

# Influence of length of incision and number of suture lines on the biomechanical properties of incisional gastropexy

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## Abstract

**Objective:** To determine the effect of the length of incision and of the number of suture lines on the load to failure of incisional gastropexy in an ex vivo model.

**Study design:** Ex vivo study.

**Sample population:** Thirty-six hound-mix fresh canine cadavers.

**Methods:** Specimens were randomly divided into four groups of incisional gastropexies varying in length of incision (2 or 4 cm) and number of suture lines (one or two). Load to failure was measured. Number of suture bites on each side of the gastropexy and number of inadvertent full thickness gastric suture bites were recorded.

**Results:** Incisional gastropexies performed with one or two suture lines sustained loads to failure of  $53.80 \pm 12.10$  N and  $53.30 \pm 10.60$  N ( $P = .887$ ), respectively. Loads to failure equal to  $49.70 \pm 10.80$  N and  $57.30 \pm 10.60$  N ( $P = .048$ ) were measured on incisional gastropexies performed with 2- or 4-cm-suture lines, respectively. There was no interaction between the length of the incision and the number of suture lines ( $P = .634$ ).

**Conclusion:** Length of incision but not number of suture lines influenced the biomechanical properties of gastropexies in this acute cadaveric model.

**Clinical significance:** According to this acute in vitro experiment, gastropexy can be performed with either one or two suture lines.

## 1 | INTRODUCTION

Gastropexy has been used to prevent recurrence of gastric dilatation and volvulus (GDV) and has been prophylactically recommended in predisposed breeds to prevent the development of a gastric volvulus.<sup>1,2</sup> Prophylactic incisional gastropexy is now commonly used laparoscopically and since unidirectional barbed sutures have become available, the trend is to perform intracorporeal suturing to perform the gastropexy.<sup>3-6</sup>

Incisional gastropexy traditionally requires the creation of two seromuscular flaps in the pyloric antrum and an incision in the transverse abdominis muscle caudal to the last rib

on the right side. Two simple continuous suture lines are performed between the seromuscular flaps and the transverse abdominis muscle.

Gastropexies performed with a single suture line have been reported in two studies.<sup>4,7</sup> However, the procedures in both studies were not true incisional gastropexies; in neither study was a transverse abdominis incision performed and in one study, the gastropexy was performed with an interrupted rather than a continuous pattern.

The length of an incisional gastropexy with or without laparoscopy is typically reported as between 3 and 5 cm.<sup>3,5,6,8-12</sup> However the optimal length of an incisional gastropexy has not been determined.

Shortening the length of the gastropexy incision or minimizing the number of suture lines would simplify the

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procedure, especially in cases of intracorporeal suturing. No study evaluating the effect of the number of suture lines and the length of the incision on the load to failure of an incisional gastropexy has yet been published.

The objective of this study was to determine the effect of the number of suture lines and of the length of the incision on the load to failure of an incisional gastropexy in an *ex vivo* model. We hypothesized that the number of suture lines and the length of the suture lines would affect the load to failure of incisional gastropexies performed in a canine cadaver model.

## 2 | MATERIALS AND METHODS

Stomachs and abdominal walls were collected from dogs that had been euthanatized for reasons unrelated to this study. These dogs were purpose-bred dogs that were euthanatized as part of an unrelated skills laboratory (IACUC No. 17-7102A). The samples were tested within 12 hours of euthanasia. Between tissue harvesting and testing, the tissue samples were refrigerated at 2 °C. Tissue samples were randomly assigned to one of four incisional gastropexy groups: 2-cm-incision and two-suture-line (2LL) group, 4-cm-incision and two-suture-line (4LL) group, 2-cm-incision and one-suture-line (2 L) group, and 4-cm-incision and one-suture-line (4 L) group.

Stomach and body walls were harvested and incisional gastropexy was performed by the same individual (R.J.W). Incisions through the seromuscular layer of the pyloric antrum and the transversus abdominis muscle were performed with a scalpel blade, the length of which was determined by group allocation. Incision lengths were measured to ensure that they adhered to sample grouping. The edges of the incisions were closed either in two simple continuous lines or by using one simple continuous line with 2–0 polyglyconate (Maxon; Medtronic, Minneapolis, Minnesota) suture with a taper point needle (GS 22; Medtronic). In the group closed with one suture line, bites were taken from each side of the incision in the stomach and transversus abdominis muscle on each pass. Bites were placed 3 to 4 mm apart for each sample. The number of bites for each suture line was recorded.

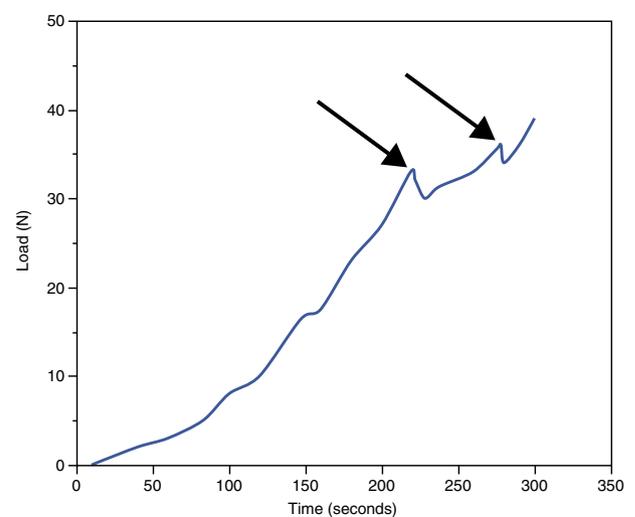
### 2.1 | Mechanical testing

Load to failure of the gastropexy constructs was measured with a distraction device as previously described.<sup>9,11</sup> Before each distraction, the system was zeroed, and the construct was mounted within the distraction system. The construct was placed under mild tension without loading the sample, which was monitored on the load waveform. Gastropexies were distracted at 0.4 mm/second until failure, which was

defined as either tearing of the tissue or breakage of the suture. Gastropexies were distracted until the initial point of failure had propagated to the majority of the gastropexy. The distraction load was recorded and converted to a waveform by using a standard data acquisition system (DATAQ Instruments, Akron, Ohio). Load to failure was recorded in Newtons at the time of first tearing of the tissue or breakage of the suture (Figure 1). Gastropexies were observed during distraction for failure or slippage of the construct. If slippage occurred, the sample was discarded, the data were removed from the study, and the sample was replaced by another construct. The stiffness of the constructs was determined by calculating the slope of the load-to-failure curve in the linear portion of the recording before the first tearing. A linear regression was made to determine the slope. After distraction, gastropexies were evaluated for the presence of sutures in the lumen of the stomach.

### 2.2 | Data analysis

The load to failure was normally distributed according to a Shapiro–Wilk test. Two-way analysis of variance (ANOVA) was used to evaluate the effect of the length of the incisions and the number of suture lines and their interaction on the load to failure of the incisional gastropexy. The total length of the gastropexy was determined by multiplying the length of the gastropexy by the number of suture lines. The correlation between this and the load to failure was evaluated with ANOVA. Correlation between the number of suture bites of the gastropexy and the load to failure was evaluated with ANOVA. Two-way ANOVA was used to evaluate the effect



**FIGURE 1** Load deformation curve illustrating initial load to failure of a gastropexy performed as 2 cm in length with one suture line. The leftmost arrow indicates initial load to failure (not catastrophic) and the rightmost arrow indicates a subsequent failure point (also before catastrophic failure)

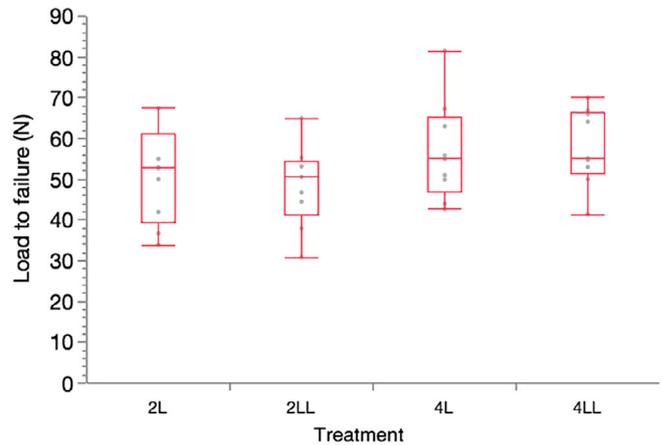
of the length of the incisions, the number of suture lines, and their interaction on the slope of the load distraction curve of the incisional gastropexy. One-way ANOVA was used to evaluate the effect of the number of knots (two vs four) on the load to failure of the gastropexy. The gastropexies completed with two knots or anchor points were the same as the gastropexies completed with one suture line because one knot was placed at each end of the suture line. The gastropexies completed with four knots or anchor points were the same as the gastropexies completed with two suture lines. Data are reported as mean  $\pm$  SD and  $P < .05$  was considered significant.

### 3 | RESULTS

Thirty-six samples were entered in the study, with nine in each group. Samples were collected at six different time points. The number of samples processed per time point varied (from four to nine). During testing, one sample slipped from the distraction device. This sample was removed from the study and replaced by a new construct. All gastropexies failed by tissue failure through the seromuscular layers of the stomach. This occurred initially at one knot or anchor point of the suture line and then progressed along the length of the suture line.

The mean load to failure for the 2-cm and 4-cm one-suture-line groups was  $50.90 \pm 11.90$  N and  $56.70 \pm 12.30$  N, respectively. The mean load to failure for the 2-cm and 4-cm two-suture-line groups was  $48.6 \pm 10.0$  N and  $57.9 \pm 9.40$  N, respectively. The load to failure was  $49.70 \pm 10.80$  N for the gastropexies performed with a 2-cm-long suture line and  $57.30 \pm 10.60$  N for the gastropexies performed with a 4-cm-long suture line ( $P = .048$ ). The load to failure was  $53.80 \pm 12.10$  N for the gastropexies performed with one suture line (equivalent to two knots) and  $53.30 \pm 10.60$  N for the gastropexies performed with two suture lines (equivalent to four knots;  $P = .887$ ; power = 0.88). There was no interaction between the length of the incision and the number of suture lines ( $P = .634$ ; power = 0.667; Figure 2). When the load to failure was evaluated in correlation with the total length of the gastropexy (length of gastropexy  $\times$  number of suture lines to give 2-, 4-, and 8-cm total lengths), the load to failure of the gastropexy did not correlate with the total length of the gastropexy ( $r^2 = 0.05$ ;  $P = .163$ ).

The number of suture bites was  $7.10 \pm 0.60$  for the 2 L group and  $6.90 \pm 0.30$  for the 2LL group ( $P = .346$ ). The number of suture bites was  $10.60 \pm 0.70$  for the 4 L group and  $10.20 \pm 0.40$  for the 4LL group ( $P = .256$ ). A single gastric intraluminal suture bite was found in the 2LL group and in the 4 L group. The load to failure of the gastropexies did not correlate with the number of suture bites used for the gastropexy ( $r^2 = 0.05$ ;  $P = .220$ ). The slope of the linear portion of the load deformation curve was



**FIGURE 2** Box and whisker plot of load to failure of the incisional gastropexies for the four groups tested. The central bar within the box represents the median with the ends of the box representing the lower and upper quartiles. The whiskers on either end represent the range of the data

$0.362 \pm 0.033$  N/second for the gastropexies performed with a 2-cm-long suture line and  $0.365 \pm 0.032$  N/second for the gastropexies performed with a 4-cm-long suture line ( $P = .937$ ). The slope was  $0.359 \pm 0.033$  N/second for the gastropexies closed with one suture line (equivalent to two knots) and  $0.369 \pm 0.032$  N/second for the gastropexies closed with two suture lines (equivalent to four knots,  $P = .816$ ).

### 4 | DISCUSSION

The load to failure of an incisional gastropexy was affected by the length of the suture line in this canine cadaveric model. The load to failure of an incisional gastropexy was not affected by the number of suture lines or the interaction between the number of suture lines and the length of the suture lines in these canine cadavers. For all the constructs, the suture pulled out of the seromuscular flaps of the stomach, and the failure originated at a knotted anchor point of the suture line and then propagated to the remainder of the gastropexy.

Load to failure for incisional gastropexies performed in either an open or a laparoscopic manner in the acute cadaveric model has been reported to range from 38.5 to 69 N, which is similar to our results.<sup>9,11</sup> In both reports, failure at the seromuscular flaps of the stomach was described, which is similar to our results.

The reported length of an incisional gastropexy is typically between 3 and 5 cm. A length of 4 cm was chosen in this study to represent an average of this length, and a length of 2 cm was chosen to represent a shortened gastropexy length. The length of the incision to create the gastropexy had an effect on the load to failure of an incisional gastropexy performed in the canine cadaver. Gastropexies performed with a

4-cm incision had a higher load to failure than gastropexies performed with a 2-cm incision. However, even though the 2-cm gastropexy was weaker than the 4-cm gastropexy, the 2-cm gastropexy was still quite strong, and the magnitude of this difference was barely significant in these data. The number of suture bites, which is related to the length of the suture lines, did not have an effect on the load to failure of the gastropexy. In addition to this, when the gastropexies were re-categorized according to total length of the gastropexy (2, 4, and 8 cm), the total length did not correlate with the load to failure. Although this is in contrast to the difference seen between the 2-cm and 4-cm groupings, it does provide evidence that the total length of the incision may have minimal effect on the load to failure. In addition to this, the clinical significance of load to failure of a gastropexy is unknown because the strength required for a safe gastropexy is not known.

The number of lines of suture did not affect the load to failure of incisional gastropexies performed in this cadaveric model. This may be evidence that closure of an incisional gastropexy with one suture line is sufficient. The use of only one suture line may increase the risk of failure in the short term because the entire gastropexy relies on one suture line while healing. If this suture fails, the entire gastropexy could unravel, while if two suture lines are present the second line is a potential reinforcement. However, it has been shown that one suture line could provide a safe chronic gastropexy in dogs.<sup>4,7</sup> Mathon et al<sup>7</sup> reported a load to failure of 51 N at 10 weeks after performing a gastropexy with a one-suture-line interrupted technique, the biomechanical strength of which is similar to our results. Takacs et al<sup>4</sup> reported intact single line laparoscopic gastropexy on ultrasound in 15 dogs at a median of 220 days postoperatively. However, in most (43/63) of these cases, the gastropexy site was not prepared with the traditional incision and instead was prepared with monopolar electrosurgery. Biomechanical testing was not performed in the Takacs et al<sup>4</sup> study because the study was performed with client-owned dogs. The mode of failure was very consistent between groups in this study. As described by Arbaugh et al,<sup>9</sup> the gastropexies failed at the level of the seromuscular flap, with the suture tearing through the flap. The constructs were mounted in a fashion that reproduces the anatomical situation in the canine abdomen; however, during distraction, the constructs would shift in position placing more tension on one specific anchor point. The failure started at one of the anchor points of the suture lines where a knot was located before it propagated through the rest of the gastropexy. Because of this mode of failure, the number of knots (and, hence, the number of suture lines) did not affect the load to failure of the gastropexy and the stiffness of the construct in this canine cadaver model.

To the best of our knowledge, stiffness of a gastropexy has not been previously documented. Stiffness was evaluated

to further document the effect of the number of knots or anchor points on the constructs. Unidirectional barbed suture is commonly used for laparoscopic gastropexies. Unidirectional barbed sutures were not used in our study because Arbaugh et al<sup>9</sup> had previously shown that the unidirectional sutures have an effect on the load to failure in an acute cadaveric model. In that study, gastropexies performed with unidirectional barbed sutures were reported to be stronger than gastropexies performed with smooth sutures.<sup>9</sup> It was postulated that unidirectional barbed suture increases the number of anchor points along the entire length of the gastropexy which, resulted to a higher load to failure in that study.

This study has several limitations. Because our study was performed with standard suture rather than knotless barbed suture, our results can support only the use of one suture line for gastropexy closure with standard suture. Additional research with knotless barbed suture is required to evaluate the effect of this suture. However, because previous work has shown that gastropexies performed with knotless barbed suture are stronger than those performed with standard suture, it may be that gastropexies with knotless barbed suture are equivocal if not increased in strength compared with this study.

Because our study was a cadaveric study, we could not evaluate the effect of healing on the biomechanical strength of the gastropexy. However, it is still a clinically valuable study because this cadaveric study represents the immediate postoperative period. Although it is unclear when and how gastropexies fail, the data reported in the literature seem to provide evidence that incisional gastropexies tested after several weeks of healing have a higher load to failure than those tested acutely.<sup>7,12</sup> Because the initial gastropexy strength appears weaker, we suggest that this may be when a gastropexy is most likely to fail. However, because the strength of a gastropexy required to prevent GDV is unknown, it is possible that all gastropexies in this study would be sufficient in a live animal. Load to failure at first tearing rather than catastrophic failure was recorded because it was difficult to define catastrophic failure as the tissue kept tearing along the suture in the seromuscular flaps of the stomach.

The biomechanical strength of incisional gastropexies performed with a 4-cm-long incision had a higher load to failure than incisional gastropexies performed with a 2-cm-long incision in this acute cadaveric model. Closure in one or two suture lines did not have an effect on the biomechanical strength.

## CONFLICT OF INTEREST

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

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