

Effect of Petroleum Gauze Packing on the Mechanical Properties of Suture Materials

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OBJECTIVE: To test the tensile properties of knotted suture made of 4 different suture materials and exposed to petroleum gauze.

STUDY DESIGN: We tested the tensile strength of United States Pharmacopeia size 0–0 gauge polydioxanone, polyglyconate, glycolide/lactide copolymer, and silk when exposed to petroleum packing or saline. Suture materials were randomized, and knots were tied and then evaluated via tensiometer to the point of knot failure.

RESULTS: A total of 285 knots were tied in 8 groups based on material and exposure to saline or petroleum gauze. We found that petroleum exposure knots failed at a mean of 116.7 N (SD = 31.5) and that saline soaked knots failed at 123.8 N (SD = 32.0). We conducted a 4 × 2 factorial analysis of variance, finding knots exposed to petroleum failed at a statistically significantly lower tensile strengths than saline soaked knots ($p = 0.002$).

CONCLUSION: Petroleum-exposed sutures fail at lower tensions than saline-exposed sutures. (*J Surg* 69:37–40. © 2012 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: suture techniques, tensile strength

COMPETENCIES: Patient care, Medical knowledge, Practice Based learning and Improvement

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INTRODUCTION

Sutures seldom remain dry when they are placed during surgery. Wetting the suture with blood, urine, or peritoneal fluid decreases the friction between strands holding the knot tight. In gynecology, sutures in the vaginal cavity are exposed to a persistently moist environment from secretions of vaginal glands, transudate from the vaginal epithelium, and blood postoperatively, thus diminishing the tensile strength of the knotted suture. Furthermore, sterile vaginal gauze coated with petroleum is routinely placed against vaginal sutures at the end of many pelvic surgeries while the patient is under anesthesia. Vaginal gauze packing provides direct pressure dressing on the vaginal cuff to minimize postoperative hemorrhage. This packing is removed the next day. This is a common practice in other surgical procedures, such as chest tube placement. Although the efficacy of vaginal packing has been previously investigated, little is known regarding the effect of petroleum packing on the tensile strength of sutures.

Sutures are commonly tied in the vagina during many procedures, including apical vault suspension, colporrhaphy, vagina hysterectomy, and midurethral sling. It is plausible that petroleum gauze packing in the vagina may cause knots to loosen and avoid packing the vagina at the end of a case. Suture has been tested dry or after being soaked in a multitude of fluids.¹ Tera and Auberg soaked their suture in subcutaneous rabbit tissue and found a significant decrease in knot holding power after 1 week in situ.² However, several in vitro studies have found no significant difference between knots tied with dry suture and knots tied in serum-coated suture.^{3,4} One suggested explanation for the results is that the serum coating partially evaporates during in vitro testing causing the suture to become tacky and to lose its lubricating ability.⁵

To date, no studies have provided evidence to support a deleterious effect of petroleum-soaked vaginal packing upon suture integrity. In fact, a paucity of information regarding the

effects of petroleum gauze on the tensile properties of sutures exists. The purpose of this study was to test the tensile properties of knotted suture made of 4 different suture materials when exposed to a petroleum vaginal pack.

MATERIALS AND METHODS

Four suture materials were chosen for the study: polydioxanone (PDS-II; Ethicon, Inc, Somerville, New Jersey), silk (Sofsilk; Covidien, Inc, Norwalk, Connecticut), glycolide/lactide copolymer (Polysorb; Covidien, Inc), and polyglyconate (Maxon; Covidien, Inc). For all sutures, a 0-0 gauge United States Pharmacopeia size suture was used. Silk is no longer commonly used in gynecologic surgery, but it is a historical “gold standard” for suture handling.⁶ Square knots were tied randomly by a single obstetrician/gynecologist over 2 weeks to avoid fatigue. Recommendations for the number of throws were not provided by the manufacturers of the suture materials, but previous studies have shown that it is necessary to secure the suture with 6 throws to avoid untying.⁷ All knots were tied wearing surgical gloves on a jig made of 2 hex-head screws 50 mm on center. The study was deemed exempt by the Cleveland Clinic Institutional Review Board.

In our clinical practice, the upper vagina is packed first, with moderate pressure being exerted to ensure a tight fit with xeroform gauze (3% bismuth Tribromophenate Petrolatum Roll Dressing, Kendall/Covidien, Inc). Gently more packing material is placed into the lower vagina, distending the walls. Ultimately, the equivalent of a baseball-sized mass of gauze approximately 1 m long and 10.2 cm in width is packed into the vagina. We mimicked this same procedure by packing half the sutures and petroleum-coated gauze into a sealed plastic bag. This minimized evaporation in the simulated vaginal environment. The other set of knots were soaked in 0.9% sodium chloride to mimic in vivo conditions. The petroleum-soaked knots were left in the plastic bag for 12 hours to simulate the average amount of time vaginal packing is left in place. Tensile forces were evaluated via tensiometer with the point of knot failure, which was defined as either untying or breaking of the knot.

The tied suture was then immediately transferred to a Chatillon LTCM-100 tensiometer (Ametek, Largo, Florida) where the tails were cut to 3-mm length (Fig. 1).⁸ The tensiometer continuously measured load while each suture loop was separated at a rate of 5 mm/minute. Failure was defined as breakage of the suture or tail slippage greater than 3 mm, and tensile strength or tension at failure was defined as the tensile force (N) measured at failure. To determine the effects of petroleum gauze and material on knot strength, we conducted an analysis of variance (ANOVA) with tests for factors and their interaction.

Statistical analysis was performed using SPSS (SPSS Institute, Cary, North Carolina). A power analysis was conducted to estimate the necessary sample size for determining whether there was an effect size between the 2 treatments (petroleum/

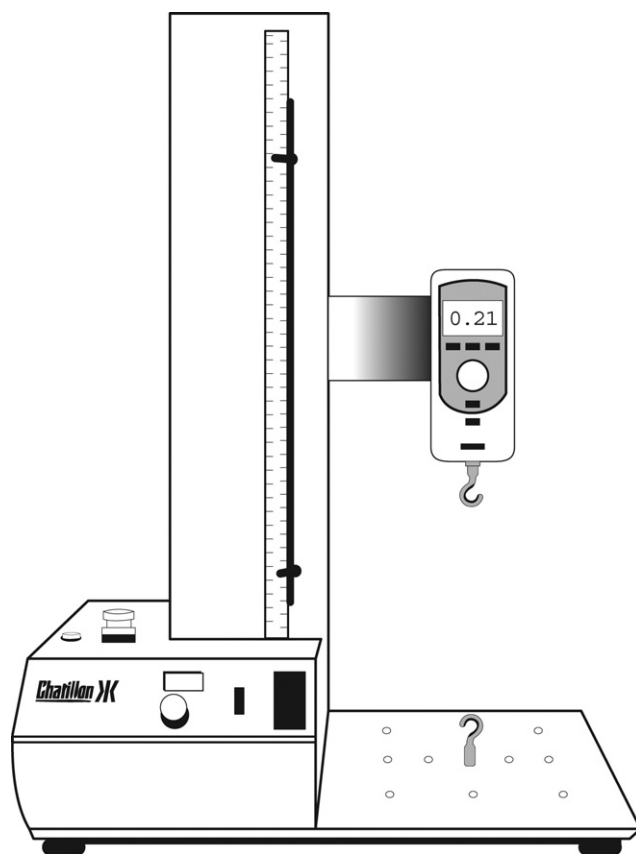


FIGURE 1. Tensiometry device elongating suture until failure.

saline) with power of 80% and a type I error rate of 5%. We needed data from a minimum of 68 knots per group (ie, a total of 136 knots).

RESULTS

The proportion of knots exposed to saline versus knots exposed to petroleum is presented in Table 1. In all cases, knots that began to unravel continued to untie completely. The loads needed to break suture were always greater than those required for suture untying.

A total of 285 knots were tied using 4 types of material (polydioxanone, silk, glycolide/lactide copolymer, and polyglyconate), with some exposed to petroleum-coated gauze and others soaked in saline. Table 1 displays the descriptive statistics for the Newtons at failure for each material type and exposure to petroleum or to saline. Among the knot failures, 6 untied rather than broke, and 5 that untied were polyglyconate sutures that had been exposed to petroleum. We compared the load at failure for the knots that untied (mean = 129.4, standard deviation [SD] = 22.4) with petroleum-coated polyglyconate sutures that did not untie (mean = 136.9, SD = 24.8) and they did not statistically differ ($p = 0.52$). The only other knot that came untied was a polydioxanone knot, which failed at a significantly lower tensile strength than the polydioxanone knots that did not untie ($p < 0.001$).

TABLE 1. Newtons to Knot Failure: Ultimate Load in Newtons Required for Failure by Suture Exposed to Saline or Petroleum

Material	Soaking Solution	N	Mean	SD
Polyglyconate	Saline	50	143.7	24.7
	Petroleum	51	136.2	24.5
	Total	101	139.9	24.8
Glycolide/lactide	Saline	51	138.7	9.8
	Petroleum	51	131.5	9.6
	Total	102	135.1	10.3
Silk	Saline	24	82.8	4.7
	Petroleum	24	71.9	4.2
	Total	48	77.4	7.0
Polydioxanone	Saline	17	79.1	15.2
	Petroleum	17	76.9	5.4
	Total	34	78.0	11.3
Total	Saline	142	123.9	32.0
	Petroleum	143	116.7	31.5
	Total	285	120.3	31.9

To determine whether material and/or petroleum application had an effect on tension at failure, we conducted a 4 × 2 factorial ANOVA. Knots exposed to petroleum gauze failed at lower tensile strengths than saline-exposed knots (p = 0.002). Silk and polydioxanone each failed at lower tensile loads than both polyglyconate and glycolide/lactide (p < 0.05 for each comparison).

DISCUSSION

Knots exposed to petroleum gauze failed at lower tensile strengths than saline-exposed knots. This finding is important in understanding the effects that petroleum packing has on suture tensile strength, as petroleum packing is commonly used in surgery.

Several factors can predispose knots to untie; these factors include the number of throws, the tying technique, the environment surrounding the suture and knot, the properties of the suture material, and the knot end length.^{5,9,10} Some suture materials have an inherently low coefficient of friction, meaning the knot will likely untie at a lower load. Special coatings allow sutures to pass more easily through tissues by lowering the coefficient of friction and improving handling characteristics. Suture coating applied by the manufacturer and a coating of petroleum from the vaginal gauze both increase the rate of untying among suture. Petroleum vaginal packing lowers that coefficient of friction further between throws and should be used sparingly. In addition, a randomized double-blind study showed no significant difference in the number of hematomas between groups with and without vaginal packing; however, clinically there was a trend toward more significant complications in the patients without any vaginal packing.¹¹ Lastly, adding an extra throw in the first throw to create a surgeon's knot in knots soaked with saline has not been shown to be effective at decreasing the rate of untying.

These findings are generalizable beyond suture placed in the vagina. Coated permanent sutures are 2 commonly used materials in advanced laparoscopy for pelvic organ prolapse and incontinence repairs. The braided strands of polyester and polyglactin create tissue drag from the crevices between the individual strands. An additional petroleum coating can be applied for braided suture before laparoscopic suturing to further decrease the coefficient of friction. The clinical application of this study may be useful in understanding vaginal cuff dehiscence if greased braided suture is used for cuff closure. Lubricating suture with petroleum may explain the failure of some sutures for laparoscopic Burch urethropexy as well. Although lubricating the synthetic sutures at the time of laparoscopy is effective, we recommend that suture manufacturers reduce the tissue-drag of sutures by developing a temporary, nontoxic coating specifically for laparoscopic suturing.

There are several limitations to this study. Although there is a 7.1 Newton difference between knots after exposure to saline or petroleum, the clinical significance of this difference is unknown. It is possible that the tensiometer device that we used to measure tensile strength could affect breaking strength. Also we are unable to determine whether the petroleum or the bismuth tribromophenate bacteriostatic solution coating the gauze causes these effects. In addition, this was purely an in vitro study, not involving the unique biological properties of the peritoneal or vaginal environments.

Suture is a commonly implanted device, although it is rarely studied. The tensile strength of knots tied in the vagina should not be compromised as a result of the tradition of vaginal packing without evidence.

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