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ORIGINAL ARTICLE

Novel low-cost prostate resection trainer – description and preliminary evaluation

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Abstract

Background Transurethral resection of the prostate (TURP) is a challenging operation for residents with limited endoscopic experience. A number of virtual TURP simulators have been validated in the past. This study is the first description and preliminary evaluation of a non-virtual, low-cost TURP trainer as a teaching tool for residents in urology.

Methods Dr K. Forke's prostatic resection trainer (PRT; LS 10-2/S, Samed GmbH, Dresden, Germany) was tested during the surgical training of a resident. Under the supervision of an experienced senior surgeon, three aspects were examined: the resection trainer's approximation to reality, the ease of instruction, and the potential capability to improve surgeons' psychomotor abilities with regard to the three-dimensional (3D) guidance of the instrument. The improvement in resection speed (RS) of residents with no PRT training (control group) was also compared to the results of the PRT-trained resident.

Results During the PRT training, the resident displayed clear improvement in resection quality (RQ) and a 27% increase in RS ($p = 0.03$). In the post-training stage, the PRT-trained resident showed a more constant progress rate, to a maximum RS of 0.37 g/min (35% increase; $p = 0.01$), whereas the control group displayed varied RS learning curves. Composed of a synthetic material, which can be resected by standard instruments, the trainer offers a haptical experience that is particularly realistic and may provide an increased learning rate.

Conclusion From the findings, we conclude that this novel PRT is suitable for daily use and offers an effective and more affordable alternative to virtual simulators. Further validation studies will follow and new fields of application will be tested. Copyright © 2011 John Wiley & Sons, Ltd.

Keywords BPH; prostatic resection trainer; TURP; virtual simulator; surgical education; learning curve

Introduction

Approximately 5.6 million men in the USA suffer from symptomatic benign prostatic hyperplasia (BPH) (1). Currently, about 60 000 operations are performed annually in Germany to treat BPH. While alternative methods of treatment are increasingly being developed, transurethral resection of the prostate (TURP) is still the most frequently used surgical treatment method and continues to be the gold standard in the treatment of symptomatic drug-refractory benign prostatic hyperplasia (2).

As a result, both the quality of the surgeon and surgical technique play vital roles when evaluating the operation outcomes after TURP. This is underscored by the fact that the morbidity rates published can vary considerably (1,3,4). Past studies, however, have been unable to investigate the impact of endourological surgical ability on morbidity, due to a lack of standardized objective measurement methods. At any rate, TURP represents a procedure that is difficult to convey in practice and a surgical challenge to inexperienced surgeons. It requires surgeons to be able to orientate themselves and work in a small 3D anatomical area under two-dimensional (2D) optical control. Furthermore, it requires advanced psychomotor abilities, due to the continuously controlled and simultaneous guidance of the resectoscope and the resectoscope loop while, at the same time, operating the electric power unit using both hands and feet (6). However, the problem of severe bleeding during resection due to insufficient electrical power has been minimized considerably (7–9), so that endoscopically less experienced and younger surgeons can now utilize this surgical technique at an earlier stage. Nevertheless, this established surgical technique can potentially give rise to a number of known complications if it is inadequately implemented, due to spatial–visual miscalculations or a lack of cognitive motor skills (10). Unfortunately, the number of procedures during residency has declined. At the same time the rate of surgical adverse events, as measured by the need for subsequent procedures, has increased (6,10,11). These interventions demand a long learning curve (12,13). Thus, resection trainers are useful, since a good surgical result primarily depends on the surgical technique and the quality of its implementation.

In the past, various resection models have been developed and presented. Most training models were virtual training simulators, which were investigated in a number of different studies (6). Our aim was to describe, for the first time, a novel, low cost, non-virtual trainer for TURP and to report its preliminary evaluation as a teaching tool for residents in urology.

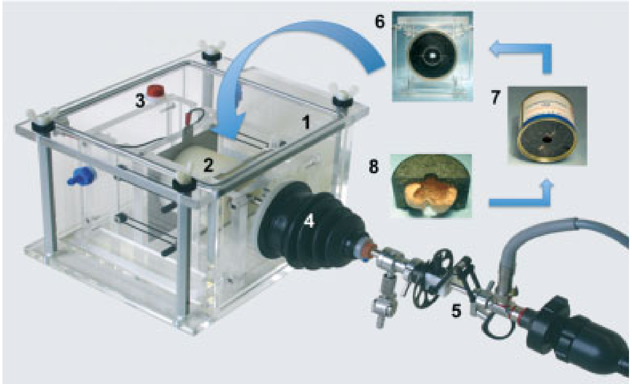

Figure 1. Dr K. Forke's prostate resection trainer (LS 10-2/S, SAMED GmbH, Dresden, Germany). 1, acrylic glass bladder chamber; 2, quick-acting clamping device for a training prostate; 3, suprapubic access; 4, penis simulator; 5, resectoscope; 6, quick-acting clamping device removed from the trainer and inserted with a training prostate LSA; 7, training prostate LSA removed from the clamping device; 8, training prostate LSA after resection without the metal cover and partly removed from the plastic–styrofoam capsule

Figure 2. Training prostate type LSA. (A) The unprepaired training prostate, like a 'tin of tuna', which can be stored vacuum-packed. (B) The prepaired training prostate with the prostatic capsule consisting of a plastic–styrofoam mix and the blanked out urethra after removal of the metal cover

Materials and Methods

Prostate resection trainer

Dr K. Forke's resection trainer (LS 10-2/S) is a mobile device, consisting of several plastic components, for the resection of a synthetically manufactured prostate model (training prostate) using standard endoscopic equipment. Thus, this resection trainer is not a virtual simulator. The trainer consists of a penis simulator, featuring a urethra, a specifically constructed device for the insertion of a different training prostate, a bladder chamber and a simulated suprapubic access, as well as optional intermittent or continuous-flow irrigation (Figure 1). It offers the opportunity of using either monopolar or bipolar power. Currently, two different training prostates are being offered: the media capsule type LSG, without anatomical structures, and the LSA [Figures 1 (inset 7) and 2], with anatomical structures (prostatic capsule and seminal colliculus, each consisting of a plastic–styrofoam mix). The synthetic prostatic tissue in the capsule is a mixture of different organic components.

Study design

Eight anatomical capsules (LSA) were resected. The exercises were executed using four anatomical capsules/day over 2 successive days. Two capsules of the LSG type (non-anatomical) were resected in advance for the purpose of testing the handling of the resection trainer.

The resection of the capsules was performed by a trainee (resident, without TURP experience) under the instruction and observation of one supervisor (experienced senior physician), in accordance with systematic requirements. The goal was a symmetrical, consistent resection result down to the prostatic capsule. This should be achieved by: (a) the resection of the base

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of the training prostate at 6 o'clock; (b) the resection of the lateral walls at 3 and 9 o'clock; (c) the resection of the remaining lateral walls towards 6 o'clock, followed by the upwards resection to 12 o'clock; and (d) paracollicular resection. The angle of the sphincter from dorsal–distal to ventral–proximal should be taken into consideration with regard to the extent of the resection. In doing so, a standardized resection procedure, as would be performed with a medium-sized prostate with a volume of ca. 30–40 ml, should be observed. Furthermore, the improvement in RS of the trainee was measured during 20 TURPs under the same supervisor in the post-training stage. Additionally, the learning curve achieved in the first eight TURPs was compared to the respective results of a retrospective control group [residents with no PRT training ($n = 3$) under different supervisors]. In the post-training stage the PRT-trained trainee will be termed 'surgeon 1', the control group 'surgeons 2, 3 and 4'. Statistical significance was measured using the Mann–Whitney U-test. The resections were performed using a resectoscope manufactured by Karl Storz GmbH. The power source used was a unit (ICC 200) from ERBE Elektromedizin GmbH.

Analysis

The following objective data were recorded for the PRT training: resection time (RT); resection volume (RV); resection speed (RS), with comparison of average RS, RV and RT of LSA 1–4 and LSA 5–8; use of irrigation fluid; and observation of the prostatic lodge after resection to review the resection quality (RQ). The criteria used to evaluate the resected prostatic lodge included adherence to the above requirements, the symmetry of the resection and the integrity of the seminal colliculus.

Results

The trainer can be assembled at whatever location required. The capsule containing the training prostate can be used immediately after a short preparation (Figure 2). To ensure the best possible view via the resectoscope, the bladder chamber should be filled with sufficient irrigating fluid for the media capsule to be submerged (Figure 3). A monopolar cutting current with an output of 160–180 W was ideal for the resection of the synthetic prostatic tissue. Two capsules of the LSG type were resected for the purpose of testing the handling of the resection trainer. This non-anatomical model, however, already provides an impression of the resection of a 3D cylindrical space. Media capsules 3–10 were of the anatomical LSA type and were resected in sets of four per day, on 2 successive days and in accordance with the above requirements. The transverse diameter of the resectable organic medium was 4.5 cm, its height was 3.5 cm and the length of the prostatic urethra was 4 cm. The volume of the artificial training prostate LSA amounted to 50 ml. In LSA capsules

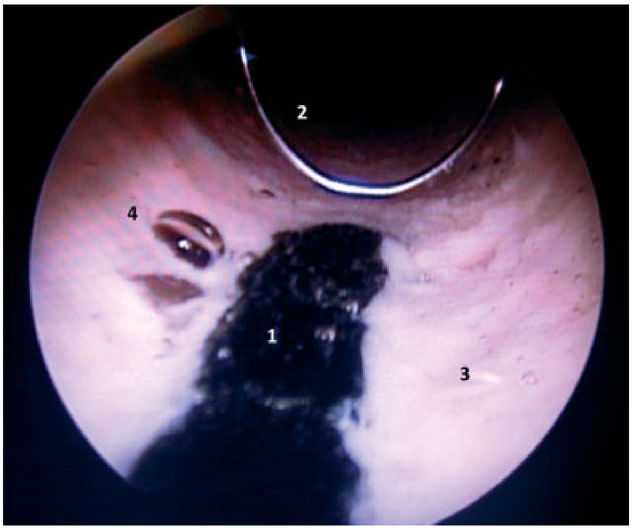

Figure 3. View through the resectoscope into the submerged training prostate type LSA before resection: 1, colliculus seminalis; 2, resectoscope loop; 3, artificial prostate tissue; 4, air bubble

1–4, 5–6 (average 5.5 ± 0.4) g tissue was resected in an average RT of 32.5 ± 1.4 min. In LSA capsules 5–8, 8–9 (average 8.5 ± 0.57) g tissue was resected within an average RT of 37.5 ± 3.7 min. Through the supervisor's training, the resident displayed a distinct learning curve, which was discernible as an improvement of RS and RV. While in the first half of the training course (LSA 1–4) the average RS was 0.17 ± 0.02 g/min, this increased to 0.23 ± 0.01 g/min in the second half (LSA 5–8). This was an improvement of 27% ($p = 0.03$) in the RS, which was achieved by a 36% increase ($p = 0.03$) in the RV (Figure 4). An average of 12.5 l irrigating fluid was used per media capsule resected. While the resection volume was static after the resection of the first five LSA capsules (thus a maximum resection volume of 8–9 g had been achieved), the quality of the resection continuously improved. Under the constant observation of the supervisor, the second part of the training (LSA 4–8) showed that the resection requirements were significantly better implemented (Figure 5A, B).

In the post-training stage the average RS during TURPs 1–4 was 0.22 ± 0.06 g/min, which was consistent with the PRT training RS. The RS did not increase until TURP 8, but was associated with a small statistical range (SD 0.06–0.07), indicating consistent performance of PRT-trained surgeon 1. The control group (surgeons 2–4) showed irregular changes of the RS in both directions without statistical significance and with a larger statistical range (SD 0.1–0.26), which may suggest external influences (Figure 6). There was no significant statistical difference in the average prostate size in the compared groups. However, in the performance of 20 TURPs, the learning curve of PRT-trained surgeon 1 showed an increase in RS from 0.24 ± 0.09 to 0.37 ± 0.1 g/min, which was related to a 35% progress ($p = 0.01$). This was realized by both a reduction of the RT and an increase of the RV. The average RT

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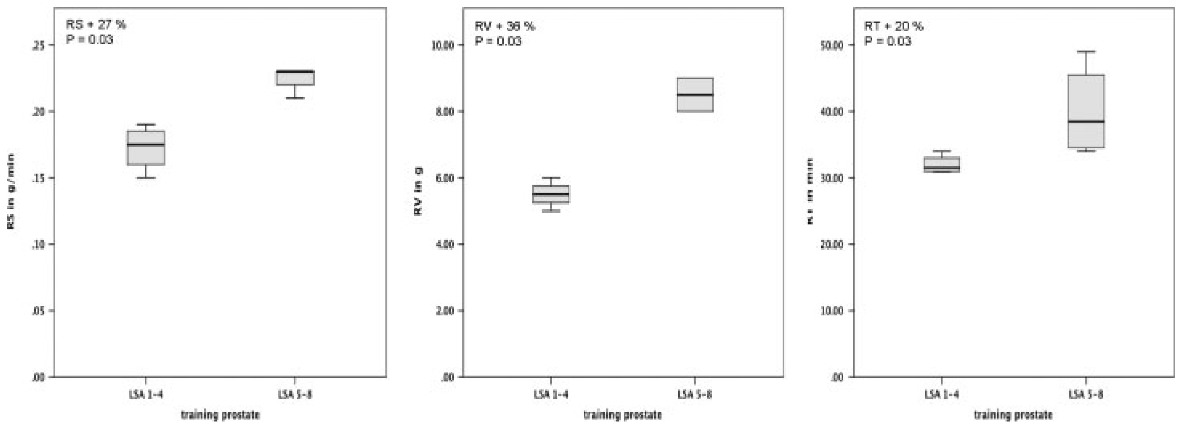
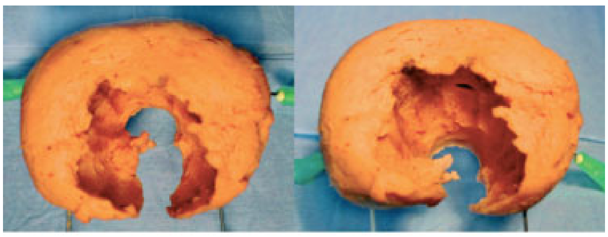


Figure 4. Boxplot comparing the development of the resection speed in g/min (RS), the resection volume in g (RV) and the resection time in min (RT) while using the prostate resection trainer (PRT) between training prostate LSA 1–4 and LSA 5–8. Error bars, 95% CI

A



B

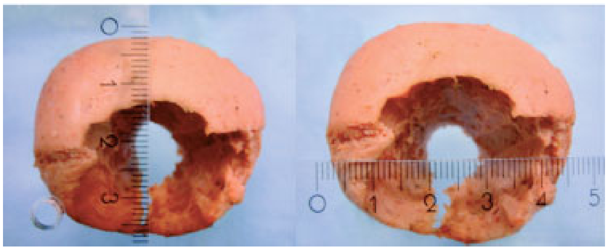


Figure 5. (A) Training prostate LSA 1 removed from anatomical capsule following resection. Viewing direction is from the bladder to the apex. The urethra is represented by the round hole that is centrally located in the back, distal to the colliculus seminalis. This was removed with the artificial capsule to help display the model. The 6 o'clock position corresponds with the completely resected median lobe. Overall, the resection result of this first resected training prostate is irregular, with a small resection volume (RV) of 5 g. Primary deficits were seen in regard to the extent of the resection in the lateral lobes and particularly the paracollicular area. Even a lesion of the seminal colliculus occurred in the first LSA training prostate. (B) Training prostate LSA 8 removed from anatomical capsule following resection. Due to the initial guidance of the supervisor throughout the training, the resident was able to independently implement the instruments safely and orientate the equipment in the three-dimensional space in the final training course. Compared to LSA 1 (A), the resection result is more uniform and symmetrical, with a nearly doubled resection volume (9 g). The other measurements conform to (A). The ruler has been added to the image to demonstrate the dimensions

declined from 72 ± 22 to 63 ± 27.5 min (−13%), the RV increased from 17.8 ± 6.9 to 22.6 ± 11.9 g (+27%), but both parameters are separately statistically insignificant (Figure 7, Table 1).

Discussion

Dr Forke's training device LS 10-2/S offers a practical alternative to virtual simulators (6) because it provides an opportunity for didactic training of the resection of prostatic tissue in a 3D space and the opportunity to experience it haptically through the use of synthetic prostatic tissue. The resection trainer is ideally suited for the purposes of surgical training and can be well utilized to convey the systematic resection of tissue in a 3D aqueous medium, to inexperienced surgeons using standard instruments, based on the relevant anatomical structures. The study has shown that only a few resection capsules are necessary to improve the speed and volume of the resection. Likewise, a more uniform, more systematic and more safely implemented resection result can be achieved by just a few hours of training. A requirement for this is that the trainees are trained by an experienced surgeon. The feeling experienced when cutting the synthetic prostatic tissue of the anatomical capsules is realistic and, in the aqueous medium, the resected tissue behaves similarly to human tissue. However, the power supply unit used requires a higher watt output for smooth cutting than for human tissue (160–180 vs 140 W).

Due to the way the device is constructed, the irrigating fluid drain valve of the bladder chamber was regularly obstructed by resected material, which resulted in the overflowing of the chamber and required the manual flushing of the drain valve, thus interrupting the resection process. In newer models of the device, this problem was solved. Furthermore, it became apparent that the movement of the resectoscope shaft towards retro-lateral was restricted, due to limited movement of the penis simulator. As a result, the prostatic capsule could not be fully reached in these areas, which limited the resection volume. This problem was also solved in the newest model, according to the manufacturer's statement. Aditionally, in the latest model some modifications were implemented to save irrigating fluid and to make the cleaning of the trainer more convenient.

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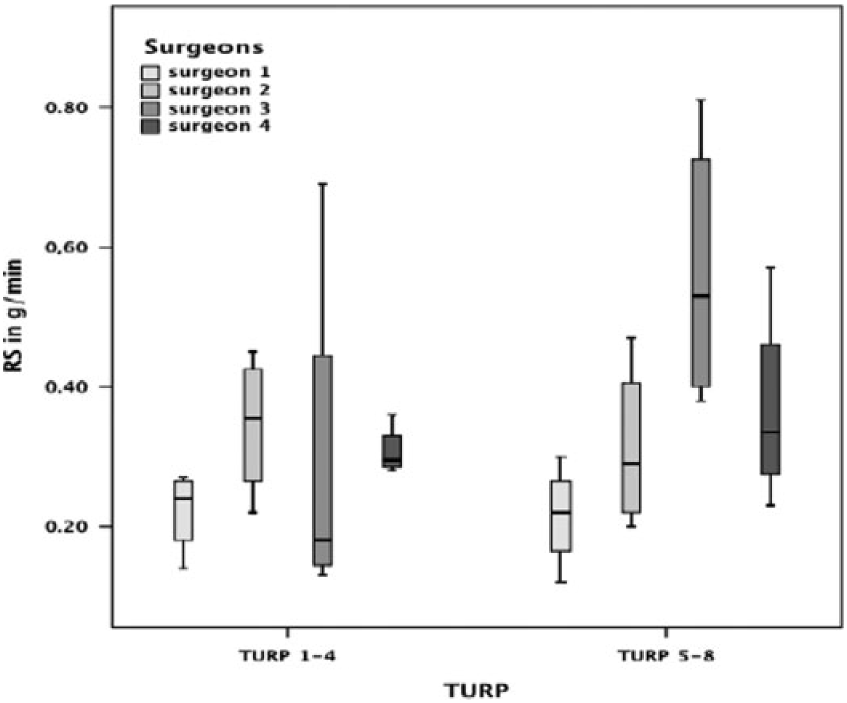

Figure 6. Boxplot comparing the development of the resection speed in g/min (RS) of the PRT-trained surgeon 1 and the untrained surgeons (2–4) in TURP 1–4 and TURP 5–8. Error bars, 95% CI

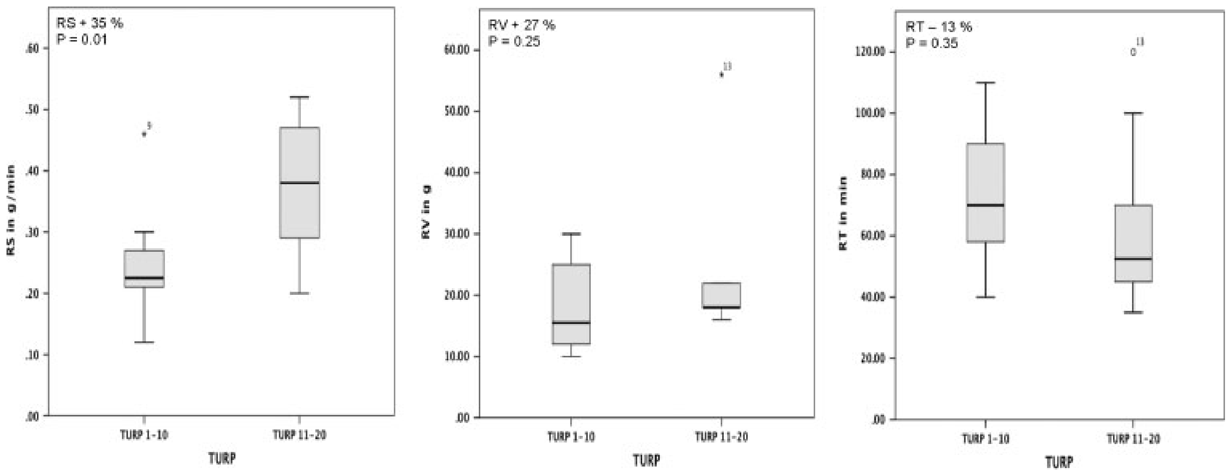

Figure 7. Boxplot comparing the development of the resection speed in g/min (RS), the resection volume in g (RV) and the resection time in min (RT) between TURP 1–10 and TURP 11–20 of the PRT-trained resident (surgeon 1). Error bars, 95% CI

The training device does not simulate the bleeding of the prostate during resection as it occurs in reality and which could render surgery more complicated. Not claiming to offer a perfect simulation, the resection trainer requires the training of basic transurethral prostate resection skills through a realistic 3D presentation of the prostatic bed in an aqueous medium, with the opportunity to apply typical and original instruments. Currently, there exists only one comparable product on the market, manufactured by Limbs and Things™ (Bristol, UK). A validated study on this resection trainer has not yet been published.

In the post-training stage the trainee involved in this study also routinely implemented the systematic approach applied in the TURP, which was learned by using the resection trainer. During the 20 TURPs, the supervisor did not need to interrupt or help surgeon 1 at any time. The ability of surgeon 1 to work independently is reflected in the initially slower RS with small statistical range in contrast to the peer group (surgeons 2–4), who needed the active assistance of the supervisors. Due to the retrospective study design, the peer group's results were probably influenced by different confounding variables (bleeding, complications, the individual talents and skills of each surgeon), but especially by the intervention of different supervisors, which cannot be measured. Therefore, a direct comparison of the learning curves of both groups has to be considered critically. A strictly

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Table 1. Data image of the resection results in TURP between surgeons 1–4 and in PRT training of surgeon 1

	Parameters	Surgeon 1	Surgeon 2	Surgeon 3	Surgeon 4
Results TURP	PV TURP 1–4 [1–10]	50.00 ± 14.14 [47.00 ± 15.67]	47.75 ± 17.90	35.00 ± 20.40	37.50 ± 21.00
	PV TURP 5–8 [11–20]	38.75 ± 17.97 [46.20 ± 15.67]	38.75 ± 12.50	44.25 ± 20.70	45.00 ± 17.30
	PV TURP 1–8 [1–20]	44.38 ± 16.13 [46.60 ± 15.26]	43.25 ± 15.10	39.63 ± 19.70	41.25 ± 18.30
	RS TURP 1–4 [1–10]	0.22 ± 0.06 [0.24 ± 0.09]	0.35 ± 0.10	0.30 ± 0.26	0.31 ± 0.04
	RS TURP 5–8 [11–20]	0.22 ± 0.07 [0.37 ± 0.10]	0.31 ± 0.12	0.56 ± 0.20	0.37 ± 0.14
	RS TURP 1–8 [1–20]	0.21 ± 0.06 [0.31 ± 0.12]	0.33 ± 0.10	0.43 ± 0.26	0.34 ± 0.10
	Supervisors (*n*)	1.00	4.00	5.00	3.00
	OP/supervisor (*n*)	20.00 ± 0.00	2.00 ± 2.00	1.60 ± 0.89	2.66 ± 2.08
Results PRT training	RS LSA 1–4	0.17 ± 0.02			
	RS LSA 5–8	0.23 ± 0.01			
	RS LSA 1–8	0.20 ± 0.03			
	RV LSA 1–4	5.50 ± 0.40			
	RV LSA 5–8	8.50 ± 0.57			
	RV LSA 1–8	7.00 ± 1.67			
	RT LSA 1–4	32.00 ± 1.40			
	RT LSA 5–8	37.50 ± 3.70			
	RT LSA 1–8	34.75 ± 3.92			

PV, prostate volume (g); RS, resection speed (g/min); RT, resection time (min); RV, resection volume (g); OP, operations; supervisors, experienced surgeons educating trainees; LSA, training prostate; ±, standard deviation; statistical test, Mann–Whitney U-test.

standardized prospective approach under a common supervisor would be necessary to reduce the variables.

An individual quantitative and qualitative learning curve of the prostate resection can be achieved by the prostate resection trainer (PRT), but the PRT-trained surgeon 1 was unable to achieve a RS of 1 g/min in the post-training stage after 20 TURPs. This observation corresponds to a different RS learning curve study by Furuya *et al.* (12), which used a TURP number of $n = 81$ to achieve a steady state in the RS of 0.8 g/min. However, the efficiency of TURP depends not as much on incision skills as it does on the speed, accuracy of orientation, haemostasis and the surgeon's talent (3). The quick recognition of anatomical landmarks will assure effective and safe resection (14). Dr K. Forke's resection trainer meets that claim in a broad sense, by effectively initiating the trainees' learning curve in an educational setting without the risk of damage to the patient. Thus, the PRT may contribute to reduction of necessary TURPs in a residency. In addition, the PRT seems to enhance the RS learning curve in the post-training stage. In comparison to the study of Furuya *et al.* (12), who achieved a constant RS of 0.8 g/min after 81 TURPs, the trainee in our study reached a RS of 0.37 g/min after just 20 TURPs. This could be explained by the PRT's feasibility to offer as many training sessions as needed in a short and variable time frame for improving the surgeons' skills. Once again, however, individual talent plays an unknown role in this comparison. Our data should be interpreted as preliminary findings without claiming statistical significance concerning the trainer's capacity to improve the surgeon's skills. A larger data pool is currently not available, due to the novelty of the PRT and the limited number of TURPs at a university clinic educating several residents. Further validation of the tool in terms of face, content and construct validity are necessary and will follow to verify the trainer's promising pretests.

Conclusion

Due to the non-virtual style, Dr K. Forke's resection trainer (LS 10-2/S, Samed GmbH) gives an extraordinarily realistic haptical experience with the opportunity to use standard resection instruments. This makes the trainer suitable for daily use and thus offers an effective but more affordable alternative to virtual simulators.

In response to the positive results of this preliminary study, the Department of Urology at the Charité will routinely use this tool in the surgical training of residents preparing for TURP. Within the framework of the proposed use of the trainer, further validation studies will follow and new fields of application will be tested.

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