Prostate tissue retrieval after holmium laser enucleation of the prostate; assessment of non-morcellation approaches

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Abstract Objectives: To review non-morcellation approaches for tissue retrieval after holmium laser enucleation of the prostate (HoLEP) and whether these approaches demolish the advantages of the HoLEP procedure.

Patients and methods: We reviewed our prospectively maintained laser prostate database for HoLEP procedures where non-morcellation approaches were used for retrieval of the enucleated adenoma. Non-morcellation approaches were adopted in cases of morcellator malfunction or whenever concomitant pathology indicated laparotomy. Patients were stratified into the laparotomy group (Group I) or the transurethral resection (TUR) group (Group II). Safety and efficacy of each approach were assessed and compared.

Results: Between August 2012 and July 2015, of 392 HoLEP procedures non-morcellation approaches were used for tissue retrieval in 37 (9.4%). In 19 procedures a laparotomy approach was adopted (17 mini-laparotomies and two conventional laparotomies for concomitant diverticulectomy). TUR of the enucleated adenoma was adopted in 18 patients. Baseline demographic data and indications for surgery were comparable between the groups. However, significantly larger prostates were treated in Group I. There were no significant differences between the groups for tissue retrieval time, histopathological findings of retrieved tissue, and peri-procedure biochemical changes. However, significantly more tissue was retrieved (median tissue...
weight 115 vs 38 g) and at a faster rate (4.6 vs 1.09 g/min) in Group I. The median hospital stay was similar in both groups, but the median time to catheter removal was longer in Group I (5 vs 2 days). Minimal and similar peri-procedure complications were reported in both groups and in both groups there was a significant and comparable improvement in all urinary outcome measures.

**Conclusion:** In the absence or malfunction of a tissue morcellator, or whenever concomitant pathology indicates laparotomy, non-morcellation tissue retrieval approaches are feasible options for endourologists practicing transurethral enucleation of prostate adenoma. These approaches are valid alternatives retaining most of the advantages of the transurethral prostate enucleation procedure.

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**Introduction**

For over two decades transurethral enucleation of prostate adenoma using a holmium laser (HoLEP) has been extensively studied. HoLEP was promoted as a size independent procedure [1], being a cost-effective alternative to open prostatectomy [2] with the advantages of being safe in patients with bleeding disorders, reducing hospital stay and catheter time, and minimising the need for blood transfusion. The procedure has stood the test of time well [3]. Furthermore, the feasibility of HoLEP with concomitant urological procedures has been proven [4]. However, the acknowledged limitation of this procedure remains the tissue retrieval approach after transurethral enucleation [5].

Today, transurethral morcellation of the intravesical prostate adenoma is the standard tissue retrieval approach; however, transurethral morcellation of a completely enucleated intravesical adenoma is time consuming and tedious, and is associated with extra costs for the morcellator machine and its re-usables [5]. Occasionally, impaired visibility through the indirect nephroscope after enucleation may force the surgeon to stage the procedure resulting in another session of morcellation [6].

Non-morcellation approaches entail *in situ* resection of partially enucleated adenomas [7] and open cystostomy for extraction of intravesical adenomas [8].

The objective of the present study was to review our experience of non-morcellation approaches used for tissue retrieval after HoLEP and to assess whether these approaches compromise the acknowledged advantages of the HoLEP procedure.

**Patients and methods**

After obtaining Institutional Review Board approval, we reviewed our prospectively maintained laser prostate database for HoLEP procedures that were completed using a non-morcellation tissue retrieval approach. One surgeon (A.M.E.), who had passed the learning curve for HoLEP, performed or supervised all procedures. Patients were admitted for BPH surgery whenever they had refractory LUTS with failed medical treatment, an indwelling catheter due to urinary retention, and failed trial of voiding without catheter, or refractory haematuria of prostatic origin.

**Intervention**

A 100 W holmium:yttrium-aluminium-garnet (YAG) laser (Versapulse, Lumenis Inc., Santa Clara, CA, USA) with a 550-μm end-firing flexible fibre (SlimLine™ 550, Lumenis Inc.) was used. A continuous flow 26-F resectoscope (Karl Storz, Tuebingen, Germany) was used for all procedures.

The enucleation phase of HoLEP was performed as previously described [9]. After prostate enucleation, adenoma retrieval was routinely performed using a tissue morcellator [2]; however, in the absence of morcellator cutting blades or morcellator device malfunction, non-morcellation approaches were used. Moreover, if there was concomitant urological pathology this might also be an indication to change our surgical plan regarding the tissue retrieval approach.

**Laparotomy approach (Group I)**

For adenomas that were judged significantly large by the surgeon and/or in the presence of concomitant pathology (large bladder stones/bladder diverticulum) the enucleated adenomas were completely detached to the bladder followed by meticulous haemostasis. Then, a 22-F three-way catheter was inserted and continuous bladder irrigation was instituted. Clamping of the catheter outflow was done just before cystostomy and bladder irrigation was reinstated immediately after bladder closure.

- **Mini-laparotomy approach,** unless bladder diverticulectomy was indicated; in the same lithotomy position, a transverse 3-cm lower abdominal incision deep to the anterior rectus sheath was made and the two recti separated, followed by a transverse incision in the anterior bladder wall with stay...
sutures, extraction of the intravesical adenoma followed by a water-tight closure of the bladder wall and anatomical closure without drains was performed Fig. 1a–c.

- **Conventional laparotomy approach**, after transurethral enucleation; in the supine position, a classic midline subumbilical extraperitoneal incision was made. Cystostomy was classically performed for extraction of the adenoma and any bladder stones. Then, bladder diverticulectomy was performed as indicated Fig. 1d.

**TUR approach (Group II)**

For adenomas that were judged by the surgeon as resectable within a reasonable time.

- ‘Mushroom technique’, in which adenomas were left attached at the bladder neck between the 3 and 5 o’clock positions for the left lobe, and the 7 and 9 o’clock positions for the right lobe followed by bipolar TUR of the partially detached adenoma Fig. 2a–c.

- **TUR of intravesical completely enucleated adenoma**, in cases of non-intentional separation of relatively small adenomas to the bladder. The resection of the freely detached adenoma inside the bladder is relatively difficult and associated with risk of bladder injury. So, in these instances insertion of a suprapubic 5-mm transvesical laparoscopic port with the introduction of a tissue grasper to hold the adenoma during TUR was performed Fig. 2d–f. The port was removed at the end of the procedure and a three-way 22-F urethral catheter inserted.

**Outcome measures**

Intraoperative and peri-procedure parameters were monitored and reported. The efficacy of each approach was assessed by tissue retrieval time, weight of tissue retrieved, and tissue retrieval rate. For open extraction, the retrieval time was counted from skin incision to closure. For the TUR approach, the retrieval time was counted after the introduction of the resection loop until catheter insertion. The rate of tissue retrieval was calculated by dividing the weight of the prostate specimen by the time needed for retrieval.

The safety of each approach was assessed and compared. Peri-procedure complications, hospital stay and catheter time were reported and compared. Peri-procedure haemoglobin and haematocrit values deficits

![Figure 1](image)

(a) Mini-laparotomy, adenoma extraction. (b) Mini-laparotomy, 3-cm wound. (c) Mini-laparotomy, 163.8 g extracted adenoma. (d) Conventional laparotomy, bladder diverticulum specimen and extracted enucleated adenoma and vesical stone.
were calculated and compared using the following formula; preoperative level minus the postoperative level as assessed on the first postoperative day. The blood transfusion rate was compared between the study subjects. Furthermore, urinary functional outcomes were assessed by symptom score (IPSS), and maximum

Table 1  Baseline data.

| Variable                                      | Post HoLEP extraction of prostatic adenoma | P         |
|-----------------------------------------------|--------------------------------------------|-----------|
|                                               | Laparotomy, Group I [mini-laparotomy (n = 17), conventional laparotomy (n = 2)] | TUR, Group II ['mushroom technique' (n = 16), TUR of intravesical adenoma (n = 2)] |
| Mean (SD):                                    |                                            |           |
| Age, years                                    | 66.4 (5.7)                                 | 68 (7.9)  | 0.5      |
| BMI, kg/m²                                     | 29.6 (5.1)                                 | 30.7 (3.4)| 0.4      |
| TRUS estimated prostate size, g               | 176 (30)                                   | 96.5 (26) | <0.001   |
| N (%)                                         |                                            |           |
| Patients with ASA score of III                | 2 (10.5)                                   | 3 (16.6)  | 0.5      |
| Patients with diabetes mellitus               | 4 (21)                                     | 6 (33.3)  | 0.66     |
| Indications of surgery                        |                                            |           |
| Indwelling urinary catheter, urine retention, and failed TOV | 4 (21)                                     | 5 (27.5)  | 0.2      |
| LUTs refractory to medical treatment          | 13 (68.5)                                  | 12 (67)   |           |
| Haematuria of prostatic origin                | 2 (10.5)                                   | 1 (5.5)   |           |
| Median (range) preoperative PSA level, ng/dL  | 10.5 (0.5–27)                              | 3.6 (0.1–15)| 0.004   |

ASA, American Society of Anesthesiologists; TOV, trial of voiding.
urinary flow rate ($Q_{\text{max}}$) and post-void residual urine volume (PVR) estimations were recorded, and all readmissions were reported.

**Statistical analysis**

Data analysis was conducted using the commercially available Statistical Package for Social Sciences (SPSS® 20 for Mac). Results were compared between study groups using the chi-square and Fisher’s exact tests for categorical variables, and the independent samples $t$-test and Mann–Whitney $U$-test for quantitative variables, as appropriate. A $P < 0.05$ was considered to indicate statistical significance.

**Results**

Between August 2012 and July 2015, of 392 HoLEP procedures, non-morcellation approaches were used for tissue retrieval in 37 (9.4%) procedures. In 19 procedures the laparotomy approach was adopted (Group I) which comprised of 17 mini-laparotomies and two conventional laparotomies for concomitant diverticulectomy, while TUR of the enucleated adenoma (Group II) was used in other 18 patients.

The baseline demographic data and indications for surgery were comparable between the study groups. However, in Group I, the prostates treated were larger and the baseline PSA levels were higher (Table 1).

Table 2 summarises the safety and efficacy outcome data in both groups. There were no significant differences between the groups for tissue retrieval time, histopathological findings of retrieved tissue, and peri-procedure complications.

### Table 2 Efficacy and safety profile.

| Variable                                | Laparotomy, Group I | TUR, Group II | $P$  |
|-----------------------------------------|---------------------|---------------|------|
| N (%)                                   |                     |               |      |
| BPH                                     | 15 (78.9)           | 14 (77.7)     | 1    |
| BPH with prostatitis                    | 3 (15.9)            | 4 (22.3)      |      |
| BPH with focal prostate cancer          | 1 (5.2)             |               |      |
| Median (range)                          |                     |               |      |
| Tissue retrieval time, min              | 39 (33–75)          | 42 (19–85)    | 0.1  |
| Histopathological weight of specimen, g | 115 (56–193)        | 38 (15–90)    | <0.001|
| Tissue retrieval rate (specimen weight/retrieval time), g/min | 4.6 (1.53–5.3) | 1.09 (0.6–2.2) | <0.001 |
| Haemoglobin deficit, g/dL               | 0.3 (0.4–3.5)       | 0.9 (0.1–4.3) | 0.6  |
| Haematocrit value deficit, %            | 4.9 (0.8–11.4)      | 4.9 (1.5–13.5) | 0.3  |
| Blood sodium deficit, mmol/L            | 3 (1–3)             | 0.0 (–7 to 3) | 0.09 |
| Catheterisation time, days              | 5 (5–7)             | 2 (1–3)       | 0.01 |
| Hospital stay, days                     | 1 (1–4)             | 2 (1–3)       | 0.07 |
| Peri-procedure complications, n (%)     | 2 (10.5)            | 4 (22.3)      | 0.5  |
| Bladder injury                          | –                   | 1             |      |
| Anaemia necessitates blood transfusion  | –                   | 1             |      |
| Postoperative haematuria                |                     |               |      |
| Conservative measures                   | 1                   | –             |      |
| Post retrieval cystoscopic haemostasis  | –                   | 1             |      |
| Readmissions                            |                     |               |      |
| Secondary bleeding and clot retention    | 1                   | –             |      |
| Urethral stricture for endoscopic meatotomy | –               | 1             |      |

* Preoperative minus immediate postoperative value.
biochemical changes. However, significantly more tissue was retrieved and at a median faster rate in Group I. The groups had similar median hospital stays, but the median time to catheter removal was longer in Group I.

Postoperative haematuria was reported in one patient in each group, conservative measures were satisfactory in the Group I patient, while re-cystoscopy was indicated for haemostasis in the Group II patient. One readmission was reported in each group (Table 2).

Fig. 3 shows the changes in symptom score (IPSS), $Q_{\text{max}}$, and PVR over time. There were statistically significant improvements in all urinary outcome measures from baseline to the last follow-up ($P < 0.05$). There was no statistically significant difference in any of the assessed parameters at different time points between the laparotomy (Group I) and TUR (Group II) groups ($P > 0.05$).

Peri-procedure blood transfusion was indicated in one case (2.7%).

Discussion

Transurethral enucleation of prostate adenoma is an appealing approach for management of all sizes of BPH. Enucleation has become more popular and different kinds of energy have been tried to accomplish the enucleation [10]. Morcellation of the intravesical adenoma is the standard approach for tissue retrieval after transurethral enucleation. Three commercially available morcellators are in the market, of which two have been frequently studied [5,11]. However, in most of the large series of transurethral enucleation procedures, there is a place for non-morcellation approach for tissue retrieval [3,12].

Problems with morcellation have been reported with different kinds of morcellators. Occasionally, it might oblige the surgeon to stage the procedure (secondary morcellation due to bleeding or blade malfunction) [6]. Complications secondary to morcellation include bladder mucosal injuries (up to 7.1%), perforation (up to 5.9%) [13], and bleeding (0.02–6.9%) [5]. Furthermore, mechanical problems of morcellators have been reported; in the Piranha morcellator (Wolf Inc., Knittlingen, Germany) secondary to a leak of negative pressure from the vacuum bottle/tubing set and in the VersaCut (Lumenis Inc., Santa Clara, CA, USA) morcellator obstruction of the tubing set where large tissue piece can cause malfunction of the pump and significantly reduce suction power [5].

### Table 3 Review of non-morcellation tissue retrieval approaches following different TUR enucleation techniques in the contemporary series.

| References                  | RCT/CS | Procedure | Mean (SD, range) prostate size, mL | Number of procedures | Tissue retrieval approach | Rational for non-morcellation |
|-----------------------------|--------|-----------|----------------------------------|----------------------|---------------------------|-------------------------------|
| Hochreiter et al. (2002) [7] | CS     | HoLEP     | 38 (20–70)                       | 156                  | Unipolar ‘mushroom’       | No available morcellator     |
| Elshal et al. (2012) [24]   | CS     | HoLEP     | Group 1, 94.3                    | 1054                 | Laparotomy 0.5%           | Exceptionally large prostates|
| Krambeck et al. (2010) [12] | CS     | HoLEP     | Group 2, 79.3                    |                      | Laparotomy 0.3%           | Morcellator malfunction      |
| Abdel-Hakim et al. (2010) [23] | CS     | HoLEP     | 86.5 (65.4, 20–350)             | 230                  | Laparotomy 0.1%           | Dense non-morcellating adenoma|
| Kuntz and Lehrich (2002) [21] | RCT    | HoLEP     | 114.6 (21, 100–230)             | 60                   | Unipolar ‘mushroom’ 83%   | No available morcellator     |
| Kuntz et al. (2004) [22]    | RCT    | HoLEP     | 53.5 (20, 20–95)                | 100                  | Unipolar ‘mushroom’       | No available morcellator     |
| Zhang et al. (2012) [20]    | RCT    | HoLEP     | 43.5 (23, 37.3–76.4)            | 62                   | Unipolar ‘mushroom’       | No available morcellator     |
| Zhang et al. (2012) [20]    | RCT    | ThulEP    | 46.6 (25, 34.2–79.6)            | 71                   | Unipolar ‘mushroom’       | No available morcellator     |
| Liao and Yu (2012) [19]     | CS     | PKEP      | 77.3 (56–95)                    | 160                  | Bipolar ‘mushroom’        | Routine                       |
| Luo et al. (2014) [18]      | CS     | PKEP      | 61.8 (18.7)                     | 155                  | Bipolar ‘mushroom’        | Routine                       |
| Zhao et al. (2010) [17]     | RCT    | PKEP      | 69.2 (13.5, 35–158)             | 102                  | Bipolar ‘mushroom’        | Routine                       |
| Zhu et al. (2013) [16]      | RCT    | PKEP      | 113.8 (32)                      | 40                   | Bipolar ‘mushroom’        | Routine                       |
| Chen et al. (2014) [14]     | RCT    | PKEP      | 110 (102–130)                   | 80                   | Bipolar ‘mushroom’        | Routine                       |
| Rao et al. (2013) [15]      | RCT    | PKEP      | 116.2 (32)                      | 43                   | Bipolar ‘mushroom’        | Routine                       |

RCT, randomised clinical trials; CS, case series; ThulEP, thulium laser enucleation of the prostate; PKEP, plasma kinetic enucleation of the prostate; NS, not specified; NR, not reported; NA, not applicable.
The main indications for non-morcellation approaches are concomitant pathology, and malfunction or absence of a tissue morcellator. Hochreiter et al. [7] in 2002, described the ‘mushroom technique’ for tissue retrieval after HoLEP. They concluded that combining HoLEP and TUR of partially enucleated adenomas is a safe, efficient and bloodless (no blood transfusion) surgical treatment for BPH, with no need for a mechanical tissue morcellator [7]. With the evolution of bipolar technology resection of the partially detached adenoma can be achieved without the need to change the irrigant and maintaining safety using an isotonic irrigant. Table 3 [7,12,14–24] reviews the role of non-morcellation tissue retrieval approaches used in contemporary series of transurethral enucleation procedures. In the present study, we exclusively report on these approaches in our growing HoLEP series.

Concomitant pathology requiring non-endourological management indicates laparotomy to complete the procedure. The advantage of HoLEP is that it permits a visually controlled laser-assisted enucleation of the prostate even after performing laparotomy to allow retrieval of the enucleated adenoma. No peri-procedure blood transfusions were required in HoLEP/laparotomy group (Group I) and the median hospital stay was 1 day. Conventional laparotomy was needed in the two patients with concomitant diverticulectomy. A mini-laparotomy with a small incision was used for the remaining patients in HoLEP/laparotomy group (Group I). In the absence of a tissue morcellator, mini-laparotomy is a safe, effective and convenient approach for adenoma retrieval. Large adenomas that fill most of the bladder cavity might hinder safe morcellation. Open extraction is the preferred option with exceptionally large prostates [24]. The ‘mushroom technique’, particularly if a bipolar electrosurgical generator is available, might be a reasonable option for tissue retrieval. Resection in situ of a partially detached adenoma is safe, effective and bloodless [7]. In the HoLEP/TUR group (Group II), one case unusually required postoperative blood transfusion after a lengthy procedure with TUR of a completely detached intravesical adenoma; however, the overall median haemoglobin and haematocrit values deficits were comparable between Groups I and II. Furthermore, the median hospital stay was similar in both groups (Table 2). There were no statistically significant differences between the groups for peri-procedure complications. When considering the efficiency of both procedures, significantly more tissue was retrieved and at a faster rate in the HoLEP/laparotomy group (Group I; Table 2). The pathology of the retrieved specimens was similar in both groups.

Fig. 4 shows an algorithm outlining our approach for tissue retrieval after transurethral prostate enucleation. Morcellation is routinely performed provided that a perfectly working morcellator and cutting blades are

![Algorithm for tissue retrieval approaches after transurethral enucleation of prostate adenoma.](image-url)
available. Non-morcellation approaches are valid options in cases of an absence of a perfectly working morcellator, very large prostates, and when there is concomitant lower urinary tract pathology. Piao et al. [25] identified men aged $\geq 65$ years and a total prostate volume of $\geq 65$ mL as independent predictors for hard nodules resistant to morcellation, with mainly dense fibrous tissue forming these nodules. Hard nodules resistant to morcellation make morcellation cumbersome and time-consuming. Ishikawa et al. [26] showed that morcellation efficiency may decrease significantly in larger glands of $> 80$ g enucleated weight. Monn et al. [27] showed that a larger prostate volume significantly reduced morcellation efficiency; furthermore, a history of UTI and clean-intermittent catheterisation were associated with modest increases in morcellation times. Secondary HoLEP after previous transurethral prostate surgery is associated with a lower morcellation rate [24].

Lithotripsy for large bladder stones of $> 2$ cm using pneumatic or holmium laser lithotripsy could be associated with bladder complications that might abort same session prostatectomy [28]. The presence of a large median lobe affecting the visibility of the vesical stone might be an indication to start the procedure by prostate enucleation followed by a mini-laparotomy to extract the vesical stone and the enucleated prostate adenoma. Concomitant transurethral prostatectomy and suprapubic minimal incision cystolithotripsy have been reported to be superior to a staged procedure [29].

Limitations of the present study include the small sample size and retrospective nature. However, to the best of our knowledge, this is the first report that addresses different viable non-morcellation approaches for tissue retrieval after transurethral enucleation of prostate adenoma. Another limitation is that the choice of the approach was purely based on surgeon preference.

Conclusion

Non-morcellation tissue retrieval approaches are valid options for endourologist practicing transurethral enucleation of prostate adenoma. In the absence of or malfunction of a tissue morcellator, or whenever concomitant pathology indicates laparotomy, these approaches are valid alternatives that retain most of the advantages of the transurethral prostate enucleation procedure.

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Conflicts of interest

None.

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