

Robotic Assisted Versus Pure Microsurgical Vasectomy Reversal: Technique and Prospective Database Control Trial

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Abstract

Microsurgical vasectomy reversal is a technically demanding procedure. Previous studies have shown the possible benefit of robotic assistance during such procedures. Our goal was to compare robotic assisted vasovasostomy and vasoepididymostomy to standard microsurgical vasovasostomy (MVV) and vasoepididymostomy (MVE). The use of robotic assistance for vasectomy reversal may provide the microsurgeon with improved visualization, elimination of tremor, and decreased fatigue and obviate the need for a skilled microsurgical assistant. This study provides the first clinical prospective control trial of robotic assisted versus pure microsurgical vasectomy reversal. The use of robotic assistance in microsurgical vasovasostomy and vasoepididymostomy may have benefit over MVV and MVE with regards to decreasing operative duration and improving the rate of recovery of postoperative total motile sperm counts based on our study.

Keywords

- ▶ vasovasostomy
- ▶ vasoepididymostomy
- ▶ robotic
- ▶ vasectomy
- ▶ reversal

Vasectomy is considered one of the most reliable family-planning methods currently available because of its simplicity, effectiveness, and low morbidity rate.¹ An estimated 40 to 60 million men worldwide rely on this method of contraception. About 2% of these men undergo a reversal operation within the first 10 years after the vasectomy because of a desire to become fertile again (usually due to a new relationship).^{1,2} Vasectomy reversal is a technically demanding procedure. Since the introduction of the operating microscope in 1975 for this kind of surgery, there has been an improvement in success rates.^{3,4} The use of the operative microscope to achieve greater fertility rates and vas patency after vasovasostomy has become a standard for the microsurgeon who treats male infertility.⁴ However, this technique requires a great degree of microsurgical training and a skilled surgical assistant.

The development of robotic assisted procedures in several surgical fields continues to expand.⁵⁻⁹ There are several potential benefits: a stable, ergonomic, scalable control system with three-dimensional visualization and magnification; elimination of tremor with simultaneous ability to control three instruments and a camera; ability to integrate up to three visual inputs simultaneously in the surgeon console, similar to a fighter pilot cockpit. All these features may provide surgeons an advantage when performing complex microsurgical procedures. The use of robotic assistance for vasectomy reversal could potentially provide the microsurgeon with improved visualization, decreased fatigue and obviate the need for a skilled surgical assistant. This study presents the current technique and outcomes for robotic assisted microsurgical vasovasostomy (RAVV) and vasoepididymostomy (RAVE).

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Methods

Robotic Surgical Platform and Operative Setup

Intuitive Surgical (Sunnyvale, CA) offers a four-arm da Vinci type Si robotic system with high-definition (HD) digital visual magnification (up to 10 to 15 ×). The left and right arms are loaded with black diamond microneedle drivers (Intuitive Surgical, Inc., Sunnyvale, CA). The additional fourth arm provides the microsurgeon with one additional tool such as micro Potts scissors (Intuitive Surgical, Inc., Sunnyvale, CA).

We have developed a unique simultaneous tri-visual robotic platform utilizing three different video inputs through the TilePro software (Intuitive Surgical, Inc., Sunnyvale, CA). The three views available simultaneously for the microsurgeon are (1) the da Vinci Si 3D HD camera view, (2) the VITOM optical 16 to 20× camera lens system view (Karl-Storz Inc., Tuttlingen, Germany) and 3) a 40 to 100× optical microscopic view from the intra-op andrology laboratory microscope (Nikon Inc., Tokyo, Japan). This new tri-view in the robotic console allows the surgeon to use the da Vinci camera for the overall tissue and suture handling at a medium zoom and simultaneously provides the VITOM 16 to 20× magnification view to see fine ultrastructural detail (→Fig. 1). In standard microscopic microsurgery, due to the limited depth of field, the microscope has to be zoomed in or out for different components of the procedure. The use of this tri-view system improves operative efficiency by obviating the need to zoom in and out during microsurgical vasectomy reversals. The ability to also simultaneously see the fluid that the andrologist is assessing for sperm provides significant improvement in operative efficiency by enhancing the real-time communication between the microsurgeon and the laboratory staff (this alone has saved 15 to 20 minutes on procedures because

the surgeon is able to communicate and visualize the fluid real-time with the andrologist while operating).

The VITOM camera system (Karl-Storz Inc., Tuttlingen, Germany) is set up using the point setter nitrogen-powered arm and a microadjustment manipulator as shown in →Fig. 2. The operative setup is as illustrated in →Fig. 3.

Surgical Technique

The patient is placed in a supine position. The scrotum is prepared and the two ends of the vas or the epididymis are brought out of the skin incision in standard microsurgical fashion. The distal vas (away from the testicle) is dissected to allow a tension-free anastomosis to the proximal vas or epididymis. The proximal vas is carefully transected with a #11 blade. Efflux from the lumen is expressed and collected on a glass slide. Phase contrast microscopy (andrology laboratory microscope) is used to assess for the presence of sperm on the slides. If there is any sperm found, or if the efflux is copious and clear or milky, then a RAVV is performed. If the efflux has no sperm and is thick and pasty, then a RAVE is performed.

RAVV Technique

The distal end of the vas is now transected. The two clean ends of the vas are now approximated to each other to confirm a tension-free anastomosis. The adventitia from either end of the vasa is now secured together with a 3-0 prolene suture to create a tension-free anastomosis. The robot is now positioned to perform the microsurgical vasovasostomy. The left-side vasovasostomy is generally performed first. Black diamond microforceps are loaded on the right and left robot arms. The zero-degree camera lens is

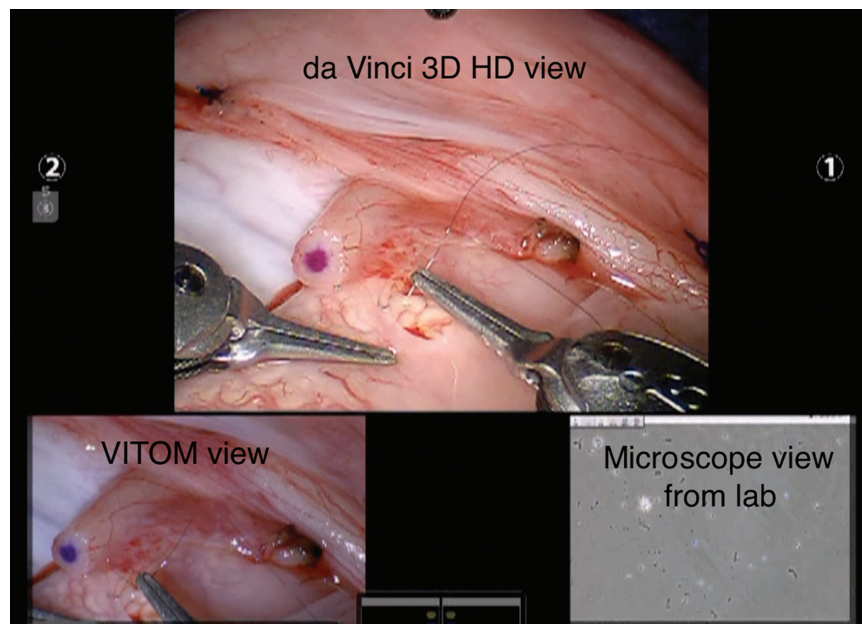


Figure 1 The simultaneous tri-view in the surgeon console: (1) da Vinci Si 3D HD camera view. (2) VITOM optical 16–20× camera lens system view (Karl-Storz Inc., Tuttlingen, Germany). (3) 40–100× optical microscopic view from the intra-op andrology laboratory microscope (Nikon Inc., Tokyo, Japan).

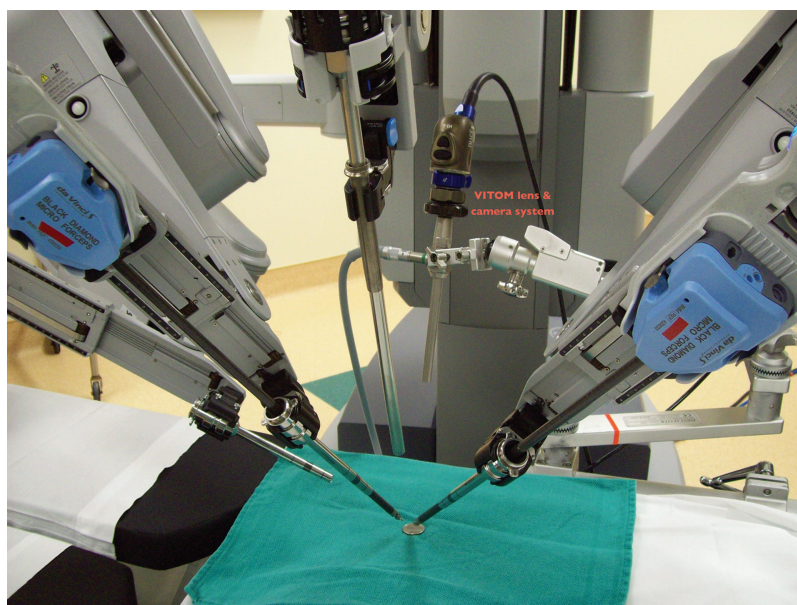


Figure 2 Operative setup for the robotic platform with the additional VITOM lens camera system and point setter nitrogen powered arm (5th arm).

loaded onto the robot camera arm. The micro Potts scissors are loaded onto the fourth robot arm. The two ends of the vas are placed over a ¼-inch Penrose drain. The assistant irrigates the field with saline using a 10-mL syringe with an 18-gauge angiocatheter tip. Weck sponge sticks are used to dry the field.

The assistant now passes the 9-0 nylon suture that is kept in its inner packaging to the surgical field. The suture is grasped using the black diamond right-hand grasper and cut to ~2 inches length using the micro Potts scissors (left-hand fourth arm). The 9-0 nylon suture is held and manipulated using the black diamond forceps in both left and right arms as

needle drivers. The posterior muscularis layer of the two ends of the vas is now approximated (► **Fig. 4**). The suture is cut using the micro Potts scissors.

Two or three double-armed 10-0 nylon sutures are now placed to re-anastomose the posterior mucosal lumen of the vas (► **Fig. 5**). The sutures are placed inside out to ensure good mucosal approximation. All sutures are placed before they are tied.

Three double-armed 10-0 nylon sutures are used to close the anterior mucosal lumen of the vas (► **Fig. 6**). Five to six 9-0 nylon sutures are used to approximate the anterior muscularis layer of the vas (► **Fig. 7**). The Penrose drain is gently removed from under the repair. The vas is placed back into the scrotal cavity. The same procedure is now performed on the contralateral right side by repositioning the robot away from the patient to the right scrotum.

The dartos layer is closed using a running 3-0 chromic suture. The skin is closed using a 5-0 vicryl running suture. Bacitracin ointment is applied over the incision. Fluff dressing with athletic scrotal support is applied. An ice pack is carefully applied to the scrotum in the recovery room.

RAVE Technique

The RAVE procedure starts from above if there is no sperm in the fluid from the proximal vas and the fluid is thick and pasty. The scrotal incision is enlarged by another 1 to 2 cm inferiorly. The testicle is delivered and the tunica is incised to expose the epididymis. The adventitial layer of the epididymis is incised above the level of epididymal obstruction (blue/gray zone with dilated epididymal tubules above this area). A 3-0 prolene suture is utilized to approximate the adventitia of the epididymis to the muscularis of the vas to prevent tension between the anastomosis. The robot is now positioned to perform the microsurgical vasoepididymostomy (MVE) as

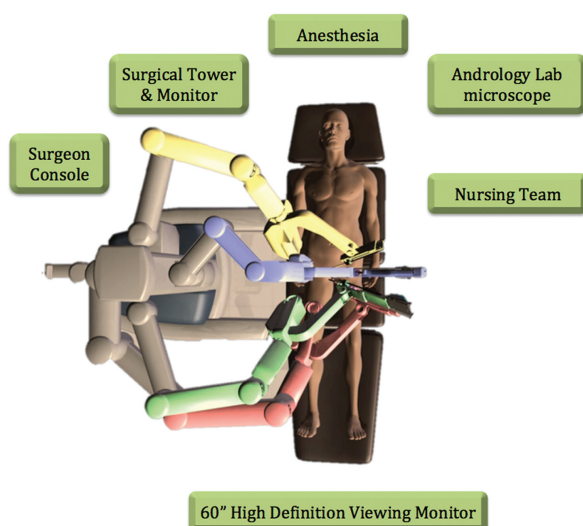


Figure 3 General layout of the operative room equipment for robotic assisted microsurgical vasectomy reversal.

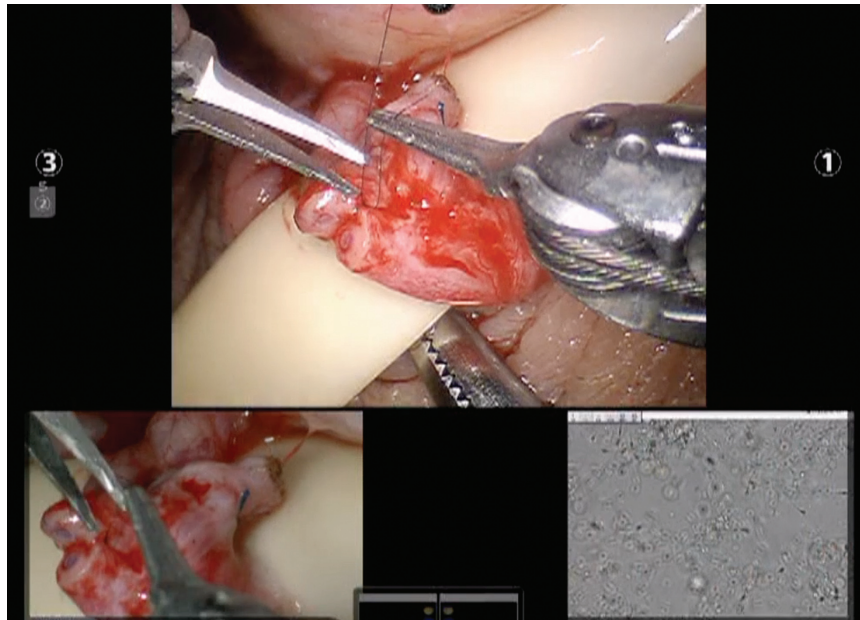


Figure 4 Placement of two posterior 9-0 nylon vas deferens muscularis anastomosis sutures during robotic assisted microsurgical vasovasostomy.

described earlier. The black diamond microforceps are loaded on the right and left robot arms. The zero-degree camera lens is loaded onto the robot camera arm. An ophthalmologic microblade is held in the fourth arm with black diamond microforceps, or a Potts scissor may be used in the fourth arm. Two 10-0 nylon double-armed suture needles are placed longitudinally through a single epididymal tubule to expose the tubule (►Fig. 8). This tubule is then incised longitudinally using the microblade between the two suture needles to create a lumen in the tubule. Alternatively, the tubule may be

incised with a Potts scissor in the fourth robotic arm. The fluid is then aspirated (►Fig. 9) and examined under a separate phase contrast microscope for the presence of sperm (andrology laboratory microscope).

The two double-armed 10-0 nylon needles in the epididymal tubule are advanced through, and then all four of the needles are brought inside out on the vas mucosal lumen to involute the epididymal tubule lumen into the vas lumen (►Fig. 10). Five to six 9-0 nylon sutures are placed circumferentially to approximate the muscularis of the vas to the

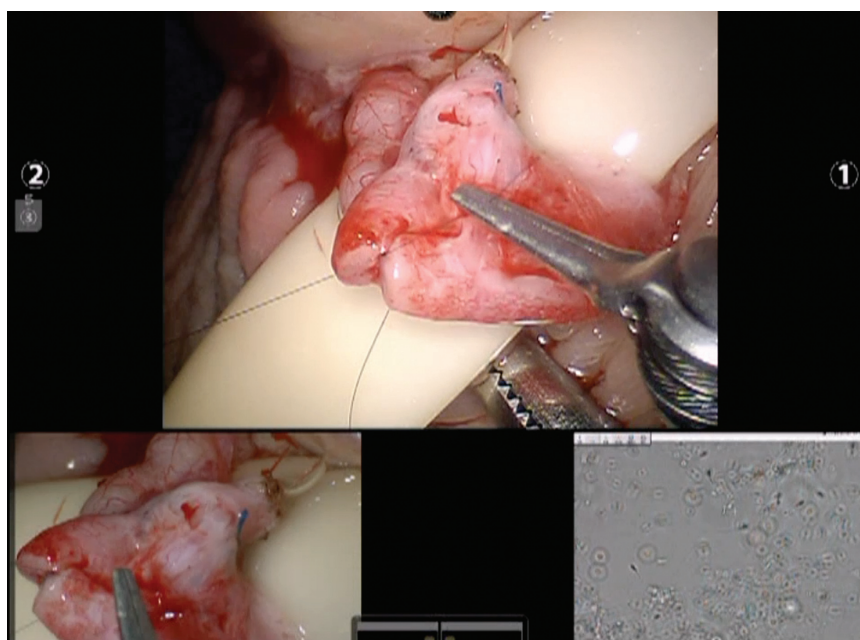


Figure 5 Placement of two or three posterior vasal mucosal lumen 10-0 nylon double-armed sutures during robotic assisted microsurgical vasovasostomy.

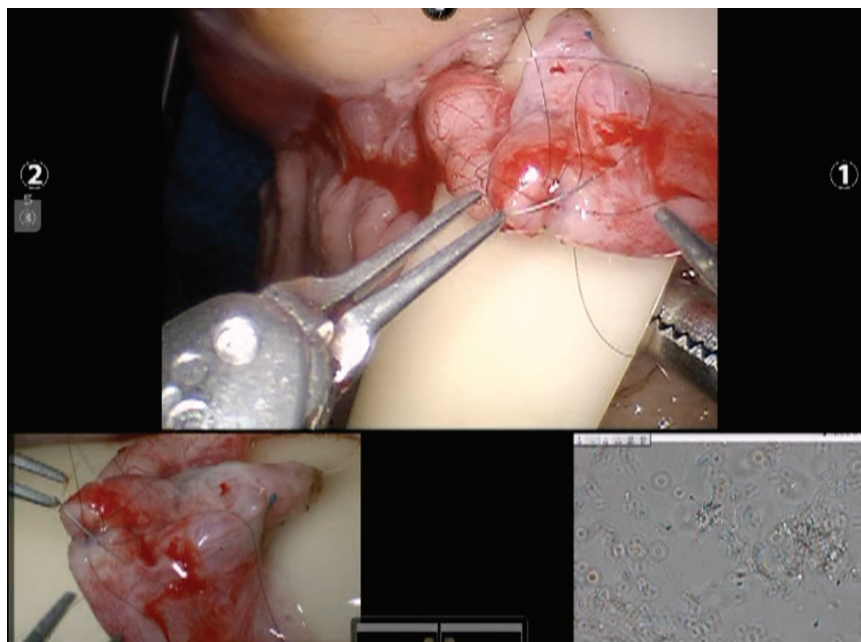


Figure 6 Placement of three anterior vasal mucosal lumen 10-0 nylon double-armed sutures during robotic assisted microsurgical vasovasostomy.

adventitia of the epididymal tubule (►Fig. 11). The testicle and anastomosis are carefully delivered back into the scrotum. The dartos layer is closed using a running 3-0 chromic suture. The skin is closed using a 4-0 chromic running suture. Bacitracin ointment is applied over the incision. Fluff dressing with athletic scrotal support is applied. An ice pack is carefully applied to the scrotum in the recovery room.

Clinical Study Design & Methods

We designed an institutional review board (IRB)-approved prospective database based control study to compare RAVV

and RAVE to standard microsurgical vasovasostomy (MVV) and MVE. Between August 2007 and February 2012, 155 vasectomy reversal cases performed by a single fellowship-trained microsurgeon were reviewed. The primary end point was operative duration. The secondary end point was total motile sperm count at 2, 5, 9, and 12 months postoperatively. Case breakdown was as such: 110 with robotic assistance, 45 pure microsurgical. 66 cases bilateral RAVV, 44 cases RAVE on at least one side, 28 cases bilateral MVV, and 17 cases MVE on at least one side. Selection of approach (robotic versus pure microscopic) was based on patient choice. Preoperative

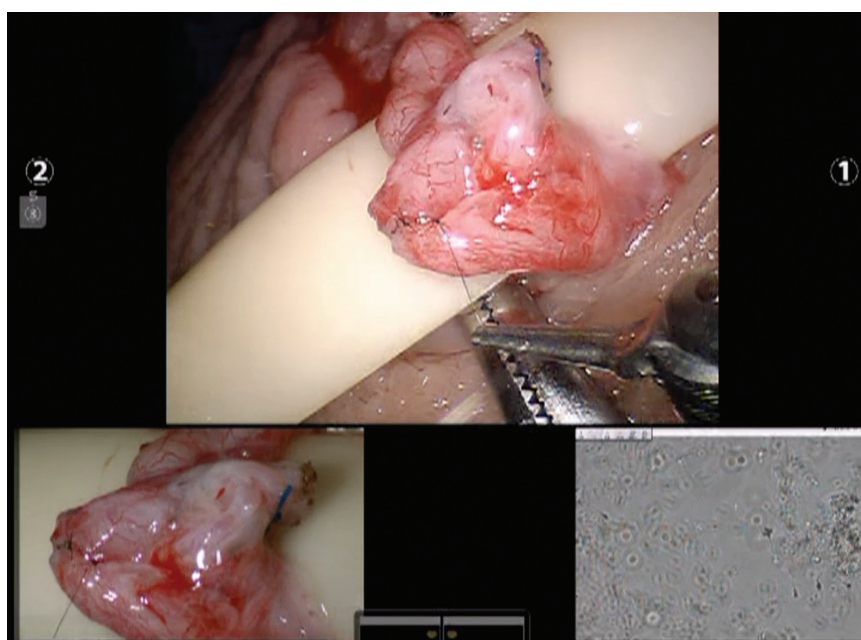


Figure 7 Placement of five or six anterior and circumferential vas deferens muscularis 9-0 nylon sutures during robotic assisted microsurgical vasovasostomy.

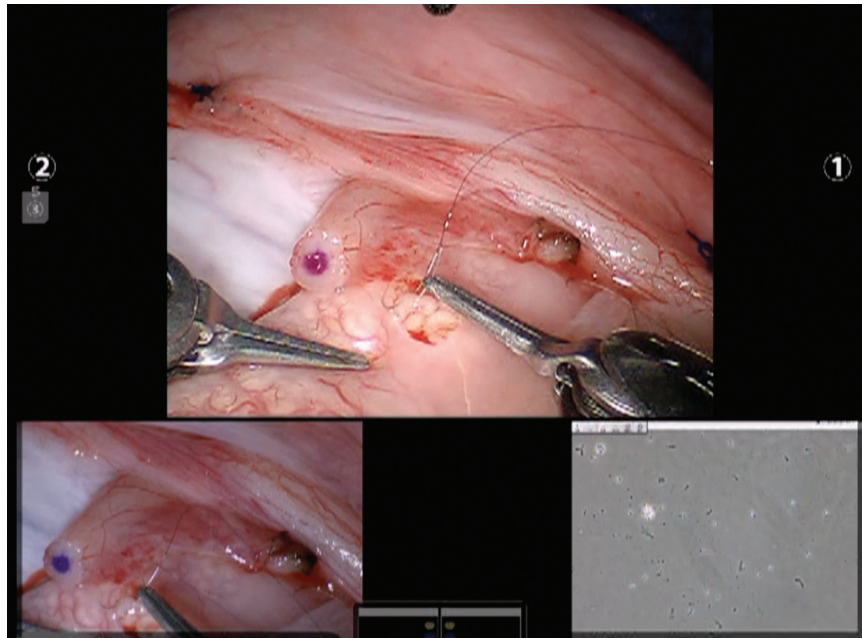


Figure 8 Two 10–0 nylon double-armed suture needles are placed longitudinally through a single epididymal tubule during robotic assisted microsurgical vasoepididymostomy.

patient characteristics were similar in both groups. The same suture materials and suturing techniques (two-layer 10–0 and 9–0 nylon anastomosis for RAVV; 10–0 nylon double-armed longitudinal intussusception technique for RAVE) were used in both approaches.

Results

Median clinical follow-up was 17 months (range 1 to 52 months). Median duration from vasectomy in the RAVV group was 7 years (range 1 to 21 years) and 6.5 years (range

1 to 19 years) in the MVV group ($p = 0.3$). Median age of the patients in the RAVV group was 41 and 39 in the MVV group ($p = 0.4$).

A patency of 96% was achieved in the RAVV cases and 80% in MVV (>1 million sperm/ejaculate). There was a statistically significant difference in patency rates between the two groups ($p = 0.02$). Pregnancy rates (within 1 year postop) did not differ significantly for the two groups: 65% for the RAVV and 55% for the MVV. Operative duration (skin to skin) started at 150 to 180 minutes initially for the first 10 cases for RAVV, but median operative duration was significantly

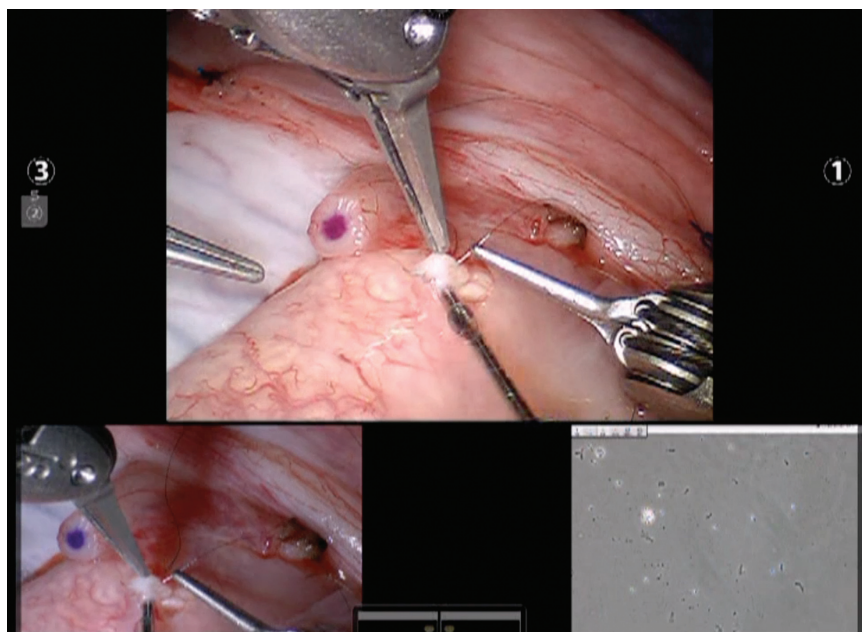


Figure 9 Robotic assisted microsurgical vasoepididymostomy: Epididymal tubule incised with Potts Scissor or ophthalmologic blade and then fluid aspirated for microscopic examination.

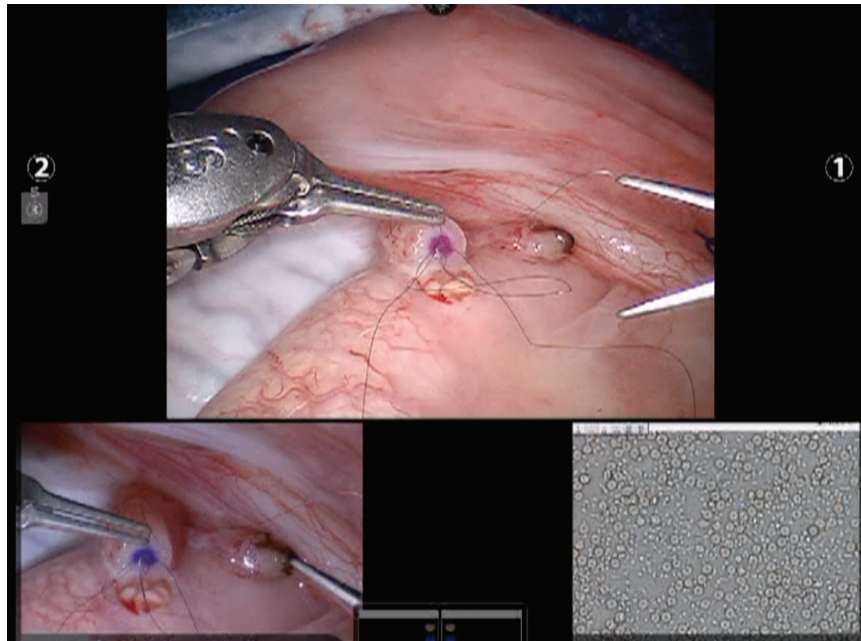


Figure 10 Robotic assisted microsurgical vasoepididymostomy: The two double armed 10-0 nylon needles in the epididymal tubule are advanced through and then all four of the needles are brought inside out on the vas mucosal lumen to involute the epididymal tubule lumen into the vas lumen.

decreased in RAVV at 97 minutes (range 40 to 180 minutes) compared with MVV at 120 minutes (range 60 to 180 minutes), $p = 0.0003$. RAVE at 120 minutes (range 60 to 180 minutes) was significantly faster than MVE at 150 minutes (range 120 to 240 minutes), $p = 0.0008$. Suture breakage and needle bending reduced significantly after the first 10 RAVV cases. Mean postoperative total motile sperm counts were not significantly higher in RAVV/RAVE versus MVV/MVE, but the rate of postoperative sperm count recovery was

significantly greater in RAVV/RAVE. ►**Fig. 12** illustrates the postoperative mean sperms counts in both groups.

Discussion

The robotic technique in this initial study appears to be safe, with comparable outcomes to the standard microsurgical approach. Subjectively, there appeared to be ergonomic advantages to using the robotic system over the microscopic

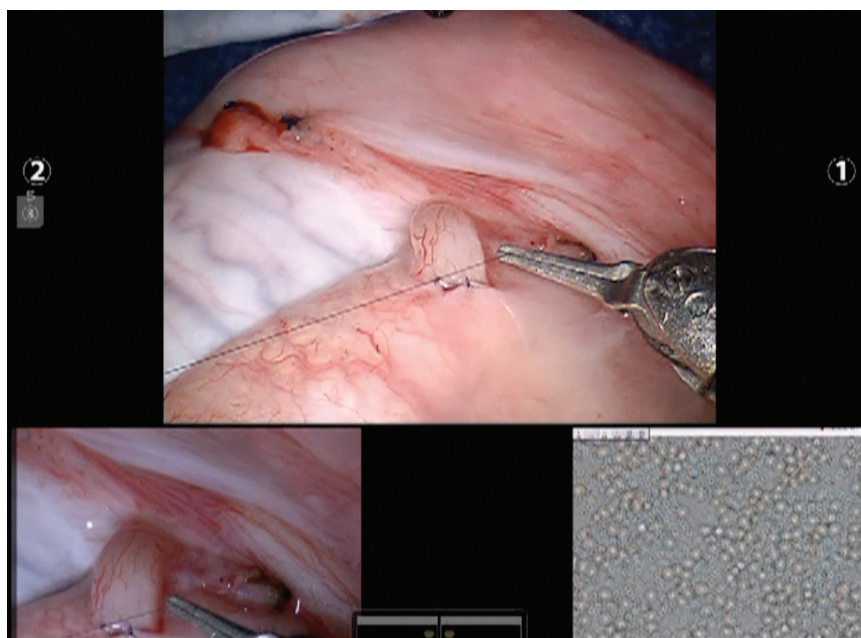


Figure 11 Robotic assisted microsurgical vasoepididymostomy: Five to six 9-0 nylon sutures are placed circumferentially to approximate the muscularis of the vas to the adventitia of the epididymal tubule.

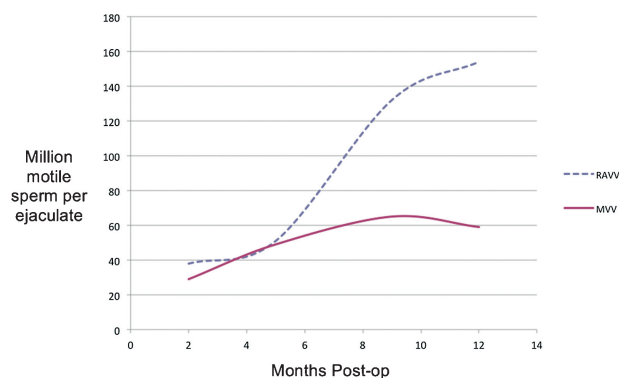


Figure 12 Postoperative mean total motile sperm counts per ejaculate in the robotic assisted microsurgical vasovasostomy and standard microsurgical vasovasostomy groups.

platform. Objectively, there appears to be increased operative efficiency with RAVV compared with MVV. Despite the surgeon's previous extensive background in microsurgical and robotic surgery (fellowships in each discipline), there was a learning curve associated with robotic microsurgery. The operative duration, number of suture breaks and needle bends decreased rapidly after the first 10 cases.

The robotic reversals initially had longer operative durations (150 to 180 minutes) than standard microsurgical reversals (usually 120 to 150 minutes depending on whether vasoepididymostomy is needed). There was an additional 30 to 60 minutes to prepare the robot at the beginning of the case: this time significantly decreased with experience, as the operating room staff became more familiar with our setup. The duration of preparation for the robot (prior to the case) is routinely ~20 to 25 minutes now (this is similar to the time the staff takes to prepare the microscope for pure microsurgical cases). This learning curve in the initial robotic cases was also observed Kuang et al.^{10,11} Six years ago, Schiff et al^{12,13} showed in a prospective randomized control trial in an animal model that robotic assistance could significantly reduce operative duration in RAVV compared with MVV. Our study confirms these findings in a prospective human trial.

Previous studies have shown that patency rate varies between 97% and 71% depending on the interval between vasectomy and reversal procedure.¹⁴ Our patient series breakdown in terms of years from vasectomy was as follows for RAVV and MVV respectively: <3 years from vasectomy, 8.3% and 10.7%; 3 to 8 years, 46.7% and 60.7%; 9 to 14 years, 26.7% and 17.9%; and ≥15 years, 18.3% and 10.7%. Based on these expected patency rates, the duration-adjusted expected patency rates for our two groups would be 83.2% for RAVV and 85.5% for MVV. In our study the RAVV patency rate was 96% and the MVV patency rate was 80%. Although there was a statistically significant difference in patency rates in this study ($p = 0.02$) between RAVV over MVV, there may be some confounding variables. The surgeon did start performing these procedures just after completing a fellowship, and most of the MVV cases were performed earlier in the series and the RAVV cases were performed almost exclusively in the

later part of the series. There may be an inherent learning-curve bias to better outcomes as the series matures and this may overamplify the difference between RAVV over MVV patency rates. However, this does support the notion that RAVV may allow a surgeon to achieve outcomes similar to very mature retrospective case reviews of well-established microsurgeons in a shorter amount of time. The series of RAVV cases presented in this study are the first 110 robotic cases performed by this surgeon, and the patency outcomes closely match those of microsurgeons who have performed several hundred MVV cases.

Mean postoperative total motile sperm counts were not significantly higher in RAVV/RAVE versus MVV/MVE. However, the rate of sperm return to the ejaculate after surgery was greater in RAVV/RAVE. For RAVV, the mean rate of return of sperm to the ejaculate postop was 13 million motile sperm per month (the slope of the mean sperm counts 2, 5, 9, and 12 months postop). For MVV, the mean rate of return of sperm to the ejaculate postop was 3 million motile sperm per month.

The improved operative efficiency and eliminated need for a skilled assistant in RAVV/RAVE has reduced the cost of this reversal procedure to less than the regional average cost for MVV/MVE. The total out-of-pocket cost of the robotic reversal procedure for the patient at our facility (hospital setting) including operating room, anesthesia, and surgeon fees is \$5,600. The use of robotic assistance has allowed the microsurgeon to go from performing two to three microsurgical cases to five to six such cases in the same time period due to decreased surgeon fatigue and improved surgical efficiency.

Conclusion

The use of robotic assistance in microsurgical vasovasostomy and vasoepididymostomy may have potential benefit over MVV and MVE with regards to decreasing operative duration and improving the rate of recovery of postoperative total motile sperm counts. The advantages of a stable microsurgical platform, ergonomic surgeon instrument controls, elimination of tremor, magnified immersive 3D vision, and simultaneous tri-view ability all contribute to improved surgical efficiency. Further evaluation and longer follow-up is needed to assess its clinical potential and the true cost-benefit ratio. However, the preliminary results are quite promising.

Note

None of the authors have any disclosures.

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