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Correspondence:
Matthias Trottmann, Department of Urology, University Hospitals Munich – Campus Grosshadern, 81377 Munich, Germany.
E-mail: matthias.trottmann@med.uni-muenchen.de

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Micro-endoscopy of the human vas deferens: a feasibility study of a novel device in several ex vivo models

[1]M. Trottmann, [1,2]R. Sroka, [3]C. Braun, [4]B. Liedl, [5]H. Schaaf, [3]M. Graw, [1]A. J. Becker, [1]C. G. Stief and [1]W. Y. Khoder

[1]Department of Urology, Klinikum Grosshadern, University of Munich, Munich, Germany, [2]LIFE Centre, University Hospital of Munich, Munich, Germany, [3]Department for Forensic Medicine, University of Munich, Munich, Germany, [4]Department of Urogenital Surgery, Clinics for Surgery Munich-Bogenhausen, Munich, Germany, and [5]Polydiagnost GmbH, Hallbergmoos, Germany

SUMMARY

The aim of this study was to show limitation as well as potential of micro-endoscopy techniques as an innovative diagnostic and therapeutic approach in andrology. Two kinds of custom-made micro-endoscopes (ME) were tested in ex vivo vas deferens specimen and in post-mortem whole body. The semi-rigid ME included a micro-optic (0.9 mm outer diameter [OD], 10.000 pixels, 120° vision angle [VE], 3–20 mm field depth [FD]) and an integrated fibre-optic light source. The flexible ME was composed of a micro-optic (OD = 0.6 mm, 6.000 pixels, 120° VE, 3–20 mm FD). The ex vivo study included retrograde investigation of the vas deferens (surgical specimen $n = 9$, radical prostatectomy $n = 3$). The post-mortem investigation ($n = 4$) included the inspection of the vas deferens via both approaches. The results showed that antegrade and retrograde rigid endoscopy of the vas deferens were achieved as a diagnostic tool. The working channel enabled therapeutic use including biopsies or baskets. Using the flexible ME, the orifices of the ejaculatory ducts were identified. In vivo cadaveric retrograde cannulation of the orifices was successful. Post-mortem changes of verumontanum hindered the examinations beyond. Orifices were identified shaded behind a thin transparent membrane. Antegrade vasoscopy using flexible ME was possible up to the internal inguinal ring. Further advancement was impossible because of anatomical angle and lack adequate vision guidance. The vas deferens interior was clearly visible and was documented by pictures and movies. Altogether, the described ME techniques were feasible and effective, offering the potential of innovative diagnostic and therapeutic approaches for use in the genital tract. Several innovative indications could be expected.

INTRODUCTION

Fifteen percent of infertile men suffer from azoospermia, which can be distinguished as obstructive (OA) or non-obstructive azoospermia (NOA). OA, which comprises 40% of azoospermia cases (6% of azoospermic men), is the consequence of physical blockage of the male duct system between rete testis and ejaculatory ducts (Wosnitzer *et al.*, 2014). Aetiologies of NOA include toxic exposures or abnormal testicular development (Jow *et al.*, 1993). Every type has its specific management raising the bar for adequate diagnostic tools (Jarow *et al.*, 1989).

The development of modern technologies is promising. One interesting method is the usage of micro-endoscopic instruments, for the inspection of minute cavities or holes. Despite an outer diameter lower than 2.2 mm (7 Fr), these instruments consist of a high-performance fibre optic with different lengths of endoscope up to one metre and more. Micro-endoscopy was first described for cholangiopancreatography (Cotton, 1972). Thereafter, breast ductoscopy, sialoendoscopy and nasolacrimal duct endoscopy have been applied in clinical settings (Matsunga *et al.*, 2004; Strychowsky *et al.*, 2012; Lieberman & Casiano, 2015; Schrötzlmair *et al.*, 2015).

There are few studies of micro-endoscopy investigations of the reproductive tract. The feasibility of vesiculoscopy, as one of the advanced diagnostic techniques, was reported (Shimada & Yoshida, 1996; Okubo *et al.*, 1998; Yang *et al.*, 2002; Carmignani *et al.*, 2005; Li *et al.*, 2008; Wang *et al.*, 2012). It has been proved safe and effective in the diagnosis and treatment of ejaculatory duct obstruction (Li *et al.*, 2008), seminal vesicle stones (Cuda *et al.*, 2006) and refractory haematospermia (Han *et al.*, 2009; Liu *et al.*, 2009) in small number of cases. Micro-endoscopy of the vas deferens has not yet been successfully performed (Carmignani *et al.*, 2005). Reasons may be because of the small lumen of the seminal duct and the narrow internal inguinal ring (Kuckuck *et al.*, 1975).

Current pre-clinical study was performed to show the procedure of visual investigation of the vas deferens by means of innovative micro-endoscope techniques and to examine the option of a new tool in the examination and in potential treatment of OA.

MATERIALS AND METHODS

The study was approved by the Ethics Committee of the University of Munich (project number 161-12). The relatives of dead men gave written permission to perform in situ procedures.

Equipment

Two instrumental sets (Polydiagnost GmbH, Hallbergmoos, Germany) were used in the procedures. For this study, different components of existing micro-endoscopes were specifically assembled together.

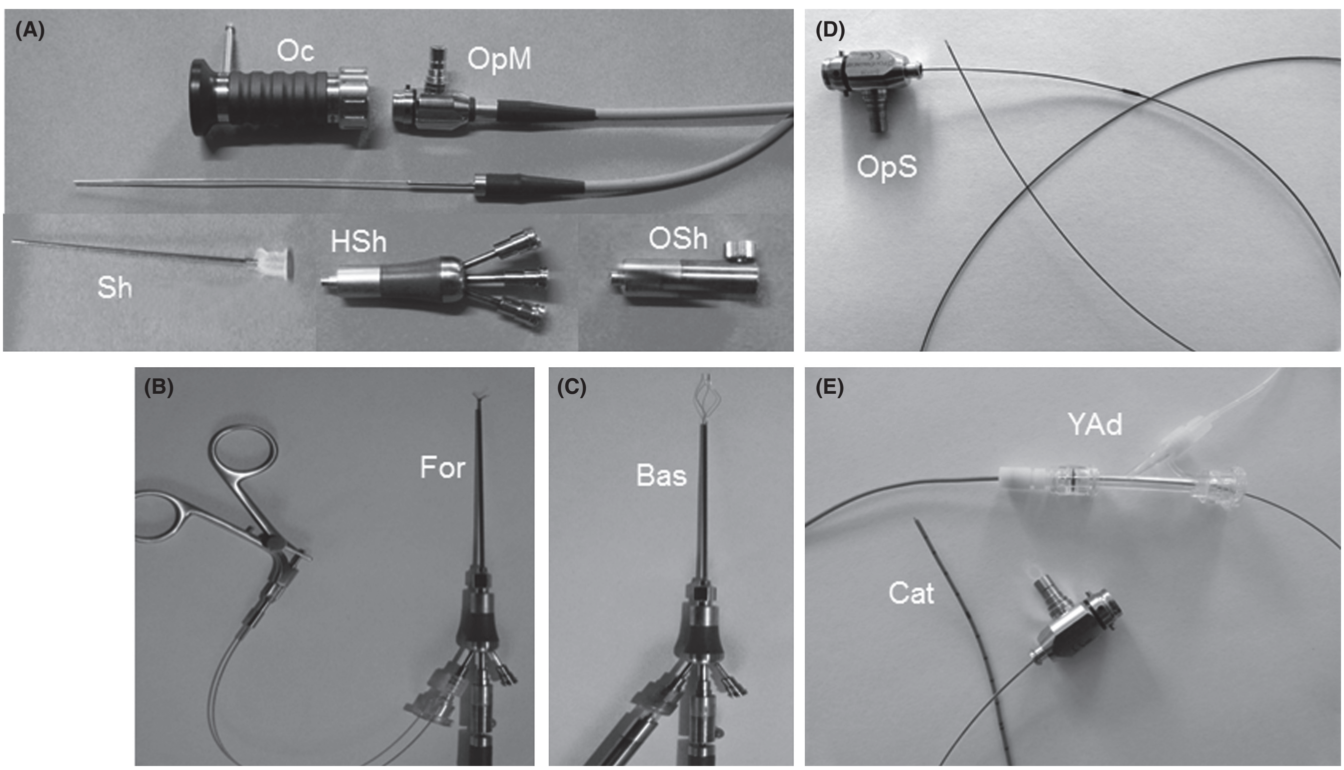
A semi-rigid micro-endoscope (Fig. 1A) was used for ex vivo investigation of vas deferens. It was composed of 10.000 pixel semi-rigid optic modular with an integrated fibre-optic light source. This system possessed a 120° vision angle in water and a field depth of 3–20 mm. The outer diameter (OD) was 0.9 mm. It was connected to standard endoscopic camera system via zoom ocular through light adapter. The system included an optic shifter (length 26 mm), short handle with its three female luer-lock connections for irrigation and instrumentation like biopsy forceps (OD = 0.8 mm; Fig. 1B) or 3-wire basket (OD = 0.38 mm; Fig. 1C). The endoscope sheath had an inner diameter (ID) of 1.05 mm and an OD = 1.15 mm (working length 90 mm). A larger size sheath was used for insertion of forceps or baskets (ID = 1.8 mm; OD = 2.0 mm). This micro-endoscope was slowly introduced and withdrawn in the lumen of the vas deferens under fluid irrigation.

The *flexible micro-endoscope* (OD = 0.6 mm; length 150 cm; Fig. 1D) had a 6.000 pixel resolution and an integrated fibre-optic light source. This system possessed 120° vision angle in water with a field depth of 3–20 mm. It was connected via zoom ocular and light adapter to the standard endoscopic camera system. For irrigation, the micro-endoscope was inserted via a Y-shaped adapter into a curved-tip 4.8 Fr ureteric-catheter (Coloplast, Germany; Fig. 1E). During examination of post-mortem men, the flexible micro-endoscope was guided by a flexible cystoscope (Karl Storz, Germany) along the urethra up to the verumontanum.

Ex vivo examinations on explants

Seminal ducts of surgical specimens were removed from transsexual men (n = 9), consisting of the testes with 13 cm testicular cord en-bloc. Additionally, radical prostatectomy specimens (n = 3) consisting of the prostate with prostatic urethra,

Figure 1 The two used micro-endoscope systems (Polydiagnost GmbH, Hallbergmoos, Germany): (A) Semi-rigid micro-endoscope composed of a 10.000 pixels semi-rigid optic modular (OpM; PD-DS-1083), with a 120° vision angle in water, a field depth of 3–20 mm and an outer diameter of 0.9 mm. It is connected with a zoom ocular (Oc; PD-DS-4001) and a light adapter to a standard endoscopic camera system. The system includes an optic shifter (OSh; PD-DS-1210), short handle (HSh; PD-DS-1320) and different shafts (Sh; PD-DS-1015; PD-DS-1025). Insertion of biopsy forceps (B: For; PD-DS-TI-5110) or 3-wire basket (C: Bas; PD-TI-3503) through the handle. (D) Flexible micro-endoscope (OpS) with integrated fibre-optic light source (120° vision angel in water, field of depth of 3–20 mm; outer diameter of 0.6 mm; length of 150 cm) connected via a zoom ocular and light adapter to a standard endoscopic camera system. (E) For irrigation, the micro-endoscope was inserted via a Y-shaped adapter (YAd; PD-CA-0203) into a curved-tip ureteric catheter (Cat).



part of verumontanum, the seminal vesicles and the vas deferens (length 3 cm) were examined. All investigations were performed within one hour after removal.

The semi-rigid micro-endoscope was introduced in the vas deferens of testicular specimens up to the epididymis (Fig. 2A). The biopsy forceps as well as the 3-wire basket were inserted through the working channel to test its feasibility as potential treatment tools.

The semi-rigid micro-endoscope was used for the examination of prostate specimens in both antegrade (through the vas deferens) and retrograde (through the seminal openings in both sides of the verumontanum) directions up to the seminal vesicles. Similar to standard endoscopic manoeuvres, a hydrophilic-coated guidewire (Urolix™, Urotech, Germany; OD = 0.89 mm) was introduced to guide the micro-endoscope. All procedures were documented with video and pictures identifying the anatomical structures and findings.

Post-mortem examinations of the vas deferens

The vas deferens of post-mortem men were investigated within 24–48 h after death ($n = 4$). In a dorsal position and after flexible cystoscope examination of the urethra and bladder, a guidewire was inserted via the Y-shaped adapter into the curved-tip 4.8 Fr ureteric catheter. Fluid irrigation through this catheter was started to widen the inner lumen, improve vision and ease the intraluminal manipulations. The identified orifices of the ejaculatory ducts were intubated in a retrograde manner. The flexible micro-endoscope was guided by the curved-tip ureteric catheter under direct vision until insertion, then the 0.6 mm endoscope was pushed forward. The key point was to move the micro-endoscope along the correct prospective direction under visual guidance to avoid urethral injury.

A second experimental step was to prove the feasibility of vas deferens examination through scrotal incision. For this purpose, the vas deferens was cut through a scrotal neck incision (Fig. 2B). A guidewire as aforementioned (Pathfinder™, Boston Scientific Corporation, Marlborough, MA, USA; OD = 0.46 mm) was inserted for endoscopic guidance into the proximal or distal part of vas deferens. Using the flexible micro-endoscope, the interior of vas deferens was visualised over a length of 13 cm up to the internal inguinal ring. The key point of this step was the trial to overcome the kinking of the vas at the internal ring.

Continuous water perfusion through the endoscopic micro-sheath was found mandatory during both procedures to avoid sticking of the micro-endoscope to the vas mucosa hindering the endoscopic vision. We documented the amount of the irrigation water over the time. In a separate experiment, we tried to quantify the intraluminal water pressure at the tip of the described ureteric catheter during irrigation of vas specimen ($n = 2$) by means of an urodynamic measurement system (Ellipse, Andromed, Taufkirchen, Germany). In this set-up, the specimen was fixed to the catheter and the free end of the tissue specimen was closed by ligation, thus a closed pressure system was achieved.

Procedures were documented with videos and imaging.

RESULTS

Ex vivo examinations on explants

Figure 3A (Video Clip S1) shows the feasibility of visual inspection of the inner lumen of the vas deferens in retrograde direction (testicular and prostatectomy specimens) as well as in antegrade direction (prostatectomy specimen) using the described semi-rigid micro-endoscope. The feasibility of diagnostic and therapeutic use of this system was demonstrated as it was possible to take biopsies using the biopsy forceps (Fig. 3B, Video Clip S2) and to open and close the baskets.

In a similar manner, the attempts to observe the interior of the seminal vesicles in prostatectomy specimen using semi-rigid micro-endoscope were successful. The micro-endoscope was inserted after identifying the wire guide (WG) leaving the orifice of the ejaculatory duct (star; Fig. 3C). It was possible to follow the wire through the ejaculatory duct (Fig. 3D). There was some resistance to insert the system into the orifice of the seminal vesicle because of its narrowness and bending. By further movement of the endoscope, two orifices were identified at the junction of the vas deferens (VD) and seminal vesicle (SV, Fig. 3E). It was not possible to introduce the micro-endoscope over the distal end of the seminal vesicle.

Using the described semi-rigid micro-endoscope, it was feasible to examine the interior of the vas deferens antegradely. The mucosa lining of the vas deferens was smooth, containing some empty blood vessels in comparison with the wall of the ampulla of the vas deferens, which seemed irregular.

Post-mortem examinations

The transurethral retrograde approach was difficult because of the tortuous course within the ampulla with resistance to passage of the endoscope and guidewire. Although, the post-mortem changes of the verumontanum (V) raised a problem, it was possible to identify the laterally lying orifices of the ejaculatory ducts (arrows, Fig. 3F,G).

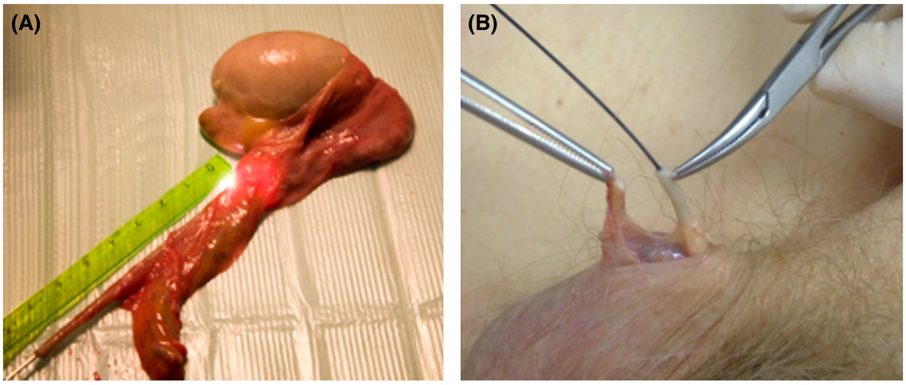


Figure 2 (A) External view of the examination of an orchiectomy specimen. The semi-rigid endoscope can be inserted in a retrograde direction for 8 cm close to the epididymis. (B) Preparation of the vas deferens of men post-mortem. A guidewire is inserted into the distal part.

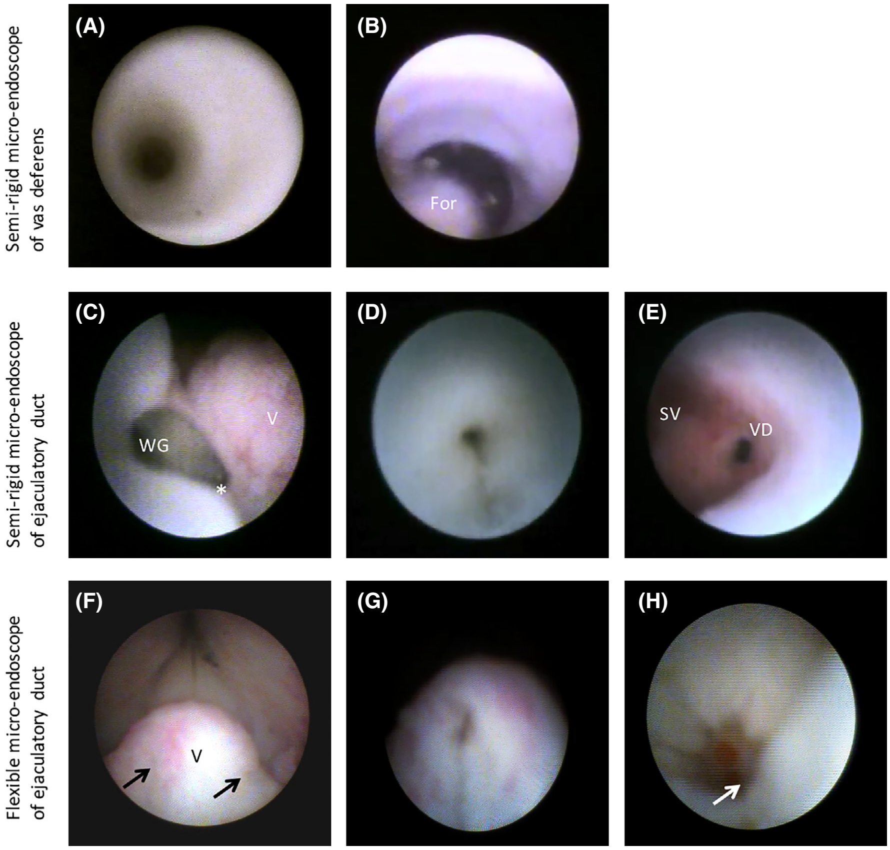


Figure 3 Internal micro-endoscopic view of the vas deferens (A, additionally, see Video Clip S1) by semi-rigid endoscope. (B) Demonstrating the biopsy forceps (For) in the lumen of the vas, proving the feasibility to take tissue biopsy (additionally, see Video Clip S2). Internal micro-endoscopic views of the prostatectomy specimen by the semi-rigid micro-endoscope (C–E, additionally, see Video Clip S3). (C) View onto verumontanum (V), demonstrating the antegrade-inserted wire guide (WG) coming out of the orifice of the ejaculatory duct (*). (D) Inside view of the ejaculatory duct. (E) Image of the orifice of the vas deferens (VD) as seen from the interior of the seminal vesicle (SV). Transurethral view of the verumontanum (V) and the orifices of the ejaculatory ducts in post-mortem examinations by the flexible endoscope (F, arrows; additionally, see Video Clip S4). (G) Cystoscopic views of the right orifice on closer examination. (H) Endoscopic view of the orifice of the ejaculatory duct after opening by irrigation (arrow).

The flexible micro-endoscope was transurethrally inserted into the ejaculatory duct lumen under the guidance of the flexible cystoscope, which shows the feasibility of the diagnostic procedures using this custom-made micro-endoscope. Finally, the micro-endoscope was pushed through the orifice of the ejaculatory duct, imaging its inner lumen (arrow, Fig. 3H). The duct was narrow and offered some resistance, potentially caused by its curvature.

As shown in Fig. 2, using the scrotal approach, the retrograde examination was feasible over a length of 13 cm up to the internal inguinal ring. Further movement of the flexible micro-endoscope against the existing slight resistance was not possible because of the angle and the lack of vision guidance. On the other hand, the antegrade examination up to the tail of epididymis was feasible too. These findings confirmed the results of ex vivo investigations on explanted tissue specimen with regard to diagnostic and therapeutic uses.

Measurement of the amount of water and intraluminal water pressure in case of irrigation

A good view was achieved by an intermittent irrigation flow of a total amount of 1 mL per min. By this, the measured intraluminal pressure was between 30 and 50 cm H_2O. Reaching a maximum pressure of 1000 cm H_2O, there was neither macroscopic deformation nor a perforation of the vas observed.

DISCUSSION

Several studies have reported about various methods for the evaluation of patients with suspected vas deferens pathology. Therefore, the medical history and the physical examination, which includes the measurement of the testicular volume, the documentation of the testicular consistency and the palpation of the epididymis and seminal duct are essential. Furthermore, laboratory values, most significantly follicle-stimulating hormone (FSH) are typically normal in OA patients (Wosnitzer *et al.*, 2014). But there is still a lack of standard management concepts of OA, particularly to specify the precise location of obstruction.

There are several causes of OA to be differentiated. Besides epididymal obstruction, e.g. in patients suffering of Young´s syndrome, the absence of the vasa deferentia e.g. in patients with congenital bilateral absence of the vas deferens (CBAVD) are found in 1% of infertile men in total and in up to 6% of those with obstructive azoospermia (Ferlin *et al.*, 2007). The most common cause of obstruction of the vas deferens is vasectomy performed for elective sterilization. An iatrogenic injury of the vas is seldom and can occur during the performance of a hernia repair. Furthermore, ejaculatory duct obstruction, either congenital or acquired (e.g. after infection) can occur and is estimated to be responsible for 1–5% of male infertility cases (Smith *et al.*, 2008).

An ideal minimally invasive tool allowing investigation and treatment of seminal duct pathologies are unavailable. Transurethral seminal vesiculoscopy is an evolving new technique that deals with micro-endoscopic diagnosis and treatment of seminal tract diseases. Endoscopy of seminal vesicle was first reported as an ex vivo procedure in radical cystoprostatectomy specimens (Shimada & Yoshida, 1996) and thereafter, in vivo evaluation of seminal vesicles (Yang *et al.*, 2002). Several reports have described this procedure using an ureteroscope for the diagnosis and treatment of patients with seminal tract disorders, for example, laser lithotripsy of seminal vesicle stone (Cuda *et al.*, 2006) or diagnosis of haematospermia (Han *et al.*, 2009; Liu *et al.*, 2009). These procedures are still at an immature stage.

Considering the several reasons of OA, especially patients suffering from a central localised obstruction, for example, of the ejaculatory duct obstruction or the distal part of the vas, would be an ideal candidate for these procedures.

The diameter of fiberscope was made smaller using the thinner fibreoptic imaging bundles while the image quality has been continuously improved over the last decade (Wang *et al.*, 2012). The custom-made micro-endoscopic set-up used in this study provides some additional advantages over the previously described instruments (Shimada & Yoshida, 1996; Okubo *et al.*, 1998; Yang *et al.*, 2002; Cuda *et al.*, 2006; Li *et al.*, 2008; Han *et al.*, 2009; Liu *et al.*, 2009; Wang *et al.*, 2012). Combining good image quality with resolution of 6.000 and 10.000 pixels with thin working sheath and work channel for ureteric catheter for water irrigation provides clearest views of the interior of vas deferens. Additionally, using a catheter enables guidance of the flexible micro-endoscope into the orifice of the ejaculatory duct. For the retrograde experiments, it was possible to apply a flexible cystoscope with a working channel of 6.5 Fr to insert the ureteric catheter (4.8 Fr) through which the flexible micro-endoscope can be introduced in the sense of a mother–baby system.

There are some anatomical facts inherent to vasoscopy in this regard. The ejaculatory duct is immobile (2–3 cm long), while vas deferens is mostly freely movable (30–50 cm). The internal diameter of vas differs and depends on anatomical localisation, ranging from 0.93 ± 0.13 mm to 1.24 ± 0.16 mm (Kuckuck *et al.*, 1975). There are known narrow points along its anatomical course, which are the orifice of ejaculatory ducts and the internal and external inguinal rings (Liu *et al.*, 2009). This knowledge is mandatory when dealing with the challenge of any micro-endoscopic procedure for the vas.

Current study described the visual examination of the clinically relevant length of vas deferens up to the bending at external inguinal ring. Bench experiments showed the feasibility of the procedure using the described instruments as well as the required manoeuvres and handling skills to fulfil procedure. Transurethral insertion of the flexible micro-endoscope into the seminal orifices in post-mortem men was found to be possible. Similar in vivo studies had proved the same results in small numbers of patients (Yang *et al.*, 2002; Carmignani *et al.*, 2005; Cuda *et al.*, 2006; Li *et al.*, 2008; Han *et al.*, 2009; Wang *et al.*, 2012).

Current study proved the feasibility of both antegrade and retrograde directions, which is of clinical relevance for the diagnosis, as well as the therapy. Our experience showed that the critical parts of vasoscopy are the junction of vas deferens with seminal vesicle, the internal inguinal ring and the proximal part of the vas deferens with its pars epididymica. It was not possible to pass the convoluted part. There are multiple reasons for the difficulty of a passage. First, narrowness hindered the passage and thus the complete retrograde examination. Second, there was the strong curvature of the internal ring, in which radius is smaller than the possible bending of the micro-endoscope without harming the tissue. Last but not least, because post-mortem examinations were performed in best case 24 h after death, tissue changes like oedema and deterioration hampered optimal testing conditions.

Through scrotal approach, it was possible to insert semi-rigid microscope including the working sheath in retrograde and antegrade manner that additionally enables different therapeutic options like biopsy, laser treatment or liquid aspiration.

This study used direct dynamic video imaging to address the challenges encountered in the endoscopic diagnosis and treatment of genital tract diseases. This is an attempt to reduce or minimise the associated complications to other in vivo investigative methods like, for example, radiation by CT scan. It can be envisioned that this technique could help to examine OA in infertile men. Additional options offered by micro-endoscopy are thinkable as listed in Table 1. The feasibility to retrieve spermatozoa in cases of ejaculatory dysfunction (e.g. spinal cord injuries) was already described (Colpi *et al.*, 1992). The application of a micro-endoscope in this context could improve this approach. If this would have an advantage over using a small butterfly needle to aspirate spermatozoa directly from the epididymis remains to be seen. Furthermore, some studies showed the potential of a laser application as an alternative for vasectomy. Described either as an external application (Cilip *et al.*,

Table 1 Potential options of micro-endoscopy of the vas deferens for male reproductive health

Option	Advantage/Benefit	Disadvantage/Risk	Reference
Tool for further examination of OA	Localisation of obstruction (e.g. stones of vas)	Perforation/injury of vas	Cuda *et al.*, (2006) Schrötzlmair *et al.*, (2015)
Treatment tool in case of OA	Removal of obstruction (e.g. laser of stones or removal by baskets)		
	Dilatation or laser-assisted recanalisation by vaporisation		Gaboardi *et al.*, (1991)
	Aspiration of spermatozoa (e.g. in case of central obstruction)		Colpi *et al.*, (1992)
Alternative to vasectomy	Intraluminal laser coagulation of vas	Perforation/injury of vas, non-permanent occlusion	Wen *et al.*, (2003)
	Insertion of a reversible 'locking device'		–
Diagnostic tool in case of suspicious mass of seminal vesicles	Possibility of gaining a histology	Perforation/injury of vas, difficulties of gaining, insufficient tissue sample	Matsunga *et al.*, (2004)
Diagnostic tool in case of haematospermia	Possibility of gaining a histology/ microbiology		Han *et al.*, (2009)
Diagnostic tool in case of persistent infection (e.g. chronic prostatitis)	Possibility of gaining a intraductal microbiology		–
Treatment of persistent infection	Application of antibiotics/analgesics intraluminal	Risk of perforation by exceeded pressure	

2012) or as an intraluminal laser coagulation (Wen *et al.*, 2003), it is imaginable that a laser fibre can be guided through the working channel of a micro-endoscope and occlude the vas from inside. Alternative to a laser application, endoscopic insertion of a reversible 'locking device' into the lumen of the vas deferens can be envisioned as a further interesting alternative to vasectomy. Additionally, an expected future indication could be to reopen a central luminal obstruction of the seminal duct, for example, by mechanical dilatation or laser-assisted recanalisation by vaporisation, as it is already routine in cardiology and pulmonology (Hujala *et al.*, 2003; Al-Ameri *et al.*, 2012). The successful recanalisation of an azoospermic patient with ejaculatory duct agenesis by laser was already described in a case report (Gaboardi *et al.*, 1991). If a radical advanced technology can be used to attempt to reconstruct the ductal defects after vasectomy, remains to be seen. Furthermore, one can hypothesise that a micro-endoscopic approach could support local drug application (e.g. antibiotics or analgesics) in case of chronic prostatitis or to improve microbiological examinations. Last but not least, there could be a profit for the work-up of patients suffering of haematospermia (Han *et al.*, 2009) or for the further investigation of suspicious masses in the prostate or seminal vesicles by taking a precise biopsy.

Based upon the performed investigations, there are some surgical recommendations for this innovative surgery approach. Urethrocystoscopic identification of orifices at both sides of verumontanum eases the first step. Retrograde insertion of semi-flexible micro-endoscope is guided by the ureter catheter under direct vision. Transparent membrane covering the orifices should be gently punctured. This may need time, effort and some trials to be achieved. By difficult localisation of orifices, the soft head of micro-endoscope could be used to rub the tissues at sides of verumontanum at their expected anatomical locations, as well as to penetrate the covering membrane helping to find the best way into the ejaculatory ducts. The technical requirements of retrograde examination of the vas deferens are similar to standard cystoscopic manoeuvres. Water or saline irrigation should be used to prevent sticking of mucous membrane to the optic obscuring vision and to minimise any possible mechanical damage to the mucous membrane during manipulations.

Technical challenges have to be underlined. This includes the limited endoscopic view and the impossibility to proceed beyond the curvature at inguinal ring. Similar to vasography, cannulation might cause vasal lesions and lead to some postoperative consequences, like infection or scaring causing vas obstruction. Intraoperative fluid irrigation has also its inherited problems and consequences, for example, potential vas rupture or mucosal irritation.

The separate experiments showed that a good view could be achieved by an intermittent irrigation flow of a total amount of 1 mL per min. By this, the intraluminal pressure was measured to be in the range of 30 and 50 cm H_2O. Although the final crash-test showed that reaching a maximum pressure of 1000 cm H_2O resulted in neither macroscopic deformation nor any perforation of the vas; further studies especially on the microstructure (e.g. histology) are necessary. The measured pressures are in accordance to the findings by Kihara *et al.* who investigated the physiological intraluminal pressure in the vas to explore the mechanism of sperm transport (Kihara *et al.*, 1995). By these examinations, a maximum pressure of 263 cm H_2O was described for the pars epididymica and 26 cm H_2O for the middle of the vas.

Lastly, the micro-endoscope is fragile, and the difference in weight between the camera and probe makes it difficult to handle for the first time, which should raise the importance of dry training as well as considering an individual learning curve. Preoperative training and meticulous preparations should be also directed to avoid all mentioned possible problems and complications.

Nevertheless, the described innovative micro-endoscopic approach seems feasible for potential future diagnostic and therapeutic interventions in modern andrology.

CONCLUSION

Micro-endoscopic vasoscopy looks feasible, minimally invasive and effective. It seems to be adequate for several diagnostic and therapeutic indications in andrology. Further studies are necessary to evaluate the actual clinical benefit of this new technique.

ETHICAL STANDARDS

All experiments were performed under declaration of Helsinki and ethical approval of Ethics Committee of the University of Munich (project number 161-12).

CONFLICT OF INTEREST

All authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTIONS

Protocol/project development: Trottmann, Sroka, Braun, Liedl, Schaaf, Graw, Becker, Stief, Khoder. Experiments: Trottmann, Sroka, Braun, Schaaf, Khoder. Data collection or management: Trottmann, Sroka, Schaaf, Khoder. Data analysis: Trottmann, Sroka, Schaaf, Becker, Khoder. Manuscript writing/editing: Trottmann, Sroka, Becker, Stief, Khoder.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Video Clip S1. Internal view of the vas deferens by the semi-rigid micro-endoscope.
Video Clip S2. Biopsy forceps in the lumen of the vas are opened and closed.
Video Clip S3. Internal micro-endoscopic views of the ex vivo examinations of prostatectomy specimen by the semi-rigid micro-endoscope in a retrograde direction.
Video Clip S4. Transurethral view of the verumontanum, views of the right orifice on closer examination and the look into the ejaculatory duct in post-mortem examinations.