Painful ejaculation (n (%))	1 (3.3)	2 (4)	0.000	1.000

Values are presented as numbers and percentages.

of retrograde ejaculation has been reported to range from 63.3% to 77.3% [11]. Our current results showed that the incidence of urinary incontinence in the control group following HoLEP was 24%; this finding concurred with previously published studies. In contrast, the incidence of retrograde ejaculation in the control group of the current study was 38%; this was lower than the incidence reported previously. Our analysis suggests that this may be due to effective intraoperative protection of the muscle fibers of the bladder neck. It has been reported that intraoperative injury to the bladder neck can affect the function of the internal urethral sphincter, and impair closure of the bladder neck during ejaculation, thus leading to retrograde ejaculation [12]. Previously, it was generally believed that urinary incontinence in patients after HoLEP was related to the volume of the gland. In cases involving a large prostate, the anatomical structure of the prostate fossa can change following enucleation, thus leading to a significant reduction in urethral pressure and weakening of the external urethral sphincter's ability to control urination. Previous researchers have also suggested that urinary incontinence is also related to surgical operations, such as intraoperative injury to the internal sphincter, external sphinc-

ter, genital septum transversum, and intraoperative compression of the mirror sheath, thus causing injury to the external sphincter [13, 14]. The urethral crest is an anatomical structure of the urethral folds located between the caruncle and the bladder neck (Fig. 1). Based on the findings of previous studies, we hypothesized that preserving the urethral crest during surgery and preserving the original physiological function of the caruncle to the bladder neck could play a role similar to that of the "plug", thus increasing urethral pressure and the urethral closure area during urinary storage. To further reduce the incidence of urinary incontinence and retrograde ejaculation following HoLEP surgery, we modified the technique by preserving the urethral crest during surgery. Our analysis showed that the immediate postoperative urinary control rates were 93.3% and 76% in the modified and control groups, respectively; these were significantly different, thus suggesting that preservation of the urethral crest reduced the incidence of urinary incontinence. One patient in the modified group experienced urinary retention following removal of the catheter; however, the catheter was removed after 1 week of catheterization, and no true urinary incontinence was observed in either of the groups at the 6-month follow-up. Therefore, in terms of short-term efficacy, preserving the urethral crest did not increase the incidence of urinary retention. However, the long-term efficacy of this technique requires further investigation.

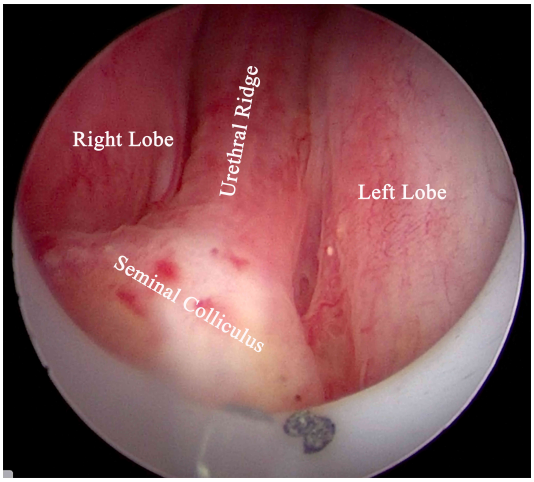

FIGURE 1. The urethral ridge (dashed line), the left prostatic lobe (on the left), and the seminal colliculus anteriorly.

Various modified techniques have been reported to reduce the incidence of postoperative retrograde ejaculation. A previous study considered transurethral plasma enucleation of the prostate with preservation of the bladder neck and the urethral mucosa of the prostate tip, and reported that the incidence of retrograde ejaculation was 31.0% in the modified group compared with 65.7% in the control group, thus indicating a significantly more effective outcome [15]. In addition, some researchers have reported that preservation of the proximal seminal caruncle tissue during HoLEP surgery resulted in a significantly lower incidence of retrograde ejaculation at 12 months post-surgery in the modified group (40%) when compared to 75% in the control group [11]. The urethral crest is an anatomical structure connecting the tip of the prostate and the bladder neck (Fig. 1). Based on this anatomical feature, we hypothesized that preservation of the urethral crest could further reduce the incidence of retrograde ejaculation. However, in traditional HoLEP surgery, the middle lobe was resected without preservation of the urethral crest (Fig. 2). In the modified group, the urethral crest tissue was preserved based on the original HoLEP technique (Fig. 3). A comparison of data between the two groups of cases in this study at 6 months post-surgery found no significant difference in IIEF-5 scores. In addition, the modified group had a lower incidence of decreased ejaculation volume and painful ejaculation; however, there was no difference between the two groups in this respect. There were 5 cases of retrograde ejaculation (16.7%) in the modified group and 19 cases (38%) in the control group when tested 6 months post-surgery; this difference was statistically significant.

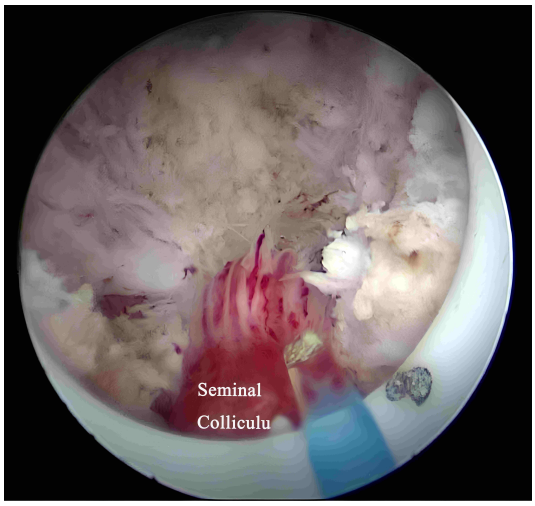

FIGURE 2. Postoperative changes in the prostatic fossa without preservation of the urethral ridge.

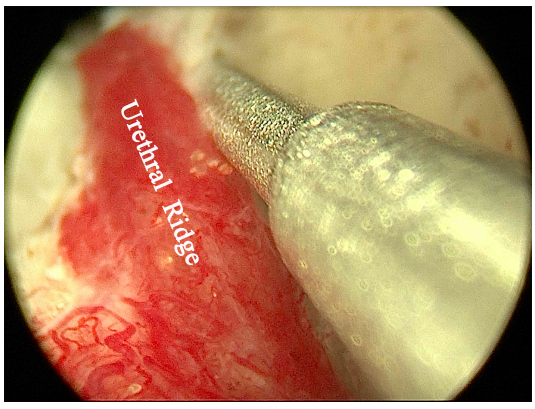

FIGURE 3. Postoperative changes with preservation of the urethral ridge; the dashed area shows the preserved urethral ridge.

This suggests that preservation of the urethral crest may improve the incidence of retrograde ejaculation. In our opinion, this type of operation, which preserves the urethral crest,

maintains urethral tension, and increases the closing pressure of the prostatic urethra, can better preserve urinary control function and reduce the occurrence of retrograde ejaculation. In addition, some researchers have investigated the correlation between retrograde ejaculation and the quality of sexual activity, thus suggesting that retrograde ejaculation is not independently associated with sexual satisfaction when tested by multivariate logistic regression analysis [16].

There are several limitations to this study that need to be considered. First, this study involved retrospective analysis with a small sample size; this may have introduced bias and limited the generalizability of our results. A prospective study with a larger sample size and longer follow-up period is also necessary to validate our findings. Second, factors such as preoperative prostate-specific antigen level, a history of prostate puncture, postoperative infection, secondary bleeding, and the preoperative use of indwelling urinary catheters, were not included in our analysis; this may have influenced our results. Third, urethral pressure assessment *via* urodynamic examination was not routinely performed to evaluate the functionality of the urethral muscles. Forth, no cystoscopic review of surgical wound healing was performed after surgery. Finally, our study population only included younger patients with BPH; this may have introduced age bias.

5. Conclusions

Our analyses showed that the efficacy and safety of HoLEP with preservation of the "urethral ridge" were similar to those of traditional surgical techniques while offering superior preservation of urinary control functionality and a reduced incidence of retrograde ejaculation, without any serious complications. This approach can enhance the quality-of-life of patients during the postoperative period.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

RJF and QLW—designed the study. RJF—collected and analyzed the data, wrote the manuscript. RJF and STZ—interpreted the results. CL and YLH—provide advice and supervise in experiments. QLW and NHL—reviewed and edited the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The present study protocol was reviewed and approved by the institutional review board of Xiamen Haicang Hospital (No. KY-2022009). As this is a retrospective study, patient consent was not required and it was approved by the institutional review board.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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