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Review Article

Technical Aspects of Holmium Laser Enucleation of the Prostate for Benign Prostatic Hyperplasia

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Holmium laser enucleation of the prostate (HoLEP) is a minimally invasive procedure and a size-independent treatment for benign prostatic hyperplasia with excellent long-term surgical outcome. HoLEP has become an alternative to conventional transurethral resection of the prostate or open prostatectomy owing to its efficacy and safety. Although HoLEP is known to have a steep learning curve, very few articles have addressed the technical aspects of HoLEP. Herein, we described detailed techniques and tips for HoLEP as performed at Seoul National University Hospital in a step-by-step manner with extensive review of the literature.

Keywords: *Holmium laser enucleation of the prostate; Morcellation; Prostate surgery; Prostatic hyperplasia; Surgical procedure*

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INTRODUCTION

Benign prostatic hyperplasia (BPH) is a common condition in the aged male. Transurethral resection of the prostate (TURP) is the standard treatment for symptomatic BPH refractory to medical treatment [1,2]. However, 15% to 20% of TURP patients experience significant complications, and the mortality rates of TURP are reported to be up to 0.2% to 2.5% [3-6]. Recently, diverse minimally invasive procedures have been introduced. These new procedures show outcomes comparable to those of TURP with decreased morbidity.

Laser ablation of the prostate using a holmium:yttrium-aluminum-garnet (Ho:YAG) laser (wavelength, 2,140 nm) was first introduced in 1995 [7]. Because the Ho:YAG laser is strongly absorbed by water molecules, the depth of tissue penetration is very short (0.5 mm). Therefore, the prostatic tissue can be ablated only when it is in direct contact with the laser. The holmium laser has a very low ablation velocity and thus has been applied to only small prostates (20–30 g) [8]. This technique was modified to perform direct resection of adenomatous tissue with pulsating stream bubbles at the tip of the firing optical fiber (holmium laser resection of the prostate, or HoLRP) [9]. With the introduction of a mechanical tissue morcellator, the procedure was further refined to the present holmium laser enucleation of the prostate (HoLEP) [9,10].

Recent results suggest that the clinical outcomes of HoLEP are comparable to those of TURP or open prostatectomy with reduced irrigation-related complications and shorter catheter periods and hospital stays [11-15]. Moreover, HoLEP has a lower immediate complication rate [16] and has the merits of a favorable cost-benefit ratio [17-19] with comparable or superior long-term surgical outcomes [16,19,20]. Despite such excellent clinical advantages of HoLEP, it is not yet widely practiced and has limited acceptance in the urological community. The reason is that it is technically challenging and has a steep learning curve. Some surgical groups have claimed that an operator needs at least 20 to 30 cases of experience to attain a plateau of the learning curve [15,19,21,22], whereas others argue that up to 50 cases are necessary [23,24].

An intensive mentor-based approach may shorten the adaptation period [22,25]. But, hands-on courses and training programs for HoLEP are scarce in the urologic society. In this respect, in the present article, we aimed to describe detailed technical aspects of HoLEP on the basis of our experience in addition to presenting an extensive review of the literature.

PREOPERATIVE CONSIDERATIONS

HoLEP can be offered to any patient who has bladder outlet obstruction and benign prostatic enlargement. Patients are selected on the basis of symptoms with consideration of a validated symptom score, physical examination, frequency/volume chart, prostate-specific antigen, uroflowmetry [22,23,26], transrectal ultrasonography of the prostate (TRUS) [7,25,27-29], and, if indicated, pressure flow studies [22,30]. In early cases, we routinely performed urethrocystoscopy, although we currently perform it only in selected cases to evaluate urethral abnormalities, the severity of anatomical obstruction, and the three-dimensional structure of the prostate. We were also concerned that the 26-Fr resectoscope sheath might be too thick for Asian patients. However, when gentle 30-Fr curved metallic sound dilatation was performed, there were usually no major problems in most cases. Other Asian groups have described that they perform metallic sound dilatation to prevent meatal stricture [23].

TRUS can provide valuable information about the prostatic adenoma. This information is an important parameter for surgeons when first learning the procedure [29]. The surgeon should reconstitute the tridimensional configuration of the adenoma by using the transverse and sagittal images of ultrasonography [25,31,32]. Such imaging is also useful to screen for unexpected comorbidities such as bladder stones [22]. In cases in which calcification is discovered at the prostate capsule on TRUS, these prostatic stones can be a landmark for defining surgical planes. In most cases, the capsule plane is very thin at the 9 to 3 o'clock position, whereas other positions have relatively thick adenoma tissue. Thus, it is safer to start enucleation at both sides of the verumontanum.

A preoperative frequency/volume chart can also provide very useful information. With the frequency/volume chart we can identify the functional bladder capacity (FBC). In patients with severe bladder outlet obstruction, secondary bladder changes occur owing to poor compliance and low capacity [33]. If the patient has a small bladder capacity, the surgeon should pay more attention to the risk of bladder injury. In most cases of morcellation, the relative bladder volume tends to be larger than the maximum cystometric capacity (MCC) measured during filling cystometry. Previous literature reports that the FBC tends to be larger than the MCC [34,35]. Therefore, when both FBC and MCC are available before morcellation, FBC is more useful than MCC in predicting a true maximal bladder volume.

Cross-matching for blood transfusion may not be necessary [22]. Our institution as well as other groups have reported extremely low transfusion rates of 0% to 1.9% [10,19,24,36]. As for the preparation of patients on oral anticoagulant therapy, there are some differences in protocols according to the institution. Some institutions suggest that patients discontinue all anticoagulants and others recommend low molecular weight heparinization before surgery [19,22,23,25,29]. Our protocol for patients concerning anticoagulants recommends that low-risk patients stop aspirin or warfarin 5 to 7 days before surgery, and low molecular weight heparinization is performed in selected conditions. Recent reviews about this issue report that laser therapy for BPH seems to decrease bleeding risk, but there are no definitive guidelines established for managing patients on anticoagulants [37].

SETTINGS FOR HoLEP

HoLEP is a transurethral procedure that uses an end-firing Ho:YAG laser fiber and aims to enucleate the whole adenoma of the prostate. The enucleated adenoma is removed by using a morcellator placed in the bladder cavity [10]. In a strict sense, HoLEP literally means *enucleation of prostate adenoma*, but in clinical practice, it is generally combined with the morcellation procedure.

The detailed equipment for HoLEP is similar in all institutional groups [10-13,19,20,22-25,29,38-41]. Generally, HoLEP surgeons use a 60 to 100-W holmium laser (Versapulse, Lumenis Ltd., Yokneam, Israel) with a power setting of 2 to 2.4 J at 25 to 50 Hz [7,10,20,26,39-41]. The 360- to 550-μm end-firing laser fibers (SlimLine, Lumenis Ltd.) [7,19,20,22,26,27,40] and 24- to 28-Fr continuous flow resectoscope are routinely used [7,10,26,27,40,41]. In the case of the 24-Fr resectoscope, Hochreiter et al. [27] reported that they did not use a morcellator but used an adjuvant transurethral resection for enucleated adenomas with the "mushroom technique". There are two different

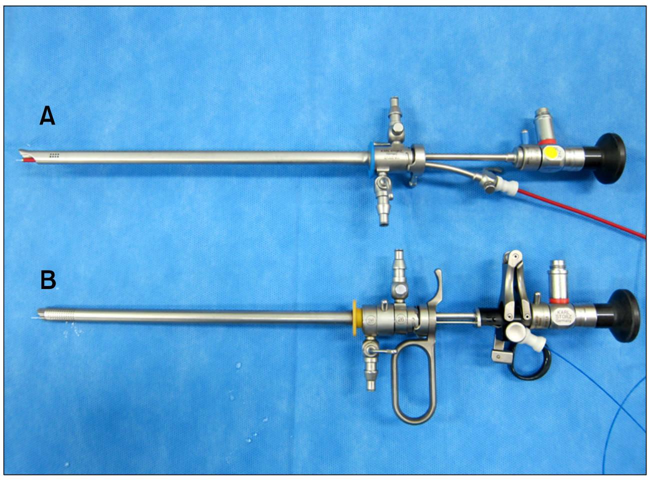

FIG. 1. Two different types of working channels for holmium laser enucleation of the prostate. (A) An Iglesias type resectoscope. (B) A conventional laser fiber stabilizing bridge.

types of inner sheaths for supporting the laser fiber. The first is an Iglesias type resectoscope (27056LA, Karl Storz, Tuttlingen, Germany) (Fig. 1A) [7], and the other is a conventional laser fiber stabilizing bridge, which requires the left hand for laser fiber advancement (such as 27026V, Karl Storz) [23,28,29,41]. Some surgeons use a 6- to 7-Fr ureteral catheter for fiber stabilization [22,23,26,28,40,41]. Tissue morcellators (Versacut, Lumenis) placed through 25- to 27-Fr indirect nephroscopes are commonly used [19,20,26,40,41]. Almost all operators use normal saline as the irrigation fluid [19,20,25,28,29,40], but a few groups do not [27]. The detailed settings for HoLEP at our institution are shown in Table 1 and Fig. 2.

SCOPE INTRODUCTION AND ORIENTATION

Under general or spinal anesthesia [10-13,19,22-25,27,38], patients are placed in a lithotomy position. It is recommended that the thighs be abducted sufficiently to allow secure manipulation of the resectoscope during dissection of both lateral lobes [29], during which the range of motion for both hands is larger than when performing TURP.

Table 1. HoLEP equipment in Seoul National University Hospital

100 W Ho:YAG laser generator (Versapulse PowerSuite; Lumenis Ltd., Yokneam, Israel)
550-mm end-firing fiber (SlimLine 550; Lumenis Ltd.)
Tissue morcellator - 0.19-inch external diameter (Versacut; Lumenis Ltd.)
Video tower and endoscopic camera. (Stryker Co., San Jose, CA, USA)
26-F continuous flow resectoscope sheath (27040SL/XA, Karl Storz, Tuttlingen, Germany)
Modified inner sheath for the laser serving (27056LA, Karl Storz)
30° Telescope (27005BA, Karl Storz)
26-F nephroscope with off-set lens (27292 AMA, Karl Storz)
Adapter for connecting to resectoscope sheath (27040 LB, Karl Storz)

HoLEP, holmium laser enucleation of the prostate; Ho:YAG, holmium:yttrium-aluminum-garnet.

After sterile draping, approximately 20 mL of lubricating jelly is injected to the urethra. After gentle sound dilatation [23,29] of the urethra, the resectoscope and working element are inserted. In the presence of a focal annular stricture, the operator may have trouble in the insertion or removal of the scope. In this case, it is a good idea to consider endoscopic internal urethrotomy for focal stricture before insertion [29]. In cases when the caliber of the urethra is too narrow for a 26-Fr resectoscope to pass, other procedures using smaller scopes such as laser vaporization or TURP may be used. If the patient has a diffuse long-segment stricture owing to a previous urethral procedure but an otherwise patent lumen, and BPH is thought to be the major cause of obstruction, we can consider a perineal urethrostomy. We have successfully performed a few cases of HoLEP with perineal access.

During enucleation, proper orientation is not easy, because the working space is small and the working distance is short [25]. Reorientation during plane dissection may be time-consuming. Operators should always keep the tridimensional structure of the prostate in mind. Because the verumontanum and bilateral ureteral orifices are important landmarks for orientation [22,29], such structures should be identified before operation. The distance from the external sphincter to the verumontanum, the degree of bladder neck elevation, the severity of bladder trabeculation, and the bladder capacity should also be kept in mind at all times.

The most important point for good orientation is that the endoscopic view be fixed in the same direction constantly. To do that, the operator has to grasp the camera with the nondominant hand throughout the procedure and manipulate the working element with the dominant hand [25,29].

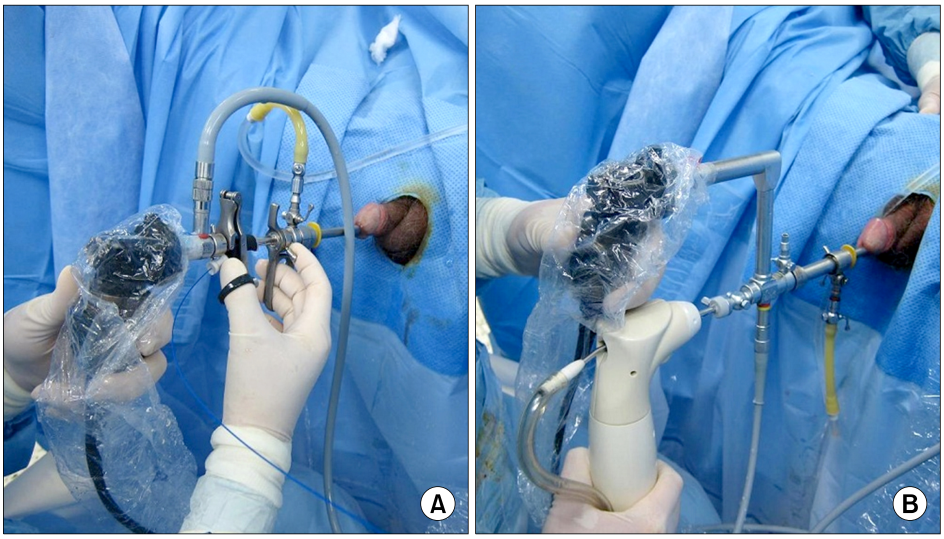

Fig. 2. Hand manipulation for holmium laser enucleation of the prostate. (A) Enucleation. (B) Morcellation.

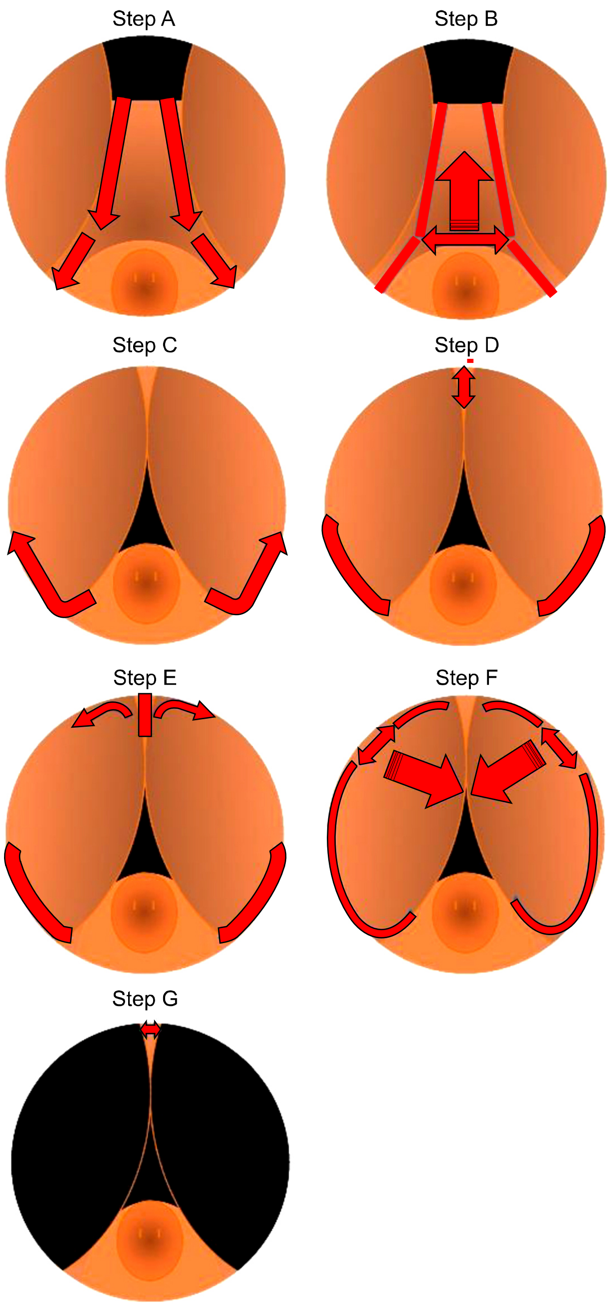

FIG. 3. The three-lobe or four-lobe technique. Step A, initial incision; step B, transverse incision for median lobe enucleation; step C, upward enucleation of both lateral lobes; step D, longitudinal incision of the anterior lobe (12 o'clock position); step E, downward enucleation of both lateral lobes; step F, completion of lateral lobe enucleation; step G, anterior lobe removal during the four-lobe technique.

ENUCLEATION

Some groups prefer the two-lobe technique, especially in cases of small prostates [19,25,29,40]. However, the same technique has been successfully applied in moderate to large prostates by Gong et al. [42]. For this technique, one incision is made initially at either the 5 or the 7 o'clock position. One lateral lobe enucleation is done on the side of the incision. The median lobe is then enucleated along with the remaining lateral lobe. However, most groups use the "three-lobe" technique in which the median lobe is resected first, followed by the lateral lobes [22,25,27,29,43]. The surgeon can lift up the lateral lobes along the enucleated planes. Removing the anterior lobe with one of the lateral lobes is referred to as the three-lobe technique. On the other hand, if the anterior lobe is removed separately after removal of the lateral lobes, this is termed the "four-lobe" technique. We use either the three- or the four-lobe technique according to the surgical situation. The schematic diagram of HoLEP in Seoul National University Hospital is as shown in Fig. 3 and the procedure is described in detail below.

INITIAL INCISION (STEP A)

First, incisions are made at the bilateral borders of the verumontanum to the depth of the prostate capsule. Then, bilateral longitudinal bladder neck incisions are made at the 5 and the 7 o'clock positions from a point distal to the ureteral orifices and on each side of the verumontanum incisions (Fig. 3, step A; Video clip 1, Supplementary material). When performing these initial incisions, finding the prostatic capsule is the most important step [22]. These incisions will serve as the standard for the depth of dissection during the rest of the procedure. The capsule is defined by whitish circular fibers running in a circular direction in contrast with yellowish charring findings when cutting prostate adenoma tissue [28,29]. As the incision progresses distally, the incision can be widened by sweeping the lateral lobes with the tip of the scope. Some groups prefer to first make an incision from the bladder neck [22,25,29] before making a transverse incision to the median lobe just proximal to the verumontanum. A further separation of the median lobe from both lateral lobes deep down to the capsular plane will be very helpful when further dissecting the median lobe along the capsular plane. During this maneuver, the lateral lobe is raised with a leverage movement of the scope beak. It can be an initial landmark of the capsule plane for the lateral lobe enucleation that will follow [29].

TRANSVERSE INCISION FOR MEDIAN LOBE ENUCLEATION (STEP B)

Subsequently, a transverse incision is made just proximal to the verumontanum, which connects the previous longitudinal incisions until the capsule planes are identified (Fig. 3, step B; Video clip 2, Supplementary material). If the baseline capsule of the median lobe is identified, the beak of the scope is pushed to sweep the median lobe below the distal part of the median lobe. This blunt dissection helps to define the plane between the adenoma and the capsule. In larger adenomas, the capsule plane tends to be identified easily [22,28]. By combining sharp cutting and blunt dissection, the adenoma can be enucleated in a retrograde manner.

The plane may not be clear near the bladder neck. Therefore, the surgeon should be careful not to undermine the fibrous tissue of the bladder neck [25,28]. In the large median lobe, the adenoma may be located deeply distal to the bladder neck. In this situation, the bladder neck side of dissection tends to be very close to the bilateral ureteral orifices. Surgeons should follow the proper planes in order to not damage the ureteral orifices. The space created after removal of the median lobe secures working space for scope movement and makes it is easier to apply the leverage movement of the scope for lifting the prostate. Enucleation of a large median lobe may result in the creation of a deep prostatic fossa and high bladder neck because the bladder neck becomes relatively narrow in comparison to the distal wide fossa area where both lateral lobes were previously located. Such an anatomical change makes urethral catheter indwelling difficult and sometimes requires guide-wire mounting before catheter indwelling ("barrel-shaped prostatic fossa" as described later in this text).

UPWARD ENUCLEATION OF BOTH LATERAL LOBES (STEP C)

Complete enucleation of one lobe at a time is recommended [25]. After enucleation of the median lobe, the endoscope is retracted distally to identify the verumontanum and the external urethral sphincter, which is generally attached distal to the verumontanum. The appropriate apical capsule plane dissection is very important for lateral lobe enucleation. Some surgeons recommend reducing the power of the laser at this point to prevent thermal injury of the external sphincter [26,28,29,40].

The technique for initial dissection of the lateral lobe was previously described. This may be helpful in finding a correct plane for apical dissection and thus is a very important point for prevention of external sphincter injury. At the initially dissected site of the lateral lobe, a careful upward prostatic mucosal incision slightly to the adenoma side, not onto the distal urethral sphincter side, should be made with the "curtain-opening incision" technique (Fig. 3, step C; Video clip 3, Supplementary material). If further inferior enucleation of the lateral lobe is performed without this upward mucosal incision, mucosal crevices can be extended distally to the bulbous urethra. When a proper plane is identified, the plane is extended upward to the 3 (left lobe) and 9 (right lobe) o'clock positions with the combination of sharp cutting and blunt lifting. Dissection should be aimed retrograde and upward. It would be better to choose to perform sharp cutting closer to the adenoma side rather than the capsular side when the plane is not clearly identified.

DOWNWARD ENUCLEATION OF BOTH LATERAL LOBES (STEPS D AND E)

A longitudinal incision along the 12 o'clock direction is made for anterior lobe dissection (Fig. 3, step D; Video clip 4, Supplementary material). Special attention should be paid to the distal end of the longitudinal incision. The verumontanum as a landmark is very important in this respect [25,28,29]. Operators should keep in mind that the incision should not be too deep [25], because the anterior lobe is often very thin and mainly consists of fibro-muscular tissues.

After the longitudinal incision, operators should find the superior aspect plane of the lateral lobes (Fig. 3, step E; Video clip 4, Supplementary material). At this point, finding a proper plane is very challenging for beginners because of the obscurity of the capsule [22]. Some operators advise antegrade dissection of the superior aspect from the bladder neck because capsule definition is easer [25,29]. But in our experience, the anterior lobe muscular fiber near the bladder neck is often attached to the prostatic capsule; thus, stripping the prostate from the capsule in a proper plane is sometimes difficult in this area. In addition, sphincter damage often occurs at the farther distal area of the 12 o'clock position where the external sphincter is located, not the bladder neck. Therefore, overzealous dissection may be risky for uncontrollable bleeding or postoperative incontinence. The upward incision made in the previously mentioned step is an important landmark for making a further longitudinal incision from the bladder neck to the most distal margin of the lateral lobe. The technical aspects of this part will be described in the next step. The bilateral horizontal incisions from the 12 o'clock position at the bladder neck are extended downward until the operator identifies the capsule plane of the lateral lobe. Dissection following this plane is performed by downward enucleation. After proper plane division, blunt dissection of the adenoma using the endoscopic beak can be applicable in the leverage and dropping manner. The dissection plane was extended to the 3 (left) and 9 (right) o'clock directions. Returning to the 6 o'clock position where the verumontanum is located and then extending the dissection of the lateral lobes is advantageous for the next step of enucleation (step F).

COMPLETION OF LATERAL LOBE ENUCLEATION (STEPS F AND G)

The last step of lateral lobe enucleation is conjoining the two planes from the upper and lower incisions (Fig. 3, step F; Video clips 5 and 6, Supplementary materials). Operators should keep the conjoining point, which is anticipated by the imaginary extension line from the two incisions, in mind [29]. The incision line that is made in step C from the bladder neck to the 12 o'clock direction terminal point of dissection (conjoining point, C point) is extended transversely to meet the upward border of the mucosal incision made two steps previously. In most cases, connection of the plane is made anteriorly (at the 2 or 10 o'clock position). To avoid damage to the sphincter, the incision should be made closer to the adenoma side (Video clip 7, Supplementary material). Contrary to this, dissection too far beyond the capsule may cause sphincter injury. Conjoining incision lines to complete the incision of the surface of the prostatic adenoma is a very important step. This step may be very challenging to beginners. Without complete dissection of the capsule, the insufficiently removed adenoma floats and interferes with the next step, and it is difficult to identify the stalk and resect at this point.

The enucleated adenoma that hangs down from the 12 o'clock direction in the previous step approaches the plane, which has moved upward; therefore, proximal advancement of the enucleation using the C point as a landmark should be performed. Using the endoscopic beak, the lateral lobe is lifted and pushed to the bladder [29]. Even though identification of the downward and upward enucleation planes is performed properly, sometimes these two planes do not meet each other properly. In such cases, in an intermediate point, dissection should be performed to connect these two planes while heading to the proximal direction.

In most cases, the anterior lobe is removed simultaneously with the right lobe (three-lobe technique). However, if the anterior lobe is large or if it is difficult to remove with the right lobe, the anterior lobe is removed separately (four-lobe technique) (Fig. 3, step G). Precaution should be taken to make a transverse incision, which must be done proximal to the external sphincter and be extended to the bladder neck to get rid of the anterior lobe.

HoLEP IN PATIENTS WITH SMALL PROSTATES

In patients with small prostates (smaller than 30 g) and without median lobe enlargement, transurethral incision of the prostate (TUIP) is recommended as the treatment option [30]. However, some groups have applied the HoLEP procedure in small prostates as in moderate to large prostates. It seems that HoLEP in a small prostate is technically more difficult because the surgical capsule is often less distinct. However, a randomized controlled trial showed that HoLEP relieves obstruction better than does TUIP in patients with small prostates [44].

In the rare situation in which a patient has only median lobe enlargement with obstructive symptoms, HoLEP may be a preferred option. However, it has not been established whether only median lobe enucleation or simultaneous lateral lobe enucleation is desirable for this situation.

HoLEP IN PATIENTS WITH LARGE PROSTATES

HoLEP theoretically is a size-independent procedure [38]. The overall efficacy of the HoLEP procedure increases proportionally to resected prostate weight [23]. The surgical outcomes are superb in large prostates, even in those larger than 100 g [11,20,38,40,45,46]. Some centers have reported their experience with HoLEP in patients with prostates larger than 350 g [11,29]. However, no guidelines have been presented on the technical difficulties of HoLEP for large prostates. HoLEP in a large prostate is generally not recommended to beginners [23,25].

The difficulties of HoLEP in large prostates are as follows. First, large prostates have more perforating feeding vessels to the adenoma from the subcapsular vessel networks. Therefore, the chances for bleeding are greater. Detailed bleeding control techniques will be mentioned later. Second, multiple surgical capsule planes are caused by the formation of multiple satellite adenomas. Therefore, operators should focus on the main adenoma nodules in advance. The satellite nodules can be removed later. Otherwise, operators can encounter very complicated surgical planes.

Third, in cases of a huge prostate, there are some difficulties in manipulating the resectoscope. We experienced difficulty in reaching the bladder neck owing to the relatively short length of the resectoscope [47]. Such difficulty caused compression of the penile shaft while using the scope. In such a situation, some groups recommend perineal urethrostomy [48,49]. In addition, severe adenoma protrusion into the bladder forms a dead angle, which creates difficulty in inspecting both the ureteral orifices and the trigone of the bladder [28].

Finally, sometimes the adenoma just distal to the bladder neck is extremely hypertrophied, and the relatively narrow, consequently formed "barrel-shaped" prostatic fossa prevents the adenoma from being pushed into the bladder. After enucleation, the enucleated adenomas fill the bladder, thus leaving insufficient space for morcellation. In this situation, sufficient bladder filling to move the orifices far from the median lobe can be helpful [45].

HEMOSTATIC TECHNIQUE

The Ho:YAG laser produces significant tissue coagulation up to a depth up to 3 to 4 mm [18,32]. The hemostatic property of the holmium laser lowers the incidence of significant perioperative blood loss [28,50]. However, significant bleeding from large arteries that is difficult to control can occasionally occur. Also, the bleeding of small vessels that occurs during a procedure should be controlled meticulously to ensure a clear endoscopic view for the following morcellation. Any bleeding of the small blood vessels can interfere with the magnified endoscopic view [22]. Bleeding vessels of the capsule mainly present in two forms, which are end vessels and creeping vessels (Video clip 8, Supplementary material). The former is likely to perforate to the adenoma, and the latter seems to form a network of vessels beneath the capsule [25]. This buried type of vessel bleeding is often difficult to coagulate with a laser and requires more attention.

Excessive focusing on one of the laser waves for hemostasis may cause capsular perforation. For better hemostasis with the holmium laser, operators should keep in mind the following points. First, hemostasis should be attended to with the defocused laser beam with a slight distance (2–3 mm from the bleeding vessel) [22,28,29,45]. Second, firing the laser at an angle may be helpful for defocusing of the laser beam [51]. Additionally, some authors have stated that the most effective hemostasis with the holmium laser was achieved at the power setting of 45 W (1.5 J with 30 Hz) [25,29,40]. We reduce the laser power to 20 W (0.5 J with 40 Hz) and ablate the bleeding vessels in a direct contact manner.

Bleeding sites during HoLEP are the apex, the bilateral sides of the verumontanum, and the 3 and 9 o'clock sides of the lateral lobe [22,25,29]. When performing surgery near these points, operators should pay more attention to bleeding. If hemostasis with the laser is difficult, switching to TUR for bleeding control may be necessary. Successful hemostasis and securing of a clear endoscopic view is very important for safe morcellation [22,29,31].

MORCELLATION

Morcellation has been used primarily for the laparoscopic removal of intra-abdominal organs in general surgery or gynecologic fields [52-55]. The morcellator was first introduced for prostatic tissue retrieval in 1998 [10]. The transurethral morcellators are designed with reciprocating blades that use a guillotine action and high-powered suction that allows simultaneous aspiration of the small pieces of prostatic tissue. It is assembled and connected to a 26-Fr offset nephroscope (Fig. 2B). Some surgical groups have reported that morcellation is relatively simple, the prostate gland can be removed safely and effectively, and there is no learning curve even for beginners [22-25]. But in our experience, there are some points for beginners to be careful of during morcellation. Bladder mucosal injury is an intraoperative complication that deserves precaution during morcellation [19,24]. The rates of bladder mucosa injuries are reported to be up to 18.2% [12,28]. Off-set nephroscopes have very small orifices for irrigation fluid; therefore, effective irrigant projection for clear endoscopic vision is limited [25]. During surgery, if the suction blade of the morcellator is not fully visible, the dome and posterior wall of the bladder may collapse in front of the scope, and such collapse can cause mucosal injury [24].

Some surgeons advocate the effectiveness of the mushroom technique [20,27], which is combined with transurethral resection of the prostatic adenoma attached to the bladder neck by a stalk to prevent potential hazards of morcellation. Other surgical groups suggest intraprostatic fossa morcellation to prevent bladder mucosa injury [25]. In most cases, however, the smaller the space the higher the possible risk of capsule injury.

We previously mentioned that meticulous hemostasis after enucleation to obtain a clear endoscopic view is essential for safe morcellation. Many other surgical groups also recommend this (Video clip 9, Supplementary material) [10,22,29,31,56]. To prevent bladder mucosal injury during morcellation, bladder distention is a prerequisite step [24,26,31,56]. Crushing of normal bladder tissue may occur in an instant; thus, operators should be prepared to lift the foot from the suction pedal at any time [22]. To determine the degree of bladder filling of the patient, the assistant should palpate the suprapubic area frequently. If distension is not sufficient, the operator should be informed. Excessive bladder distension may cause postoperative retention. However, probably owing to the short morcellation time, we have not experienced such problems in our institution. We propose the "swivel" technique, which is also helpful to prevent damage of the bladder. When the morcellator blade catches the adenoma chip, rotate the handle before aspirating the tissue. If the adenoma tissue is caught properly, the tissue can be swiveled without resistance.

Another exceptional situation can occur during morcellation. When large fragments are morcellated, small chips are often pushed back into the bladder by the flow of irrigation fluid, and in this situation, it is very difficult to grasp the adenoma in the normal orthotopic upward position. In such cases, 180 degree rotation of the handle of the morcellator with the blade facing down to the bladder trigone (upside down technique) can help suction small adenoma fragments.

At the end of the morcellation, small oval-shaped tissue fragments may be resistant to morcellation. These hard nodules are sometimes difficult to morcellate because they are not easily grasped by the morcellator blade. Some other operators have reported similar situations [22,25,28,29]. Such hard nodules, which are significantly larger than the caliber of the urethra, may damage the urethra when directly pulled out with forceps. Therefore, direct removal with forceps is not recommended. Even if removal of the nodule is not possible after raising the power of suction or blade speed, a laser incision made over the surface of the nodule may facilitate subsequent morcellation [25,29]. If hard nodules are still not easily removed despite the aforementioned techniques, adjuvant TUR can be considered [22,26]. Very rarely, mechanical failure of the morcellator blade can occur, which subsequently requires changing the blade, and has been reported by other groups [23,28].

IMMEDIATE POSTOPERATIVE CARE

After checking that no chips remain and after inspecting whether the external urethral sphincter is intact, the endoscope is removed, and then a urethral catheter is indwelled. The selected size of the urethral catheter differs slightly between surgical groups [19,22,23,25,40]. We use 22-Fr 3-way urethral catheters with 30-mL ballooning. Some groups recommend routine continuous irrigation [20], whereas others recommend continuous irrigation only in selected situations [19,39,40]. If the prostate and bladder neck are separated owing to a deep prostate fossa or narrow bladder neck (barrel-shaped prostatic fossa), Foley catheter indwelling may cause formation of a false way or capsular injury. In these cases, we mount a guide wire via the resectoscope sheath and insert the Foley catheter along this guide wire. The Foley catheter is usually removed 12 [26,28] to 24 hours [19,39-41] or 48 hours [27] after surgery. Patients are discharged after the postvoided residual volume is measured to be less than 50 mL at least two times.

RECOMMENDATIONS FOR BEGINNERS

To overcome the learning curve of HoLEP, some helpful tips are as follows. First, critically review unedited videos of experienced operators repeatedly [23]. Even after the beginner has experienced some cases of HoLEP, continuous review is recommended. In this way, previously overlooked points are often understood in a new perspective.

Second, beginners should choose appropriate cases. Cases with a total prostate volume of approximately 50 to 60 g are recommended for early experience. In our experience, when the prostate is smaller than that, capsule development is poor. On the other hand, if the prostate is larger than that, securing an endoscopic view and manipulation are very difficult. In our experience, operators may become confident with the HoLEP procedure after approximately 25 cases [57]. Other institutions also agree on appropriate selection of patients for early experience [11,15,21,29].

Finally, record your surgery with a video system, write an operation record, and objectively review your operation once again [25]. Write down important events that occurred during surgery and points for you to review. If possible, seek the advice of more experienced operators. Discuss the appropriate tissue plane and incision depth and ask for tricks for troubleshooting. A good adviser can shorten the long learning curve of HoLEP [23-25].

CONCLUSIONS

HoLEP is an efficient and cost-effective procedure for BPH treatment with favorable long-term surgical outcomes compared with conventional TURP or open prostatectomy. However, a steep operative learning curve may be the main obstacle to the widespread use of HoLEP. We have described detailed technical issues in this article. We hope that our experience will be helpful for beginners to overcome the learning curve and gain confidence with this procedure and for experienced surgeons to further improve their surgical technique.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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SUPPLEMENTARY MATERIALS

Accompanying videos can be found in the 'Urology in Motion' section of the journal homepage (www.kjurology.org). The supplementary video clips can also be accessed by scanning a QR code located on the title page of this article, or be available on YouTube (http://youtu.be/cZbM64rdnMM). Video clip 1. Initial incision. Video clip 2. Transverse incision for median lobe enucleation. Video clip 3. Upward enucleation of both lateral lobes. Video clip 4. Downward enucleation of both lateral lobes. Video clip 5. Completion of left lateral lobe enucleation. Video clip 6. Completion of right lateral lobe enucleation. Video clip 7. Tips for sphincter preservation. Video clip 8. Hemostatic technique. Video clip 9. Morcellation.

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