

# Comparison of incisional bursting strength of a bidirectional absorbable knotless suture material versus a standard continuous absorbable suture material for closure of the equine linea alba

Nicholas A. Bellitto DVM (Hons), MRCVS<sup>1</sup>  | Francina Barceló Oliver DVM, MRCVS<sup>2</sup> | Patrick J. Pollock BVMS, PhD, CertES (Soft Tissue), FHEA, DipECVS, FRCVS<sup>1</sup>

<sup>1</sup>Glasgow Equine Hospital & Practice, School of Biodiversity, One Health and Veterinary Medicine, University of Glasgow, Glasgow, UK

<sup>2</sup>Department of Equine Surgery, Private Practice, Mallorca, Spain

## Correspondence

Nicholas A. Bellitto, Glasgow Equine Hospital & Practice, School of Biodiversity, One Health and Veterinary Medicine, University of Glasgow, Glasgow, UK.

Email: [nicholas.alberto.bellitto@gmail.com](mailto:nicholas.alberto.bellitto@gmail.com)

## Funding information

Petplan Charitable Trust, Grant/Award Number: 237-275

## Abstract

**Objective:** To evaluate the use of bidirectional knotless barbed suture material for closure of the equine linea alba.

**Study design:** Laboratory study.

**Animal or sample population:** Adult light horse cadavers ( $n = 24$ ).

**Methods:** A 25 cm incision was made through the linea alba, and a 200 L polyurethane bladder was positioned within the abdomen. The linea alba was closed either using USP2/EP5 bidirectional polydioxanone barbed suture or USP2/EP5 standard polydioxanone suture in a simple continuous pattern. Closure time was recorded for each suture type. The bladder was air-insufflated at 40 L/min, and the pressure at body wall failure recorded. The length of suture used for wound closure and wound failure modes were recorded. Suture length, closure time, bursting pressure, and failure modes were compared using Welch-Aspin *t*-tests.

**Results:** The incisional bursting pressure was comparable between the two groups ( $p > .05$ ). Less suture material ( $p < .01$ ) was required with the barbed suture than the standard suture. Closure time was less for the barbed suture than the standard suture ( $p < .01$ ). Suture failure was the main failure mode in both groups (83% cases).

**Conclusions:** Closure of the equine linea alba using bidirectional barbed suture material reduced the amount of foreign material in the wound and decreased closure time without compromising incisional strength.

**Clinical relevance:** Bidirectional barbed suture material could be considered as an alternative to standard suture materials for closure of the equine line alba.

## 1 | INTRODUCTION

Knotless barbed sutures are a relatively new type of suture widely used in human surgery.<sup>1</sup> Barbed sutures

are specifically designed monofilament sutures that can be either unidirectional or bidirectional, and have dual angle barbs orientated in the opposite direction to the needle that allows the suture to embed in the tissue thus

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2023 The Authors. *Veterinary Surgery* published by Wiley Periodicals LLC on behalf of American College of Veterinary Surgeons.

resisting pull-out and eliminating the need to tie a knot.<sup>2</sup> The main reported advantages of using barbed sutures include the mitigation of some well recognized knot-associated complications,<sup>1,3</sup> reduction in wound closure time<sup>1,4-6</sup> and reduction of overall costs.<sup>4,5</sup>

Following experimental studies,<sup>7-11</sup> knotless barbed sutures have found numerous applications in equine clinical cases and are currently used for incisional closure of inguinal castrations,<sup>12</sup> laparoscopic closure of the nephrosplenic space,<sup>9,13</sup> laparoscopic closure of the internal inguinal rings,<sup>14</sup> laparoscopic uteropexy<sup>15</sup> and for thoracoscopic repair of diaphragmatic hernias.<sup>16</sup> Barbed sutures have been assessed for closure of the linea alba using animal models and have recently been used for closure of laparotomy incisions in human surgery.<sup>17-20</sup>

In human surgery, closure of laparotomy incisions using barbed sutures has been reported to reduce evisceration incidence and have similar wound-related complications as conventional sutures.<sup>20</sup> In horses, incisional complications following ventral midline laparotomy are frequently reported and may lead to prolonged hospitalization, increased financial burdens and in some cases increased mortality.<sup>21-24</sup> Complications in horses include local incisional swelling (74%) surgical site infections (7.4%–43%), incisional herniation (5.7%–18%) and dehiscence (1%–3%).<sup>21,22,25</sup>

The use of different suture materials, suture sizes and suture patterns for closure of the equine abdomen have been extensively studied using both *ex vivo* models and clinical trials in an attempt to reduce postoperative incisional complications.<sup>26-36</sup> The aim of the study described here was to determine whether a bidirectional barbed suture material could be used for closure of the equine linea alba. An *ex vivo* model described by Magee and Galuppo,<sup>29</sup> and validated by others,<sup>27,32-34,37,38</sup> was used to determine bursting strengths and mode of failure of the equine linea alba.<sup>29</sup> It was hypothesized that a bidirectional polydioxanone barbed USP2/EP5 suture material could reduce surgical time, reduce the amount of suture left in the incision and have a higher bursting strength compared to closure using a standard polydioxanone USP2/EP5 suture in a simple continuous pattern.

## 2 | MATERIALS AND METHODS

### 2.1 | Horses

A total of 24 mature horses, weighing over 350 kg, that were euthanized for reasons unrelated to the study were randomly assigned to either a barbed suture or a standard suture group. Experimental work was carried out on animals within 2 h of euthanasia in common with

previous studies investigating suture efficacy. Information regarding breed, sex, age, and use was recorded for each cadaver.

The inclusion criteria for cadavers were as follows: No previous history of abdominal surgery or obvious abdominal wall abnormalities. Post-experimental histopathological examination of cadaver material was also performed to exclude any cases with underlying pathology which could have affected the results.

Ethical approval was sought and obtained from the School of Veterinary Medicine ethics and welfare committee. Owners were provided with an information sheet, following which they were asked to sign a consent form allowing the cadavers of their horses to be used for the study.

### 2.2 | Surgical procedure and instrumentation

Following euthanasia, cadaver horses were placed in dorsal recumbency, and a 4 cm-wide nylon strap was placed around the abdomen just cranial to the pelvis to prevent failure and herniation through the inguinal fascia and/or rectum during abdominal inflation, as previously reported by Magee and Galuppo.<sup>29</sup>

A 40 cm ventral midline skin incision was made over the linea alba that was identified by palpation, and the subcutaneous tissue was then dissected to allow observation of the suture/linea alba construct during testing. A plastic template and tissue pen were used to standardize the length of the linea alba incision and position and to standardize suture placement. The fascia of the abdomen was marked for 25 cm using the pen beginning at the umbilicus and extending cranially. Using a No. 10 scalpel blade, the linea alba was incised starting at the umbilicus. Any deviation from the linea alba, which resulted in exposed muscle fibers, was recorded. The peritoneum was entered bluntly using the index finger, and the defect was enlarged.

Incisional testing was performed using an experimental model described by Magee and Galuppo.<sup>29</sup> A custom 0.9 × 1.2 m rectangular, 200 L capacity polyurethane bladder (New World Mfg, Cloverdale, California) was positioned flat in the abdomen along the ventral body wall.<sup>29</sup> One-centimeter incisions were made between the 14th and 15th rib, in the middle one-third of the left and right intercostal space, to provide access for the ingress and egress tubing (0.8 cm outer diameter).<sup>29</sup> The ingress tubing was exteriorized through a right lateral stab incision while the egress tubing was exteriorized through a left lateral stab incision.<sup>29</sup> The ingress tubing was connected to an air compressor (MaxxAir Premium Compressor, Heyner, Brandenburg, Germany) and a flow meter (MMA-26 flow meter; Dwyer

Instruments, Michigan City, Indiana) for bladder insufflation.<sup>29</sup> The egress tubing was connected to a transducer (PX 212 series pressure transducer; Omega Engineering, Stamford, Connecticut) and digital display (DP 25B-S strain gauge meter; Omega Engineering) for pressure recording.<sup>29</sup> All incisions were closed using a simple continuous pattern with tissue bites standardized at 15 mm from the edge of the incision and 15 mm apart by using the previously placed marks.

Cadavers were randomly assigned by selecting a number one or two from a bag for closure of the line alba to two different groups:

1. Barbed suture: Closure of the incision using one pack of polydioxanone USP2/EP5 bidirectional knotless barbed suture on a swaged 1/2 curve 48 mm taper needle with a 90 cm working length (Quill; Quill PDO; Surgical Specialties Corporation, Wyomissing, Pennsylvania). Closure of the linea alba was started at the center of the incision. The suture line was ended outside the incision (10 mm cranial or caudal) before being reversed by taking two retrograde passes for 2 cm to lock the suture in position as described by the manufacturer.<sup>3</sup>
2. Standard suture: Closure of the incision using one pack of polydioxanone USP2/EP5 on a swaged 1/2 curve 48 mm taper needle with a 150 cm working length (PDS, Ethicon, Johnson and Johnson, Markham, Ontario, Canada). Closure of the linea alba using the standard suture was started at the caudal aspect of the incision in one section with a knot at each end. The cranial and caudal knots were placed outside the incision (10 mm cranial or caudal) and tied with a surgeon's knot followed by four square throws (six throws total), leaving the suture ends 10 mm long. The knots were tied using Mayo-Hegar needle holders.

Celiotomies were created by an ECVS diploma holder and closed by a surgery resident under supervision of the ECVS diploma holder. The skin and subcutis were left unopposed to allow observation of the suture and linea alba construction during insufflation of the polyurethane bladder. Closure time for each incision was recorded using a stopwatch. The length of the suture material used for incisional closure was recorded, in centimeters, by measuring the suture that was left after closure and comparing this with the original suture length.

### 2.3 | Testing

After closure of the incision, the polyurethane bladder was inflated at 40 L/min, and the bursting pressure

(mmHg) of the abdomen was recorded. Each failure was recorded using a digital video recorder (iPhone 7, Apple, California), allowing failure method, time to failure and any other complications to be recorded. Digital images of all failed incisions were taken using a digital camera (iPhone 7, Apple, California). For each incision, the mode of failure (suture or fascia) was recorded after evaluation of slow-motion video with direct visualization of the incision site.

Failure mode (suture or abdominal wall) was determined for each incision. Suture failure for the standard suture was defined as suture breakage in close proximity to the knot, knot slippage, knot breakage, or breakage more than 1 cm away from the knot before abdominal wall failure. Suture failure for the barbed suture was defined as the breakage of the suture at any point. Failure of the abdominal wall was defined as a "local failure," when intact suture tore through the linea alba, or as "remote failure," when the body wall failed adjacent to the incision. Type of failure modes were expressed as percentages for each suture type. Failure of the abdominal wall was defined as a "local failure," when intact suture tore through the linea alba, or as "remote failure," when the body wall failed adjacent to the incision. Type of failure modes were expressed as percentages for each suture type.

### 2.4 | Statistical analysis

Welch–Aspin *t*-tests were used to compare centimeter deviation from the linea, closure time, amount of suture used for closure of the incision, bursting pressure, and failure mode between the barbed and standard suture material.

## 3 | RESULTS

A total of 24 equine cadavers were used, and breeds included Thoroughbreds, Warmbloods, Native breed ponies and crossbreeds. Ages ranged from 4 to 17 years. All horses weighed over 350 kg (range 364–598 kg). Histopathological examination of tissue adjacent to the incision sites did not identify any pre-existing abnormalities that could have influenced the results in any of the cadavers.

Mean bursting pressure for the barbed suture (353 mmHg; range 315–390; SD  $\pm$  37) and the standard suture (305 mmHg; range 290–320, SD  $\pm$  15) were comparable ( $p > .05$ ), (Table 1). The mean length of suture material used for closure of the linea alba was less ( $p < .01$ ) for the barbed suture (78 cm; range: 74–82; SD  $\pm$  4) than for standard suture (89 cm; range: 86–91; SD  $\pm$  3) (Table 1). No deviation from the linea alba was recorded during the creation of the incisions in either group. Mean closure

**TABLE 1** Mean  $\pm$  SD for measured variables for closure of the equine linea alba using the barbed suture and standard suture material.

	Barbed suture	Standard suture
Mean bursting pressure (mmHg)	353 $\pm$ 37	305 $\pm$ 15
Mean length of suture left in wound (cm)	78 $\pm$ 4*	89 $\pm$ 3*
Mean closure time (minutes)	4.3 $\pm$ 0.9*	5.7 $\pm$ 0.4*
Main failure mode	Suture failure	Suture failure

Note: For a given variable, values with an \* are significantly ( $p < .01$ ) different from one another.

**TABLE 2** Failure mode for closure of the equine linea alba using the barbed suture and standard suture material.

	Barbed suture	Standard suture
Suture failure		
Suture breakage	10	0
Breakage adjacent to the knot	n/a	10
Knot breakage	n/a	0
Knot slippage	n/a	0
Total	10 (83%)	10 (83%)
Fascial failure		
Local failure	0	1
Remote failure	2	1
Total	2 (17%)	2 (17%)

times were less ( $p < .01$ ) for the barbed suture (4.3 min; range: 3.5–5.2; SD  $\pm$  0.9) than for the standard suture (5.7 min; range: 5.3–6.0; SD  $\pm$  0.9) (Table 1).

Suture failure was the main failure mode for both the barbed and standard sutures (83% of cases), occurring in close proximity to all the knots for the standard suture group and at various locations along the suture for the barbed suture group (Table 2). Suture failure of the barbed suture resulted only in a partial breakage of the incision with most of the residual portion of the suture line remaining unaltered (both edges closed) in all cases; suture failure of the standard suture resulted in a complete breakdown of the suture line in all cases. The remaining two cases of the barbed suture group failed laterally from the linea alba (remote failure; 17%) while one case of the standard suture group failed immediately adjacent to the line alba (local failure; 8.5%) and the other case failed laterally from the linea

alba (remote failure; 8.5%) (Table 2). There were no effects of age, breed, or sex.

## 4 | DISCUSSION

The use of a bidirectional barbed suture material represents a novel and attractive approach to the closure of the equine linea alba. Despite the self-locking system, bidirectional barbed sutures were found to be easy to use.<sup>1,3</sup> It was determined that the bidirectional barbed knotless suture did not have a higher bursting strength than the standard suture with similar mean bursting strengths values being recorded in both groups. Closure of the equine line alba using the barbed suture took less time and resulted in less suture material within the wound than the standard suture.

The suture size selected was USP2, currently the largest commercially available size for barbed sutures. Many ex vivo studies have suggested that larger sutures would be preferable for the closure of the equine linea alba.<sup>27,36</sup> Despite this, USP2/EP5 suture materials, including polydioxanone, are commonly used in clinical practice following colic surgery with no reported increase in incisional complications.<sup>22,28,30,31,35,39</sup> In this study, bursting strengths and mode of failure following closure of the equine linea alba were assessed using an ex vivo model and determined based on a single cycle to failure as previously described.<sup>27,29,32–34,37,38</sup>

Acute abdominal dehiscence following ventral mid-line celiotomy in horses has been reported to occur at the body wall, along the suture line or at the knot with suture breakage or knot slippage.<sup>24,40</sup> In this study, suture failure was the principle mode of failure (83% of cases), occurring in close proximity to all the knots for the standard suture and at various locations along the suture line for the barbed suture. The results for the standard suture are comparable with the failure mode described in other studies.<sup>27</sup> Anderson et al.<sup>27</sup> reported that the main mode of failure when using USP2/EP5 polyglactin 910 in a simple continuous pattern was at the suture line at the level of the knot (80% of cases). While studies using larger polydioxanone suture material (USP7/EP9) in a simple continuous pattern have reported that abdominal wall failure was the only mode of failure.<sup>26,27,37</sup> The findings reported in this study suggest that modifying the structure of a monofilament suture thread such as in the barbed suture material does not affect the mechanical response of the suture.<sup>17,18</sup>

The characteristics of the barbed suture and its specific mode of failure may play a crucial role in preventing acute abdominal dehiscence in live horses. In this study, suture failure of the barbed suture resulted only in a

partial breakage of the incision, the length was not recorded, while most of the residual linea alba remained closed. Previous studies have suggested that in cases where the barbed suture should fail or the tissue tear at one point of the incision the rest of the incision could remain closed preventing dehiscence due the suture failing only as far as the nearest barb.<sup>20</sup> This is supported by a recent clinical trial which found that barbed sutures, when used for abdominal fascial closure, reduced the incidence of acute abdominal dehiscence in people.<sup>20</sup> Only the adoption of the use of barbed sutures in clinical cases will determine how the specific mode of failure of barbed suture may affect the incidence of postoperative dehiscence.

In this study, it was noted that the mean value for the amount of suture left in the abdominal wall was less for the barbed suture compared to the standard suture. This finding is likely related to the absence of knots when using the barbed suture and has been reported by others.<sup>1,3,41</sup> One of the purported advantages of reducing the amount of suture material in the incision is that this should result in less inflammatory reaction and reduce the effect of the presence of the suture on infection risk.<sup>2,3</sup> However, studies using animal models and evaluating histological sections of the line alba following closure have not reported any significant reduction in tissue inflammation between a polydioxanone barbed suture material over a standard polydioxanone suture material.<sup>17,18</sup> A recent clinical trial on the closure of the abdominal wall in human surgery did not find any significant difference in the incidence of surgical site infection between cases in which a barbed suture or a standard suture was used.<sup>20</sup> Further studies are required to determine how barbed sutures have an impact on the healing of the equine linea alba.

During this study, only one pack of barbed suture was utilized for each cadaver horse; however, if a clinical case with a longer incision required a second length of suture, this could simply begin in the center of the open section of the wound extending in both directions as described. There is no reason to believe this would affect the strength of the closure.

As previously reported and in the study described, closure of the incision took less time using the barbed suture than the standard suture.<sup>1,4-6,41-43</sup> Multiple studies support the assumption that an extended duration of surgery and anesthesia are associated with higher surgical site infection rates.<sup>28,31,44</sup> In human arthroplasty the reduced wound closure time obtained when using barbed sutures has been reported to reduce overall costs by saving operative time.<sup>4,5</sup>

The ex vivo model used in our study has been utilized widely and has been reported to closely reproduce the three-dimensional forces placed on a ventral midline

incision following laparotomy in a horse.<sup>27,29</sup> Alternative ex vivo models, that place the suture and body wall construct in a universal material testing machine and then perform a single cycle to failure test, have also been used to test suture materials and closure techniques for the equine linea alba.<sup>36,45</sup> However, testing the bursting strength would seem to be a more appropriate method, allowing the forces to be more evenly distributed along the sutured linea alba and the abdominal body wall and therefore, more closely simulating the conditions that could be encountered postoperatively during recovery from general anesthesia or during an episode of violent colic that may result in acute abdominal dehiscence.<sup>24,27</sup>

The main limitation of this study was that the sudden increase in abdominal pressure used in this ex vivo model does not necessarily represent a good model for delayed suture failures that are more likely due to repeated cycling fatigue of the suture material and incision.<sup>27,32</sup> Furthermore, bursting strength values representative of the changes in intra-abdominal pressures that can occur in live horses during the postoperative period are unavailable.<sup>27</sup> Because of these limitations, studies using this ex vivo model should not be considered a complete replacement for studies involving clinical cases and should instead be considered auxiliary and informative for the development of clinical trials in the future.

In conclusion, closure of equine linea alba using a bidirectional knotless barbed suture material reduced the amount of foreign material in the incision and decreased closure time without compromising incisional strength. All these features could make the bidirectional barbed suture material an attractive alternative to conventional standard sutures. Due to the results of this study, it is anticipated that these findings will inform a study involving clinical cases which will allow further investigation into the use of barbed sutures for closure of the line alba in live horses.

#### AUTHOR CONTRIBUTIONS

Bellitto NA, DVM (Hons), MRCVS: The primary author made a substantial contribution to the interpretation of data of the work and manuscript preparation. Barceló Oliver F, DVM, MRCVS: Contributed to data collection, data analysis, and critical revision of the manuscript. Pollock PJ, BVMS, PhD, CertES (Soft Tissue), FHEA, DipECVS, FRCVS: Contributed to the study design and critical revision of the manuscript. All authors approved the final version of the manuscript.

#### ACKNOWLEDGMENTS


The authors gratefully acknowledge the help of the staff and students of the Glasgow Equine Hospital, University of Glasgow, in particular Lynsey Bett, Mary Gatherer and

Lenka Veselovska, and the owners who so kindly donated the cadavers used in this study. Finally, we acknowledge the generous funding of the PetPlan Charitable Trust.

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest related to this study.

## ORCID

Nicholas A. Bellitto  <https://orcid.org/0000-0003-4526-9831>

## REFERENCES

- Lin Y, Lai S, Huang J, Du L. The efficacy and safety of knotless barbed sutures in the surgical field: a systematic review and meta-analysis of randomized controlled trials. *Sci Rep*. 2016;6:1-8. doi:10.1038/srep23425
- Kümmerle JM, Fogle C. Suture materials and patterns. *Equine Surg*. 5th ed. Elsevier; 2019:255-280.
- Paul MD. Bidirectional barbed sutures for wound closure: evolution and applications. *J Am Col Certif Wound Spec*. 2009;1(2):51-57. doi:10.1016/j.jcws.2009.01.002
- Zhang W, Xue D, Yin H, et al. Barbed versus traditional sutures for wound closure in knee arthroplasty: a systematic review and meta-analysis. *Sci Rep*. 2015;6:19764. doi:10.1038/srep19764
- Chan VWK, Chan PK, Chiu KY, Yan CH, Ng FY. Does barbed suture lower cost and improve outcome in Total knee arthroplasty? A randomized controlled trial. *J Arthroplasty*. 2017;32(5):1474-1477. doi:10.1016/J.ARTH.2016.12.015
- Lee S, Kee T, Jung MY, Yoon PW. A comparison of barbed continuous suture versus conventional interrupted suture for fascial closure in total hip arthroplasty. *Sci Rep*. 2022;12(1):1-7. doi:10.1038/s41598-022-07862-5
- Ruzickova P, Burns P, Piat P, Frasch MG, Beauchamp G, Elce YA. Ex vivo biomechanical comparison of 4 suture materials for laparoscopic bladder closure in the horse. *Vet Surg*. 2016;45(3):374-379. doi:10.1111/VSU.12455
- Major DS, Duff AH, Cohen ND, Hardy J. Ex vivo comparison of single-layer and double-layer laparoscopic closure of equine bladders with 2 types of barbed sutures. *Vet Surg*. 2017;46(8):1145-1153. doi:10.1111/vsu.12719
- Albanese V, Hanson RR, McMaster MA, Koehler JW, Caldwell FJ. Use of a barbed knotless suture for laparoscopic ablation of the Nephrosplenic space in 8 horses. *Vet Surg*. 2016;45(6):824-830. doi:10.1111/vsu.12520
- Nelson BB, Hassel DM. In vitro comparison of V-loc™ versus biosyn™ in a one-layer end-to-end anastomosis of equine jejunum. *Vet Surg*. 2014;43(1):80-84. doi:10.1111/j.1532-950X.2013.12081.x
- Sinovich M, Archer DC, Meunier NV, Kelly PG. Ex vivo comparison of barbed sutures for pelvic flexure enterotomy in horses. *Vet Surg*. 2020;49(3):487-495. doi:10.1111/vsu.13353
- Adler DMT, Østergaard S, Jørgensen E, Jacobsen S. Bidirectional knotless barbed versus conventional smooth suture for closure of surgical wounds in inguinal castration in horses. *BMC Vet Res*. 2020;16(1):1-8. doi:10.1186/s12917-020-02449-6
- Gandini M, Nannarone S, Giusto G, et al. Laparoscopic nephrosplenic space ablation with barbed suture in eight horses. *J Am Vet Med Assoc*. 2017;250(4):431-436. doi:10.2460/JAVMA.250.4.431
- Ragle CA, Yiannikouris S, Tibary AA, Fransson BA. Use of a barbed suture for laparoscopic closure of the internal inguinal rings in a horse. *J Am Vet Med Assoc*. 2013;242(2):249-253. doi:10.2460/javma.242.2.249
- Corsalini J, Gialletti R, Lotto E, Nannarone S. Laparoscopic uteropyxy (Mesometrium Imbrication) in three mares using a barbed suture. *J Equine Vet Sci*. 2016;40:102-105. doi:10.1016/j.jevs.2016.02.236
- Kamus L, Ruzickova P, Piat P, Trencart P, Bonilla A. Use of barbed suture for thoracoscopic repair of diaphragmatic hernias: three cases. *Equine Vet Educ*. 2022;35:e180-e185. doi:10.1111/eve.13643
- Simón-Allué R, Pérez-López P, Sotomayor S, et al. Short- and long-term biomechanical and morphological study of new suture types in abdominal wall closure. *J Mech Behav Biomed Mater*. 2014;37:1-11. doi:10.1016/j.jmbbm.2014.04.014
- Bellón JM, Pérez-López P, Simón-Allué R, et al. New suture materials for midline laparotomy closure: an experimental study. *BMC Surg*. 2014;14(1):70. doi:10.1186/1471-2482-14-70
- Kushner BS, Arefanian S, McAllister J, et al. Examination of abdominal wall perfusion using varying suture techniques for midline abdominal laparotomy closure. *Surg Endosc*. 2022;36(6):3843-3851. doi:10.1007/S00464-021-08701-W
- Ruiz-Tovar J, Llaverro C, Jimenez-Fuertes M, Duran M, Perez-Lopez M, Garcia-Marin A. Incisional surgical site infection after abdominal fascial closure with triclosan-coated barbed suture vs triclosan-coated polydioxanone loop suture vs polydioxanone loop suture in emergent abdominal surgery: a randomized clinical trial. *J Am Coll Surg*. 2020;230(5):766-774. doi:10.1016/J.JAMCOLLSURG.2020.02.031
- Kelmer G. What do we currently know about incisional complications of colic surgery? *Equine Vet Educ*. 2023;35:489-497. doi:10.1111/EVE.13763
- Shearer TR, Holcombe SJ, Valberg SJ. Incisional infections associated with ventral midline celiotomy in horses. *J Vet Emerg Crit Care*. 2020;30(2):136-148. doi:10.1111/VEC.12936
- Davis W, Fogle CA, Gerard MP, Levine JF, Blikslager AT. Return to use and performance following exploratory celiotomy for colic in horses: 195 cases (2003–2010). *Equine Vet J*. 2013;45(2):224-228. doi:10.1111/j.2042-3306.2012.00615.x
- Hann MJ, Mair TS, Gardner A, et al. Acute abdominal dehiscence following laparotomy: a multicentre, international retrospective study. *Equine Vet J*. 2022;54(4):719-725. doi:10.1111/evj.13498
- Freeman DE, Rötting AK, Inoue OJ. Abdominal closure and complications. *Clin Tech Equine Pract*. 2002;1(3):174-187. doi:10.1053/ctep.2002.35575
- Anderson SL, Bracamonte JL, Hendrick S. Ex vivo evaluation of 7 polydioxanone for closure of equine ventral midline celiotomies. *Can J Vet Res*. 2014;78(2):156-160.
- Anderson SL, Bracamonte JL, Hendrick S, Carmalt JL, Wilson DG. Ex vivo comparison of 7 polydioxanone, 2 polyglactin 910 for closure of ventral median celiotomy in horses. *Vet Surg*. 2013;42(4):463-467. doi:10.1111/J.1532-950X.2013.12002.X
- Anderson SL, Devick I, Bracamonte JL, et al. Occurrence of incisional complications after closure of equine celiotomies

- with USP 7 polydioxanone. *Vet Surg*. 2015;44(4):521-526. doi:[10.1111/J.1532-950X.2014.12275.X](https://doi.org/10.1111/J.1532-950X.2014.12275.X)
29. Magee AA, Galuppo LD, Acvs D. Comparison of incisional bursting strength of simple continuous and inverted cruciate suture patterns in the equine Linea Alba. *Vet Surg*. 1999;28:442-447. doi:[10.1111/j.1532-950X.1999.00442.x](https://doi.org/10.1111/j.1532-950X.1999.00442.x)
  30. Rinnovati R, Romagnoli N, Stancampiano L, Spadari A. Occurrence of incisional complications after closure of equine ventral midline celiotomies with 2 polyglycolic acid in simple interrupted suture pattern. *J Equine Vet Sci*. 2016;47:80-83. doi:[10.1016/j.jevs.2016.07.017](https://doi.org/10.1016/j.jevs.2016.07.017)
  31. Salciccia A, La Rebière D, De Pouyade G, Gougnaud A, et al. Complications associated with closure of the linea alba using a combination of interrupted vertical mattress and simple interrupted sutures in equine laparotomies. *Vet Rec*. 2020;187(11):94. doi:[10.1136/vr.105855](https://doi.org/10.1136/vr.105855)
  32. Souza CRS, Farnsworth KD, Ragle CA. Comparison of incisional bursting strength of 2-strand continuous crossing and simple continuous patterns for closure of the equine linea alba. *Can Vet J*. 2018;59(2):171-173.
  33. McGlinchey L, Hanson RR, Boone LH, et al. Bursting strength of surgeon's and self-locking knots for closure of ventral midline celiotomy in horses. *Vet Surg*. 2018;47(8):1080-1086. doi:[10.1111/VSU.12957](https://doi.org/10.1111/VSU.12957)
  34. Hassan KA, Galuppo LD, Van Hoogmoed LM. An In vitro comparison of two suture intervals using braided absorbable loop suture in the equine Linea Alba. *Vet Surg*. 2006;35(3):310-314. doi:[10.1111/J.1532-950X.2006.00149.X](https://doi.org/10.1111/J.1532-950X.2006.00149.X)
  35. Verkade ME, Ugahary F, Martens A, Wiemer P. Clinical and ultrasonographic evaluation of three suture techniques for closure of the equine linea alba. *Equine Vet Educ*. 2020;32(12):646-653. doi:[10.1111/eve.13109](https://doi.org/10.1111/eve.13109)
  36. Fierheller EE, Wilson DG. An In vitro biomechanical comparison of the breaking strength and stiffness of polydioxanone (sizes 2, 7) and polyglactin 910 (sizes 3, 6) in the equine Linea Alba. *Vet Surg*. 2005;34(1):18-23. doi:[10.1111/J.1532-950X.2005.00004.X](https://doi.org/10.1111/J.1532-950X.2005.00004.X)
  37. Anderson SL, Bracamonte JL, Hendrick S, Carmalt JL, Wilson DG. Ex vivo comparison of bursting strength of ventral median and right ventral paramedian celiotomies in horses. *Vet Surg*. 2013;42(4):468-472. doi:[10.1111/J.1532-950X.2013.12003.X](https://doi.org/10.1111/J.1532-950X.2013.12003.X)
  38. Weatherall KM, Boone LH, Munsterman A, Hanson RR. Ex vivo comparison of the bursting strength of an equine ventral midline celiotomy covered by two standard abdominal bandages. *Vet Surg*. 2021;50(3):615-621. doi:[10.1111/VSU.13572](https://doi.org/10.1111/VSU.13572)
  39. Colbath AC, Patipa L, Berghaus RD, Parks AH. The influence of suture pattern on the incidence of incisional drainage following exploratory laparotomy. *Equine Vet J*. 2014;46(2):156-160. doi:[10.1111/evj.12091](https://doi.org/10.1111/evj.12091)
  40. Southwood LL. Complications of the postoperative colic patient. *Complications in Equine Surgery*. Wiley-Blackwell; 2021:310-373.
  41. Durand CL. Comparison of knotless barbed suture versus monofilament suture in the oral cavity of cats. *J Vet Dent*. 2017;34(3):148-154. doi:[10.1177/0898756417715869](https://doi.org/10.1177/0898756417715869)
  42. Ting NT, Moric MM, Della Valle CJ, Levine BR. Use of knotless suture for closure of Total hip and knee arthroplasties. A prospective, randomized clinical trial. *J Arthroplasty*. 2012;27(10):1783-1788. doi:[10.1016/j.arth.2012.05.022](https://doi.org/10.1016/j.arth.2012.05.022)
  43. Duffy DJ, Duddy HR, Keating S, Gutierrez-Nibeyro SD. Influence of barbed suture on leak pressures after double-layer inverting closure of cystotomy sites in sheep. *Vet Surg*. 2018;47(7):902-907. doi:[10.1111/VSU.12935](https://doi.org/10.1111/VSU.12935)
  44. Freeman KD, Southwood LL, Lane J, Lindborg S, Aceto HW. Post operative infection, pyrexia and perioperative antimicrobial drug use in surgical colic patients. *Equine Vet J*. 2012;44(4):476-481. doi:[10.1111/j.2042-3306.2011.00515.x](https://doi.org/10.1111/j.2042-3306.2011.00515.x)
  45. Weatherall KM, Boone LH, Caldwell FJ, et al. Tensile strength and early healing of self-locking and surgeon's knots. *Vet Surg*. 2020;49(8):1580-1589. doi:[10.1111/VSU.13497](https://doi.org/10.1111/VSU.13497)

**How to cite this article:** Bellitto NA, Oliver FB, Pollock PJ. Comparison of incisional bursting strength of a bidirectional absorbable knotless suture material versus a standard continuous absorbable suture material for closure of the equine linea alba. *Veterinary Surgery*. 2023;52(8):1121-1127. doi:[10.1111/vsu.14022](https://doi.org/10.1111/vsu.14022)