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Use of an automated endoscopic suturing device does not improve mental workload or time of intracorporeal suturing among surgical residents

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Objective
To compare 2 intracorporeal suturing techniques among surgical residents.

Methods
Surgical residents at an academic teaching hospital were invited to participate. All participants completed 2 intracorporeal suturing trials in a laparoscopic trainer using either endoscopic needle drivers (END) or an automated endoscopic suturing device (ESD), with 14 days between trials. A standardized, descriptive video of each intracorporeal suturing technique was provided 7 days before the respective trial. Time to perform suturing was recorded, and participants completed a National Aeronautics and Space Administration Task Load Index (NASA-TLX) questionnaire following each trial. Suture lines were subjectively blindly scored using a standardized questionnaire by 3 surgeons.

Results
10 surgical residents across 4 years of training were enrolled. Mean time to complete the suturing trial was 5.72 ± 1.49 minutes for END and 6.00 ±2.14 minutes for ESD (P = .76). The mean NASA-TLX score was 44.60 ± 19.02 for END and 44.33 ± 22.22 for ESD (P = .83). Median suture evaluation score was 11 (IQR, 8 to 11) for END and 11 (IQR, 9 to 11) for ESD (P = .13). Mean time to perform suturing was significantly different across years of training in residency for both ESD and END (P = .006).

Conclusions
In this ex vivo model, an automated ESD provided no benefit for ease of performing intracorporeal suturing among surgical residents.

Clinical Relevance
Surgical residents can perform intracorporeal suturing with knotless barbed suture using either ESD or END. Further evaluation of the learning curve of each instrument for novice surgeons is warranted.

Keywords: laparoscopy, intracorporeal, suturing, endoscopic suturing device, endoscopic needle drivers

Laparoscopic surgery has become increasingly common in veterinary patients due to multiple purported benefits including reduced pain, morbidity, surgical time, and recovery time.[1–6] Elective prophylactic laparoscopic gastropexy is commonly performed in dogs that are considered at risk for gastric dilatation and volvulus. Common techniques for laparoscopic gastropexy include laparoscopic-assisted gastropexy (LAG) and total laparoscopic gastropexy (TLG) via intracorporeal suturing. While LAG negates the need for intracorporeal suturing, it has been associated with relatively high rates of incisional complications[7,8] as well as reduced postoperative activity compared to TLG.[9]

Intracorporeal suturing is associated with a steep learning curve and has been shown to be a barrier to the wider adoption of minimally invasive surgery in people.[10] While the use of knotless barbed suture reduces the time to perform intracorporeal suturing due to the lack of intracorporeal knot tying, a learning curve persists.[11,12] Multiple alterations to the TLG technique have been proposed to reduce or mitigate the challenge of intracorporeal suturing

Received April 18, 2026
Accepted July 9, 2026
Published online July 20, 2026

doi.org/10.2460/ajvr.26.04.0173

including use of stapling devices,[13] articulated needle drivers,[14] 3-D laparoscopy,[15] absorbable fixation straps,[16] and endoscopic suturing devices (ESD).[17,18]

In human medicine, use of an ESD has been associated with significantly reduced surgical time and cost.[19,20] Furthermore, ESDs have been shown to reduce the learning curve of intracorporeal suturing in surgical residents when compared to the use of endoscopic needle drivers (END).[20,21] Two prior studies[9,18] comparing the use of an ESD versus END for TLG in dogs found no significant difference in surgical time between techniques. However, in both studies, all procedures were performed by a surgeon with extensive minimally invasive surgery experience, and no evaluation of mental workload or procedural difficulty was performed.

The objective of this study was to compare the use of ESD versus END for intracorporeal suturing among surgical residents using a standardized ex vivo laparoscopic trainer. We hypothesized that ESD would be associated with reduced time to perform intracorporeal suturing and improved mental workload.

Methods

This study was approved by the Institutional Review Board at the University of Florida on March 5, 2025 (IRB202500217). Study participants were prospectively and voluntarily recruited via a standardized email sent to all surgical residents at the University of Florida College of Veterinary Medicine.

All participants completed 2 intracorporeal suturing trials using either an ESD (Endo Stitch; Medtronic) or END (Karl Storz) with barbed unidirectional knotless suture (V-Loc; Medtronic). Once recruited, participants were randomized to END or ESD for the first trial using a coin flip. Each trial was performed 14 days apart, with each participant subsequently crossing over to the alternate instrument on the second trial. Seven days before each trial, all participants received a standardized video describing the intracorporeal suturing technique and instrument for their respective trial. The video was narrated and described each task from start to finish, including the passage of the needle through the welded suture loop, taking a total of 5 bites including the initial bite, spacing bites 3 to 5 mm apart, and finishing by cutting the suture tag. In each video, the specific suturing instrument was shown, and proper use of the instrument was demonstrated. Participants could access and watch the video as many times as desired leading up to the trial date. Immediately before the trial, all participants received a standardized explanation and demonstration of the suturing instrument in person and were given the opportunity to ask clarifying questions. Additionally, all participants were asked if they had prior experience suturing with the instrument in either a clinical or lab setting and, if so, the number of times. If they had used the instrument more than 5 times, it was recorded as > 5.

All intracorporeal suturing trials were performed using the same laparoscopic trainer device (FLS Trainer Box; Limbs & Things). A silicone suture pad was secured within the laparoscopic trainer **(Figure 1)**. Time to complete suturing was recorded, with the timer starting as soon as the participant verbalized that they were ready, before any manipulation of the suture or silicone pad, and ending when the participant cut the suture using endoscopic hook scissors (Karl Storz). Immediately following each trial, all participants completed a previously validated questionnaire used for evaluation of technical demand and learning curves (National Aeronautics and Space Administration Task Load Index [NASA-TLX]).[22] An overall score from 0 to 100 (0 being least difficult, 100 being most difficult) was determined by a weighted average of 6 categories including mental demand, physical demand, temporal demand, effort, and perceived performance.[22]

All silicone suture pads were numbered corresponding to each participant, and each suture trial was numbered 1 or 2. Suture pads were then subjectively separately scored by 3 separate American College of Veterinary Surgery diplomates (RWW, KH, and JBC) who were blinded to participant identity, year of training, and suturing instrument. Scoring was performed using a standard questionnaire assessing tightness of the suture line, successful passage of the suture through the welded loop, suture entanglement, and tearing of the silicone pad representative of tissue trauma **(Supplementary Material S1)**. An ordinal scale was assigned to each category for a total of 11 points, with 0 being the worst score and 11 being the best score.

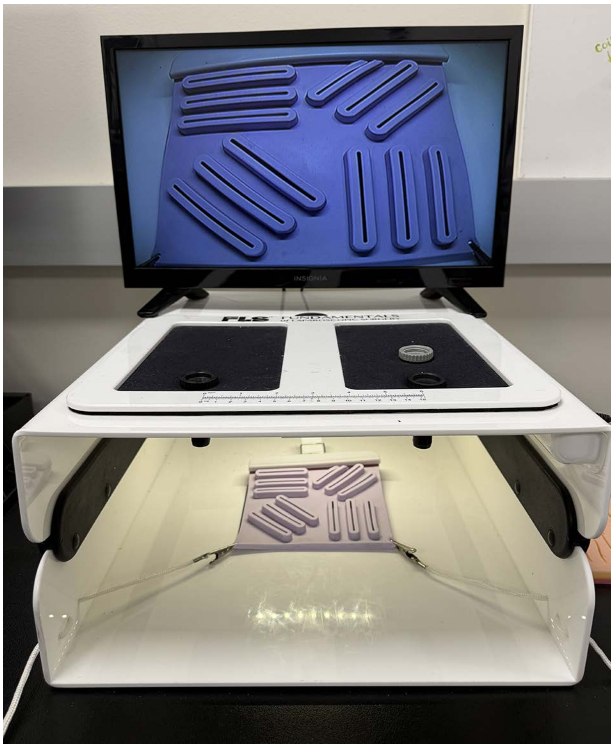

Figure 1—Representative image of the laparoscopic surgery simulator used for all suturing trials with a silicone suture pad secured within the training box.

Finally, the distance between all suture bites was measured using a standard ruler and averaged for each participant suture trial by a single observer (FPS).

Statistical analysis

Statistical analysis was performed using commercially available statistical software (JMP 19.0.01; JMP Statistical Discovery). Categorical variables were summarized by frequencies and percentages. The Shapiro-Wilk test was performed for all numerical variables to assess for normality. For variables following a normal distribution, they were summarized with mean, range, and SD. Numerical variables that did not follow a normal distribution were summarized with median and IQR. A linear mixed model was used to test differences in suturing instrument and year of training and their interaction on suture time, NASA-TLX score, subjective suture score, and distance between suture bites. Additionally, the same was performed to test differences in suturing instruments and prior experience using the instrument on the same variables. Random effects were participant and subjective evaluator to control for different internal correlations. Statistical significance was reached at $P < .05$.

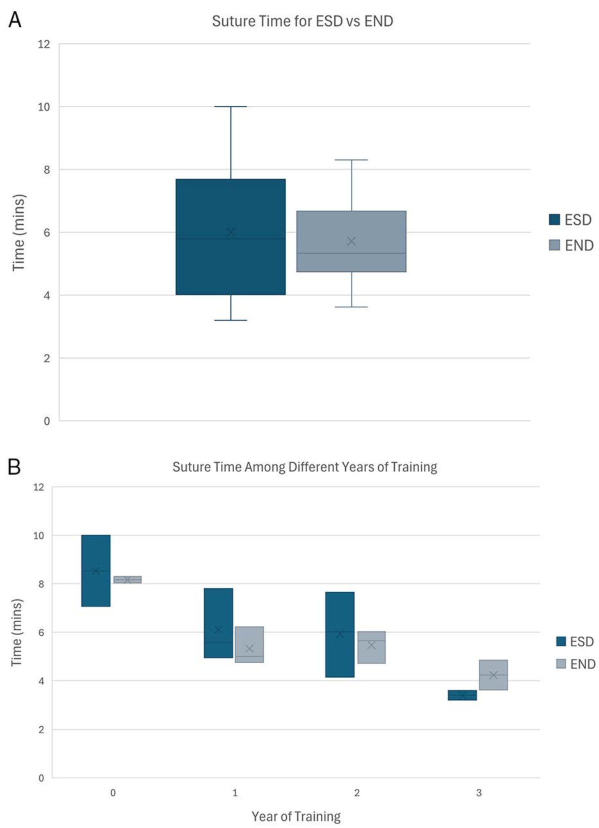

Figure 2—Box-and-whisker plots demonstrating time to complete the suturing trial for the endoscopic suturing device (ESD) versus endoscopic needle drivers (END; A) and time to complete the suturing trial between different years of training for both ESD and END (B). There was no difference in time to complete suturing between instruments, while year of training was significantly associated with time to complete suturing.

Results

Ten surgical residents were prospectively enrolled across 4 training levels: 2 preclinical residents completing their Master's degree (year 0, following completion of a rotating internship), 3 first-year residents, 3 second-year residents, and 2 third-year residents.

Mean time to complete suturing was 6.0 minutes (range, 3.2 to 10.0 minutes; SD, 2.1 minutes) for ESD and 5.7 minutes (range, 3.6 to 8.3 minutes; SD, 1.5 minutes) for END (P = .76; **Figure 2**). Mean time to complete suturing was significantly different between different years of training (P = .0061), with mean suture times of 8.35, 5.71, 5.72, and 3.82 minutes for years 0, 1, 2, and 3, respectively. When evaluating the interaction of year of training and suturing instrument effect on suturing time, there was no significant difference between instruments (P = .82).

Mean NASA-TLX was 44.3 (range, 8.3 to 77.3; SD, 22.2) for ESD and 44.6 (range, 23.7 to 80.3; SD, 19.0) for END (P = .83; **Figure 3**). There was no difference in the mean NASA-TLX between different years of training (P = .16).

Median subjective suturing score was 10 (IQR, 8 to 11) for ESD and 10 (IQR, 9 to 11) for END. There was no significant difference between subjective suturing score and year of training (P = .41) or

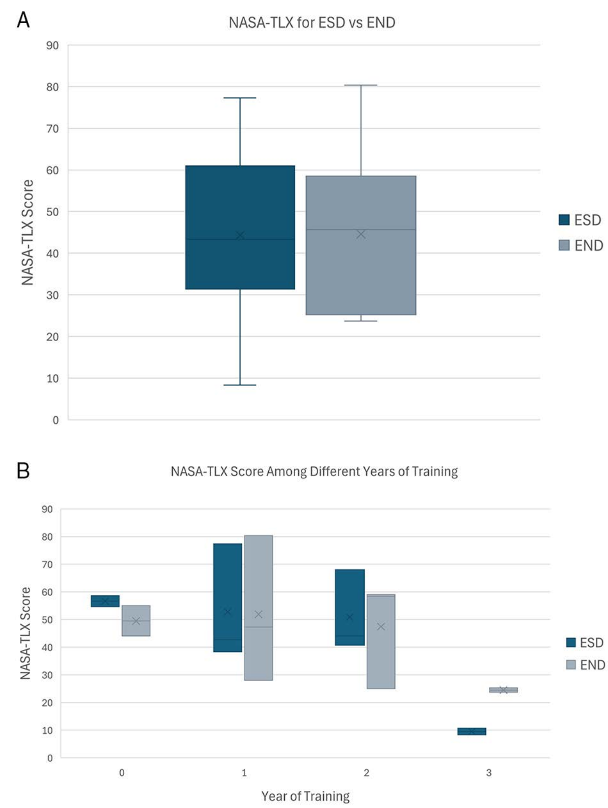

Figure 3—Box-and-whisker plots demonstrating National Aeronautics and Space Administration Task Load Index (NASA-TLX; A) scores for ESD versus END and NASA-TLX between different years of training for both ESD and END (B). There was no difference in NASA-TLX between instruments or years of training.

suturing instrument (P = .075). When evaluating the interaction of year of training and suturing instrument effect on subjective score, there was a significant difference (P = .016) in subjective score with year 0 residents having lower scores using ESD compared to all other years of training using either instrument or year 0 using END.

Average distance between suture bites was significantly different between ESD (mean, 6.2 mm; SD, 1.0 mm) and END (mean, 5.4 mm; SD, 1.3 mm; P = .023). There was no difference between the average distance between suture bites among different years of training (P = .43).

Two out of 10 (20%) participants had prior experience using ESD, with 1 participant using ESD 1 time and the other using it 5 times before the trial. Both participants with prior experience using ESD were third-year residents. Nine out of 10 (90%) participants had prior experience using END, with 3 participants using END > 5 times, 4 participants using END 1 time, 1 participant using END 2 times, and 1 participant using END 5 times before the trial. Prior experience using the suturing instrument was significantly associated with NASA-TLX (P = .029) and subjective suture score (P = .025). Prior experience using the suturing instrument had no significant effect on suturing time (P = .32).

Discussion

In this cohort of veterinary surgical residents, there was no difference in time to complete suturing or mental workload, as measured by NASA-TLX, between ESD and END. Similarly, use of either instrument resulted in a similar subjective quality of the suture line. Therefore, our hypothesis was rejected. Based on this data, either instrument can be reasonably used by surgical residents performing laparoscopic suturing.

In the current study, there was no difference in time or mental workload for laparoscopic suturing with either END or ESD among surgical residents of varying years of training. This finding was unexpected, as prior studies[23,24] have identified laparoscopic needle manipulation to be one of the most difficult skills to master for intracorporeal suturing. The benefit of the ESD is that it negates the need for needle manipulation and transfer between needle drivers. Theoretically, this should improve the ease of intracorporeal suturing by removing the most challenging step.

Unsurprisingly, year of training was associated with time of suturing, with year 0 residents (eg, before starting clinical residency) taking the longest to complete the suturing task regardless of the suturing instrument. Prior studies[25] have similarly shown early-stage trainees to have higher suturing time and lower suturing proficiency compared to senior trainees. Among laparoscopic tasks, intracorporeal suturing has been associated with the highest mental workload, based on the NASA-TLX score. However, simulation training has been shown to significantly reduce both NASA-TLX score and time to complete suturing.[26] Therefore, instituting regular simulation training in the resident curriculum, especially for early-stage trainees, should be considered to improve the learning curve and surgical time in clinical laparoscopic cases. A previous study[23] has shown that there is no correlation between the performance of basic (eg, non-suturing) laparoscopic tasks and laparoscopic suturing skills among surgical trainees, and therefore, simulation training should specifically involve suturing tasks in addition to basic laparoscopic tasks. It is likely that the more senior residents in the current study had more laparoscopic suturing experience compared to other years, as clinical opportunities to complete suturing during TLG are generally reserved for second- and third-year residents at the current institution.

Furthermore, having prior experience using the suturing instrument was associated with both the mental workload of using the instrument and the subjective scoring of the suture line. While only 2 residents had prior experience using the ESD, almost all (9 of 10) residents had prior experience using ENDs. Therefore, this may have confounded our results. Ideally, this study should be repeated with complete novices who have no experience using either instrument, evaluating the learning curve of each instrument over time. A prior study[27] in human medicine assessing a similar automated ESD in surgical residents showed a significant difference in the learning curve for the automated ESD compared to traditional suturing with END, with the automated ESD requiring fewer attempts to reach proficiency. Therefore, it is possible that with repeated attempts using both the ESD and END instruments in novice surgeons with no prior experience with either instrument, ESD may be associated with a reduced learning curve. The aforementioned study did not use barbed knotless suture and therefore included intracorporeal knot tying.[27] Therefore, it is possible that the benefit of ESD may not translate when barbed suture is used, negating intracorporeal knot tying.

Previous studies[25,26,28,29] have shown that preoperative warm-up and training with simulators or video games can improve laparoscopic surgical performance among novices. While not specifically evaluated, preoperative warm-up may also translate to improved mental workload and time to perform laparoscopic suturing. Specifically, ESD and END require different mechanisms for needle transfer, which may contribute to diminished skill in the novice. While preoperative warm-up was not evaluated in the current study, it should be considered before clinical use of either instrument by novice surgeons.

The distance between suture bites was significantly different between the ESD and END instruments, with END having suture bites closer together (roughly 5 mm) compared to ESD (roughly 6 mm). Participants were instructed to take suture bites 3 to 5 mm apart from each other, indicating that END were more accurate for achieving this goal. In clinical cases, this may result in issues such as poor tissue apposition or herniation between large suture bites in the case of herniorrhaphy. Therefore, novices using ESD in these cases should be cautious and ensure accurate suture placement. However, while the difference of 1 mm between the 2 instruments was statistically significant, it is likely not clinically significant.

Interestingly, similar results regarding accuracy were appreciated when comparing an automated ESD with END in human medicine, with the ESD having significantly lower accuracy for suture bite placement compared to traditional END.[27] Furthermore, year 0 surgical residents demonstrated the lowest subjective score using ESD compared to all other training levels using either instrument, as well as compared to their own scores with END. This may be due to the larger tips of the ESD, which can obscure the view of the relatively small needle within the jaws of the instrument. Therefore, it may be harder to visualize and ensure proper placement of the needle compared to traditional END. Additionally, when using a laparoscopic simulator, the camera is in a fixed location and cannot be moved to facilitate better vision of the needle. It is possible that this issue may be reduced in clinical cases when using a 30° laparoscope that can be directed for improved visualization of the needle of the ESD.

Limitations of this study include a small sample size from a single academic institution and a lack of standardization of prior experience with each suturing instrument. These results may not be applicable to residents from other institutions that may have different exposure to laparoscopic procedures. Additionally, this study utilized an ex vivo model with a fixed camera that may differ from true clinical cases utilizing intracorporeal suturing; however, this study design was intentional to avoid the effect of patient differences such as anatomy or size on results.

In conclusion, mental workload and time to complete suturing did not differ between END and ESD among surgical residents. Early-stage trainees took the longest to perform the suturing task, regardless of the suturing instrument. Prior experience and practice using either suturing instrument resulted in improved mental workload and quality of suturing. Therefore, either instrument can be effectively used by surgical residents completing intracorporeal suturing, and regular practice using simulators or preoperative warm-up should be considered to improve workload and the learning curve associated with either instrument. Future studies evaluating the learning curve of each instrument with knotless barbed suture are warranted.

Acknowledgments

None reported.

Disclosures

All sutures used in this study were donated by Medtronic.

No AI-assisted technologies were used in the composition of this manuscript.

Publisher's Note

Funding

The authors have nothing to disclose.

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Supplementary Materials

Supplementary materials are posted online at the journal website: avmajournals.avma.org.

Supplementary Material S1

Investigator Scoring Sheet

Investigator name: ______________________

Participant Number: ______

Trial Number: ______

Suture Tightening (circle one)

Evaluate the tightness of the suture line – suture should be pulled tight with each suture bite and flush with silicone.

0 = entire suture line loose

1 = suture loose in >2 locations

2 = suture loose in 1 location only

3 = no looseness of suture

Welded Loop (circle one)

Evaluate whether suture was successfully passed through welded loop and tightened.

0 = suture needle not passed through suture loop

1 = suture needle passed through suture loop but not pulled tight

2 = suture needle passed through suture loop and pulled tight

Suture Entanglement (circle one)

Evaluate for evidence of looping of simple continuous suture line through a previous bite after the welded loop.

0 = every bite is entangled through prior bite

1 = bites entangled in >2 locations

2 = bite entangled in 1 location only

3 = no entangling of suture bites

Tissue Trauma (circle one)

Evaluate for any trauma/tearing of the silicone mat in regions where suturing was performed.

0 = 3 or more regions of silicone tearing

1 = 2 regions of silicone tearing

2 = 1 region of silicone tearing

3 = no silicone tearing

TOTAL SCORE: __________