

GLOBAL VALUE DOSSIER FOR V-LOC™ WOUND CLOSURE DEVICE

TECHNOLOGY AND SURGICAL APPLICATIONS

Medtronic
Further, Together

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1. Disclaimer and scope

1.1. Products and aliases

This document refers to the V-Loc™ barbed suture wound closure device, including absorbable (V-Loc™ 90 and V-Loc™ 180 wound closure devices) and non-absorbable (V-Loc™ PBT wound closure device) variants. Indications, contraindications, warnings, precautions and procedure steps may vary between products and models, and availability may vary by jurisdiction. Please always refer to the indication labelling specific to your jurisdiction and read all applicable instructions for use provided with the products. Failure to adhere to these instructions for indicated applications and directions for proper deployment may increase the risk of patient injury. Note that the use of barbed suture carries risk of complications such as adhesions and small bowel obstructions, as reported in rare case reports not within the scope of this dossier.

1.2. Data sources

Data regarding preclinical and clinical application of V-Loc™ devices were derived from structured searches of published literature in PubMed (September 2017) and EMBASE (September 2017), focused only on peer-reviewed literature. General text searches for V-Loc™ wound closure device references were performed in EMBASE to include all published instances of the use of the technology (including conference presentations) without restriction of time of publication to provide an overview of product usage.

Results from the peer-reviewed literature searches were screened by application of consistent exclusion criteria across searches for specific surgical indications (see Section 8, Structured literature search details). For both clinical and non-clinical data, results were restricted to publications based on data obtained within the most recent 10 years of the search (2007 and onwards). All results were retained for screening, classed as preclinical (non-human, ex-vivo) or clinical results (all others). The clinical screening rejected those that reported data on fewer than 10 patients in all study arms such as case reports, were not focused on outcomes related to the technology (that is, no mention or comparison of outcomes resulting from the use of suture device), and articles which did not reference V-Loc™ wound closure devices by name or barbed suture technology.

Data comparing V-Loc™ wound closure devices to other barbed sutures in pre-clinical and clinical settings were considered and included in original searches, however due to paucity of publications, were not included in the present analysis. The document thus includes only comparisons between V-Loc™ wound closure device and non-barbed suture devices.

1.3. Analysis

Clinical results from individual studies are presented as reported (including indication of statistical significance where shown by study authors). Plots display means and error bars standard deviation unless otherwise indicated. Where data are amalgamated from multiple reports, please note that the individual studies will vary in terms of design, protocol, surgical technique and patient population, which may limit conclusions drawn from direct comparison and relevant analysis of statistical significance. Also, where authors did not report inference testing on results and sufficient raw data are available, results of these tests may be presented in this document, in which case details and rationale will be available. Statistically significant results, as originally reported or as calculated here, may not, however, necessarily directly translate into clinical relevance and practitioners must decide what magnitude

of effect (independently of significance) is of clinical relevance or interest. The figures presented will, however, provide insight into published evidence of outcomes that have been achieved using V-Loc™ wound closure devices during preclinical testing and patient surgical procedures.

2. Introduction to barbed suture technology and the V-Loc™ wound closure device

2.1. Overview

The following chapter provides a general overview to the surgical practice of suturing and its relation to V-Loc™ wound closure devices. Technical specifications are presented, and the extent of the application of the V-Loc™ wound closure device in clinical applications around the world is explored.

2.2. The surgical application:

During surgical procedures, it is necessary to dissect tissue. Depending on the procedure, internal tissues or structures will undergo varying degrees of modification. As a result, wounds, internal or on the surface, are created that need to heal as part of patient recovery. To aid wound healing, affected soft tissues are brought together or approximated to facilitate closure of the opening. There are multiple options available for securing the edges of the soft tissue together, including clips, staples and sutures.

2.2.1. Conventional suturing

Sutures or threads used for tissue approximation can be composed of natural or synthetic materials and are passed through the walls of the tissue via an attached needle. The most appropriate suture material (absorbable or non-absorbable) and configuration (monofilament or multifilament/braided), and needle type (such as curved or straight, cutting or taper) will depend on the nature of the tissue, the shape of the wound, and physician preference, as will the pattern of suturing. While suturing, tension on the wound must be maintained to keep the edges in suitable proximity. This aim is often achieved by an assistant manually, or with instruments. Whichever method is used, the suture must be fixed using a knot to prevent it from sliding back through the tissue under tension. Although the use of sutures dates back centuries, active research continues in optimal knotting configurations to create strong and secure knots.⁶

The tying of surgical knots is a complex subject that must be developed and assessed as a core skill among surgical trainees.^{7,8} Separate tools and training evaluations have been developed specific to robotic surgery.⁹ If not secure, the unravelling of the suture knot may "pass unrecognized as a cause of wound dehiscence",¹⁰ and under high tension repairs, unraveling rates up to 86% have been reported.¹¹ Addition of more throws to the knot to improve its security will add to its volume. The knot represents a concentration of foreign body material, which, in addition to mechanical trauma, has been proposed to explain the pronounced localization of inflammatory response and adhesion formation at the knot site.¹² Interstices formed between multifilament or braided sutures, or like those among the throws of a surgical knot, potentially provide a niche for bacteria to cause surgical site infections,¹³ while the suture material itself can be a substrate for biofilm deposition, encouraging bacterial attachment.¹⁴

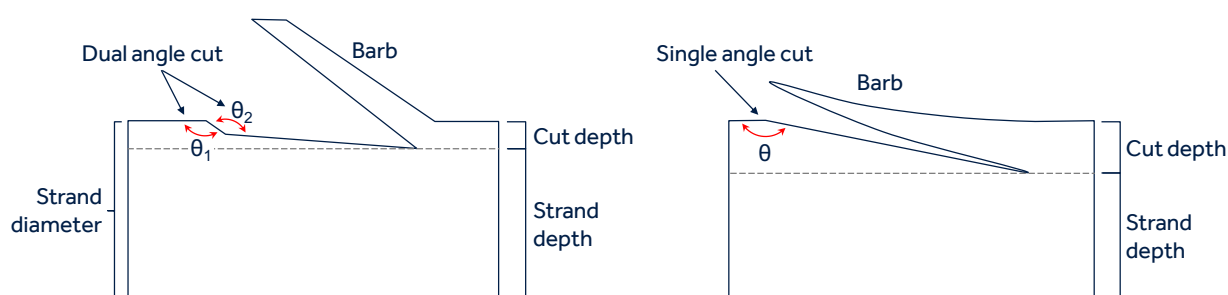
Given the above-described issues with conventional sutures and knot-tying, operative procedures may see improvements if these issues could be ameliorated. The removal of the knot to secure the suture, for example, would reduce the time needed to complete procedures and the volume of foreign material. Surgical training would also be facilitated by reducing the syllabus component of a complex array of surgical knots. To address some of the issues, barbed sutures were introduced as an alternative means of suture tissue approximation that eliminates the need for a knot for fixation.

2.2.2. Barbed sutures

A knotless alternative to the securing of surgical sutures is to introduce barbs along the length of the suture.¹⁵ From a typical synthetic suture, barbs are cut along the length in such a way as to allow smooth passage through tissue when pulled in one direction, but resistance to dislocation in the other. Barbs obviate the need for knots at the end of the suture because the tension to hold the wound surfaces together is distributed along the length of suture.

Two methods of introducing barbs to a monofilament suture are shown in Figure 2-1. In addition to the geometry of the individual barbs, their positioning along the thread is a parameter considered in design. The density (barbs per unit length), circumferential placement and orientation (unidirectional or bidirectional) have been explored in different barbed suture types for their performance in securing tissues and influence on suturing method. This document is focused on the V-Loc™ barbed suture wound closure device, details of which are presented in subsequent sections.

Figure 2-1 Suture barb geometry



Illustrated are parameters determining the geometry of barbs cut from a monofilament synthetic suture with two cutting angles (dual cut, left) or a single cut angle (right). Note the difference in strand diameter that remains unaffected by the cut using the two designs.

2.3. V-Loc™ wound closure device

The V-Loc™ wound closure device is a monofilament, dual-angle cut, unidirectional barbed suture designed to provide a suturing tissue approximation solution, alternative to conventional suturing. Available in both absorbable and non-absorbable varieties, the device can be used in surgical applications where non-barbed sutures are also indicated for soft tissue approximation (see Section 2.4 for additional details on indications). Using unidirectional barbs, the V-Loc™ device prevents the suture from slipping back through the soft tissue, without the need for a terminal knot to secure the wound.

2.3.1. Composition

Synthetic sutures are available in different formulations, each of which will interact differently with tissues. The choice of V-Loc™ wound closure device material composition will depend on the application and the need for temporary or permanent tissue approximation. Absorbable sutures, for example, are more likely to be used for internal wound closure where the sutures will not be accessible for removal, while the non-absorbable V-Loc™ device, not intended to decompose in tissue after placement, may be used for dermal wound closure. Properties of the various sutures are summarized in Table 2-1.

Table 2-1 V-Loc™ wound closure device properties

Property	V-Loc™ 90 Device ⁶⁶	V-Loc™ 180 Device ⁶⁷	V-Loc™ PBT Non-Absorbable Device ⁶⁸
Tensile strength	14 days	21 days	Permanent
Absorption profile	90-110 days	180 days	Permanent
Procedural applications	Soft tissue approximation where support is required consistent with the absorption profile	Soft tissue approximation where support is required consistent with the absorption profile	Soft tissue approximation
Color	Undyed, violet	Undyed, green	Blue
Composition	Glycolide, dioxanone and trimethylene carbonate	Copolymer of glycolic acid and trimethylene carbonate	Polybutester
Sterilization	Ethylene oxide	Ethylene oxide	Ethylene oxide
Indications*	V-Loc™ 90 and V-Loc™ 180 absorbable wound closure devices are indicated for soft tissue approximation where use of an absorbable suture is appropriate.		V-Loc™ PBT non-absorbable wound closure devices are indicated for soft tissue approximation

*Refer to Section 2.4 for further details on indications for use.

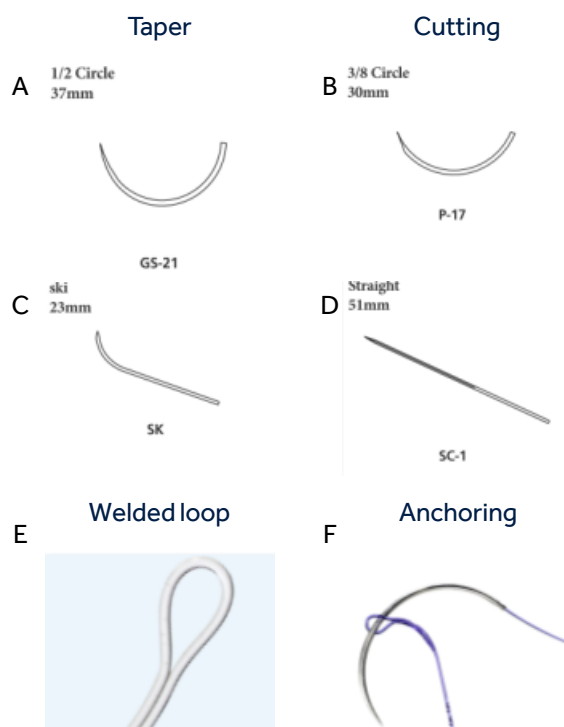
2.3.2. Production

V-Loc™ wound closure devices (both absorbable and non-absorbable) are prepared from manufactured sutures, as depicted in the dual angle cut barb geometry of Figure 2-1. Resulting in part from the dual angle, much of the strand depth is retained, thus maintaining the core physical properties of the strand. The suture labels correspond to the comparable non-barbed suture with respect to diameter and tensile strength, as the unidirectional barbs of V-Loc™ devices are cut from sutures one grade larger. For example, the V-Loc™ 90 absorbable 3-0 device is prepared from the larger 2-0 thread and subsequently has properties comparable to a conventional 2-0 suture. The creation of the barbs reduces the tensile strength of the original, non-barbed strand comparably to that of tying a knot. The resulting strand thus bears straight pull tensile strength properties in line with a suture diameter one size smaller than the original strand. Size labelling on the V-Loc™ wound closure device packaging is therefore representative of the performance that can be expected when using in place of a similarly rated non-barbed suture.

2.3.3. Suturing and anchoring

Since the barbs of the V-Loc™ wound closure device are unidirectional, the thread has a directionality such that it can only be easily pulled in one direction to pass easily through tissue. At the leading end, a needle, which can have a wide variety of configurations to suit different surgical needs, is affixed. At the other end is a secure, welded loop that forms a structure through which the needle can be passed to fix the anchor point of the continuous suture (Figure 2-2).

Figure 2-2 V-Loc™ wound closure devices



Shown is a selection of V-Loc™ wound closure needle attachments for different applications, including circular (A, B), ski (C), and straight (D), as tapered (A, C) and reverse cutting (B) or straight cutting (D) needles. The other end of the suture features a welded loop (E) and fixation at the initiation of the incision is achieved by passing the needle through the welded loop (F) and applying mild tension before proceeding with continuous suturing. Note that only a selection of needle types is shown and others are available.

2.3.4. Performance comparisons

V-Loc™ devices were designed for tissue approximation to address potential problems that occur with traditional suturing, particularly regarding knotting and its impact on speed, security and effectiveness in tissue approximation. Before consideration as a suitable alternative, however, extensive testing of properties such as tensile strength (applied force to cause strand breakage), pull-out strength (force applied to dislocate the suture against the hold of the barbs), and handling/suturing technique were performed to confirm expected behavior when applied to a surgical setting. Benchtop biomechanical, animal and human tissue investigations have been performed to evaluate the performance of V-Loc™ wound closure devices alone, and compared to conventional, non-barbed suture products. These results are explored in chapter 3, "V-Loc™ wound closure devices as an alternative to conventional sutures."

2.4. Indications for use

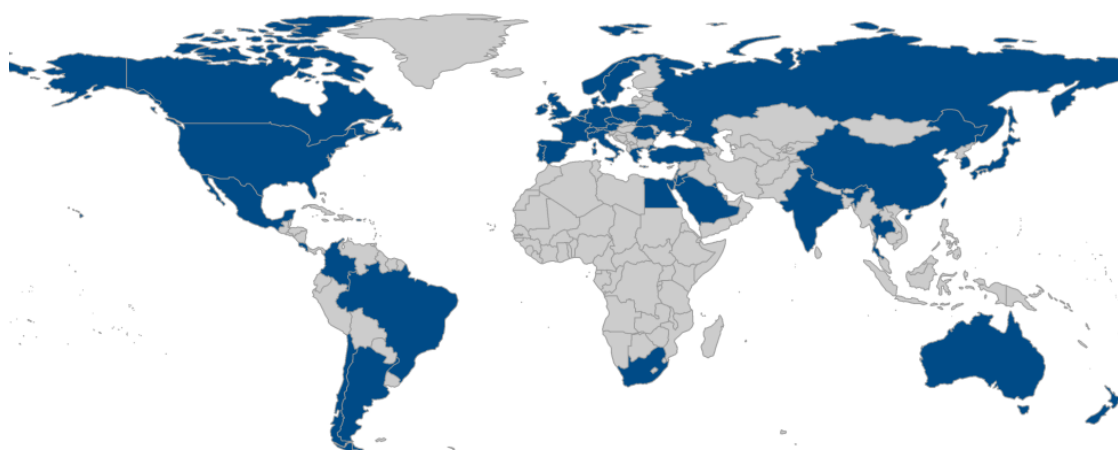
Always refer to the package insert for indications and instructions for use of V-Loc™ wound closure devices appropriate for your jurisdiction. Absorbable (V-Loc™ 90 and 180), and non-absorbable (V-Loc™ PBT), devices are indicated for use in soft tissue approximation wherever the use of standard, non-barbed absorbable or non-absorbable sutures is appropriate, respectively. The product is contraindicated for patients with allergies to its components and should not be secured by tying surgical knots, or used with interrupted suturing patterns, or for ligating vessels or luminal structures. The technology has not been established for use in fascial closures

(abdominal wall, thoracic, extremity fascial closures), gastrointestinal anastomoses, cardiovascular anastomoses, neurological, ophthalmic, orthopedic or microsurgery applications.

2.5. Extensive worldwide usage

The reach of the V-Loc™ wound closure device is expansive, with published reports (comprising peer-reviewed and non-peer reviewed literature) of its clinical application in 46 countries (Figure 2-3) spanning six continents (North America, South America, Europe, Africa, Asia and Australia). Sample publications include representation from: Argentina,^{G1} Australia,^{G2} Austria,^{G3} Belgium,^{G4} Brazil,^{G5} Canada,^{G6} Chile,^{G7} China,^{G8} Colombia,^{G9} Costa Rica,^{G10} Czech Republic,^{G11} Denmark,^{G12} Egypt,^{G13} France,^{G14} Germany,^{G15} Greece,^{G16} India,^{G17} Ireland,^{G18} Israel,^{G19} Italy,^{G20} Japan,^{G21} Jordan,^{G22} Kuwait,^{G23} Lebanon,^{G24} Luxembourg,^{G25} Mexico,^{G26} Netherlands,^{G27} New Zealand,^{G28} Norway,^{G29} Poland,^{G30} Puerto Rico,^{G31} Romania,^{G32} Russia,^{G33} Saudi Arabia,^{G34} Singapore,^{G35} South Africa,^{G36} South Korea,^{G37} Spain,^{G38} Sweden,^{G39} Switzerland,^{G40} Taiwan (Province of China),^{G41} Thailand,^{G42} Turkey,^{G43} Ukraine,^{G44} the United Kingdom,^{G45} and the United States of America.^{G46} The geographical results were obtained from top level screening of patient population descriptions or study corresponding author institutions and hospitals/care centers where the V-Loc™ wound closure device was reported used in the surgical procedure.

Figure 2-3 V-Loc™ devices have been applied in clinical settings globally



2.6. V-Loc™ wound closure devices as suturing solution

The remainder of this document presents evidence regarding the use of V-Loc™ wound closure devices (absorbable and non-absorbable) in pre-clinical and clinical applications. Its performance is presented in comparison to standard suturing (non-barbed), and alternative barbed suture products. Clinical applications of V-Loc™ devices are presented for gynecology, urology, plastics, and cardiology, as well as for robotics as applied to any of the aforementioned procedures.

3. V-Loc™ wound closure devices as an alternative to conventional sutures

3.1. Overview

Summary and key messages

- **Uncompromised strand integrity:** V-Loc™ wound closure devices demonstrate equivalent tensile strength to non-barbed suture.^{3,4}
- **Reliable performance in pre-clinical testing:** V-Loc™ wound closure devices compared to non-barbed suture have demonstrated superior fixation when tested for slippage against clips,¹⁶ and comparable maximum load in animal and human tissue models.^{1,2,17,18}
- **Low adverse tissue reaction:** In animal models,^{18,19} absorbable V-Loc™ wound closure devices have elicited similar^{18,19} and lower¹⁹ adverse tissue reactions compared to similar non-barbed sutures in the period after implantation and prior to absorption of the suture material.
- **Reduction in suturing time:** In 13 of 14 studies the use of V-Loc™ wound closure devices resulted in significantly shorter suturing time compared to non-barbed sutures.^{15,20-30}
- **Total operative time is reduced or equivalent with V-Loc™ devices:** In gynecological procedures, where suturing may comprise a large proportion of the total operative time, V-Loc™ wound closure devices have resulted in significantly lower total operative time as found in 10 of 15 studies.^{22,24,30-37} In the remaining studies,^{15,20,25,38,39} and those in cardiology,⁴⁰ urology,^{29,41-44} and plastics,⁴⁵ the total operative time between V-Loc™ devices and non-barbed sutures was equivalent.
- **Reduced to comparable intra-operative blood loss:** In gynecological and urological procedures, the use of V-Loc™ devices compared to non-barbed sutures has been shown to result in equivalent,^{20,22,29,30,32,36-39,41-44} to significantly lower^{24,25,31,33-35} intra-operative blood loss.
- **Equivalent risks of general complications:** Reported rates of complications (any complication or peri-operative complications) between the use of V-Loc™ wound closure devices and non-barbed sutures are equivalent.^{13,22,26,28,29,32,42,43,46,47}
- **Equivalent rates of infections and dehiscence:** Of specific complications reported, V-Loc™ wound closure devices have shown no increased risk of infections,^{13,20,27,28,33,39,40,48} or dehiscence^{13,20,21,23,27,31,32,39,40,45,48,49} post-operatively.

*Note that statistically-significant differences do not automatically translate into clinically-relevant differences. Such determinations of clinical relevance are at the user's discretion.

3.2. Pre-clinical data

Benchtop and ex vivo testing models permit exploration of parameters not amenable to study in a clinical setting. Further, as pre-clinical data, they are essential in establishing safety and effectiveness parameters that will be used to guide clinical applications in patients during surgeries.

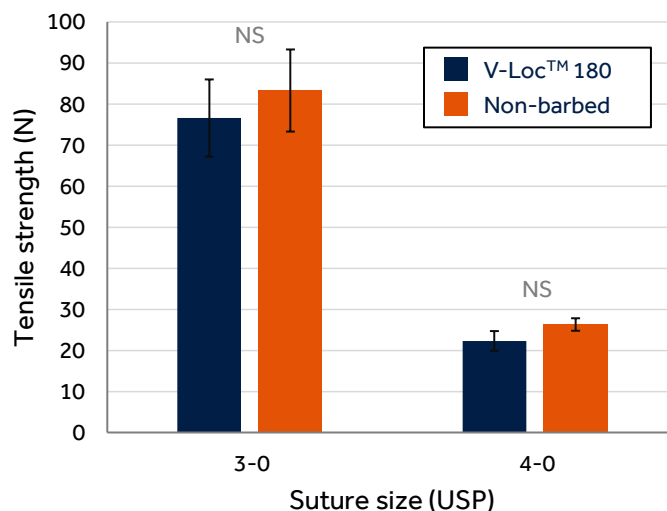
Properties that have been reported in experimental systems include general measures such as biomechanical strength of the suture (tensile strength), maximum load (or maximum holding strength to cause the repair to fail), degree of slippage (force required to displace the suture or amount of displacement under a measured force), and mode of failure under maximum load testing. Additionally, other measures specific to surgery types may be examined. In orthopedic procedures for example, for flexor tendon repair, the force required to create a 2 mm gap in the repair is considered clinical failure⁵⁰.

In addition to physical measurements, in vivo animal models provide data for biological effects. Suture repairs can be simulated in situ, and subjected to later histological examination to measure outcomes such as adhesion formation and tissue reactivity.

3.2.1. Tensile strength

As described above (Section 2.3.2), the manufacture of the V-Loc™ wound closure device is from a strand sized one step larger according to United States Pharmacopeia (USP) specifications. The completed strand after barbing has the tensile strength of a non-barbed strand one size smaller. Independently of quality assessments during manufacturing, others have performed porcine model experiments^{3,4} demonstrating the tensile strength equivalence of samples of V-Loc™ wound closure devices with non-barbed sutures (Figure 3-1).

Figure 3-1 Tensile strength of V-Loc™ 180 wound closure device and non-barbed sutures

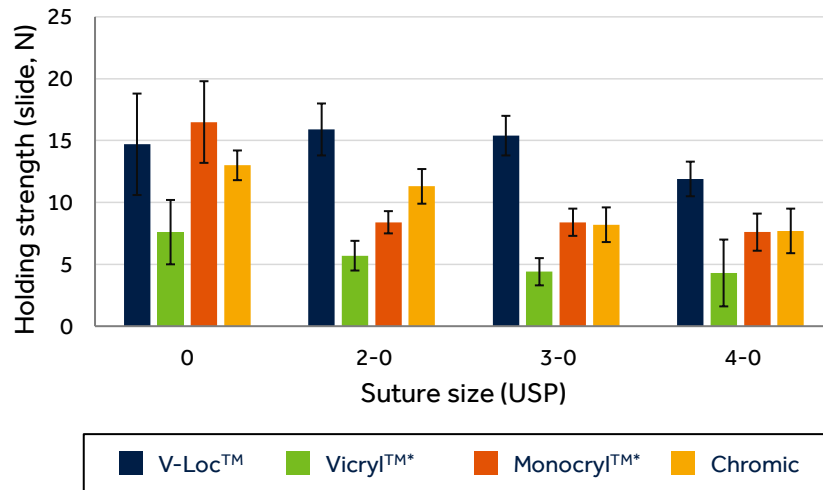


In porcine models,^{3,4} the tensile strength of different sizes of V-Loc™ 180 devices (3-0⁴ and 4-0³) was found to be equivalent. N, newtons; NS, non-significant difference; USP, United States Pharmacopeia.

3.2.2. Holding strength

Prior to implantation in tissue, the holding strength of a wound closure can be mechanically assessed. In some surgical applications, clips may be used in combination with sutures to achieve anchoring, and in one set of experiments,¹⁶ the holding strength of V-Loc™ wound closure device, here defined as the force required to cause slippage through the clip, was compared to non-barbed (Figure 3-2).

Figure 3-2 Clip holding strength of V-Loc™ wound closure device versus non-barbed sutures

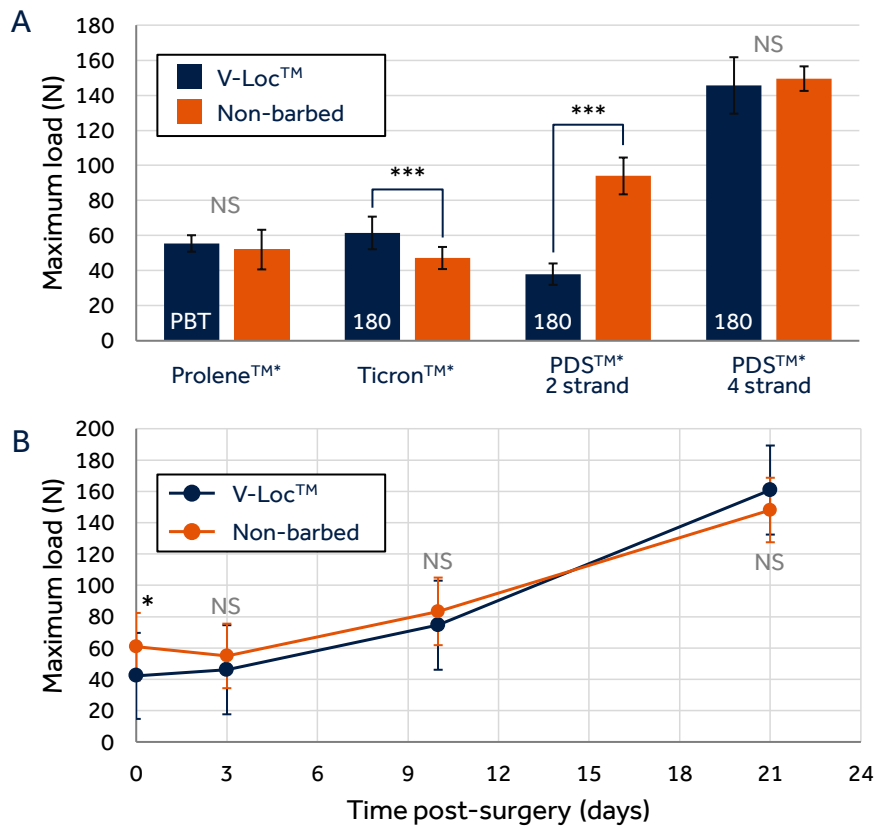


Mechanical testing results of suture materials for force required to cause slippage through polymer clips used for ligation during surgery are shown for different suture sizes.¹⁶ Higher values indicate better performance. By groupwise testing (analysis of variance, or ANOVA) all suture sizes exhibited statistically significant differences ($p < 0.001$). N, newtons; USP, United States Pharmacopeia.

3.2.3. Maximum load

Beyond measurement of holding strength, of potentially greater interest for ultimate surgical application is the assessment of the force required to cause failure of the wound closure under tissue implantation conditions. This assessment can be achieved by subjecting the seal within tissue to mechanical stress until failure occurs. Under this stress testing in tissue models (Figure 3-3), the performance of V-Loc™ has been tested in various models including animal^{1,2,18} and human,¹⁷ and has been found to be generally comparable.

Figure 3-3 Maximum load of V-Loc™ wound closure devices versus non-barbed suture in tissue models

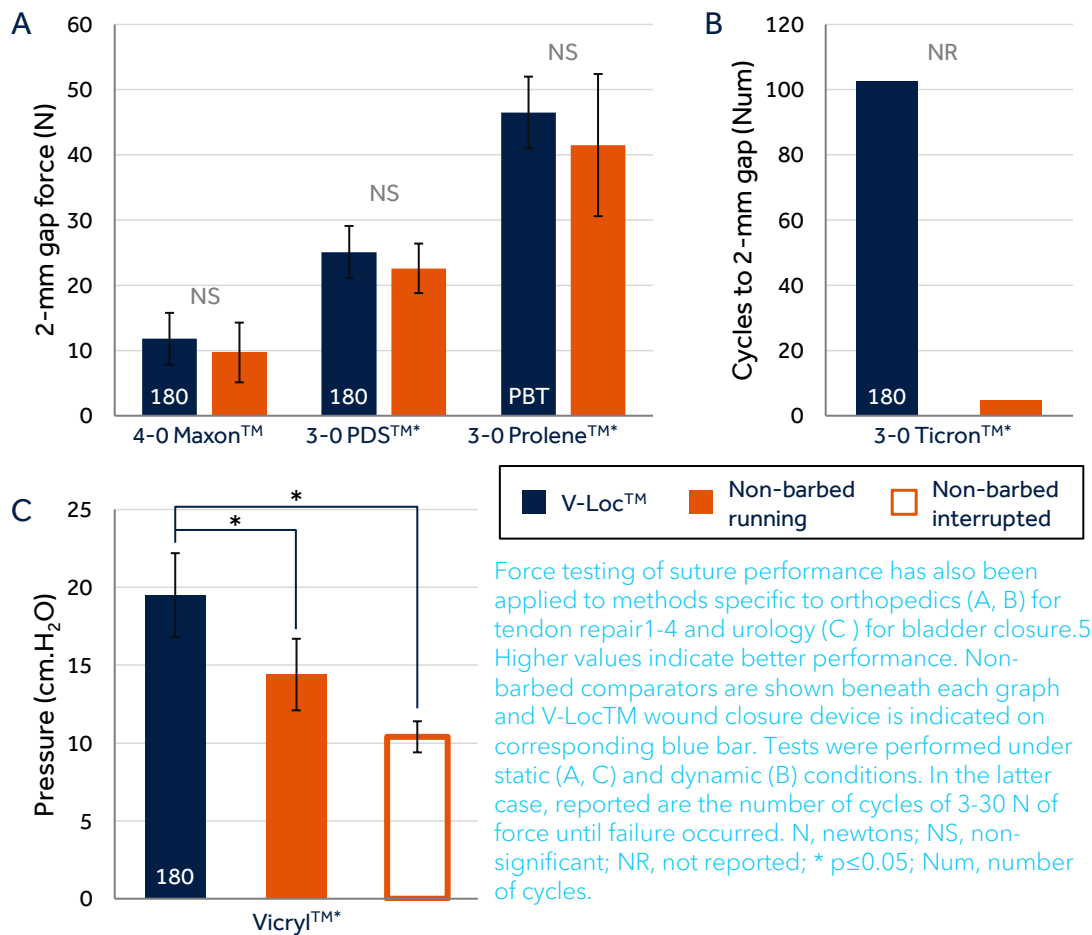


Holding strength test results from tissue experiments, A from left to right porcine (2-0 V-Loc™ PBT versus Prolene™*),¹ ovine (3-0 V-Loc™ 180 versus Ti-Cron™),² and human cadaver tendon repair (3-0 V-Loc™ 180 versus PDST™*)¹⁷ in 2-strand and 4-strand suturing configurations. A separate experiment demonstrated the change in holding strength over time in a porcine tissue model¹⁸ of 4-0 V-Loc™ 180 versus Biosyn™. In (A), the specific non-barbed comparator is shown and on the blue bars, the specific V-Loc™ wound closure device. Statistical significance is indicated above comparisons: NS, non-significant; * $p \leq 0.05$; *** $p \leq 0.001$. N, newtons.

3.2.4. Other force measurements

In addition to general testing of suture properties, tests designed for specific surgical applications have also been performed in tissue systems. For urological surgery for example, suture closure of the bladder wound can be tested for resilience of the seal, while in orthopedics, for tendon repair, the formation of a gap of 2-mm in the sealed wound is considered clinical failure.¹ In both cases, the pressure or forces required to cause these failures has been tested for V-Loc™ wound closure devices (Figure 3-4).

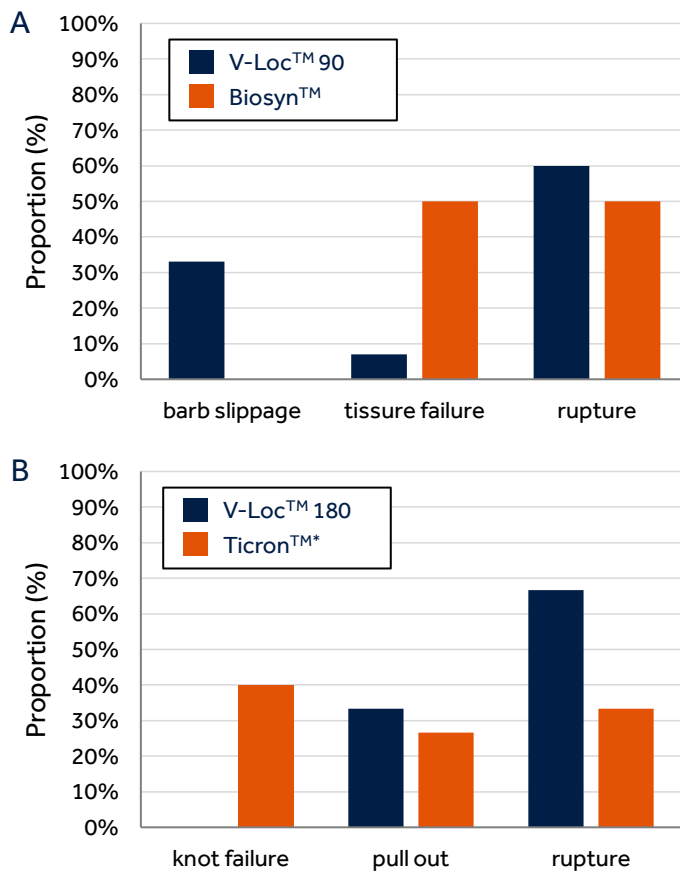
Figure 3-4 Surgery specific seal testing of V-Loc™ wound closure devices and non-barbed sutures



3.2.5. Mode of failure

The described load testing provides an indication of the limits that the wound closure can endure before failure. Additionally, the mode of failure from these experiments also provides an indication of where the potentially weakest points in the closure system may occur (Figure 3-5). Studies have reported results for V-Loc™ wound closure devices versus non-barbed suture alternatives.^{2,18} Under test conditions, suture rupture is the desired outcome, as it represents secure interaction of the device with the tissue. The most common mode of failure for the V-Loc™ device in these experiments was suture rupture, approximately twice as frequent as barb slippage or pull out, indicating the secure attachment to the tissue afforded by the barbs.

Figure 3-5 Modes of failure of V-Loc™ wound closure device versus non-barbed suture

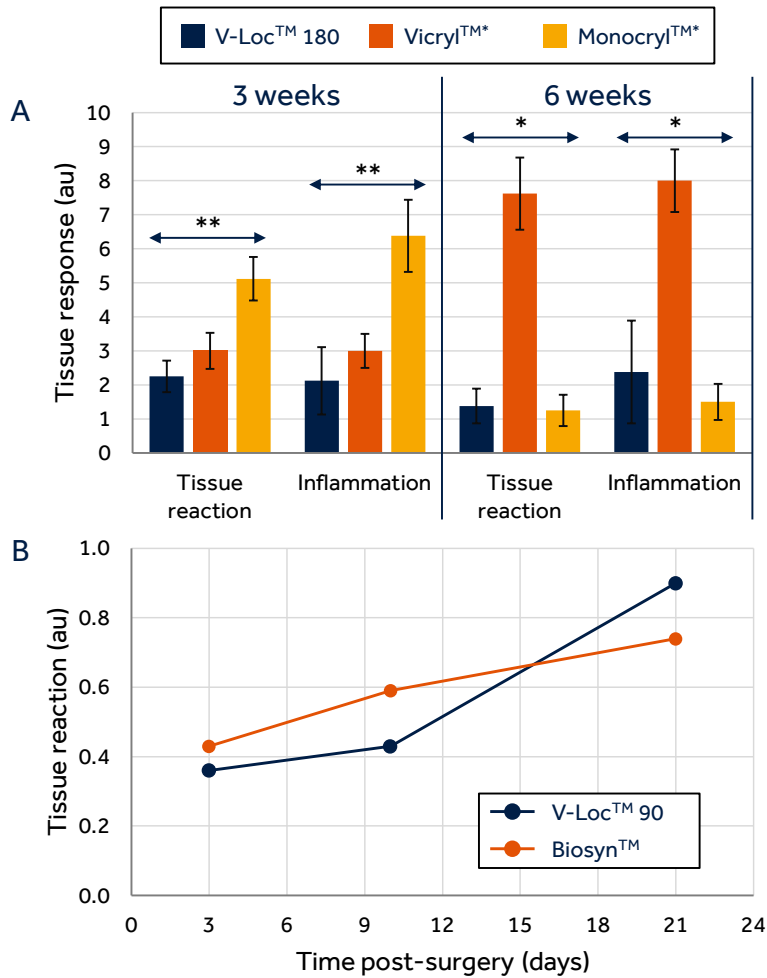


Wound closures tested until seal failure were compared regarding the mode of final failure as reported in porcine (A)¹⁸ and ovine (B)² tissue models. In the porcine testing,¹⁸ dislocation of the strand is specifically referenced as barb slippage and thus no failures in the non-barbed case were recorded as pull out failures. In both sets of experiments, the most common mode of failure for V-Loc™ devices was suture rupture, however the precise point of rupture (welded loop or strand itself) was not reported.

3.2.6. Tissue reaction

As a foreign body intended for use in surgery, a further characteristic of interest to study is the extent to which the suture to causes a tissue response. These experiments require longer exposure of the device to tissue in a living system from days to weeks. Experiments comparing V-Loc™ wound closure devices to non-barbed sutures have shown comparable to lower tissue reactivity at various timepoints after implantation, demonstrating no increase in adverse tissue response to the suture material in these model systems (Figure 3-6).

Figure 3-6 Tissue response to V-Loc™ wound closure devices and non-barbed sutures



The figure was assembled by Coreva Scientific, based on two different references. Tissue reaction was reported using arbitrary scales in murine (Figure 3-6A) from the study of Petrut et al.¹⁹ and porcine (Figure 3-6B) from the study of Zaruby et al.¹⁸ models at different timepoints after surgery. Lower values on the arbitrary unit scale correspond to lower reaction. Although statistically significant differences were observed at the group level in the murine model at both 3 and 6 weeks after surgery, post hoc testing was not reported for individual differences between pairs of the suture materials tested. V-Loc™ demonstrated the lowest tissue reaction and inflammatory response at 3 weeks, and a similarly low tissue response at 6 weeks. No significant differences were observed in separate testing with a porcine model up to 3 weeks after surgery. Vertical scale, au: arbitrary units.

3.3. Clinical data

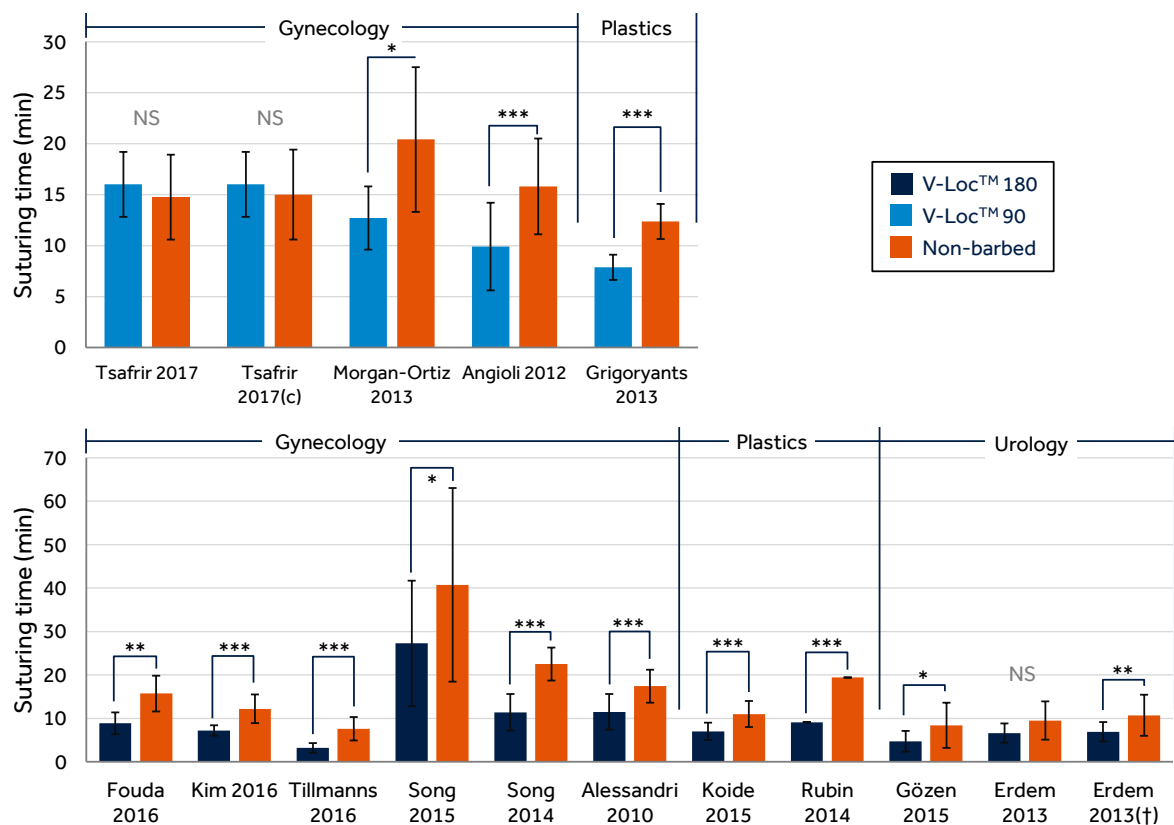
V-Loc™ wound closure devices have been approved in various settings around the world for clinical application (Figure 2-3). Reports have been published comparing their performance (specifically V-Loc™ 90 and V-Loc™ 180 wound closure devices) against absorbable non-barbed sutures in human patients. While the V-Loc™ devices have been used in a variety of surgical domains, this dossier is focused on those in which they have been directly compared with non-barbed alternatives. Data are thus presented for gynecology, urology, plastic surgery, and cardiology, with inclusion of robotic assistance among the relevant procedures.

3.3.1. Time

Various time parameters can be associated with surgical procedures and each may be defined by study. Total operative time may be considered "skin to skin", or from first incision to final closure, or may be considered the completion of the main procedure itself, separately from anesthesia, or final wound closure. In the studies considered here, where the type of suture is the main independent variable, authors may also note the time required to complete suturing, or for fixation (knotting, as with conventional sutures, or passage of the needle through the welded loop as for V-Loc™ wound closure devices).

In 13 of 14 studies where the comparison has been made between non-barbed sutures and V-Loc™ wound closure device, the use of V-Loc™ devices has resulted in statistically significantly lower time to complete suturing (Figure 3-7). The procedures in which this time reduction has been observed span multiple disciplines, and include hysterectomy,^{20-23,39} myomectomy,^{15,24,25} plastic surgery dermal closures,^{26,27} lipoabdominoplasty,²⁸ partial nephrectomy,²⁹ and other procedures.^{30,41}

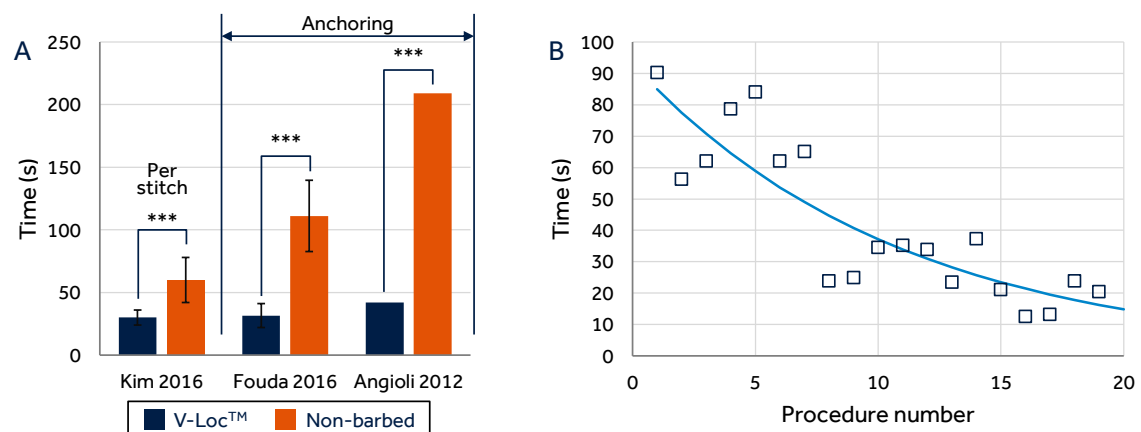
Figure 3-7 Suturing time with V-Loc™ wound closure devices compared to non-barbed sutures



The figure was assembled by Coreva Scientific, using data from several references. Results are shown for observed differences in suturing time with V-Loc™ 90 (top) and V-Loc™ 180 (bottom) wound closure devices compared to conventional non-barbed sutures. Surgical procedures under gynecology are hysterectomy (Tsafirir 2017,³⁹ Kim 2016,²⁰ Tillmanns 2016,²¹ Song 2014,²² Morgan-Ortiz 2013²³) and myomectomy (Song 2015,²⁴ Angioli 2012,²⁵ Alessandri 2010¹⁵). Plastic procedures include dermal closures (Koide 2015²⁶ and Rubin 2014²⁷) and lipoabdominoplasty (Grigoryants 2013²⁸). The urological procedures were radical prostatectomy (Gözen 2015⁴¹) and partial nephrectomy.²⁹ The latter Erdem 2013²⁹ study presented analysis as a cohort analysis and a matched pair (†) analysis where comparisons were made in a 1:1 ratio between patients matched on additional parameters such as age, operative approach, and PADUA (preoperative aspects and dimensions used for an anatomic) classification score. The study of Tsafirir 2017³⁹ included comparisons with non-barbed suture alone, and to non-barbed suture with an additional Lapra-Ty™ clip (c). Significance is indicated above the bars: NS, non-significant ($p > 0.05$); * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$).

More detailed analyses of the suturing process itself have been performed to illustrate the effect of the V-Loc™ wound closure device on suturing compared to non-barbed threads (Figure 3-8). In these comparisons, V-Loc™ wound closure devices were associated with significantly shorter times per stitch,²⁰ and times to anchor the suture compared to non-barbed sutures with knot anchoring.^{25,30} In a study where the learning curve for using V-Loc™ wound closure devices was investigated,²⁵ the time required to perform anchoring of the device (passing the needle through the welded loop) dropped quickly, decreasing by over 50% after 10 procedures (90 seconds to 34.5 seconds).²⁵

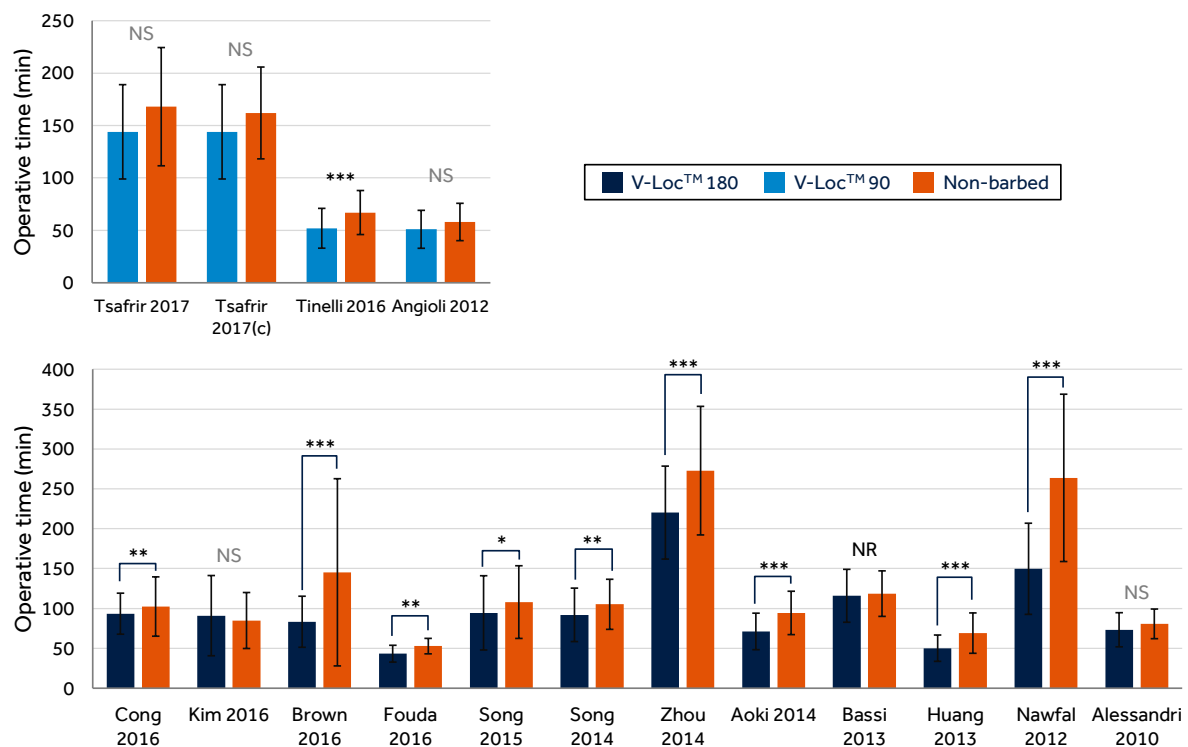
Figure 3-8 Stitch and anchoring time with V-Loc™ wound closure devices versus non-barbed sutures in gynecology



Studies have reported prospectively collected times (panel A) per stitch²⁰ and for anchoring of the suture, achieved by knotting with non-barbed sutures, or by passing the needle through the welded loop in the case of the V-Loc™ wound closure device.^{25,30} The study of Angioli et al.²⁵ noted the effect of experience on the time to pass the needle through the loop of the V-Loc™ wound closure device, demonstrating a decrease in the time required to anchor the suture with more procedures performed (panel B). Note that figure 1 of the original Angioli 2012 publication plotted a linear regression line to fit the raw data (squares) whereas here an exponential curve is shown, the latter of which demonstrates a better fit (lesser standard error and higher correlation coefficient). Significance is indicated above the bars in panel A (***) ($p \leq 0.001$). Note results are all obtained from studies of gynecological procedures (hysterectomy,²⁰ myomectomy,²⁵ and endometrioma excision³⁰) and thus may not directly translate to other surgical areas. Time is indicated in seconds (s).

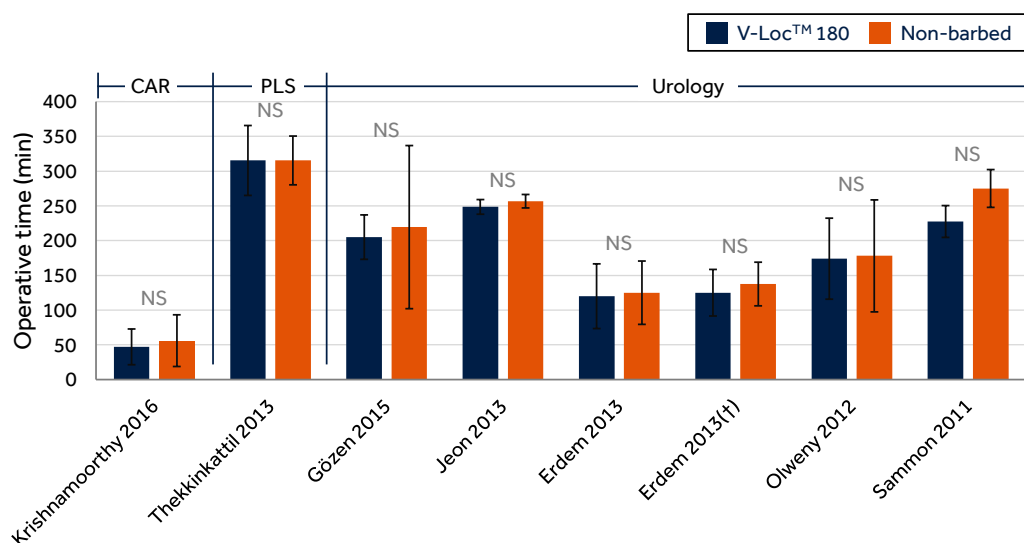
Suturing comprises one component of a surgical procedure and the time for its completion is not a common parameter recorded among surgical details (for example in retrospective studies). In contrast, the total operative time is more often noted and the effect of suture type has been investigated. The impact of V-Loc™ wound closure devices on operative time is most pronounced in gynecological procedures, where the use of the V-Loc™ wound closure device has resulted in significantly lower total operative time in 10 of 15 studies (Figure 3-9). The specific procedures where these reductions in operative time were observed included laparoscopic excision of ovarian endometrioma,³⁰ hysterectomy,^{22,31-34} and myomectomy.^{24,35-37} In the remaining gynecological investigations, as well as others from cardiology,⁴⁰ plastics,⁴⁵ and urology,^{29,41-44} the use of V-Loc™ wound closure devices resulted in equivalent total operative time compared to the use of non-barbed sutures (Figure 3-10). Authors have noted that the impact of suture device on operative time will be affected by how much of the procedure wound closure comprises²⁰ or the operative details of the procedure (such as laparoscopic intracorporeal knot tying).³⁹ Where suturing is a major component of the operation, as in myomectomy, the time savings achieved with V-Loc™ wound closure devices translate more directly into total operative time savings.²⁰ In some other surgeries, however, despite suturing also representing a major component of the operation, any differences in operative time may be more difficult to characterize, such as in plastics with bilateral procedures, where patients may often serve as their own controls.²⁶⁻²⁸ In these cases, where the control and study sides of the patient are randomized, the total operative time represents a combination of both types of suture device.

Figure 3-9 Operative time with V-Loc™ wound closure devices compared to non-barbed sutures in gynecological procedures



Results are shown for observed differences in total operative time with V-Loc™ 90 (top) and V-Loc™ 180 (bottom) wound closure devices compared to conventional non-barbed sutures. All V-Loc™ 90 procedures were gynecological. Surgical procedures under gynecology are hysterectomy (Tsafirir 2017,³⁹ Kim 2016,²⁰ Cong 2016,³¹ Brown 2016,³² Song 2014,²² Zhou 2014,³³ Bassi 2013,³⁸ Nawfal 2012³⁴) and myomectomy (Tinelli 2016,³⁵ Aoki 2014,³⁶ Song 2015,²⁴ Huang 2013,³⁷ Angioli 2012,²⁵ Alessandri 2010¹⁵). The study of Tsafirir 2017³⁹ included comparisons with non-barbed suture alone, and to non-barbed suture with an additional Lapra-Ty™ clip (c). CAR, cardiology; PLS, plastic surgery. Significance is indicated above the bars: NS, non-significant ($p > 0.05$); * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

Figure 3-10 Operative time with V-Loc™ wound closure devices compared to non-barbed sutures in non-gynecological procedures

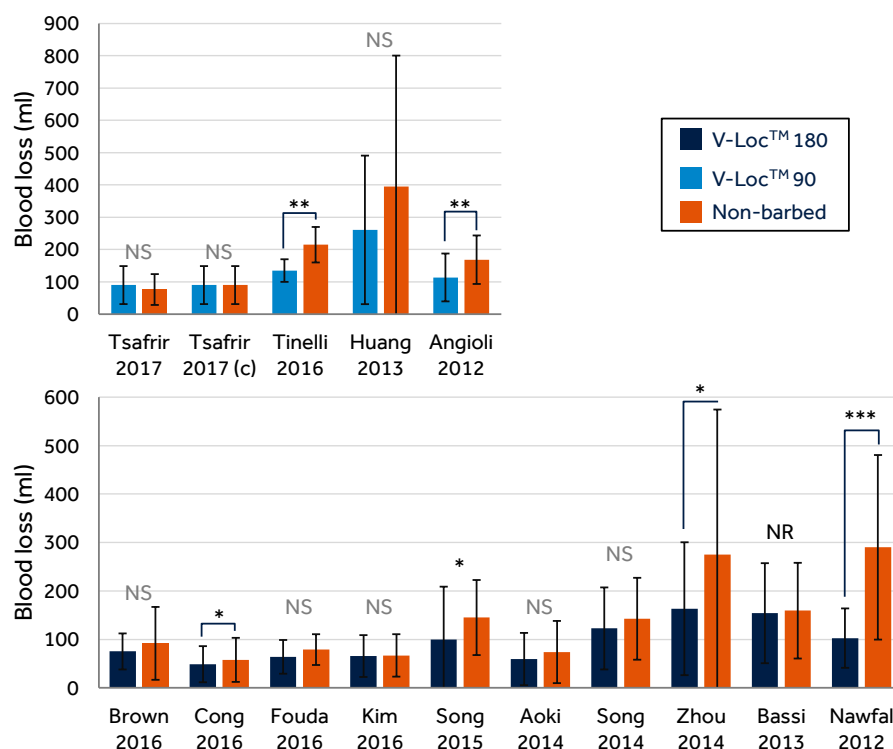


Results are shown for observed total operative time with V-Loc™ 180 wound closure devices compared to conventional non-barbed sutures. The cardiological procedures were donor leg wound closure after coronary artery bypass (Krishnamoorthy 2016⁴⁰; urological procedures partial nephrectomy (Jeon 2013,⁴² Erdem 2013,²⁹ Olweny 2012⁴³ and Sammon 2011⁴⁴) and radical prostatectomy (Gözen 2015⁴¹); and plastic surgery procedures were donor site closure during breast reconstruction (Thekkinkattil 2013⁴⁵). The Erdem 2013²⁹ study presented analysis as a cohort analysis and a matched pair (†) analysis where comparisons were made in a 1:1 ratio between patients matched on additional parameters such as age, operative approach, and PADUA (preoperative aspects and dimensions used for an anatomic) classification score. CAR, cardiology; PLS, plastic surgery. All differences were not statistically significant (NS, $p > 0.05$).

3.3.2. Estimated blood loss

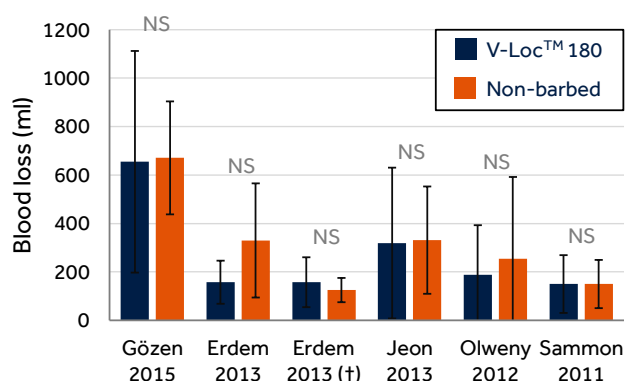
A desirable feature when considering alternatives for operative devices or techniques is the reduction of intra-operative blood loss. V-Loc™ wound closure devices have been evaluated for estimated blood loss in comparison to non-barbed sutures in gynecology^{20,22,24,25,30-39} and urology.^{29,41-44} Six of the 14 gynecological studies revealed a significant reduction in estimated blood loss with V-Loc™ devices compared to non-barbed suture,^{24,25,31,33-35} while the remaining studies demonstrated equivalence between the two devices.

Figure 3-11 Estimated blood loss with V-Loc™ wound closure devices compared to non-barbed suture in gynecological procedures



Results are shown for estimated intra-operative blood loss for gynecological procedures with V-Loc™ 90 (top) and V-Loc™ 180 (bottom) wound closure devices compared to conventional non-barbed sutures. Surgical procedures under gynecology are hysterectomy (Tsafrir 2017,³⁹ Kim 2016,²⁰ Cong 2016,³¹ Brown 2016,³² Song 2014,²² Zhou 2014,³³ Bassi 2013,³⁸ Nawfal 2012³⁴) and myomectomy (Tinelli 2016,³⁵ Aoki 2014,³⁶ Song 2015,²⁴ Huang 2013,³⁷ Angioli 2012,²⁵). The study of Tsafrir 2017³⁹ included comparisons with non-barbed suture alone, and to non-barbed suture with an additional Lapra-Ty™ clip (c). Significance is indicated above the bars: NS, non-significant ($p > 0.05$); * $p \leq 0.05$; *** $p \leq 0.001$.

Figure 3-12 Estimated blood loss with V-Loc™ wound closure devices compared to non-barbed suture in urological procedures

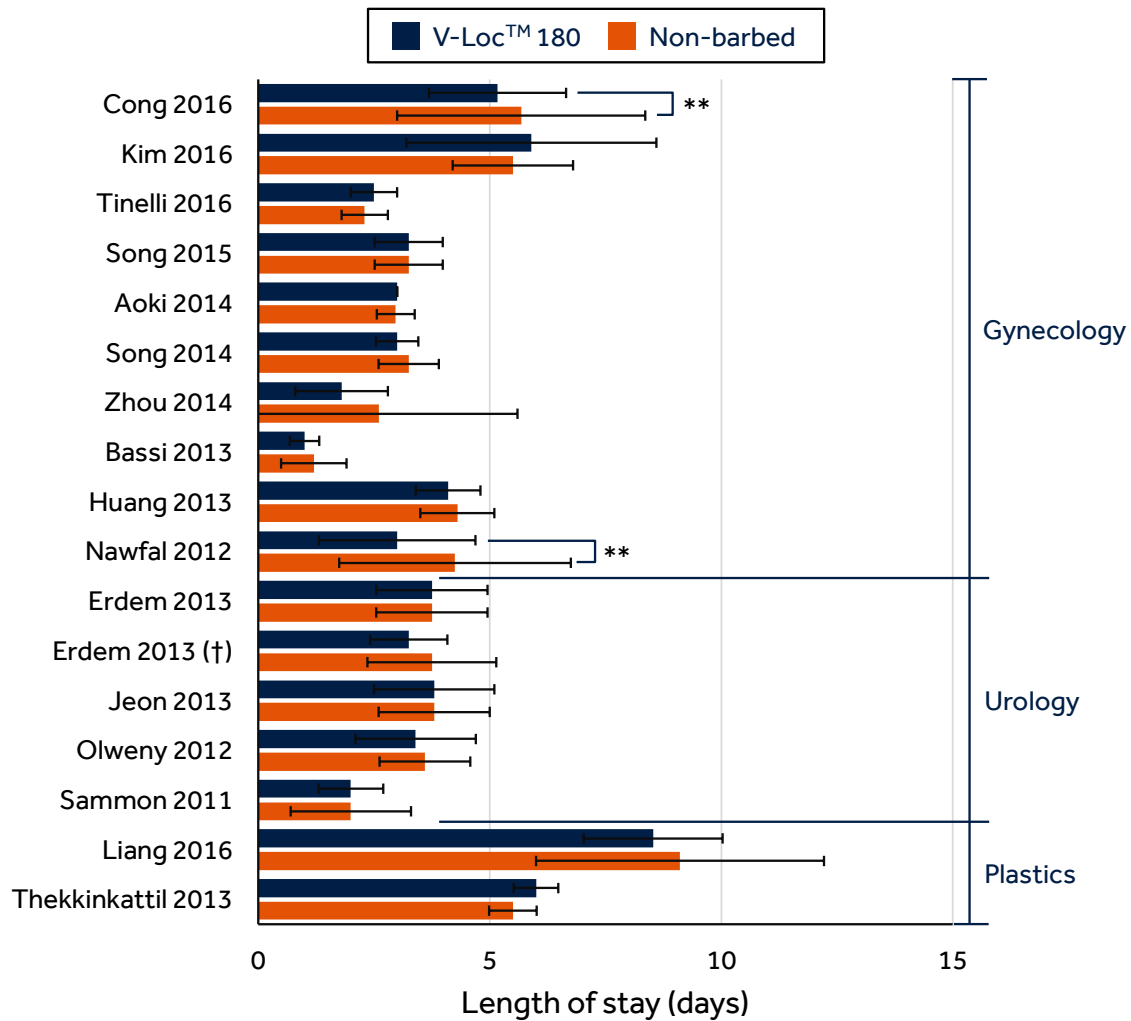


Results are shown for observed differences in estimated intra-operative blood loss in urological procedures. The urological procedures were partial nephrectomy (Jeon 2013,⁴² Erdem 2013,²⁹ Olweny 2012⁴³ and Sammon 2011⁴⁴) and radical prostatectomy (Gözen 2015⁴¹). The Erdem 2013²⁹ study presented analysis as a cohort analysis and a matched pair (†) analysis where comparisons were made in a 1:1 ratio between patients matched on additional parameters such as age, operative approach, and PADUA (preoperative aspects and dimensions used for an anatomic) classification score. All differences were non-significant (NS, $p > 0.05$).

3.3.3. Length of hospital stay

The length of hospital stay may be influenced by the treatment options used during surgical procedures. If an intervention changes the incidence or severity of adverse events, for example, the time spent in hospital after the procedure may be expected to change accordingly. Where length of stay outcome data have been reported, the use of the V-Loc™ 180 device has led to equivalent, or significantly lower hospital stays after treatment (Figure 3-13).

Figure 3-13 Length of patient hospital stay with V-Loc™ wound closure device and non-barbed suture use



Studies shown report patient length of hospital stay data with the use of V-Loc™ 180 wound closure devices compared to conventional non-barbed sutures. Surgical procedures under gynecology are hysterectomy (Cong 2016,³¹ Kim 2016,²⁰ Song 2014,²² Zhou 2014,³³ Bassi 2013,³⁸ Nawfal 2012³⁴) and myomectomy (Tinelli 2016,³⁵ Aoki 2014,³⁶ Song 2015,²⁴ Huang 2013³⁷). The urological procedures were partial nephrectomy (Jeon 2013,⁴² Erdem 2013,²⁹ Olweny 2012,⁴³ and Sammon 2011⁴⁴). The plastic surgery procedures were donor site closure during breast reconstruction (Thekkinkattil 2013⁴⁵). The Erdem 2013²⁹ study presented analysis as a cohort analysis and a matched pair (†) analysis where comparisons were made in a 1:1 ratio between patients matched on additional parameters such as age, operative approach, and PADUA (preoperative aspects and dimensions used for an anatomic) classification score. Significance is indicated adjacent to the bars: NS, non-significant ($p > 0.05$); * $p \leq 0.05$; ** $p \leq 0.01$).

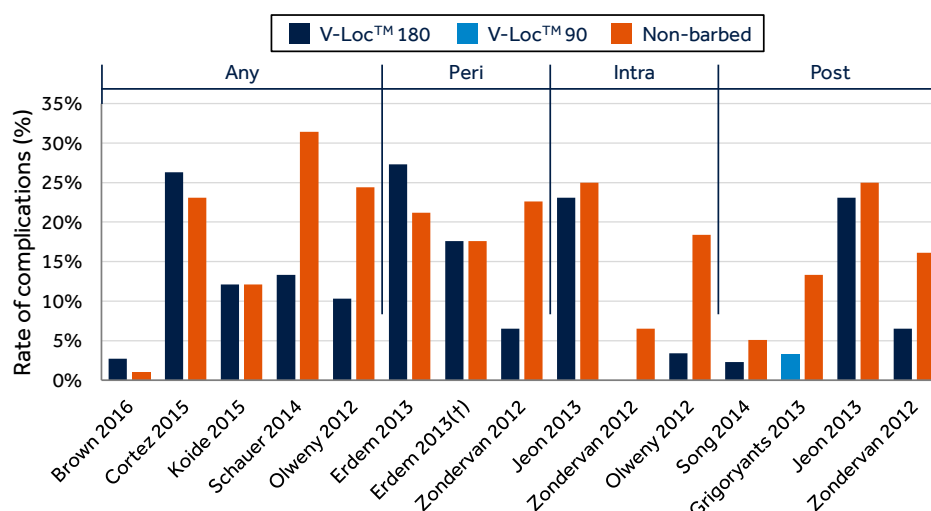
3.3.4. Complications

All surgical treatments carry some risk of developing complications. Depending on the study and the surgical area, complications may be described broadly as numbers of patients experiencing any type of adverse complication attributed to a treatment arm, or may quantify numbers of events, leaving open the possibility of patients experiencing multiple complications.

3.3.4.1. General

General complications include reports of numbers of patients who experienced any study-defined complication during the study period, which spans both peri-operative and follow-up periods. Increasing in specificity, the peri-operative period constitutes a time period around the procedure including the operation itself (intra-operative) and the period immediately after (the first post-operative hours). V-Loc™ wound closure devices have been investigated in comparison to non-barbed suture and across these described operative periods, the use of the V-Loc™ device has not led to any statistically-significant change in complication risk (Figure 3-14).

Figure 3-14 General complications associated with non-barbed and V-Loc™ wound closure devices

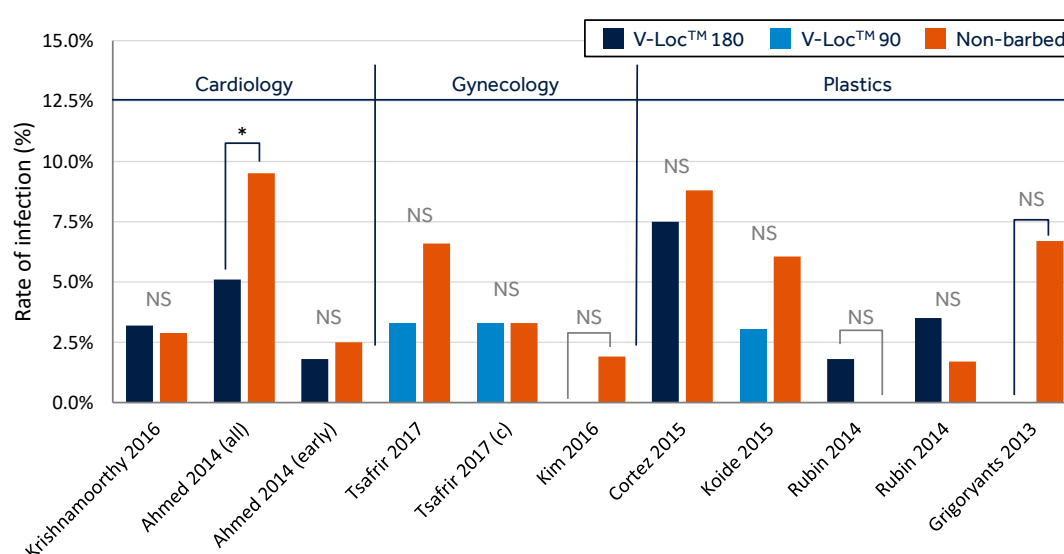


Complication rates are shown as described in the source publications. These include patients experiencing any complication attributed to the procedure (Any: Brown 2016,³² Cortez 2015,¹³ Koide 2015,²⁶ Schauer 2014,⁴⁶ Olweny 2012⁴³); those specifically defined as occurring within the peri-operative period (Peri: Erdem 2013,²⁹ Zondervan 2012⁴⁷); those occurring intra-operatively (Intra: Jeon 2013,⁴² Zondervan 2012,⁴⁷ Olweny 2012⁴³); and those occurring post-operatively (Post: Song 2014,²² Grigoryants 2013,²⁸ Jeon 2013,⁴² Zondervan 2012⁴⁷) complications (Intra- and Post- respectively). The "Any" label indicates any complication (major or minor) occurring among those examined in the respective papers. Brown 2016 (gynecology) includes dehiscence, cellulitis, bleeding, and granulation tissue.³² Cortez 2015 (plastics) includes infection, erythema, wound separation, seroma, hematoma, necrosis, and delayed wound healing.¹³ Koide 2015 (plastics) includes infection, hematoma, and wound break down as the only complications that occurred.²⁶ Schauer 2014 (urology) classified complications according to the Clavien-Dindo scale and most were minor (9 of 13 total Clavien-Dindo < 3) requiring no readmission or surgical intervention to resolve.⁴⁶ Olweny 2012 (urology) includes conversion to open, transfusions, embolization, and other non-specified complications.⁴³ The Erdem 2013²⁹ study presented analysis as a cohort analysis and a matched pair (t) analysis where comparisons were made in a 1:1 ratio between patients matched on additional parameters such as age, operative approach, and PADUA (preoperative aspects and dimensions used for an anatomic) classification score. None of the differences was reported to be statistically significantly different.

3.3.4.2. Infections

A common, specific complication recorded for different surgery types is the rate of surgical site infections (Figure 3-15). As previously mentioned (Section 2.2.1), the suture material, or knots when present may provide sites for bacteria to cause localized surgical site infections.^{13,14} V-Loc™ wound closure devices have been shown to have equivalent, to non-significantly lower rates of infection in different surgical areas. In cardiology, the use of V-Loc™ 180 wound closure devices led to a significant decrease in the number of overall infections compared to non-barbed suture.⁴⁸ Equivalent infection incidence was observed when accounting for differences in the number of catheter days, however, multivariate analysis of treatment arm parameters and demographics identified the suture type to be the only statistically-significant predictor of developing an surgical site infection ($p = 0.03$) with barbed suture associated with fewer infections than traditional suture.⁴⁸

Figure 3-15 Wound infection rates with non-barbed sutures and V-Loc™ wound closure devices

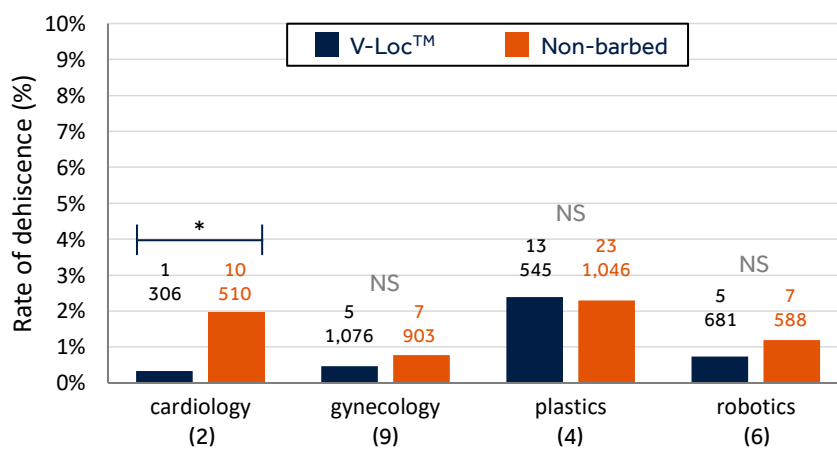


Results are shown for wound site infections with V-Loc™ 90 and V-Loc™ 180 wound closure devices compared to conventional non-barbed sutures. The cardiological procedures were donor leg wound closure after coronary artery bypass (Krishnamoorthy 2016⁴⁰ and after chest port placement (Ahmed 2014⁴⁸); gynecological procedures were hysterectomy (Tsafir 2017,³⁹ Kim 2016²⁰); plastic surgery procedures were body contouring, breast reconstruction and free flap (all in the study of Cortez 2015¹³), dermal closure (Rubin 2014²⁷), lipoabdominoplasty (Grigoryants 2013²⁸) and wound closure in various procedures (mostly abdominoplasty, Koide 2015²⁶). The study of Tsafir 2017³⁹ included comparisons with non-barbed suture alone, and to non-barbed suture with an additional Lapra-Ty™ clip (c), while the study of Ahmed 2014⁴⁸ reported infections over the entire duration of catheter days (all) and infections occurring within the first 30 days (early). Note that in the studies of Kim 2016²⁰ and Rubin 2014,²⁷ the missing bars correspond to zero subjects with infections in the V-Loc™ 180 and non-barbed suture arms respectively. The cardiology study of Ahmed 2014 explicitly excluded patient records with no complications and therefore represents only a relative, not absolute complication rate.⁴⁸ Significance is indicated above the bars: NS, non-significant ($p > 0.05$); * $p \leq 0.05$).

3.3.4.3. Dehiscence

A major concern with sutured wound closure is the potential for re-opening of the wound before it is healed. When sufficiently severe, this wound separation, or dehiscence requires major intervention such as wound packing, re-suturing, or surgery to correct. Studies have reported rates of dehiscence (requiring intervention) after wound repair when using V-Loc™ to compare to those obtained with non-barbed suture in cardiology,^{40,48} gynecology,^{20,21,23,31-33,39,49,51} and plastics surgery.^{13,27,45,52} These results have shown the rates of dehiscence with the V-Loc™ wound closure device to be equivalent to those of non-barbed suture. Results are presented as aggregate dehiscence rates, since multiple studies reported no cases of dehiscence in either treatment arm.^{20,23,31,39,49}

Figure 3-16 Rates of wound dehiscence with non-barbed sutures and V-Loc™ wound closure devices



Results of dehiscence reports were combined across studies. Shown above the bars are total numbers of patients with reported dehiscence requiring intervention over the total number of patients in the corresponding arm for the indicated surgical area. Aggregate rates are presented to incorporate studies where no incidents of dehiscence were recorded for either treatment arm,^{20,23,31,39,45,49} and for studies in which the type of V-Loc™ device (90 or 180) was not specified or results for both devices were mixed.^{13,51} Results are shown for cardiology,^{40,48} gynecology,^{20,21,23,31-33,39,49,51} plastics,^{13,27,45,52} and robotics, all of which were robot-assisted hysterectomy.^{21,32,33,39,49,51} The number of studies contributing to each surgical area is shown in parentheses. Note that the cardiology rates are comparative only, as one of the two studies⁴⁸ in its retrospective review excluded patients with no complications. Testing for differences using the Chi-squared test yielded statistical significance shown above: NS, (non-significant) $p > 0.05$; * $p \leq 0.05$.

4. Surgical applications of V-Loc™ wound closure devices

4.1. Overview

Summary and key messages

- **Applied in multiple surgical disciplines:** V-Loc™ wound closure devices have been compared to non-barbed sutures in 35 studies across gynecology,^{15,20-25,30-39,49,51} urology,^{29,41-44,46,47} plastic surgery,^{13,26-28,45,52,53} and cardiology,^{40,48} encompassing a total of 6,112 patients (2,857 V-Loc™ devices, 3,547 non-barbed devices).
- **Improved to maintained outcomes:** In none of the studies assessed were outcomes with conventional suturing significantly better than those with V-Loc™ devices.^{13,15,20-49,51-53}
- **V-Loc™ devices compared to conventional sutures in gynecology:**
 - Most studies across hysterectomy and myomectomy show significant reductions in suturing^{15,20-25} and operative^{22,24,31-37} time, while the remainder show equivalence (suture³⁹ and operative^{15,20,25,38,39}).
 - Estimated blood loss has been shown to be significantly lower^{24,25,30,31,33-35} and equivalent.^{20,22,32,36-39}
 - Length of hospital stay has been shown to be significantly shorter^{31,34} and equivalent.^{20,22,24,33,35-38}
 - Benefits demonstrated in time savings and blood loss are achieved with no increase in risks of infection,^{20,39} dehiscence,^{20,21,23,31-33,39,49,51} and post-operative bleeding.^{20,22,33,38,39}
- **V-Loc™ devices compared to conventional sutures in urology:**
 - Where suture times have been measured, these were significantly shorter with V-Loc™ devices.^{29,41}
 - Ischemia times in partial nephrectomy were significantly shorter in most studies that reported this outcome.^{29,42-44,46} One study reported equivalent times.⁴⁷
 - Operative time,^{29,41-44} estimated blood loss,^{29,41-44} and length of hospital stay^{29,42-44} were equivalent.
 - Measures of kidney function are improved significantly in early return to continence⁴¹ and non-significantly in estimated filtration rate.^{29,46,47}
- **V-Loc™ devices compared to conventional sutures in plastics:**
 - In all analyzed studies with data available, significantly shorter times for suturing²⁶⁻²⁸ and closure of individual layers^{27,28} were achieved.
 - Aggregated rates of complications reveal no increased risk of wound dehiscence,^{13,27,28,45,52} infection,^{13,26-28} erythema,^{13,27,28} seroma,^{13,27,28,45,52} or hematoma.^{13,27,52}
 - Wound drain volume was significantly lower^{45,53} and drain-free procedures are supported.⁵²
 - Cosmetic results from assessors blinded to device were found to be improved significantly²⁶ and non-significantly.²⁸
- **V-Loc™ devices compared to conventional sutures in cardiology:**
 - Two studies have reported outcomes for V-Loc™ devices and conventional sutures including results from 309 and 312 patients respectively.^{40,48}

- Skin closure time was significantly shorter.⁴⁰
- Dehiscence was both significantly lower⁴⁸ and equivalent.⁴⁰
- Infection rates (< 30 days) were comparable,^{40,48} however multivariate analysis including longer times post-surgery revealed suture type (V-Loc™ devices) to be the only statistically significant predictor of lower infection rates.⁴⁸

- **V-Loc™ devices compared to conventional sutures in robot-assisted surgery:**

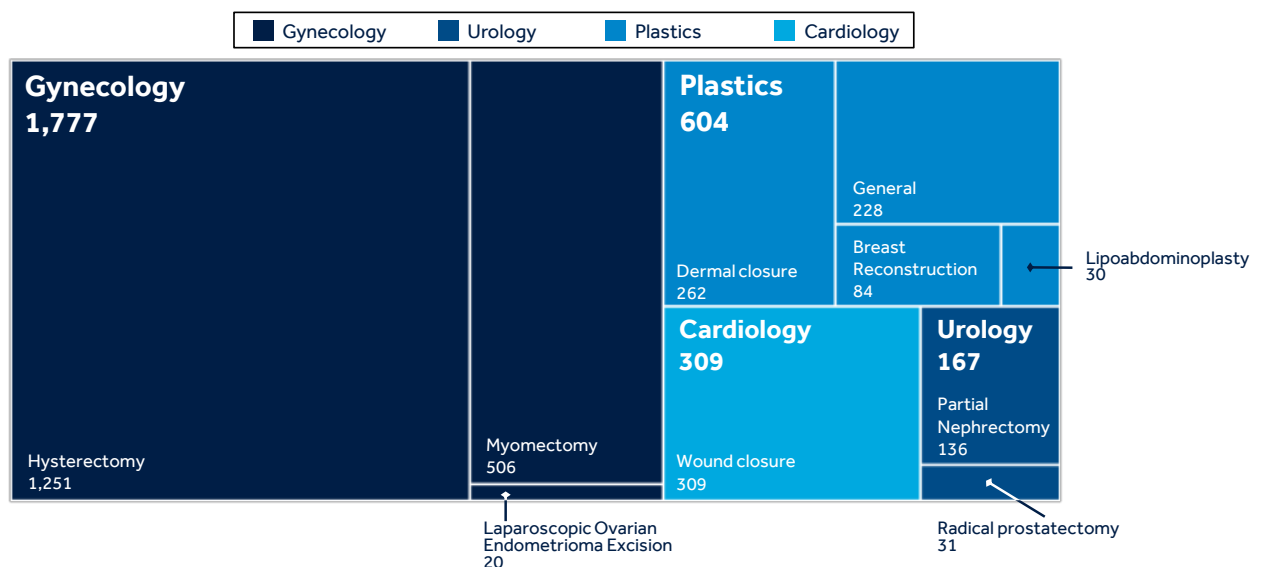
- Suture time was significantly reduced²¹ to equivalent.³⁹
- Operative time was reduced significantly in 3 of 5 studies³²⁻³⁴ and non-significantly reduced in the remaining.^{39,44}
- Blood loss was equivalent in 3 of 5 studies^{32,39,44} to significantly reduced in the remainder.^{33,34}
- Length of hospital stay was equivalent^{33,44} to significantly reduced.³⁴
- Complication rates, including major and minor events are not significantly affected.^{21,32-34,39,49,51}

*Note that statistically-significant differences do not automatically translate into clinically-relevant differences. Such determinations of clinical relevance are at the user's discretion.

V-Loc™ wound closure devices have been successfully applied in a number of surgical areas. Many of these results have been presented in Section 3.3, where comparisons between V-Loc™ wound closure devices and non-barbed sutures have been performed, categorized into surgical outcomes common across multiple surgical areas. In the following sections, some of these results will be revisited, but the focus is on outcomes of special relevance to individual surgical areas. Data are presented where multiple studies are available for analysis.

The surgical areas under consideration are gynecology,^{15,20-25,30-39,49,51} urology,^{29,41-44,46,47} plastic surgery,^{13,26-28,45,52,53} and cardiology.^{40,48} In total, across these investigations, 2,857 patients have been treated with V-Loc™ devices and had outcomes compared to those achieved with non-barbed sutures from 3,547 patients (Figure 4-1). Among these patients, a subset has also been treated in robot-assisted surgeries. These procedures fall within the gynecological^{21,32-34,39,49,51} and urological domains.⁴⁴ Note that these counts reflect only studies where direct comparisons between V-Loc™ wound closure devices and non-barbed sutures have been performed, and are therefore exclusive of single arm reports. The actual number of patients treated with V-Loc™ devices is therefore higher than that indicated here.

Figure 4-1 Surgical area overview of comparative V-Loc™ wound closure device studies in indicated procedures



Patients who have been treated with V-Loc™ wound closure devices in studies comparing outcomes with those from non-barbed sutures. Surgical areas are indicated in bold and procedures within each area are indicated in normal face. Patients numbers in the V-Loc™ device treatment arm are shown. In the "Plastics" surgical category, "general" includes breast reconstructions, body contouring, and free flap procedures, but these were not stratified to provide patient counts. BR, breast reconstruction; LAP, lipoabdominoplasty; PN, partial nephrectomy; RP, radical prostatectomy.

4.2. Gynecology

Patient outcomes in gynecological procedures comparing V-Loc™ wound closure devices to non-barbed suture have been most thoroughly reported for gynecological procedures. These 19 studies with 1,777 patients receiving V-Loc™ wound closure devices in comparison with 1,762 patients receiving non-barbed sutures include hysterectomy,^{20-23,31-34,38,39,49,51} myomectomy,^{15,24,25,35-37} and endometrioma excision.³⁰

4.2.1. Peri-operative outcomes

Data regarding comparisons between V-Loc™ wound closure devices and conventional sutures for suturing time (Figure 3-7), time to anchor the suture (Figure 3-8), operative time (Figure 3-9), estimated intra-operative blood loss (Figure 3-10), length of hospital stay (Figure 3-13) and overall complications (Figure 3-14) have been presented earlier in Section 3. Study results are summarized in (Figure 4-1). Results indicate V-Loc™ wound closure devices to result in significantly better to equivalent outcomes in the procedures and outcomes assessed. In none of the studies recovered did non-barbed suture yield statistically significantly better outcomes for suture time, operative time, intraoperative blood loss, or length of hospital stay. In one study where hospital stays were relatively short, authors instead calculated the odds ratio of a length of stay longer than one day.³⁴ They found through their retrospective analysis that the odds of such a stay of longer than 1 day to be 2.7 times higher for non-barbed sutures compare to V-Loc™ wound closure devices.³⁴

Table 4-1 Study summary data for V-Loc™ devices versus non-barbed suture in gynecology

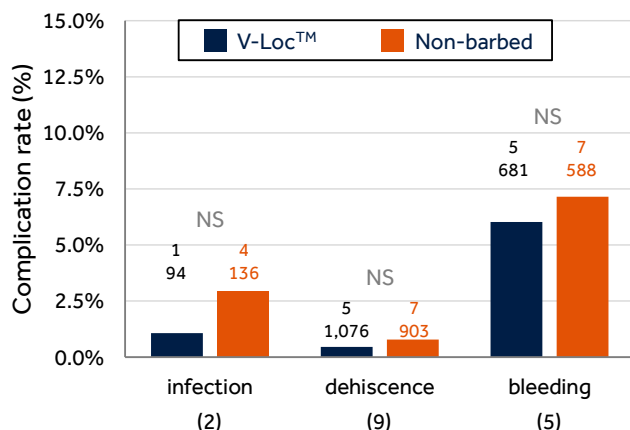
Parameter	Procedure	V-Loc™ device lower	Equivalent	Non-barbed suture lower
Suture time	Hysterectomy	4 studies (80%) ²⁰⁻²³	1 study (20%) ³⁹	0 studies (0%)
	Myomectomy	3 studies (100%) ^{15,24,25}	0 studies (0%)	0 studies (0%)
	LEOE	1 study (100%) ³⁰	0 studies (0%)	0 studies (0%)
Operative time	Hysterectomy	5 studies (62.5%) ^{22,31-34}	3 studies (37.5%) ^{20,38,39}	0 studies (0%)
	Myomectomy	4 studies (67%) ^{24,35-37}	2 studies (33%) ^{15,25}	0 studies (0%)
	LEOE	1 study (100%) ³⁰	0 studies (0%)	0 studies (0%)
Intra-operative blood loss	Hysterectomy	3 studies (37.5%) ^{31,33,34}	5 studies (62.5%) ^{20,22,32,38,39}	0 studies (0%)
	Myomectomy	3 studies (60%) ^{24,25,35}	2 studies (40%) ^{36,37}	0 studies (0%)
	LEOE	1 study (100%) ³⁰	0 studies (0%)	0 studies (0%)
Length of stay	Hysterectomy	2 studies (33%) ^{31,34}	4 studies (67%) ^{20,22,33,38}	0 studies (0%)
	Myomectomy	0 studies (0%)	4 studies (100%) ^{24,35-37}	0 studies (0%)

Summary data are presented by study for hysterectomy (12 studies),^{20-23,31-34,38,39,49,51} myomectomy (6 studies),^{15,24,25,35-37} and LEOE (1 study)³⁰ where comparisons between V-Loc™ wound closure devices and non-barbed sutures in gynecological procedures were reported. Missing studies from any outcome indicate data were not reported. "Lower" indicates reported statistically significantly lower results, taken as p-value ≤ 0.05 as reported inference testing. LEOE, laparoscopic excision of ovarian endometrioma.

4.2.2. Complications

Combining results across studies (procedures and V-Loc™ wound closure devices), weighted average complication rates for infection, dehiscence, and post-operative bleeding are comparable to non-barbed sutures (Figure 4-2).

Figure 4-2 Mean gynecological complication rates with V-Loc™ devices compared to non-barbed sutures



Weighted average complication rates are presented as the total number of events for each over the total number of patients in each arm (V-Loc™ device versus non-barbed sutures). The number of studies contributing to each complication outcome is shown in parentheses. Data are from studies that reported outcomes for infection,^{20,39} dehiscence,^{20,21,23,31-33,39,49,51} and post-operative bleeding.^{20,22,33,38,39} NS, non-significant.

4.3. Urology

In the surgical area of urology, seven studies have performed comparison between V-Loc™ wound closure devices (167 patients) and non-barbed suture (167 patients). The included procedures were partial nephrectomy^{29,42-44,46,47} and radical prostatectomy.⁴¹

4.3.1. Peri-operative outcomes

Earlier in Section 3, data were presented of comparisons between V-Loc™ wound closure devices and non-barbed sutures for suturing (Figure 3-7) and operative time (Figure 3-8), estimated intra-operative blood loss (Figure 3-12), length of hospital stay (Figure 3-13) and overall complications that included results from urological studies (Figure 3-14). Study results are summarized in (Table 4-2). Across these reports, V-Loc™ wound closure devices are equivalent to non-barbed sutures in operative time, intra-operative blood loss, and length of hospital stay, with significantly lower suture times seen in the two studies reporting such data.^{29,41} Note that among the partial nephrectomy publications, in one study by Erdem 2013, this equivalence was achieved for these parameters despite significantly larger mean tumor size in the V-Loc™ device group compared to the non-barbed group ($p = 0.009$).²⁹ In no report did non-barbed sutures achieve significantly better performance among these parameters.

Table 4-2 Study summary data for V-Loc™ devices versus non-barbed suture in urology

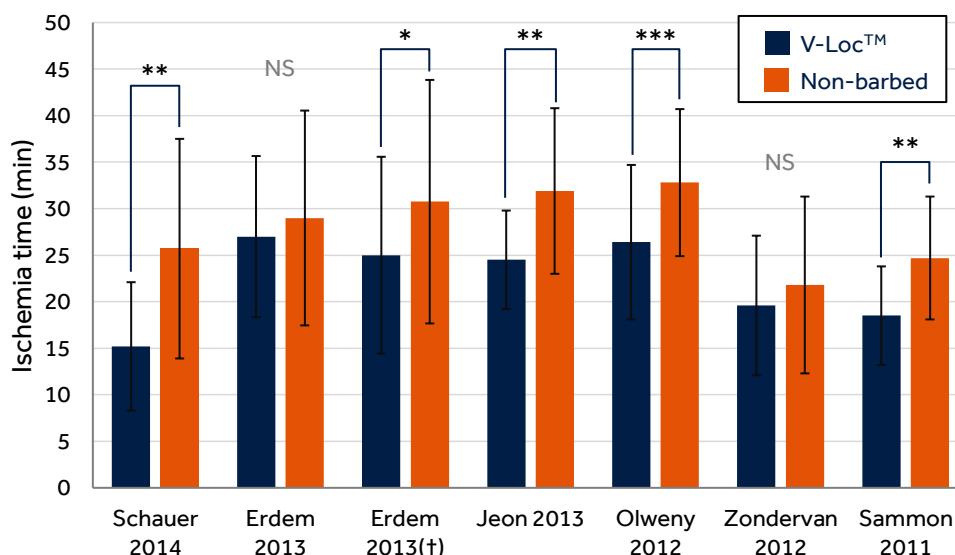
Parameter	Procedure	V-Loc™ device lower	Equivalent	Non-barbed suture lower
Suture time	Partial nephrectomy	1 study* (100%) ²⁹	0 studies (0%)	0 studies (0%)
	Radical prostatectomy	1 study (100%) ⁴¹	0 studies (0%)	0 studies (0%)
Operative time	Partial nephrectomy	0 studies (0%)	4 studies (100%) ^{29,42-44}	0 studies (0%)
	Radical prostatectomy	0 studies (0%)	1 study (100%) ⁴¹	0 studies (0%)
Intra-operative blood loss	Partial nephrectomy	0 studies (0%)	4 studies (100%) ^{29,42-44}	0 studies (0%)
	Radical prostatectomy	0 studies (0%)	1 study (100%) ⁴¹	0 studies (0%)
Length of stay	Partial nephrectomy	0 studies (0%)	4 studies (100%) ^{29,42-44}	0 studies (0%)

Summary data are presented by study for partial nephrectomy (6 studies total)^{29,42-44,46,47} and radical prostatectomy (1 study)⁴¹ where comparisons between V-Loc™ wound closure devices and non-barbed sutures were performed. Missing studies from any outcome indicate data were not reported. "Lower" indicates reported statistically significantly lower results, taken as p-value ≤ 0.05 as reported inference testing. *In the Erdem 2013²⁹ study, the significantly lower suture time was obtained from the matched pair analysis, where comparisons were made in a 1:1 ratio between patients matched on additional parameters such as age, operative approach, and PADUA (preoperative aspects and dimensions used for an anatomic) classification score. In the non-matched group, the V-Loc™ device group had a statistically significantly larger mean tumor size (p = 0.009).²⁹

4.3.2. Time parameters

During partial nephrectomy for the removal of neoplasia, blood flow through the kidney is interrupted in intraoperative ischemia. This ischemia, during which the kidneys are held at body temperature (warm) or chilled (cold) is applied for better visualization and to minimize blood loss during tumor excision.⁴⁶ The duration of this interruption (the ischemia time) is of clinical interest, as authors have identified the duration of this surgical step to be a key modifiable predictor of renal function after nephron sparing surgery, and suggest there is a generally accepted principle that this time should be reduced.²⁹ In this regard, comparative studies where the data have been reported have shown a trend towards shorter ischemia times with V-Loc™ wound closure devices compared to non-barbed sutures (Figure 4-3).^{29,42-44,46,47} These time reductions were significant in 5 of 6 studies,^{29,42-44,46} while in the remainder, the observed decreases in ischemia time were not significantly different.⁴⁷

Figure 4-3 Partial nephrectomy ischemia time with V-Loc™ devices compared to non-barbed sutures

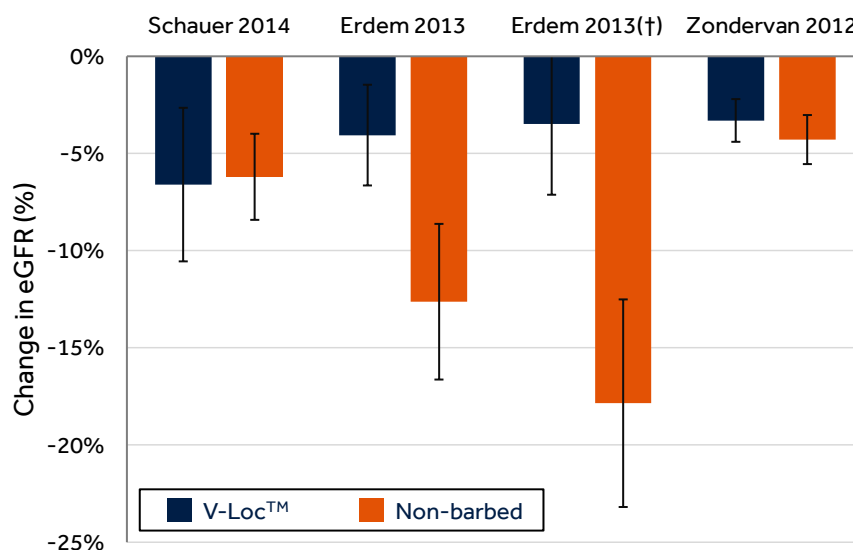


Reported warm (Erdem 2013,²⁹ Jeon 2013,⁴² Olweny 2012,⁴³ Sammon 2011,⁴⁴ and Zondervan 2012⁴⁷), and cold (Schauer 2014⁴⁶) ischemia times are shown for studies reporting comparative data between V-Loc™ wound closure devices and non-barbed sutures. The Erdem 2013²⁹ study presented analysis as a cohort analysis and a matched pair (†) analysis where comparisons were made in a 1:1 ratio between patients matched on additional parameters such as age, operative approach, and PADUA (preoperative aspects and dimensions used for an anatomic) classification score. Significance is indicated above the bars: NS, non-significant ($p > 0.05$); * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

4.3.3. Kidney function

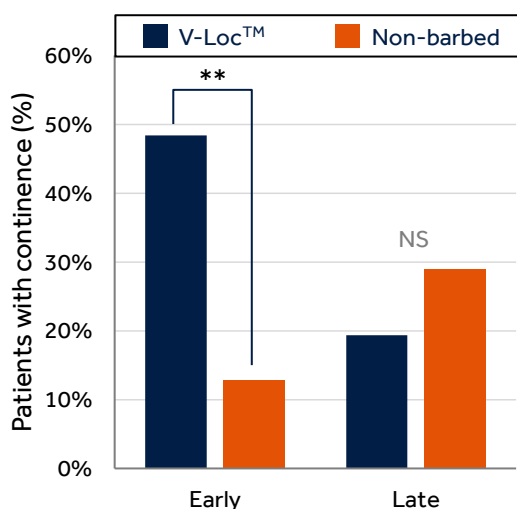
As a post-operative outcome, the function of the kidney is a natural consideration after urological procedures. In partial nephrectomy, common characterizations of kidney function are measured blood levels of creatinine, or the estimated glomerular filtration rate, or eGFR. Studies that have measured changes in eGFR after partial nephrectomy comparing V-Loc™ devices to non-barbed sutures devices (Figure 4-4). After radical prostatectomy, the return to continence is a reported measure (Figure 4-5). In both cases, the use of V-Loc™ wound closure devices in comparison to non-barbed sutures yielded comparable impact on kidney eGFR after partial nephrectomy^{29,46,47} and significantly more patients returning to continence sooner after radical prostatectomy.⁴¹

Figure 4-4 Change in eGFR after partial nephrectomy with V-Loc™ wound closure devices versus non-barbed suture



The mean change in estimated eGFR after partial nephrectomy is shown as a percentage of the baseline pre-operative eGFR, with error bars representing standard error of the mean (SEM). All comparisons were not statistically significantly different ($p > 0.05$). eGFR, estimated glomerular filtration rate.

Figure 4-5 Timepoint of return to continence with V-Loc™ wound closure devices versus non-barbed sutures



In a study of radical prostatectomy, patient numbers were recorded for the timepoint at which they returned to continence post-surgery.⁴¹ The early period was defined as 0-3 months and the late period as 13-24 months.⁴¹ A higher proportion of patients in the early continence period is associated with a faster return to normal functioning compared to patients who only return to continence later after surgery.

4.4. Plastic surgery

A wide variety of plastic surgery procedures have seen investigations of V-Loc™ wound closure device outcomes compared to those for non-barbed sutures. Here, results from 7 reports including 604 patients receiving V-Loc™ devices have been compared to outcomes for 1,106 patients receiving non-barbed sutures. In some of these studies where bilateral procedures were performed, patients served as their own controls by randomization of which side of the patient is treated with which device. The procedures under consideration were breast reconstruction,^{45,52,53} general dermal or wound closure,^{26,27} lipoabdominoplasty,²⁸ and a study combining results for breast reconstructions, body contouring, and free flap surgeries.¹³

4.4.1. Peri-operative outcomes

Of the 7 plastic surgery investigations, 3 were randomized controlled trials with bilateral procedures where patients served as their own controls (device randomized to one side).²⁶⁻²⁸ In such cases, overall operative parameters such as total blood loss or total operative time cannot be stratified by device since both were used in the same procedure. The time required for suturing, however, can be attributed to individual devices and has been shown to be significantly shorter where V-Loc™ devices were used, compared to non-barbed sutures (Figure 4-6).

In two studies where suture devices were used in different patient groups, data were collected on length of hospital stay (Figure 4-7).^{45,53} The outcome was not significantly different between the two treatment groups, indicating that the use of V-Loc™ devices did not significantly increase the risk of a longer hospital stay compared to non-barbed sutures.

Figure 4-6 Suturing time in plastic surgery procedures with V-Loc™ devices and conventional sutures

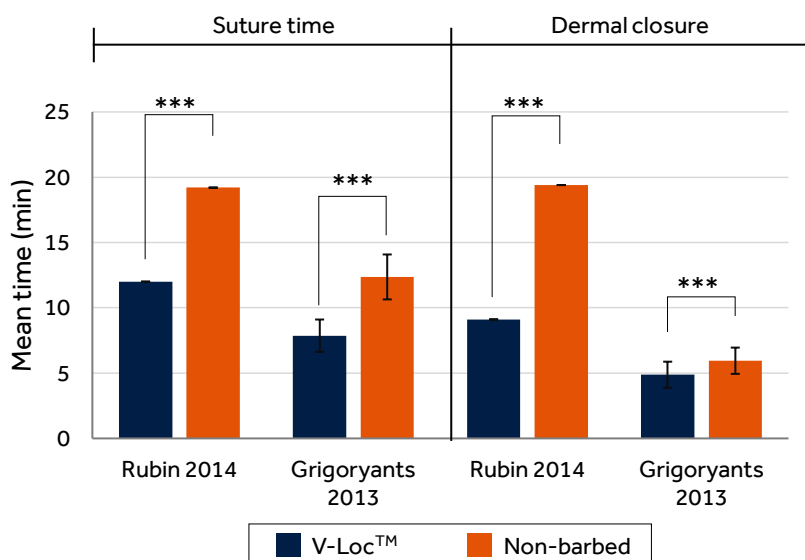
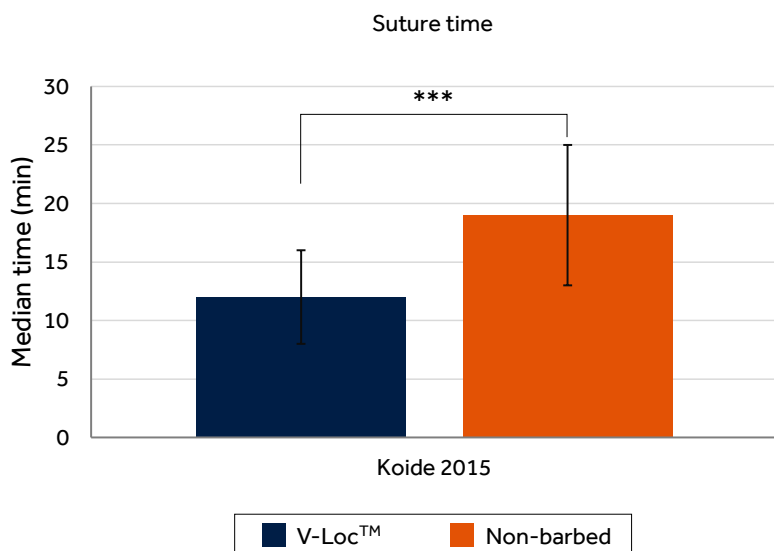
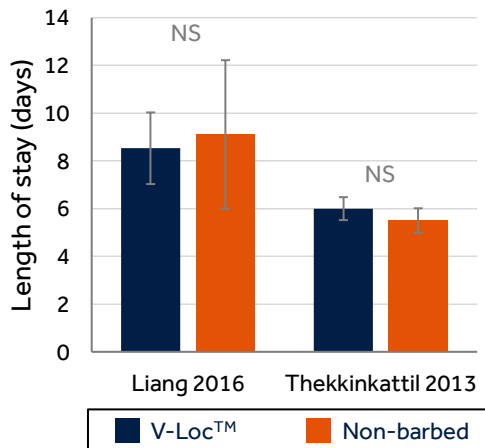


Fig4-6b
Mean (SD) suture and dermal closure time

Data are shown from comparative V-Loc™ wound closure device and conventional suture studies where the suturing time was recorded. Koide 2015²⁶ reported median time, while the others (Rubin 2014,²⁷ and Grigoryants 2013²⁸) reported mean time, and are therefore presented separately, for clarity. In the comparisons, suture time (Koide 2015,²⁶ Rubin 2014,²⁷ Grigoryants 2013²⁸) refers to total suture time, while dermal closure correspond to times described as dermal closure where deep dermal sutures were not used (Rubin 2014)²⁷ and upper dermis closure time (Grigoryants 2013).²⁸ Significance is indicated above the comparisons, *** $p \leq 0.001$.

Figure 4-7 Length of hospital stay in plastic surgery procedures with V-Loc™ devices and conventional sutures

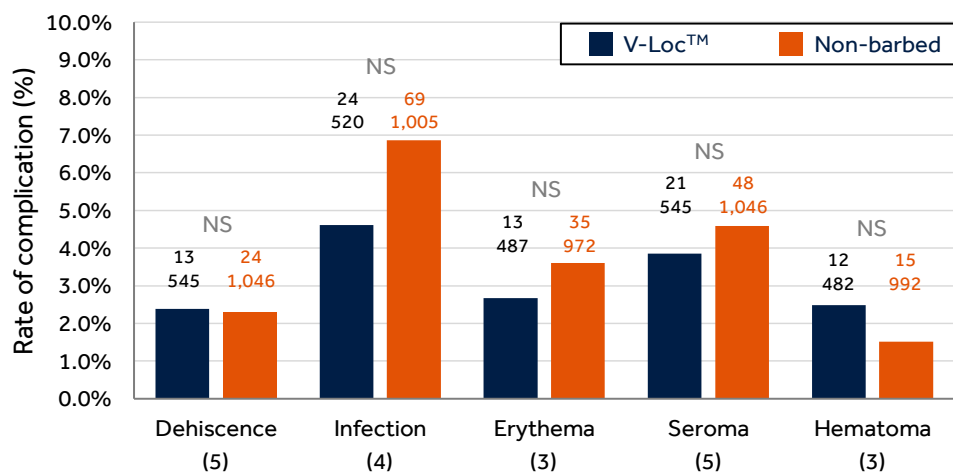


Data are shown from studies where lengths of stay were reported from V-Loc™ wound closure devices and non-barbed sutures in separate patient groups.^{45,53} In the study of Thekkinkattil 2013, twice as many patients underwent reconstruction as an immediate procedure in the V-Loc™ device group compared to the conventional suture group (20 vs 10 patients), although this difference was not significant. Neither comparison yielded statistically significant differences (NS, non-significant, $p > 0.05$).

4.4.2. Complications

Plastic surgeries may be performed for various reasons, for example as elective cosmetic procedures^{13,26,27} or as part of cancer management (reconstructive breast surgery).^{13,52,53} The corresponding complications of interest will therefore vary, and will include specific complications of special interest to the plastic surgery domain such as cosmesis.^{26,54}

Figure 4-8 Aggregate rates of complications for V-Loc™ wound closure devices and non-barbed sutures in plastic surgery procedures



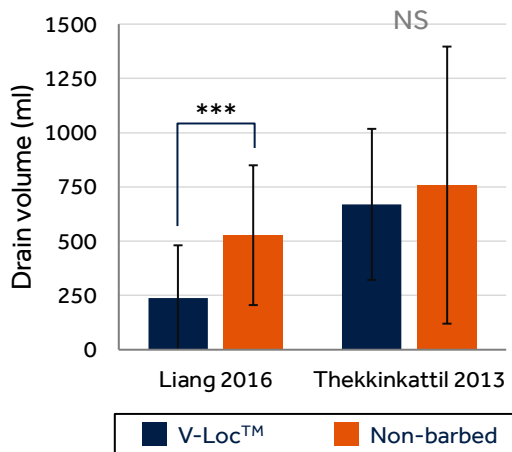
Rates of complications are shown across studies of soft tissue approximation during plastic surgery procedures where the complications have been reported: wound dehiscence,^{13,27,28,45,52} infection,^{13,26-28} erythema,^{13,27,28} seroma,^{13,27,28,45,52} and hematoma.^{13,27,52} The number of studies contributing to each comparison is shown in parentheses. Above the comparisons, counts of events are shown above total numbers of patients or treatment cases. Differences were not statistically significant (NS, $p > 0.05$ by Chi-squared test).

For outcomes presented across multiple studies, complication rates are presented as aggregates (Figure 4-8). Total numbers of events are divided by the total number of patients, or by the number of treatment cases in studies where the two sides of the same patient served as study and control. This mean weighted rate incorporates data from studies where zero events were recorded in each arm. Data from multiple studies were available for wound dehiscence,^{13,27,28,45,52} infection,^{13,26-28} erythema,^{13,27,28} seroma,^{13,27,28,45,52} and hematoma.^{13,27,52}

4.4.3. Wound management in reconstructive surgery

As mentioned above, breast reconstruction is one type of surgery in which soft tissue approximation with V-Loc™ wound closure devices has been investigated in comparison to conventional sutures.^{45,52,53} As part of the procedure, sections of tissue from elsewhere on the body were harvested, resulting in wounds at the donor site in need of management. The removal of such large sections of tissue can create dead spaces in which fluid may accumulate, and drains may be placed to remove this excess fluid with the aim of reducing risk of seroma.^{52,55} While the merits of drain usage are still debated, a general aim to improve patient outcomes after abdominal procedures is to reduce the potential for fluid accumulation by reducing dead spaces, or to perform suturing (progressive tension sutures or PTS) in such a way as to obviate the need for drains.^{52,56} Benefits of avoiding drains include improved patient mobility, less care management if drains are still present after discharge, and removing a potential route of entry for infections.⁵² When used, authors have proposed early drain removal to improve patient outcomes.^{52,57} The volume collected from drainage should also be ideally reduced, as this reduction will promote earlier drain removal.⁵³ Studies examining V-Loc™ wound closure devices in comparison with conventional sutures have found their use to contribute to no-drain procedures.⁵² In this study, an investigation was undertaken of the PTS technique to avoid drains, and then the use of V-Loc™ devices with this suturing method.⁵² While the benefits of PTS to reduce complications of seroma have been demonstrated, the authors added barbed sutures "to minimize the cost of additional operative time" required with PTS. In separate studies where drains were used, authors compared drain volumes between V-Loc™ wound closure devices and non-barbed sutures, revealing that the use of the barbed suture significantly⁵³ and non-significantly⁴⁵ reduced the volume collected in the drains (Figure 4-9). The use of V-Loc™ wound closure devices has therefore been shown both to contribute to drain-free procedures and to the reduction of drain volume, which may aid in instilling confidence in surgeons using drains who are looking to forgo their use altogether.⁵³

Figure 4-9 Differences in wound drainage volume between patients treated with V-Loc™ wound closure devices and non-barbed sutures



Volume collected in abdominal (Liang 2016)⁵³ and back (Thekkinkattil 2013)⁴⁵ was reported for V-Loc™ wound closure devices versus non-barbed sutures for donor site closure after different forms of breast reconstruction surgery. Significance is shown above the comparisons: NS, non-significant ($p > 0.05$); *** $p \leq 0.001$.

4.5. Cardiology

Two studies have examined the impact of suture type (V-Loc™ wound closure device versus non-barbed suture) in procedures relevant to cardiology, namely, wound closure after radiologically placed chest ports⁴⁸ and in the donor leg after coronary artery bypass graft surgery.⁴⁰ Together, these studies present results for 309 patients who received V-Loc™ devices compared to 312 who received non-barbed suture. With relatively fewer reports (in comparison to gynecology with 19 and urology with 7), fewer conclusions regarding outcomes with V-Loc™ wound closure devices compared to non-barbed sutures can be generalized. From these reports, comparable results were obtained between the two technologies for operative time (Figure 3-10)⁴⁰ and some infections (Figure 3-15, early infections⁴⁸ and deep wound infections⁴⁰). Many parameters such as suture time, intra-operative blood loss, and length of hospital stay were not reported. For overall complications, one study found no major complications in either treatment arm,⁴⁰ while the other retrospective study specifically excluded patient records with no complications, as the investigation focused on identification of risk factors.⁴⁸ In this study, reported rates are therefore comparative only and do not reflect an absolute complication rate.⁴⁸

Where statistically significant differences between V-Loc™ devices and non-barbed sutures were found, these indicated improved performance for the V-Loc™ wound closure device. With V-Loc™ devices compared to non-barbed sutures respectively, skin closure time (not explicitly described as suture time only) was faster (5.95 versus 10.67 minutes, $p < 0.001$),⁴⁰ dehiscence was both significantly lower (0% versus 1.6%),⁴⁸ and equivalent (3.0% versus 4.4%),⁴⁰ and the proportion of total (5.1% versus 9.5%) and local (0.4% versus 2.7%) infections was lower.⁴⁸ In the latter study of infections, the authors noted a significantly shorter catheter time with the V-Loc™ device group compared to the non-barbed group, which may partially explain the lower proportion of infections encountered; however, in multivariate analysis taking the number of catheter days into account, the suture type (V-Loc™ device versus non-barbed suture) was the only significant independent risk factor for infection ($p = 0.03$).⁴⁸

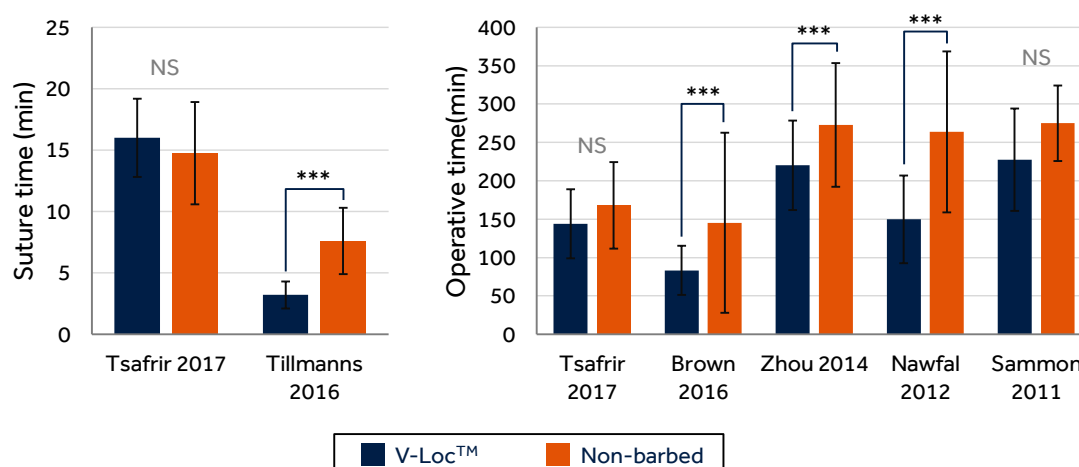
4.6. Robot-assisted surgeries

Surgeries with robot assistance where V-Loc™ wound closure devices have been compared to non-barbed sutures include gynecological (hysterectomy)^{21,32-34,39,49,51} and urological (partial nephrectomy)⁴⁴ procedures. These 8 studies include outcomes of 614 patients receiving V-Loc™ wound closure devices in comparison to 683 patients in non-barbed suture study arms. It should be noted that one of these reports, the retrospective study of Brown et al., 2016 consisted of both robotic (224 patients with V-Loc™ devices and 46 non-barbed sutures) and non-robotic (151 V-Loc™ devices, 53 non-barbed sutures) hysterectomies, constituting 57% and 43% of procedures, respectively.³² Demographic analysis of the groups found significant differences in baseline characteristics between the treatment groups. The patients treated with V-Loc™ devices compared to those with non-barbed sutures were older (53.4 ± 11.3 years versus 48.3 ± 9.5 years, $p < 0.001$), and the indications for surgery were also different. In the V-Loc™ device treatment group, more patients were indicated for surgery due to known or suspected malignancy (32.8% versus 18.2%, $p = 0.004$) and fewer were for uterine fibroids (31.7% versus 52.5%, $p < 0.001$).³² These differences in baseline characteristics may confound conclusions drawn from assessment of the performance of the two devices. Data are subsequently presented for outcomes as previously shown throughout Section 3.3, grouped for any procedure (gynecologic or urologic) where robot assistance was involved.

4.6.1. Time parameters

For time parameters (Figure 4-10), V-Loc™ wound closure devices have been reported to be associated with equivalent³⁹ and significantly reduced²¹ suturing times compared to non-barbed sutures. In total operative time reports, 3 of 5 studies showed significantly reduced times for V-Loc™ devices compared to non-barbed sutures,³²⁻³⁴ while the remaining 2 studies reporting this outcome demonstrated equivalence.^{39,44}

Figure 4-10 Time parameters in robot-assisted surgeries for V-Loc™ devices and non-barbed sutures

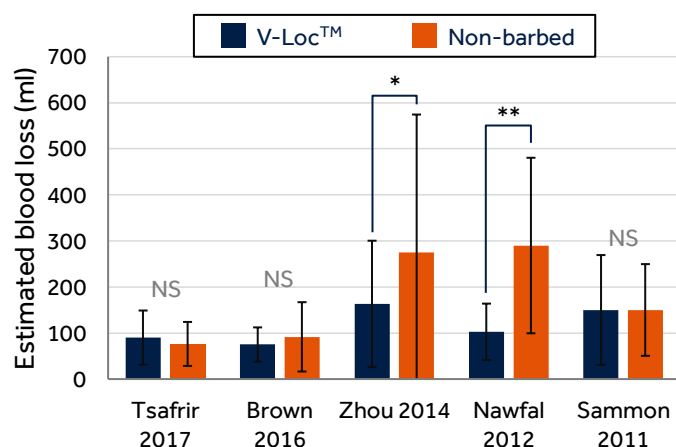


Data are shown for studies of robot-assisted procedures where suture time (left; Tsafrir 2017³⁹ and Tillmanns 2016²¹) and total operative time (right; Tsafrir 2017,³⁹ Brown 2016,³² Zhou 2014,³³ Nawfal 2012,³⁴ and Sammon 2011⁴⁴) were reported for comparisons between V-Loc™ wound closure devices and non-barbed sutures. Significance is shown above the comparisons: NS, non-significant ($p > 0.05$); *** $p \leq 0.001$.

4.6.2. Other peri-operative outcomes

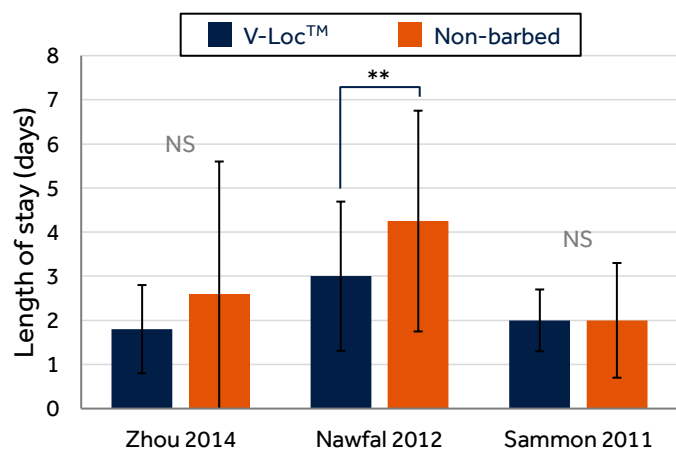
Analysis of robot-assisted surgeries for estimated blood loss (Figure 4-11) and length of hospital stay (Figure 4-12) demonstrated similar results in comparisons of V-Loc™ wound closure devices and non-barbed sutures, where all results ranged from significantly improved to equivalent.^{32-34,39,44} In estimated blood loss, significant reductions were seen in 2 of 5 studies for V-Loc™ devices compared to conventional sutures,^{33,34} while the remainder showed equivalence.^{32,39,44} In length of hospital stay data, a significantly shorter duration of hospitalization was associated with V-Loc™ devices over conventional sutures in 1 of 3 studies,³⁴ while the remainder demonstrated equivalence.^{33,44}

Figure 4-11 Estimated blood loss in robot-assisted surgeries for V-Loc™ devices and non-barbed sutures



In studies comparing estimated intra-operative blood loss between patients treated with V-Loc™ wound closure devices and non-barbed sutures,^{32-34,39,44} significance is shown above the comparisons: NS, non-significant ($p > 0.05$); * $p \leq 0.05$; ** $p \leq 0.01$.

Figure 4-12 Length of hospital stay in robot-assisted surgeries for V-Loc™ devices and non-barbed sutures

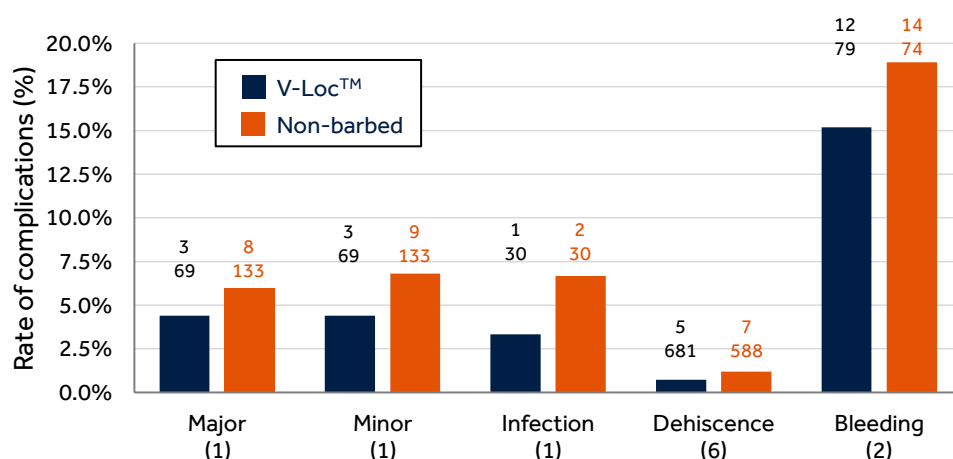


In studies comparing length of hospital stay between patients treated with V-Loc™ wound closure devices and non-barbed sutures,^{33,34,44} significance is shown above the comparisons: NS, non-significant ($p > 0.05$); ** $p \leq 0.01$.

4.6.3. Complications

Complications related to surgical procedures may be reported generally or as specific types, depending on the nature of the procedure. Individual studies examining robot-assisted procedures comparing V-Loc™ wound closure devices to conventional sutures have reported overall complications (inclusive of dehiscence, granulation, bleeding, and cellulitis),³² with complications classified as major or minor,^{33,34} and for the specific outcome of infections (Figure 4-13).³⁹ Rates of complications can also be aggregated across multiple studies as total numbers of reported events over total patient numbers (Figure 4-13), and in robotic procedures, such analysis was possible for dehiscence^{21,32,33,39,49,51} and post-operative bleeding.^{33,39} Across all studies, differences between the use of V-Loc™ wound closure devices and non-barbed sutures were not significantly different, and often numerically, non-significantly lower.^{21,33,39,49,51} As previously noted, in the one case where complications were not numerically lower with V-Loc™ devices compared to non-barbed devices, the V-Loc™ wound closure device group exhibited potentially confounding characteristics significantly different than in the control population, such as older and more cases of malignancy as the surgical indication.³² These results indicate that the use of V-Loc™ wound closure devices in place of conventional sutures does not increase rates of complications.

Figure 4-13 Rates of complications in robot-assisted surgeries for V-Loc™ devices and non-barbed sutures



Data are shown from individual studies or aggregated where multiple are available for complications reported in publications examining robotic surgeries and performing comparisons between V-Loc™ wound closure devices and non-barbed sutures. "Overall" complications in the reporting study, included patients experiencing dehiscence, cellulitis, bleeding and granulation after hysterectomy.³² Other complications included major (complications requiring surgical intervention) and minor (spontaneously resolving or requiring no intervention).³⁴ Specific complications were determined for infection,³⁹ dehiscence,^{21,32,33,39,49,51} and post-operative bleeding.^{33,39} Above the bars, counts of events are shown above the total number of patients in the corresponding treatment arm. None of the differences was statistically significant ($p > 0.05$).

5. Economic impact of the V-Loc™ wound closure device in patient care

5.1. Overview

Summary and key messages

- **V-Loc™ wound closure devices are cost-saving to cost neutral in gynecology:** In studies (in gynecology) where cost data were reported, the use of V-Loc™ barbed suture technology was found to be cost saving for vaginal cuff closure²¹ to equivalent over entire robotic hysterectomy procedures.³⁹
- **Material costs with V-Loc™ devices are not necessarily increased:** Although the suture cost with V-Loc™ devices is typically higher than that for non-barbed suture alone, the use of clips to achieve the knotless fixation provided by V-Loc™ may result in higher material costs.^{39,49}
- **Suturing time reduced with V-Loc™ devices compared to non-barbed sutures:** Analysis across multiple studies reveals V-Loc™ wound closure devices to significantly decrease suturing time in the surgical areas of gynecology,^{15,20-25,30,39} and plastics,²⁶⁻²⁸ with non-significant decreases in urology^{29,41} in comparison to the use of non-barbed sutures.
- **Overall operative time reduced or equivalent with V-Loc™ devices compared to non-barbed sutures:** Overall operative time has been shown to be significantly decreased in analysis across gynecology^{15,20,22,24,25,30-39} where 10 of the 15 studies independently reported significant decreases^{22,24,30-37}
- **Significantly lower surgical difficulty:** Both for the specific task of suturing,^{24,30} and for the operative procedure overall,^{15,22,24} the use of V-Loc™ wound closure devices has demonstrated significantly lower ratings of surgical difficulty compared to conventional non-barbed sutures.

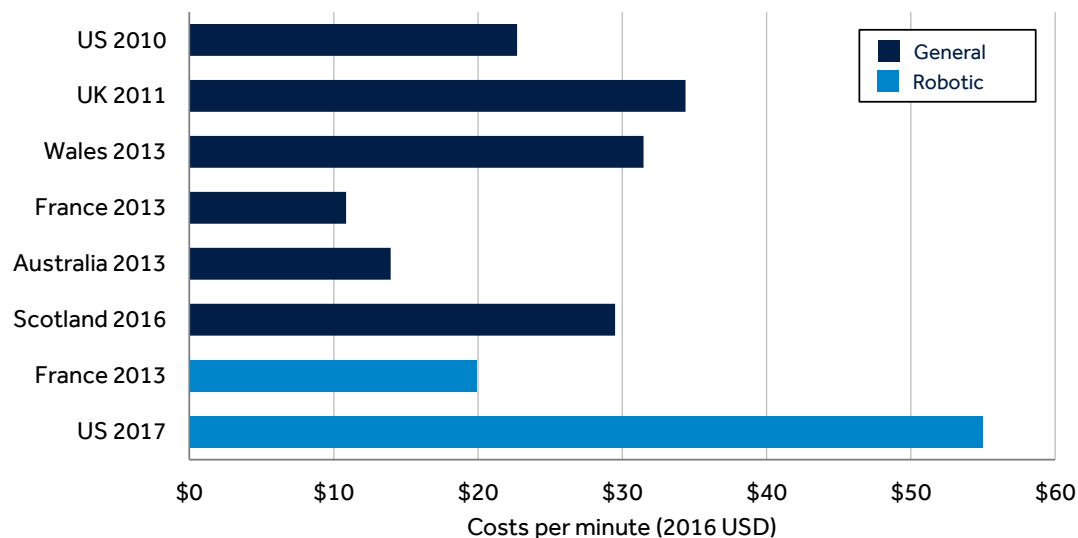
5.2. Health economics of surgery

Patient outcomes, including safety considerations, benefits or risk of complications are factors often included when considering alternatives for intervention or treatment. At the same time, economic implications must also be considered given finite resources that must be distributed among patients. The health economics of surgery seeks to balance patient benefits with costs and resource allocation considerations.

For any surgery, costs are comprised of fixed and variable components.⁵⁸ Fixed components in a hospital setting may include administration, building rental, capital equipment and staffing salaries and these costs are not likely to be influenced by changes in surgical intervention or volume. Variable costs on the other hand, may include direct costs for consumables or consumption of hospital resources and these may change with procedure volume.⁵⁸ One example is operating room occupancy, where longer procedures can be considered to consume more facility resources and thereby contribute to total procedure costs. As an economic quantification of this consumption, operating room costs have been reported and they vary by setting (Figure 5-1). In seeking cost-saving strategies, the variable costs per procedure, which will include factors such as operative time and resource utilization, post-operative

complications, and patient experience⁵⁸ are one area more readily targeted than fixed costs. Changes to procedures that may reduce components of the variable costs (operating room time or complications for example) have the potential to save money for healthcare providers.

Figure 5-1 Operating costs per minute in various settings



Studies where costs (not charges) have been reported per minute of operating room time. Labels correspond to setting and publication year, noting that currency year may differ according to details in the respective sources. Costs were first converted to United States Dollars (USD) from their respective currencies using the annual average exchange rate for the corresponding year from the United States Internal Revenue Service.^a These costs were subsequently inflated to the year 2016 using consumer price index tables.^b Costs were reported for general procedures in most cases: US 2010 from a single study,⁵⁸ UK 2011 estimated from multiple studies,⁵⁹ Wales 2013 reported by a single NHS trust^c, France 2013 from a single center for laparoscopic hysterectomy or lymphadenectomy,⁶⁰ Australia 2013 from a national register,⁶¹ Scotland 2016 from regional average.^d The remaining two studies specified costs per minute for robotic surgeries in studies of hysterectomy or lymphadenectomy⁶⁰ and hysterectomy.³⁹

While a useful indicator of resource use, time savings cannot be directly converted into financial savings by simple application of the per minute operating room cost. The realization of such benefit may require administration-level reorganization of operating room schedules for example. Saving operating room time potentially yields other benefits (see Section 5.4), and the quantification of per minute costs into financial savings has thus been used as a comparative indicator to highlight the impact of surgical intervention choices.^{21,39,59,60,62}

5.3. Reported economic impact of V-Loc™ devices

As described (Section 5.2), surgical costs include both fixed and variable components and of these, the type of suture device used will contribute to the variable costs. Although the V-Loc™ wound closure device is typically more expensive than non-barbed sutures alone, the final variable cost will consist of these consumable materials

^a <https://www.irs.gov/individuals/international-taxpayers/yearly-average-currency-exchange-rates>

^b Table PCU622 110622110, General medical and surgical hospitals inflation data

^c Freedom of information request Fol.13.319, <http://www.cardiffandvaleuhb.wales.nhs.uk/freedom-of-information-disclosure-log-20-2>

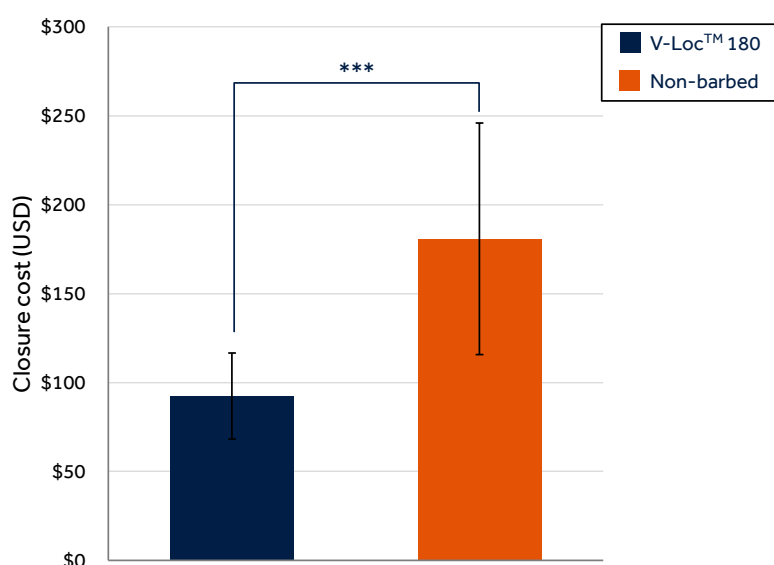
^d Table RX140X_2016, <http://www.isdscotland.org/Health-Topics/Finance/Costs/Detailed-Tables/Theatres.asp>

as well as hospital resource consumption. A more comprehensive analysis of costs is required to understand the impact that V-Loc™ wound closure devices may have on hospital budgets.

Material costs may or may not increase to varying degrees with barbed compared to non-barbed suture use, dependent on factors such as the number of sutures used in each case,^{27,45} and for non-barbed sutures, whether the suture is fixed with knots or with absorbable clips.³⁹ As a knotless alternative, absorbable clips have been reported to be from 49%³⁹ to 14 times⁴⁹ more expensive than V-Loc™ devices in comparative studies.

Of the studies returned that matched the search inclusion criteria, only two reported on the direct cost impact of the use of V-Loc™ wound closure devices versus non-barbed sutures, both in the domain of gynecology (specifically, hysterectomy procedures).^{21,39} Direct costs in these randomized controlled trials were determined from surgical time and supply costs for vaginal cuff closure (Figure 5-2),²¹ while in a separate study, vaginal cuff closure and total operative costs could be derived using the reported local institutional costs and general operating room costs, again both based on duration of closure and total surgery (Figure 5-3).³⁹

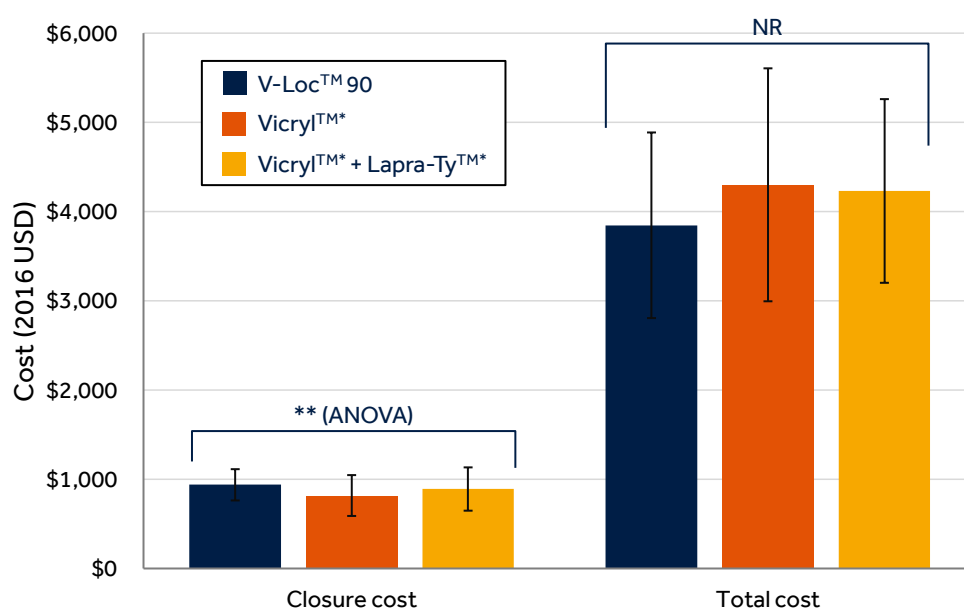
Figure 5-2 Direct analysis of cost of closure in robotic hysterectomy with V-Loc™ wound closure device versus non-barbed suture



Data are presented from the randomized controlled trial comparing the use of V-Loc™ 180 wound closure device and non-barbed suture of Tillmanns et al., 2016.²¹ Costs were reported for vaginal cuff closure in robotic hysterectomy. The cost difference shown includes effect on cost due to difference in suturing time and suture consumables. The difference was reported to be statistically significant (***) $p \leq 0.001$.

From these studies, the analysis including both the device costs and operative time found the V-Loc™ wound closure device to be less expensive than a comparable closure procedure using knots and non-barbed suture.²¹ The second analysis in robotic hysterectomy, with higher operative room costs, found differences among the costs of the vaginal cuff closure phase of surgery alone, with the V-Loc™ device more expensive than the knotted non-barbed, or clipped non-barbed alternatives.³⁹ The study authors, however, noted a non-statistically significant difference in the total operative time, which was lowest for the V-Loc™ device. Using their published robotic vaginal cuff closure costs in combination with general operating room costs (United States, Figure 5-1) for the remainder of the surgical time, the overall operative costs are equivalent among the three methods.³⁹

Figure 5-3 Direct analysis of closure and total procedure costs between V-Loc™ wound closure device and non-barbed suture



Data are presented from the randomized controlled trial of Tsafrir et al., 2017 comparing V-Loc™ 90 wound closure device versus non-barbed suture in robot-assisted laparoscopic hysterectomy.³⁹ In the non-barbed suture arms, sutures were fixed by knotting, or separately with Lapra-Ty™ clips. Costs were reported in the study for vaginal cuff closure and found statistically significantly different by three-way analysis of variance, but pairwise differences were not reported. These costs were derived from the per minute robotic operating room cost. This analysis was extended to estimates of the total operative cost using a conservative estimate of non-robotic operating room costs in the United States (Figure 5-1) in conjunction with the operative times reported in this study. Significance is shown were reported (** $p \leq 0.01$). ANOVA, analysis of variance; NR, not reported.

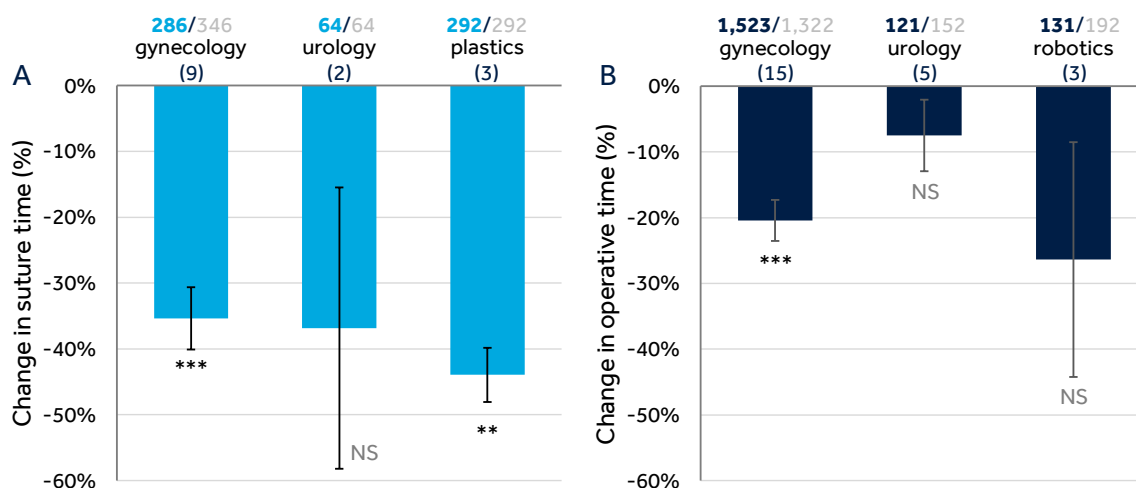
5.4. Indirect health-economic impact of V-Loc™ devices

The choice of technologies applied during surgical intervention may have an effect on economics and patient outcomes. For the former, the direct impact of the use of V-Loc™ wound closure devices compared to non-barbed sutures has been shown to be cost-saving for vaginal cuff closure during laparoscopic hysterectomies²¹ to potentially cost-neutral for total robotic hysterectomy operative costs,³⁹ even when including suture supply costs. Following this analytic scheme, potential cost savings due to decreased hospital resource consumption may be inferred in other surgical domains where V-Loc™ wound closure device use has been compared to non-barbed suture. Analysis across multiple studies reveals V-Loc™ wound closure devices to significantly decrease suturing time in the surgical areas of gynecology (hysterectomy,^{20-23,39} myomectomy,^{15,24,25} and other³⁰ procedures), and plastics,²⁶⁻²⁸ with non-significant decreases in urology^{29,41} in comparisons to the use of non-barbed sutures (Figure 5-4). Of the 14 studies considered in this analysis (where suturing times were recorded), 13 independently reported statistically significant reductions in suture time.^{15,20-30,41}

The impact of the use of barbed over non-barbed suture on operative time will largely be determined by the proportion of the procedure represented by suturing. For example, endoscopic suturing has been described as the main operative step of laparoscopic myomectomy, since it is the primary factor that influences perioperative uterine bleeding.²⁵ In contrast, in one analyzed study of partial nephrectomy where multiple time parameters were recorded, conventional suture time was 7% of total operative time (median 8.4 min of 1120 min).²⁹ When results from multiple studies are aggregated by weighted mean, significant reductions in total operative time with

V-Loc™ wound closure devices compared to non-barbed sutures can be seen in gynecology (hysterectomy,^{20,22,31-34,38,39} myomectomy,^{15,24,25,35-37} and other³⁰). Overall surgical time also shows reductions in urology^{29,41-44} and robot-assisted surgeries (laparoscopic hysterectomy^{33,34} and partial nephrectomy⁴⁴) compared to non-barbed sutures, but these differences were not statistically significant (Figure 5-4).

Figure 5-4 Aggregate change in time with V-Loc™ wound closure device use over non-barbed sutures



Weighted mean change in suturing (A) and operative (B) time are shown, aggregated from multiple studies for the surgical areas shown. Change is given as a percentage of the control (non-barbed) operative time. Values above the bars indicate the patient numbers in the V-Loc™ wound closure device arm (bold) and control (non-barbed arm, grey), the bars are the weighted mean percent change and the error bars correspond to standard error of the mean (SEM). Only surgical areas with more than one study (indicated in parentheses) reporting the indicated time are included. For suture time, surgical areas were: gynecology,^{15,20-25,30,39} urology,^{29,41} and plastics.²⁶⁻²⁸ For total operative time, surgical areas were: gynecology,^{15,20,22,24,25,30-39} urology,^{29,41-44} and robotics.^{33,34,44} Additional areas described in Chapter 4, suture time in robotics²¹ and total operative time in cardiology⁴⁰ and plastics⁴⁵ consisted of only one study each and were not included. Statistical significance is indicated below the bars as determined from one sample t-test against the null hypothesis that the time reduction is zero. NS, non-significant ($p > 0.05$); ** $p \leq 0.01$; *** $p \leq 0.001$.

Even in cases where the total operative time is not significantly impacted with V-Loc™ wound closure devices, additional benefits may be conferred by their use over non-barbed sutures strictly from the reduction in suture time. In myomectomy, for example, faster suturing is directly correlated with a reduction in intraoperative bleeding, owing to the short time in which the myometrium remains open.²⁵ In partial nephrectomy, where suture wound closure is a determinant of warm ischemia time, the use of V-Loc™ devices has been described as having "a significant contribution on reducing WIT [warm ischemia time] and may prevent time-dependent renal damage."²⁹

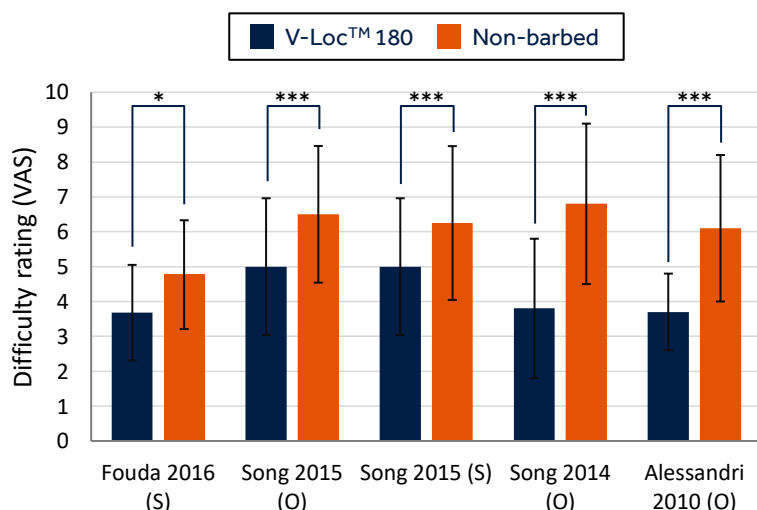
5.5. Surgeon ratings of suturing difficulty

In addition to operative data and patient outcomes, studies examining the application of V-Loc™ wound closure devices in patient care have also quantified handling of the device in comparison to non-barbed technology. Authors have acknowledged the potential for increases in material costs for barbed compared to non-barbed sutures, but this cost difference would be mitigated by increased value with V-Loc™ wound closure devices from other potential benefits such as increased efficiency or improved patient outcomes. These additional, per suture cost increases have thus been described by physicians as "negligible, given the increases in efficiency gained,"⁴⁴ and

that "in light of improved vaginal cuff outcomes with barbed suture in other studies, this may be money well spent."³⁹

Patient outcomes are the main consideration in evaluating surgical interventions, but the outcome for the surgeon is also of relevance. Fixation of conventional sutures with knots is a complex skill,^{7,8} and especially in laparoscopy, suturing is widely considered one of the most difficult and time-consuming tasks performed, in part due to intracorporeal knot tying.^{22,24,31} Technologies that alleviate this burden may thus provide benefits beyond those heretofore described in operative parameters, patient outcomes, or costs. In this regard, surgeon experience in handling V-Loc™ devices compared to non-barbed sutures has been found to be of significant benefit when measured (Figure 5-5). Results show, across multiple studies (in gynecology, as the only domain where these ratings have been quantified), that difficulty ratings are significantly lower with V-Loc™ wound closure devices compared to conventional sutures both in the specific task of suturing,^{24,30} and for the operative procedure overall.^{15,22,24}

Figure 5-5 Surgeon operative and suturing difficulty ratings for non-barbed sutures and V-Loc™ wound closure devices



Displayed are surgeon ratings (means and standard deviations) for suturing (S) and overall operative (O) level of difficulty from studies where data were prospectively collected. All procedures were in gynecology (Fouda 2016,³⁰ Song 2015,²⁴ Song 2014²² and Alessandri 2010¹⁵). VAS, visual analog scale. Note that the 2015 study of Song et al.²⁴ reported medians and ranges. These were converted to means and standard deviations using the method of Wan et al., 2014 for the estimation of parametric from reported non-parametric values.⁶³

5.6. User experience with V-Loc™ wound closure device

The positive results obtained in the various surgical areas for patient outcomes (Section 3.3 and chapter 4), economic considerations (Sections 5.3 and 5.4), and facilitation of performing surgical procedures (Section 5.5) are further supported by published commentary from providers who have used V-Loc™ wound closure devices in patient practice. A collection of these published comments from independent authors of studies where V-Loc™ wound closure devices were compared to non-barbed sutures, and who have no declared connection (financial, educational, consulting or otherwise) to Medtronic include:

Regarding overall benefits to patients and providers:

- **Tinelli 2016, tissue approximation within gynecology:** "CBS [continuous barbed suture with V-Loc™ devices] intuitively makes the procedure [laparoscopic myomectomy] easier and shortens the learning curve by comparison with TIS [traditional interrupted sutures]."³⁵
- **Song 2015, tissue approximation within gynecology:** "The use of barbed suture in LESS-M effectively reduces the time required for suturing, thereby decreasing the total operative time, the operative blood loss, and the surgical difficulty."²⁴
- **Ahmed 2016, tissue approximation within cardiology:** "These findings show the potential to decrease local wound-related complications with barbed suture, as the rates of local infection and those requiring wound packing were significantly lower."⁴⁸
- **Aoki 2014, tissue approximation within gynecology:** "...unlike conventional continuous sutures, barbed sutures do not require an assistant to apply tension to the suture thread, which may also contribute to a reduction in suturing time."³⁶
- **Song 2014, tissue approximation within gynecology:** "Use of barbed suture in single-port TLH [total laparoscopic hysterectomy] aided surgeons by reducing operative time, suturing time, and surgical difficulty."²²
- **Erdem 2013, tissue approximation within urology:** "...we believe that the previously described features of SRBS [self-retaining barbed suture] has a significant contribution on reducing WIT [warm ischemia time] and may prevent time-dependent renal damage"²⁹
- **Alessandri 2010, tissue approximation within gynecology:** "This type of suture [V-Loc™ device] may be particularly useful for gynecologists with less experience in endoscopic surgery and intracorporeal knot tying."¹⁵

Regarding potential material cost differences between barbed and conventional sutures:

- **Tsafrir 2017, tissue approximation within gynecology:** "... in light of improved vaginal cuff outcomes with barbed suture in other studies, this may be money well spent."³⁹
- **Neubauer 2013, tissue approximation within gynecology:** "At the study institution, the average cost of using 2-0 monofilament synthetic absorbable suture [...] is greater than that associated with using only a single 2-0 absorbable welded-loop barbed suture."⁴⁹
- **Thekkinkattil 2013, tissue approximation within plastic surgery:** "The need for greater number of PDS II sutures reduces the expenditure difference between the two suture groups."⁴⁵
- **Sammon 2011, tissue approximation within urology:** "We think [this] increase in costs is negligible given the increases in efficiency gained... Also there are potential cost benefits to society of a reduction in warm ischemia time in terms of preservation of renal function."⁴⁴

6. Conclusions

Suturing is a common method of approximating tissues to aid in healing after surgical procedures. Conventional suturing typically requires knots for fixation, to prevent the thread sliding back through the tissue. The tying of knots, however, is a complex surgical skill,^{7,8} and the unravelling of knots can lead to considerable rates of wound dehiscence.^{†,10,11} Barbed sutures provide an alternative to knot fixation, avoiding potential problems or complications associated with surgical knots.

The V-Loc™ wound closure device was developed to meet this surgical need. The unidirectional barbed, monofilament suture is available as absorbable (V-Loc™ 90 and V-Loc™ 180 wound closure devices) or non-absorbable (V-Loc™ PBT wound closure device) sutures. V-Loc™ devices have been reported in published clinical application in at least 46 countries.^{G1-G46} Peer-reviewed, clinical comparative studies (versus conventional, non-barbed sutures) in peer-reviewed literature have included several indicated procedures in surgical areas, such as gynecology,^{15,20-25,30-39,49,51} urology,^{29,41-44,46,47} soft tissue approximation during plastic surgery,^{13,26-28,45,52,53} and cardiology,^{40,48} also with robot-assisted procedures among them,^{21,32-34,39,44,49,51} encompassing over 6,000 patients.

Results from these comparative studies have revealed the use of V-Loc™ wound closure devices to improve or maintain clinical outcomes. Across all surgical specialties, most studies (13 of 14 studies where data were reported) have demonstrated significant reductions in suturing time,^{15,20-30,39,41} and in gynecology, significant reductions in operating time.^{22,24,30-37} In all other cases, the operative time was not significantly different.^{15,20,25,29,38-45} Other patient parameters including intra-operative blood loss^{20,22,24,25,29-39,41-44} and risk of complications such as infection^{13,20,27,28,39,40,48} and dehiscence^{13,20,21,23,27,31-33,39,40,45,48,49,51,52} are either improved or equivalent; in no report did non-barbed sutures achieve significantly better results among these outcomes. The subset of robotic procedures (primarily gynecological), revealed significant reductions in operative time in most studies (3 of 5), with non-significant reductions in the remainder. Estimated blood loss was reduced^{33,34} to equivalent,^{32,39,44} and length of hospital stay was also shorter³⁴ to equivalent^{33,44} with V-Loc™ devices in robot-assisted procedures compared to non-barbed sutures. As for the general consideration of all surgical areas and procedures, there was no increased risk of complications with V-Loc™ devices when measured among the papers with robot-assisted surgeries.^{21,32,33,39,49,51}

In terms of economics, V-Loc™ wound closure devices have been suggested to be cost saving, or cost-effective or both. While the material cost of the suture is more expensive than conventional sutures, the benefits in reduced time for operative stages^{15,20-28,30,39} and overall,^{15,20,22,24,25,30-39} and the use of fewer additional materials (more sutures,^{27,41,45} or clips to achieve knotless fixation^{39,49}) compared to conventional suturing have been suggested to mitigate this difference via reduced usage of hospital resources. These suggestions have been borne out in reports of cost analyses of V-Loc™ wound closure device use, where at one institution, material costs with V-Loc™ devices were lower than the conventional suture and absorbable clip alternative.⁴⁹ In other studies, vaginal cuff closure was found to be significantly lower cost,²¹ and the overall operative cost in a robot-assisted gynecological procedure non-significantly lower if V-Loc™ wound closure devices were used.³⁹ Where increased material costs have been noted, authors have described this difference as "negligible, given the increases in efficiency gained,"⁴⁴ and that "this may be money well spent."³⁹ Surgeons have especially noted the reduction in difficulty with V-Loc™ devices versus

† Results in benchtop or animal testing may not directly translate to human patients.

conventional suturing in gynecology for the task of suturing^{24,30} and for the operative procedure overall.^{15,22,24} This improved surgical experience is accompanied by a short learning time,^{25,35} allowing techniques involving use of V-Loc™ devices "to be easily performed, even in inexperienced hands, even without intracorporeal knot tying and advanced suturing skills."⁴¹

The benefits achievable with V-Loc™ wound closure devices over conventional, non-barbed sutures have been demonstrated across diverse surgical specialties, such as gynecology, urology, plastic surgery, and cardiology. They are also seen when considering different types of robot-assisted surgeries. Achieving these positive effects for patient outcomes, surgeon experience, and resource consumption does not come at the expense of increased risks for adverse events for patients, demonstrating the value of the V-Loc™ wound closure device and validating its addition to the surgeon's armamentarium.^{†,5,45}

7. Source data tables

7.1. Pre-clinical data

Refer to Section 1.2 for scope of literature presented in the following data tables. Data extracted from pre-clinical studies in mechanical and tissue testing models are shown in (Table 7-1).

Table 7-1 V-Loc™ wound closure device non-clinical source data

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure		
Paka B, et al., 2017 ¹⁶	United States	Mech	Vicryl			Num	7	8		Count		
						Holding Strength [slide] (N)	14.7 (4.1)	7.6 (2.1)		Mean (SD)		
			V-Loc (0)	Monocryl			Num	7	7		Count	
							Holding Strength [slide] (N)	14.7 (4.1)	16.5 (1.6)		Mean (SD)	
			Chromic				Num	7	6		Count	
							Holding Strength [slide] (N)	14.7 (4.1)	13.0 (1.4)		Mean (SD)	
			V-Loc (2-0)	Vicryl				Num	7	7		Count
								Holding Strength [slide] (N)	15.9 (2.6)	5.7 (1.2)		Mean (SD)
Monocryl					Num	7	7		Count			
					Holding Strength [slide] (N)	15.9 (2.6)	8.4 (1.1)		Mean (SD)			

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure
Paka B, et al., 2017 ¹⁶	United States	Mech		Chromic		Num	7	7		Count
						Holding Strength [slide] (N)	15.9 (2.6)	11.3 (2.7)		Mean (SD)
				Vicryl		Num	7	7		Count
						Holding Strength [slide] (N)	15.4 (3.3)	4.4 (0.9)		Mean (SD)
			V-Loc (3-0)	Monocryl		Num	7	7		Count
						Holding Strength [slide] (N)	15.4 (3.3)	8.4 (1.1)		Mean (SD)
				Chromic		Num	7	7		Count
						Holding Strength [slide] (N)	15.4 (3.3)	8.2 (1.5)		Mean (SD)
				Vicryl		Num	7	7		Count
						Holding Strength [slide] (N)	11.9 (1.2)	4.3 (1.4)		Mean (SD)
			V-Loc (4-0)	Monocryl		Num	7	7		Count
						Holding Strength [slide] (N)	11.9 (1.2)	7.6 (1.4)		Mean (SD)
				Chromic		Num	7	7		Count
						Holding Strength [slide] (N)	11.9 (1.2)	7.7 (1.8)		Mean (SD)

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure
			V-Loc (any)			Hem-o-lok/Lapra-Ty anchor combination used during MI partial nephrectomy				
						Holding strength compared using Hem-o-lok and Lapra-Ty clips as anchor, measuring force for suture to slide through clip				
						Stat test ANOVA with Tukey HSD post, 0.05 level of sig but present no pairwise test results by suture type, only ANOVA by suture size				
						One challenge during PN is avoiding the tearing of the parenchymal tissue while applying tension on a suture...the ability of the tissue to support the applied tension is improved significantly by using a closing system that can distribute the tension over a larger surface area.				
Sull A, et al., 2016⁴	United States	Porcine	V-Loc 180 (3-0)	PDS (3-0)		Num	10	10		Count
						Tensile strength (N)	76.6 (9.4)	83.3 (10.0)	0.086	Mean (SD)
						2mm gap resistance (N)	25.1 (4.0)	22.6 (3.8)	NS	Mean (SD)
Api M, et al., 2015⁶⁴	Turkey	Murine	V-Loc 180 (3-0)	Vicryl (polyglactin 910; 3-0)		Num	10	10		Count
						Tissue rxn (au) Eosinophils neutrophils	2 (1-3)	3 (2.5-3)	0.15	Median (IQR)
						Tissue rxn (au)	1 (0.5-1.5)	3 (1.5-3)	0.01	Median (IQR)

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure
						Macrophages-foreign body giant cells				
						Tissue rxn (au) Mononuclear cells	2 (1.5-3)	3 (3-3)	0.04	Median (IQR)
						Adhesions (N)	3.5	2	0.008	Median (IQR)
						Num	20	20		Count
						Holding Strength [tiss tear] (N)	55.5 (4.7)	52.0 (11.3)	NS	Mean (SD)
						2mm gap resistance (N)	46.5 (5.5)	41.5 (10.9)	< 0.05	Mean (SD)
Joyce CW, et al., 2014¹	Ireland	Porcine	V-Loc PBT (2-0)	Prolene (3-0)		Other physical (mm ²) CSA	85.7 (17)	87.8 (20)	NS	Mean (SD)
						Other physical (%) change CSA	2.8% (0.4)	7.7% (6.7)	< 0.001	Mean (SD)

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure
						Mode of failure (rupture)	20	20		Count
						"We found the V-Loc barbed suture was easy to handle and quite robust for flexor tendon repair."				
						All failures under testing due to ruptures				
						Num	8 (repair)/ 3(mech)	8 (repair)/ 3(mech)		Count
						Tensile strength (N)	22.3 (2.41)	26.3 (1.53)	0.082	Mean (SD)
						1mm gap resistance (N)	8.3 (3.15)	4.4 (1.65)	0.05	Mean (SD)
						2mm gap resistance (N)	11.8 (3.97)	9.7 (4.58)	0.47	Mean (SD)
Sato M, et al., 2014³	Japan	Porcine	V-Loc 180 (4-0)	Maxon (4-0)	2-strand Kirchmayr-Kessler	Stretch (mm)	40.9 (5.95)	62.5 (5.03)	0.009	Mean (SD)
						Stroke to 1mm gap (mm)	5.5 (1.19)	3.5 (0.39)	0.017	Mean (SD)
						Stroke to 2mm gap (mm)	6.9 (0.93)	6.0 (0.95)	0.15	Mean (SD)
						Mode of failure	5	1		Count

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure
						(knot failure)				
						Mode of failure ("tendon break")	0	6		Count
						Mode of failure (rupture)	3	1		Count
						"In testing system, tensile strength corresponds to muscular strength and stroke the distance of joint motion... we thus hypothesize that tendon repaired by barbed suture can receive passive motion, thus setting up a wide range of motion without gap formation."				
						Num	15	15		Count
						Maximum load (N)	61.5 (9.3)	47.2 (6.3)	< 0.001	Mean (SD)
						2mm gap resistance (cycles)	102.5	4.7		Mean (NR)
Peltz TS, et al., 2014²	Australia	Ovine	V-Loc 180 (3-0)	Ti-Cron™ braided polyester (3-0)	3D suture method	Mode of failure (knot failure)	0	6		Count
						Mode of failure (pull out)	5	4		Count

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure			
						Mode of failure (rupture)	10	5		Count			
						Testing via cycles of 3-30N load applied, pausing at intervals of 10 cycles. Max 250N, then to final failure							
Petrut B, et al., 2013¹⁹	Romania	Murine	V-Loc 180 (3-0)	Vicryl (3-0)	Num	8	8			Count			
					Tissue rxn (au) 3 wks	2.25 (0.463)	3.00 (0.53)	* < 0.01	Mean (SD)				
					Inflamm (au) 3 wks	2.12 (0.99)	3.00 (0.50)	* < 0.01	Mean (SD)				
					Tissue rxn (au) 6 wks	1.38 (0.51)	7.62 (1.06)	* < 0.03	Mean (SD)				
					Inflamm (au) 6 wks	2.38 (1.51)	8.00 (0.92)	* < 0.03	Mean (SD)				
							PDS II (3-0)	Num	8	8			Count
				Tissue rxn (au) 3 wks	2.25 (0.463)	5.12 (0.64)		* < 0.01	Mean (SD)				
				Inflamm (au) 3 wks	2.12 (0.99)	6.38 (1.06)		* < 0.01	Mean (SD)				
				Tissue rxn (au) 6 wks	1.38 (0.51)	1.25 (0.46)		* < 0.03	Mean (SD)				
				Inflamm (au) 6 wks	2.38 (1.51)	1.50 (0.53)		* < 0.03	Mean (SD)				
				Authors observe that throughout study period, V-Loc suture maintained strength and shape, and was associated with adhesions, although these were not quantified.									
		Porcine	V-Loc 180			Num	16	16		Count			

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure					
Gözen AS, et al., 2012⁵	Turkey, Germany			Vicryl polyglactin 910	interrupted	Leak press (cm H ₂ O)	19.5 (2.7)	10.4 (1.0)	< 0.05	Mean (SD)					
						Volume to leak (ml)	419.7 (49.4)	276.3 (40.8)	< 0.05	Mean (SD)					
						Suture time (min)	7.13 (0.52)	15.2 (2.08)	< 0.05	Mean (SD)					
							Num	16	16		Count				
					running	Leak press (cm H ₂ O)	19.5 (2.7)	14.4 (2.3)	< 0.05	Mean (SD)					
						Volume to leak (ml)	419.7 (49.4)	353.8 (56.9)	< 0.05	Mean (SD)					
						Suture time (min)	7.13 (0.52)	9.1 (0.53)	< 0.05	Mean (SD)					
					K-W testing by group, no pairwise difference (post-hoc) testing										
					"Closing the pig bladder with running knotless barbed polyglyconate suture provides a more effective and faster watertight bladder closure than traditional polyglactin 910 suture material."										
					"This type of suture [V-Loc] may be particularly useful for surgeons with less experience in laparoscopic surgery and intracorporeal knot-tying."										
Zaruby J, et al., 2011¹⁸	United States	Porcine	V-Loc 90 (4-0)	Biosyn (4-0)		Num	16	16		Count					
						Maximum load (kgf) day 0	4.3 (2.8)	6.2 (2.2)	< 0.05	Mean (SD)					

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure
						Maximum load (kgf) day 3	4.7 (2.9)	5.6 (2.1)	NS	Mean (SD)
						Maximum load (kgf) day 10	7.6 (2.9)	8.5 (2.2)	NS	Mean (SD)
						Maximum load (kgf) day 21	16.4 (2.9)	15.1 (2.1)	NS	Mean (SD)
						Tissue rxn (au) day 3	0.36	0.43	0.209 (ANOVA)	Mean (NR)
						Tissue rxn (au) day 10	0.43	0.59	0.169	Mean (NR)
						Tissue rxn (au) day 21	0.9	0.74	0.419 (ANOVA)	Mean (NR)
						Inflamm (Num)	2	6		Count
Zaruby J, et al., 2011 ¹⁸	United States	Porcine	V-Loc 90 (4-0)	Biosyn (4-0)		Swelling (Num)	1	2		Count
						Dehiscence (Num)	0	2		Count
						Mode of failure (barb slip) pooled	33	0		Percentage

Reference	Country	Model	Device	Comp	Method	Outcome	V-Loc™	Comp	Sig	Measure
						Mode of failure (rupture) pooled	60	50	< 0.05	Percentage
						Mode of failure (tissue failure) pooled	7	50	< 0.05	Percentage

Zeplin PH, et al., 2011¹⁷	Germany	Human	V-Loc 180 (3-0)	PDS (3-0)	2-strand	Num	15	15		Count
					Kirchmayr-Kessler	Maximum load (N)	38 (6.1)	94 (10.5)	< 0.001	Mean (SD)
					4-strand	Num	15	15		Count
					Kirchmayr-Kessler	Maximum load (N)	145.6 (16.1)	149.5 (7.0)	0.0737	Mean (SD)
					"Single knot techniques are preferred to 2-knot techniques due to the lower suture volume within the repair and greater tensile strength."					

In "device" and "comparator" columns, sizes (0, 2-0, 3-0, etc) are given in parentheses when reported and correspond to USP (United States Pharmacopeia) sizing specifications. Devices Biosyn™, Hem-o-lok™, Lapra-Ty™, Maxon™, Monocryl™, Prolene™, Ti-Cron™, V-Loc™ are registered trademarks.

ANOVA, analysis of variance; au, arbitrary units; Comp, comparator; CSA, cross-sectional area; IQR, interquartile range; inflamm, inflammation; kgf, kilogram-force; K-W, Kruskal-Wallis; Mech, mechanical model (testing suture with plastic ligating clips in vitro); MI, minimally invasive; N, newtons; NR, not reported; NS, non-significant; Num, number; PDS™, polydioxane; PDS™ II, polydioxanone; rxn, reaction; SD, standard deviation; Sig, significance testing (p-value, or NS as reported); tiss tear, tissue tearing/rupturing; Tukey HSD, Tukey honest significant difference.

7.2. Cardiology clinical data

Data extracted from comparative clinical studies with V-Loc™ wound closure device data relevant to cardiology are shown in (Table 7-2).

Table 7-2 V-Loc™ wound closure device and non-barbed suture data in cardiology

Reference	Country	Study type	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Krishnamoorthy B, et al., 2016⁴⁰	United Kingdom	RCT	donor leg wound closure	V-Loc 180	Monocryl (3-0)	N	36	70		Count
						Time skin closure (min)	5.95 [5.00]	10.67 [4.11]	< 0.001 (all barb)	Median [IQR]
						Operative time (min)	47.08 [29.26]	56 [30]	0.051	Median [IQR]
						Prolonged length of stay (> 7 d)	10 (33.3%)	11 (20.8%)	0.825	Count
						Adverse skin reaction (N)	1 (3.1%)	18 (27.3%)	< 0.001 (all barb)	Count
						Excessive scarring (N)	0 (0.0%)	13 (19.4%)	0.001 (all barb)	Count
						Normal healing (N)	9 (29.0%)	12 (17.6%)	< 0.001 (all barb)	Count
						Normal healing, no erythema (N)	22 (71.0%)	13 (19.1%)	< 0.001 (all barb)	Count

Reference	Country	Study type	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
						Dehiscence (N)	1 (3.2%)	3 (4.5%)	0.62	Count
						Infection (N)	1 (3.2%)	2 (2.9%)	NR	Count
						"Greenberg et al. made a clear model demonstrating how the suture had a reduction in its tensile strength by the thinning and stretching that comes with tying surgical knots."				
						"They found a 35-95% decrease in tensile strength with the weakest point being the knot and the second weakest the length of suture immediately adjacent to the knot."				
						N	273	442		Count
						Dehiscence (N)	0 (0%)	7 (1.6%)	0.04	Count
						Infection treated by packing (N)	0 (0%)	7 (1.6%)	0.04	Count
						Infection (N) all	14 (5.1%)	42 (9.5%)	0.03	Count
Ahmed O, et al., 2014⁴⁸	United States	Retro cohort	wound closure post chest port placement	V-Loc 180 (3-0)	Polysorb (3-0)	Infection, early post-op (N)	5 (1.8%)	11 (2.5%)	0.56	Count
						Infection, local (N)	1 (0.4%)	12 (2.7%)	0.02	Count
						V-Loc group had a statistically-significantly lower number of catheter days than conventional group				
						"These findings show the potential to decrease local wound-related complications with barbed suture, as the rates of local infection and those requiring wound packing were significantly lower"				

Reference	Country	Study type	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
						In multivariate analysis, barbed vs non-barbed suture was the single parameter analyzed that predicted port infection that reached statistical significance (p = 0.03)				

Comp, comparator; d, days; IQR, interquartile range; N, number of patients; post-op, post-operative; Proc, procedures; RCT, randomized controlled trial; Retro, retrospective; Sig, (measure of) significance (p-value when reported or calculable); Retro, retrospective; Sig

Note in the study of Krishnamoorthy 2016,⁴⁰ p-values shown for significance testing were derived from comparison between non-barbed and all barbed sutures included in the study, which included non V-Loc™ devices.

All product names (Monocryl, PolySorb, V-Loc) are trademarks of the respective rights holders.

7.3. Gynecology clinical data

Data extracted from comparative clinical studies with V-Loc™ wound closure device data relevant to gynecology are shown in (Table 7-3).

Table 7-3 V-Loc™ wound closure device and non-barbed suture data in gynecology

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Tsafir Z, et al., 2017³⁹	United States	RCT	Hys	Robo	V-Loc 90 (2-0)	Vicryl (0) + LapraTy	N	30	30		Count
							Suture time (min)	14.5 (11-24)	13 (8-26)	0.09 (ANOVA)	Median (Range)
							Operative time (min)	2.4 (0.75)	2.7 (0.73)	0.19 (ANOVA)	Mean (SD)
							Intra-op blood loss (ml)	50 (10-250)	50 (10-250)	0.34 (ANOVA)	Median (Range)
							Urinary retention (N)	1 (3.3%)	0 (0%)	NR	Count

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							Dehiscence (N)	0 (0%)	0 (0%)	NR	Count
							Post-op bleeding (N)	5 (16.6%)	4 (13.3%)	NR	Count
							Infection (N)	1 (3.3%)	1 (3.3%)	0.43	Count
							Pain (N, 1 year)	0 (0%)	0 (0%)	0.01 (Fisher)	Count
							Cost (material)	\$44.00	\$65.60		Value
							Cost (procedure)	\$869.0 (649.0-1364.6)	\$780.6 (505.6-1495.6)	0.007 (ANOVA)	Value
							"Cost analysis in our trial indicated that the use of barbed suture would add 38 dollars compared to interrupted vicryl suture, which had equivalent long-term outcomes. However, in light of improved vaginal cuff outcomes with barbed suture in other studies, this may be money well spent."				
Brown DN, et al., 2016 ³²	United States	Retro cohort	TLH	Robo + non-Robo	V-Loc 180	Vicryl polyglactin 910	N	375	99		Count
							Operative time (min)	83 (62-105)	132 (74-230)	< 0.001	Median (IQR)
							Intra-op blood loss (ml)	75 (50-100)	75 (50-150)	0.12	Median (IQR)
							Complic (ANY)	10 (2.7%)	1 (1.0%)	0.47	Count
							Length of stay (N, same day)	86 (23.1%)	14 (14.1%)	0.04	Count

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure						
							Length of stay (N, 1 day)	243 (65.1%)	76 (76.8%)	0.04	Count						
							Length of stay (N, 2 days)	30 (8.0%)	9 (9.1%)	0.04	Count						
							Length of stay (N, ≥3 days)	14 (3.8%)	0 (0.0%)	0.04	Count						
							Granulation (N)	4 (1.1%)	0 (0%)	0.58	Count						
							Dehiscence (N)	3 (0.8%)	0 (0%)	> 0.99	Count						
							Surgical numbers: V-Loc (224 robotic, 151 TLH), conventional (46 robotic, 53 TLH). Outcomes stratified only by suture-type, not robotic assistance.						N	306	184		Count
							Operative time (min)	93.46 (25.72)	102.43 (37.20)	0.002	Mean (SD)						
							Intra-op blood loss (ml)	48.67 (37.26)	57.61 (45.49)	0.019	Mean (SD)						
							Length of stay (d) post-op	5.17 (1.48)	5.68 (2.68)	0.007	Mean (SD)						
							Length of stay (d) total	11.61 (4.81)	13.21 (4.81)	0	Mean (SD)						
VCG (N)	6 (1.96%)	8 (4.34%)	NR	Count													
Dehiscence (N)	0	0	NR	Count													
Cong L, et al., 2016³¹	China	Retro cohort	TLH		V-Loc 180	Polysorb (CL-914)											

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Fouda UM, et al., 2016³⁰	Egypt	RCT	LEOE	Lap	V-Loc 180 (2-0)	Vicryl polyglactin 910 (2-0)	N	20	20		Count
							Suture time (min)	8.85 (2.52)	15.7 (4.12)	< 0.001	Mean (SD)
							Fixation time (sec)	31.6 (9.56)	111.15 (28.45)	< 0.001	Mean (SD)
							Operative time (min)	43.3 (10.54)	52.8 (9.69)	0.005	Mean (SD)
							Intra-op blood loss (ml)	63.85 (34.82)	78.8 (31.78)	0.164	Mean (SD)
							Surgeon rating (VAS)	3.68 (1.37)	4.77 (1.56)	0.025	Mean (SD)
							"Continuous suturing is the best option for controlling bleeding from endometrioma bed and reconstructing the ovary."				
							"Knot tying and suturing with conventional smooth sutures are time-consuming and technically challenging for laparoscopic surgeons."				
"Knots decrease the tensile strength of suture, induce a foreign body reaction, and create an unequal distribution of tension across the suture line that may affect uniform tissue healing. Moreover, knots tied laparoscopically are weaker than knots tied manually or robotically."											
Kim JH, et al., 2016²⁰	South Korea	Retro cohort	TLH		V-Loc 180	Vicryl polyglactin 910	N	64	106		Count
							Suture time (min)	7.2 (1.2)	12.2 (3.3)	< 0.001	Mean (SD)
							Time per stitch (min)	0.5 (0.1)	1.0 (0.3)	< 0.001	Mean (SD)
							Operative time (min)	91.0 (50.3)	84.9 (35.1)	0.354	Mean (SD)

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							Intra-op blood loss (ml)	65.5 (43.2)	66.8 (43.8)	0.85	Mean (SD)
							Length of stay (d)	5.9 (2.7)	5.5 (1.3)	0.196	Mean (SD)
							Dehiscence (N)	0 (0%)	0 (0%)		Count
Kim JH, et al., 2016²⁰	South Korea	Retro cohort	TLH		V-Loc 180	Vicryl polyglactin 910	Post-op bleeding (N)	2 (3.1%)	8 (7.5%)	0.323	Count
							Infection (N)	0 (0%)	2 (1.9%)	0.775	Count
							N	33	34		Count
Tillmanns TD, et al., 2016²¹	United States	RCT	Hys	Robo	V-Loc 180 (2-0)	Vicryl (2-0)	Suture time (min)	3.2 (1.1)	7.6 (2.7)	<0.001	Mean (SD)
							Post-op dyspareunia (N) [of x 3 mo intercourse]	1/9 (11%)	4/9 (44%)	NR	Count
							Granulation (N)	0 (0%)	2 (5.9%)	NR	Count
							Dehiscence (N)	0 (0%)	1 (1.9%)	NR	Count
							Cost (material)	22	7.17		Value
							Cost (closure) \$22/min	\$92.4 (24.2)	\$180.8 (65.1)	<0.001	Mean (SD)
							Cost (closure) \$62/min	\$220.4 (68.2)	\$484.8 (173.1)	<0.001	Mean (SD)

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							Cost (closure) \$133/min	\$444.4 (145.2)	\$1,016 (362.1)	<0.001	Mean (SD)
							OR costs assessed at low, mid, high estimates of \$22, \$62 and \$133/min				
							"From another perspective, physicians performing 3 of these surgeries per day could gain 15 extra non-OR minutes in their days."				
							"Although Lapra-Ty may decrease vaginal cuff closure time, this suture [method] is likely to be cost-prohibitive, as it requires two VICRYL sutures (\$5 each) and two Lapra-Ty clips (\$183 each) for a total of \$376."				
Tinelli R, et al., 2016³⁵	Italy	Retro cohort	Myo	Lap	V-Loc	Polysorb GS-21 (0)	N	360	360		Count
							Operative time (min)	52 (19)	67 (21)	0.001	Mean (SD)
							Intra-op blood loss (ml)	135 (35)	215 (55)	0.006	Mean (SD)
							Length of stay (d)	2.5 (0.5)	2.3 (0.5)	0.072	Mean (SD)
							Post-op fever (N)	22 (6.1%)	27 (7.5%)	0.07	Count
							Uterine scar area (mm ²) 24h	30.1 (1.5)	36 (1.5)	0.06	Mean (SD)
							Uterine scar area (mm ²) 30d	7.4 (1.3)	9.1 (1.5)	0.07	Mean (SD)

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							Uterine scar area (mm ²)	4.5 (1.5)	4.2 (1.5)	0.06	Mean (SD)
							"CBS [continuous barbed suture with V-Loc] intuitively makes the procedure easier and shortens the learning curve by comparison with TIS [traditional interrupted sutures]."				
							N	30	30		Count
							Suture time (min)	19 (6-65)	27 (9-100)	0.027	Median (range)
							Operative time (min)	69 (25-215)	91 (32-218)	0.014	Median (range)
							Intra-op blood loss (ml)	100 (15-450)	145 (40-350)	0.04	Median (range)
Song T, et al., 2015²⁴	South Korea	Prosp consec	Myo	Lap	V-Loc 180 (1-0)	Vicryl (1-0)	Intra-op complic (N)	0	0	> 0.999	Median (range)
							Length of stay (d)	3 (2-5)	3 (2-5)	0.563	Median (range)
							Surgeon rating (VAS) overall	4 (2-10)	7 (2-10)	0.001	Median (range)
							Surgeon rating (VAS) suturing	4 (2-10)	7 (1-10)	< 0.001	Median (range)
Song T, et al., 2015²⁴	South Korea	Prosp consec	Myo	Lap	V-Loc 180 (1-0)	Vicryl (1-0)	"Laparoscopic suturing is widely considered to be one of the most difficult and time-consuming tasks performed during laparoscopy."				
	Japan		Myo	Lap			N	41	42		Count

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Aoki Y, et al., 2014 ³⁶		Retro cohort			V-Loc 180 (0)	Polysorb (0)	Operative time (min)	71.2 (22.9)	94.4 (27.2)	<0.001	Mean (SD)
							Intra-op blood loss (ml)	59.3 (54.0)	73.8 (64.2)	0.199	Mean (SD)
							Length of stay (d)	3.00 (0.00)	2.97 (0.41)	0.314	Mean (SD)
							"...the use of barbed suture reduces operation time by approximately 25%; thus, the time in the operating room and personnel costs are reduced."				
							"...the needle can be easily passed through the loop, and this hastens the work and improves stability."				
Song T, et al., 2014 ²²	South Korea	Case control	TLH	Lap	V-Loc 180 (1-0)	Vicryl or Monocryl	N	43	59		Count
							Suture time (min)	11.4 (4.2)	22.5 (3.8)	< 0.001	Mean (SD)
							Operative time (min)	92.0 (33.5)	105.2 (31.4)	0.002	Mean (SD)
							Intra-op blood loss (ml)	50 (10-380)	80 (10-400)	0.054	Median (range)
							Length of stay (d)	3 (2-4)	3 (2-5)	0.827	Median (range)
							Post-op compic (N)	1 (2.3%)	3 (5.1%)	0.636	Count
							Post-op bleeding (N)	1 (2.3%)	2 (3.3%)	> 0.999	Count

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Song T, et al., 2014²²	South Korea	Case control	TLH	Lap	V-Loc 180 (1-0)	Vicryl or Monocryl	Surgeon difficulty rating (VAS)	3.8 (2.0)	6.8 (2.3)	<0.001	Mean (SD)
							"Use of barbed suture in single-port TLH aided surgeons by reducing operative time, suturing time, and surgical difficulty."				
							"the principal limitation to increasing the use of barbed suture is that it is more expensive than traditional suture; however, the reduction in surgical time may balance this cost."				
Zhou Y, et al., 2014³³	United States	Retro cohort	TLH	Robo, Lap	V-Loc 180	Polyglactin 910	N	49	44		Count
							Operative time (min)	220.2 (58.3)	272.8 (80.6)	0.00	Mean (SD)
							Intra-op blood loss (ml)	163.2 (137.2)	274.9 (299.5)	0.02	Mean (SD)
							Length of stay (d)	1.8 (1.0)	2.6 (3.0)	0.11	Mean (SD)
							Granulation tissue (N)	4 (8.2%)	12 (27.3%)	0.03	Count
							Dehiscence (N)	1 (2.0%)	0 (0.0%)	1.00	Count
							Post-op bleeding (N)	7 (14.3%)	10 (22.7%)	0.42	Count
							Number of clinic visits	2.6 (0.8)	2.9 (1.5)	0.2	Mean (SD)
							Healing time (weeks)	7.7 (3.4)	8.5 (4.1)	0.32	Mean (SD)
							Note BMI was higher in the barbed group compared to non-barbed (33.3[8.4] kg/m ² vs 29.7[6.5]kg/m ² , p=0.0251)				

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							"Uccella et al [2011] show the incidence of cuff dehiscence to be 1.64% in robotic-assisted hysterectomy, which was much higher than the vaginal (0.18%) and laparoscopic (0.64%) approaches."				
Bassi A, et al., 2013³⁸	Canada	Retro cohort	TLH	Lap	V-Loc 180	0-PDS	N	63	139		Count
							Operative time (min)	115.9 (4.18)	118.6 (2.42)	NR	Mean (SEM)
							Intra-op blood loss (ml)	153.97 (13.01)	159.17 (8.38)	NR	Mean (SEM)
							Length of stay (d)	1.0 (0.04)	1.2 (0.06)	NR	Mean (SEM)
							Post-op fever (N)	5 (7.9%)	0 (0%)	0.003	Count
							Post-op bleeding (N)	0 (0%)	3 (2.2%)	NS	Count
							Post-op UTI (N)	1 (1.5%)	1 (0.7%)	NS	Count
							"...we found that suturing the vaginal cuff with V-Loc was technically less demanding than suturing with PDS suture. In fact, its availability has allowed more gynaecologists in our institution to perform laparoscopic suturing."				
Drudi L, et al., 2013⁵¹	Canada	Retro	Hys	Robo	V-Loc (NR)	Vicryl or Vicryl + Biosyn	N	118	323		Count
							Dehiscence (N)	1	6	NR	Count
Huang MC, et al., 2013³⁷	Taiwan	Prosp	mini-lap, Myo	Lap	V-Loc (NR)	Safil (polyglyco)	N	34	34		Count
							Operative time (min)	50.2 (16.5)	69.1 (25.3)	0.0008	Mean (SD)

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
						lic acid, 1-0)	Intra-op blood loss (ml)	260.9 (230)	394.7 (406)	0.108	Mean (SD)
							Blood transfusion (N)	2 (5.8%)	4 (12%)	NS	Count
							Length of stay (d)	4.1 (0.7)	4.3 (0.8)	0.486	Mean (SD)
							Failure of mini-lap (N)	2 (5.8%)	3 (8.8%)	NS	Count
							N	25	25		Count
Morgan-Ortiz F, et al., 2013²³	Mexico	Prosp, non-random	TLH	Lap	V-Loc 90	Polyglactin 910	Suture time (min)	12.7 (3.1)	20.4 (7.1)	0.029	Mean (SD)
							Dehiscence (N)	0 (0%)	0 (0%)	NR	Count
							N	76	58		Count
							Bowel obstruction (N)	0 (0%)	0 (0%)	NR	Count
							Dehiscence (N)	0 (0%)	0 (0%)	NR	Count
Neubauer NL, et al., 2013⁴⁹	United States	Retro cohort	TH	Robo	V-Loc 180 (2-0)	Monofil (2-0)	Cost (material)	\$26.00	\$376.00	NR	Value
							"At the study institution, the average cost of using 2-0 monofilament synthetic absorbable suture (US \$5.00 each; on average, 2 sutures per case) and absorbable suture clips (\$183.00 each; on average, 2 per case) is greater than that associated with using only a single 2-0 absorbable welded-loop barbed suture (\$26.00 each)				

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure	
							"After 1 year, all attending surgeons switched over to the welded-loop method of vaginal cuff closure owing to its ease of use."					
							"Of the 2 techniques, we now prefer knotless vaginal cuff closure. The unidirectional barb of this suture precisely secures the tissue at numerous points, evenly distributing the closure forces and enabling a fast and safe knot-free vaginal cuff closure during robotic hysterectomy."					
							"this closure technique works well in an academic environment, where surgeons range in skill level (resident physician, fellow, attending surgeon), and eliminates dependence of the cuff closure on robotic tying."					
Angioli R, et al., 2012²⁵	Italy	Prosp + retro control	Myo		V-Loc (NR, 2-0)	Polyglactin (2-0)	N	19	20		Count	
							Suture time (min)	9.9 (4.3)	15.8 (4.7)	0.0004	Mean (SD)	
							Anchoring [knot/loop] (sec)	42.1	209	<0.0001	Value	
							By linear regression, time for V-Loc anchoring 1 proc, 76 sec; 5 proc, 61 sec; 10 proc, 42 sec; 15 proc, 23 sec					
							Operative time (min)	51 (18.1)	58 (17.8)	0.0616	Mean (SD)	
							Intra-op blood loss (ml)	113.7 (74.1)	168.6 (75.1)	0.0076	Mean (SD)	
							Intra-op complic (N)	0 (0%)	0 (0%)	NR	Count	
Post-op fever (N)	1 (5%)	1 (5%)	NR	Count								

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							"Use of a barbed suture may aid surgeons during laparoscopic suturing by reducing operative time, suturing time, and blood loss."				
							"Faster suturing is directly correlated with a reduction in intraoperative bleeding, owing to the short time in which the myometrium remains open."				
							"...there was a significant reduction in time [required to pass needle through welded loop] with increasing number of procedures"				
Nawfal AK, et al., 2012³⁴	United States	Retro cohort	TLH	Robo, Lap	V-Loc 180	Vicryl	N	69	133		Count
							Operative time (min)	135 (30-299)	175 (80-625)	< 0.001	Median (range)
							Intra-op blood loss (ml)	50 (10-300)	75 (10-1000)	<0.001	Median (range)
							Length of stay (d)	1 (1-9)	1 (1-14)	0.01	Median (range)
							Length of stay >1d (Odds Ratio)	0.37 [0.18, 0.76]			Ratio [95%CI]
Alessandri F, et al., 2010¹⁵	Italy	RCT	Myo	Lap	V-Loc 180	Vicryl	N	22	22		Count
							Suture time (min)	11.5 (4.1)	17.4 (3.8)	< 0.001	Mean (SD)
							Operative time (min)	73.3 (21.4)	80.7 (18.6)	0.177	Mean (SD)
							Complic (major)	0 (0%)	0 (0%)	NR	Count
							Cost (material)	€ 20.00	€ 7.30	NR	Value

Reference	Country	Study type	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							Surgeon difficulty rating (VAS)	4 (2-6)	7 (2-9)	< 0.001	Median (range)
							Surgeon difficulty rating (VAS)	3.7 (1.1)	6.1 (2.1)	< 0.001	Mean (SD)
"This type of suture [V-Loc] may be particularly useful for gynecologists with less experience in endoscopic surgery and intracorporeal knot tying."											

95%CI, 95% confidence interval; ANOVA, analysis of variance (simultaneous multiway comparisons); BMI, body mass index; Comp, comparator; Complic, complications; Consec, consecutive patients; d, days; h, hours; Fisher, Fisher's exact test; Hys, hysterectomy; Intra-op, intra-operative; IQR, interquartile range; Lap, laparoscopic; LEOE, laparoscopic excision ovarian endometrioma; mini-lap, mini-laparotomy; Myo, myomectomy ; N, number of patients; NR, not reported; NS, non-significant; OR, operating room; Post-op, post-operative; Pre-op, pre-operative; Proc, (surgical) procedure; Prosp, prospective (data collection); RCT, randomized controlled trial; Retro, retrospective; Robo, robot-assisted; SD, standard deviation; Sig, (measure of) significance (p-value when reported or calculable); TLH, total laparoscopic hysterectomy; UTI, urinary tract infection; VAS, visual analog scale; VCG, vaginal cuff granulomata.

Surgeon VAS ratings in studies of Song 2014,²² Song 2015,²⁴ Fouda 2016,³⁰ Alessandri 2010¹⁵ refer to difficulty. Higher values indicate greater difficulty.

In the study of Tillmanns²¹ the outcome reporting dyspareunia were presented as the number of patients who experienced the complication as a fraction of the number of patients who had resumed intercourse within 3 months (x).

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7.4. Plastic surgery clinical data

Data extracted from comparative clinical studies with V-Loc™ wound closure device data in plastic surgery are shown in (Table 7-4).

Table 7-4 V-Loc™ wound closure device and non-barbed suture data in plastic surgery procedures

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Liang DG, et al., 2016 ⁵³	Australia	Prosp consec	PM, BR		V-Loc 180 (2-0)	NR	N	26	27		Count
							Length of stay (d)	8.53 (1.50)	9.11 (3.11)	0.401	Mean (SD)
							Wound drain (ml)	238.31 (242.66)	527.78 (322.07)	0.0005	Mean (SD)
							"Potential economic benefits [of early drain removal] include earlier hospital discharge, improved patient flow, and reduced health-care costs."				
" In our study, we have demonstrated that use of a barbed suture quilting technique results in a significant decrease in drain output. The implications of this include earlier drain removal instilling confidence in surgeons who wish to forgo abdominal drains altogether."											
Nagarkar P, et al., 2016 ⁵²	United States	Retro	donor site closure DIEP BR	PTS	V-Loc 180 (3-0)	Vicryl (2-0)	N	25	50		Count
							Complic (ANY)	2 (8%)	16 (32%)	NR (0.021)	Count 8
							Dehiscence (N)	2 (8%)	10 (20%)	NR (0.181)	Count 4
							"To minimize the cost of additional operative time, we utilized the running barbed suture (V-LOC) and estimate that this technique required an additional 15-30 minutes in our early experience [compared to 50 minutes with				

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure							
Cortez R, et al., 2015 ¹³	United States	Retro cohort	BC, BR, FF		V-Loc 90 (200) V-Loc 180 (10) both (18)	NR	non-barbed]. However, with practice, the senior surgeon (M.S-C.) now only required 10-15 minutes."											
							N	228	713		Count							
							Complic (ANY)	60 (26.3%)	165 (23.1%)	NR	Count							
							Delayed healing (N)	7 (3.1%)	21 (2.9%)	NR	Count							
							Post-op erythema (N)	11 (4.8%)	33 (4.6%)	NR	Count							
							Dehiscence (N)	5 (2.2%)	10 (1.4%)	NR	Count							
							Infection (N)	17 (7.5%)	63 (8.8%)	NR	Count							
Koide S, et al., 2015 ²⁶	Australia	RCT	elective plastic surgery wound closure		V-Loc 180 (3-0)	Maxon (3-0)	N	33	33		Count							
							Suture time (min)	12 (4)	19 (6)	< 0.001	Median (IQR)							
							Complic (ANY)	4 (12.1%)	4 (12.1%)	NR	Count							
							Infection (N)	1 (3.0%)	2 (6.1%)	NR	Count							
							Hollander score (au) summed score	16 (8)	24 (8)	0.0075	Median (IQR)							
							Cosmesis measured by 9 independent assessors blinded to suture type on modified Hollander scale from 0 (best) to 6 (worst)											
							"The use of barbed sutures in place of smooth sutures also resulted in less needle handling, providing a safer environment not only for the surgeon, but also for the											

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure				
							nursing staff. This increased efficiency should further increase the reduction in needle-stick injuries, which most hospitals promote."								
Rubin JP, et al., 2014²⁷	United States	RCT	dermal closure	All	V-Loc 180 (115) V-Loc 90 (114)	Monocryl	N	229	229		Count				
							Dermal closure (total) (min)	12	19.2	< 0.001	Mean				
							Total number of sutures (N)	2.0	3.3	< 0.001	Mean				
							Dermal closure (total) (min)	11.8	18.1	< 0.001	Mean				
							Total number of sutures (N)	2.0	3.3	< 0.001	Mean				
							Dermal closure (total) (min)	11.8	19.8	< 0.001	Mean				
				Brs	V-Loc 180 (115) V-Loc 90 (114)	Monocryl	Total number of sutures (N)	1.8	3.3	<0.001	Mean				
				Rubin JP, et al., 2014²⁷	United States	RCT	dermal closure	All	V-Loc 180	Monocryl	N	115	115		Count
											Complic (at least 1)	30 (26.1%)	9 (7.8%)	0.001	Count
Dehiscence (N)	2 (1.7%)	1 (0.9%)	> 0.99								Count				
Post-op bleeding (N)	0 (0%)	2 (1.7%)	NR								Count				

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
					V-Loc 90	Monocryl	Infection (N)	4 (3.5%)	2 (1.7%)	0.69	Count
							Pain incision site (N)	3 (2.6%)	1 (0.9%)	0.63	Count
							N	114	114		Count
							Complic (at least 1)	19 (16.7%)	9 (7.9%)	0.09	Count
							Dehiscence (N)	4 (3.5%)	2 (1.8%)	0.69	Count
							Post-op bleeding (N)	0 (0%)	0 (0%)	NR	Count
							Infection (N)	2 (1.8%)	0 (0%)	0.5	Count
							Pain incision site (N)	0 (0%)	2 (1.8%)	NR	Count
Rubin JP, et al., 2014²⁷	United States	RCT	dermal closure	All			"This time savings may provide great advantages in both reduced anesthesia time and fewer required resources for surgical procedures."				
Grigoryants V, et al., 2013²⁸	United States	RCT	LAP		V-Loc 90	Polyglactin 910	N	30	30		Count
							Suture time (sec) all layers	472.0 (74.2)	741.8 (103.2)	< 0.0001	Mean (SD)
							Upper dermis closure time (sec)	292.6 (59.8)	356.8 (60.3)	< 0.0001	Mean (SD)
							Suture extrusion (N)	1 (3.3%)	1 (3.3%)	NR	Count

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							Post-op complic (N)	1 (3.3%)	4 (13.3%)	NR	Count
							Dehiscence (N)	0 (0%)	1 (3.3%)	NR	Count
							Infection (N)	0 (0%)	2 (6.7%)	NR	Count
							Cost (material)	(\$47-\$94.60)	(\$45.79-\$91.38)	NR	Range
							Scar appearance (VSS)	6.09 (2.27)	6.27 (1.91)	0.77	Mean (SD)
							"Although V-Loc 90 for abdominoplasty is slightly more expensive, the more significant advantage, in our experience, comes from reduced wound closure time and therefore reduced operating room/anesthesia time, less surgeon fatigue, and fewer postoperative wound complications."				
							"In our experience, wound closure using barbed sutures was faster and technically easier. Both the total closure time and closure of each layer were faster with barbed sutures."				
Thekkinkatil DK, et al., 2013 ⁴⁵	United Kingdom	Retro cohort	donor site closure, BR		V-Loc 180	PDS II (2-0)	N	33	24		Count
							Operative time (min)	311 (300-335)	319 (282-345)	0.881	Median (IQR)
							Length of stay (d)	6 (5-7)	5 (5-7)	0.329	Median (IQR)
							Dehiscence (N)	0 (0%)	0 (0%)	NR	Count
							"The number of PDS II sutures used per patient was variable as more sutures were used by surgeons who were performing hand tying... the need for greater				

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							number of PDS II sutures reduces the expenditure difference between the two suture groups."				
							"all surgeons found the barbed suture easy and convenient to handle while quilting"				

Abd, abdominal (procedures); au, arbitrary units; BC, body contouring; BR, breast reconstruction; Brs, breast (procedures); Comp, comparator; Complic, complications; Consec, consecutive patients; DIEP, deep inferior epigastric artery perforator; FF, free flap; GBP, Great Britain Pounds Sterling; LAP, lipoabdominoplasty; IQR, interquartile range; NR, not reported; Post-op, post-operative; Prosp, prospective (data collection); RCT, randomized controlled trial; Retro, retrospective; SD, standard deviation; Sig, (measure of) significance (p-value when reported or calculable); VSS, Vancouver Scar Scale.

Where reported, suture sizes according to USP (United States Pharmacopeia) are shown in parentheses after suture name.

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7.5. Urology clinical data

Data extracted from comparative clinical studies with V-Loc™ wound closure device data relevant to urology are shown in (Table 7-5).

Table 7-5 V-Loc™ wound closure device and non-barbed suture data in urology

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure						
Gözen AS, et al., 2015⁴¹	Germany	Prosp + retro control	RP	Lap	V-Loc 180 (2-0)	Vicryl polyglact in (2-0)	N	31	31		Count						
							DV ligature time (min)	4.7 (2.4)	8.4 (5.2)	0.04	Mean (SD)						
							DVC control (min)	18.7 (6.3)	29.3 (10.7)	< 0.001	Mean (SD)						
							Operative time (min)	205 (31.1)	219.4 (48.8)	0.27	Mean (SD)						
							Intra-op blood loss (ml)	654.8 (457.5)	670.9 (233.2)	0.35	Mean (SD)						
							Late continence (ULR, %)	0.0113 (67.7%)	0.0577 (41.9%)	0.61	Count						
							Early continence (ULR, %)	0.0239 (48.3%)	0.0874 (12.9%)	0.005	Count						
							"We began to perform DVC [dorsal vein complex] suturing with V-Loc in January 2011, and we have been using this suture and suturing technique in all LRP [laparoscopic radical prostatectomy] and RALP [robot-assisted laparoscopic radical prostatectomy] procedures recently."										
							"Moreover, V-Loc was more cost-effective than a stapler."										
							"The technique can be performed, even in inexperienced hands without intracorporeal knot tying and advanced suturing skills."										

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							"In our opinion, this [less ULR, urine loss ratio] was because DVC was safely controlled with the V-Loc on the mid part of the prostate."				
Schauer I, et al., 2014⁴⁶	Austria	Retro cohort	PN	Open, cold ischemia	V-Loc (NR)	NR	N	15	35		Count
							Cold ischemia time (min)	15.2 (6.9)	25.7 (11.8)	< 0.01	Mean (SD)
							Complic (ANY)	2 (13.3%)	11 (31.4%)	0.32	Count
							Decline in eGFR (%) discharge	6.6% (15.3%)	6.2% (13.1%)	0.94	Mean (SD)
							Post-op eGFR (ml/min/1.73m ²)	68.3 (18.3)	70.4 (22.8)	0.74	Mean (SD)
							Pre-op eGFR (ml/min/1.73m ²)	73.8 (19.8)	74.3 (26.3)	0.94	Mean (SD)
Erdem S, et al., 2013²⁹	Turkey	Matched pair	PN	Lap, warm ischemia	V-Loc 180 (3-0)	Polyglactin 910 (3-0)	N	17	17		Count
							Suture time (sec)	350 (240-720)	505 (270-1290)	0.004	Median (range)
							Warm ischemia time (min)	19 (12-50)	28 (10-57)	0.037	Median (range)
							Operative time (min)	110 (90-190)	140 (80-190)	0.368	Median (range)
							Intra-op blood loss (ml)	100 (30-400)	140 (20-200)	0.986	Median (range)

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							Peri-op complic (N)	3 (17.6%)	3 (17.6%)	1	Count
							Length of stay (d)	3 (2-5)	3 (2-7)	0.224	Median (range)
							Decrease in eGFR (ml/min/1.73m ²)	0 (-23-39)	9.0 (-12-62)	0.176	Median (range)
							Post-op eGFR (ml/min/1.73m ²)	82.4 (22-189)	83 (51-138)	0.48	Median (range)
							Pre-op eGFR (ml/min/1.73m ²)	91.4 (52-226)	92 (59-138)	0.593	Median (range)
							Paired analysis matched patients on sex, age (within 5 years), BMI within WHO BMI classification), PADUA score and operative approach				
Erdem S, et al., 2013²⁹	Turkey	Matched pair	PN	Lap	V-Loc 180 (3-0)	Polyglactin 910 (3-0)	N	33	33		Count
							Suture time (sec)	350 (165-720)	400 (190-1290)	0.099	Median (range)
							Warm ischemia time (min)	22.0 (14-50)	25.0 (9-57)	0.067	Median (range)
							Operative time (min)	110.0 (70-190)	120.0 (70-190)	0.763	Median (range)
							Intra-op blood loss (ml)	100.0 (30-400)	150.0 (20-1,000)	0.303	Median (range)

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							Peri-op complic (N)	9 (27.3%)	7 (21.2%)	0.566	Count
							Length of stay (d)	3 (2-7)	3 (2-7)	0.961	Median (range)
							Decrease eGFR (ml/min/1.73m ²)	7.0 (-34-39.3)	10.0 (-32-62)	0.186	Median (range)
							Post-op eGFR (ml/min/1.73m ²)	93.0 (22-189)	85.0 (45-135.4)	0.404	Median (range)
							Pre-op eGFR (ml/min/1.73m ²)	99.0 (52.0-226.0)	94.0 (59.0-149.0)	0.700	Median (range)
							"This suture [self-retaining barbed suture V-Loc] may encourage urologists to perform LPN [laparoscopic partial nephrectomy] in more challenging and larger tumors that may need longer warm ischemia durations." "...we believe that the previously described features of SRBS has a significant contribution on reducing WIT and may prevent time-dependent renal damage"				

Jeon SH, et al., 2013⁴²	United States	Consec + control	PN	Lap	V-Loc 180	Polyglactin 910	N	13	24		Count
							Warm ischemia time (min)	24.5 (5.3)	31.9 (8.9)	0.01	Mean (SD)
							Operative time (min)	248.5 (37.2)	256.7 (39.2)	0.54	Mean (SD)
							Intra-op blood loss (ml)	319.2 (311.3)	331.3 (221.6)	0.89	Mean (SD)

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure	
Olweny EO, et al., 2012⁴³	United States	Retro cohort	PN	Lap	V-Loc 180	Polyglactin 910	Intra-op complic (N)	3 (23.1%)	6 (25%)	0.9	Count	
							Length of stay (d)	3.8 (1.3)	3.8 (1.2)	0.9	Mean (SD)	
							Post-op complic (N)	3 (23.1%)	6 (25%)	0.9	Count	
							"The use of V-Loc sutures for renorrhaphy during LPN is safe and feasible and significantly reduces WIT. The use of V-Loc sutures did not increase postoperative morbidity after partial nephrectomy in our series."					
							"...reasons for decrease in WIT could include eliminating the need for both knot tying and maintaining constant tension on the non-barbed suture, freeing up both hands for intracorporeal suturing."					
							N	29	49		Count	
							Warm ischemia time (min)	26.4 (8.3)	32.8 (7.9)	< 0.001	Mean (SD)	
							Operative time (min)	174 (35)	178 (41)	0.7	Mean (SD)	
							Intra-op blood loss (ml)	188 (205)	255 (337)	0.34	Mean (SD)	
							Intra-op complic conversion (N)	1 (3.4%)	9 (18.4%)	0.06	Count	
Complic (ANY)	3 (10.3%)	12 (24.4%)	0.13	Count								
Length of stay (d)	3.4 (1.3)	3.6 (0.98)	0.4	Mean (SD)								
			PN				N	31	31		Count	

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure						
Zondervan PJ, et al., 2012⁴⁷	Netherlands, Germany	Case control		Open, Lap	V-Loc 180	Polyglactin 910	Ischemia time (min)	19.6 (7.5)	21.8 (9.5)	0.312	Mean (SD)						
							Intra-op complic (N)	0 (0%)	2 (6.5%)	NR	Count						
							Decrease in eGFR (ml/min/1.73m ²)	0.0 (-4.3-14.2)	0.0 (-4.6-18.6)	0.735	Median (range)						
							Post-op complic (N)	2 (6.5%)	5 (16.1%)	NR	Count						
							Post-op eGFR (ml/min/1.73m ²)	73.6 (24.4)	81.1 (22.3)	0.307	Mean (SD)						
							Pre-op eGFR (ml/min/1.73m ²)	81.7 (23.4)	75.0 (26.5)	0.301	Mean (SD)						
							N	15	15		Count						
Sammon J, et al., 2011⁴⁴	United States	Consec	PN	robotic	V-Loc 180	Polyglactin	Warm ischemia time (min)	18.5 (5.3)	24.7 (6.6)	0.008	Mean (SD)						
							Operative time (min)	227.5 (66.7)	275 (49.2)	0.49	Median (SD)						
							Intra-op blood loss (ml)	150 (119.3)	150 (99.6)	0.35	Median (SD)						
							Length of stay (d)	2.0 (0.7)	2.0 (1.3)	0.86	Median (SD)						
							Cost (material) 3 cm defect	\$158.80	\$146.25	NR	Mean						
							"We think a \$12.55 increase in cost per case is negligible, given the increases in efficiency gained. The collective decrease in warm ischemia time or operative time over										

Reference	Country	Study	Proc	Proc details	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							multiple cases could also contribute to cost savings. Also there are potential cost benefits to society of a reduction in warm ischemia time in terms of preservation of renal function."				

ANOVA, analysis of variance (simultaneous multiway comparisons); BMI, body mass index; Comp, comparator; Complic, complications; Consec, consecutive patients; Consec+control, consecutive patients with non-consecutive control group[Jeon]; d, days; DV, dorsal vein; DVC, dorsal vein complex; eGFR, estimated glomerular filtration rate; Intra-op, intra-operative; Lap, laparoscopic; N, number of patients; NR, not reported; PADUA, pre-operative aspects and dimensions used for an anatomic (score classification); Peri-op, peri-operative; PN, partial nephrectomy; Post-op, post-operative; Pre-op, pre-operative; Proc, (surgical) procedure; Prosp, prospective (data collection); RCT, randomized controlled trial; Retro, retrospective; RP, radical prostatectomy; SD, standard deviation; Sig, (measure of) significance (p-value when reported or calculable); SRBS, self-retaining barbed suture; ULR, urine loss ratio; WHO, World Health Organization; WIT, warm ischemia time.

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7.6. Robot-assisted surgery clinical data

Data extracted from comparative clinical studies with V-Loc™ wound closure device data where robot-assisted surgeries were performed are shown in (Table 7-6). Note that these studies are also represented in tables Table 7-3 and Table 7-5, collected here for grouping of robot-assisted surgery results.

Table 7-6 V-Loc™ wound closure device and non-barbed suture data in robot-assisted surgeries

Reference	Country	Study type	Group	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Tsafrir Z, et al., 2017³⁹	United States	RCT	GYN	Hys	V-Loc 90 (2-0)	Vicryl (0)	N	30	30		Count
							Suture time (min)	14.5 (11-24)	12 (9-26)	0.09 (ANOV A)	Median (Range)
							Operative time (h)	2.4 (0.75)	2.8 (0.94)	0.19 (ANOV A)	Mean (SD)
							Intra-op blood loss (ml)	50 (10-250)	50 (5-200)	0.34 (ANOV A)	Median (Range)
							Urinary retention (N)	1 (3.3%)	2 (6.6%)	NR	Count
							Dehiscence (N)	0 (0%)	0 (0%)	NR	Count
							Post-op bleeding (N)	5 (16.6%)	1 (3.3%)	NR	Count
							Infection (N)	1 (3.3%)	2 (6.6%)	0.43 (ANOV A)	Count
							Pain (N, 1 year)	0 (0%)	3 (23.1%)	0.01 (Fisher)	Count

Reference	Country	Study type	Group	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Tsafrir Z, et al., 2017³⁹	United States	RCT	GYN	Hys	V-Loc 90 (2-0)	Vicryl (0) + LapraTy	Cost (material)	\$44.00	\$6.50		Value
							Cost (procedure)	\$869.0 (649.0-1364.6)	\$666.5 (501.5-1436.5)	0.007 (ANOV A)	Median (Range)
							N	30	30		Count
							Suture time (min)	14.5 (11-24)	13 (8-26)	0.09 (ANOV A)	Median (Range)
							Operative time (min)	2.4 (0.75)	2.7 (0.73)	0.19 (ANOV A)	Mean (SD)
							Intra-op blood loss (ml)	50 (10-250)	50 (10-250)	0.34 (ANOV A)	Median (Range)
							Urinary retention (N)	1 (3.3%)	0 (0%)	NR	Count
							Dehiscence (N)	0 (0%)	0 (0%)	NR	Count
							Post-op bleeding (N)	5 (16.6%)	4 (13.3%)	NR	Count
							Infection (N)	1 (3.3%)	1 (3.3%)	0.43	Count
							Pain (N, 1 year)	0 (0%)	0 (0%)	0.01 (Fisher)	Count
							Cost (material)	\$44.00	\$65.60		Value
							Cost (procedure)	\$869.0 (649.0-1364.6)	\$780.6 (505.6-1495.6)	0.007 (ANOV A)	Value

Reference	Country	Study type	Group	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Brown DN, et al., 2016³²	United States	Retro cohort	GYN	TLH	V-Loc 180	Vicryl polyglactin 910	"Cost analysis in our trial indicated that the use of barbed suture would add 38 dollars compared to interrupted vicryl suture, which had equivalent long-term outcomes. However, in light of improved vaginal cuff outcomes with barbed suture in other studies, this may be money well spent."				
							N	375	99		Count
							Operative time (min)	83 (62-105)	132 (74-230)	< 0.001	Median (IQR)
							Intra-op blood loss (ml)	75 (50-100)	75 (50-150)	0.12	Median (IQR)
							Complic (ANY)	10 (2.7%)	1 (1.0%)	0.47	Count
							Length of stay (N, same day)	86 (23.1%)	14 (14.1%)	0.04	Count
							Length of stay (N, 1 day)	243 (65.1%)	76 (76.8%)	0.04	Count
							Length of stay (N, 2 days)	30 (8.0%)	9 (9.1%)	0.04	Count
							Length of stay (N, ≥3 days)	14 (3.8%)	0 (0.0%)	0.04	Count
							Granulation (N)	4 (1.1%)	0 (0%)	0.58	Count
Dehiscence (N)	3 (0.8%)	0 (0%)	> 0.99	Count							

Reference	Country	Study type	Group	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Tillmanns TD, et al., 2016²¹	United States	RCT	GYN	Hys	V-Loc 180 (2-0)	Vicryl (2-0)	Surgical numbers: V-Loc (224 robotic, 151 TLH), conventional (46 robotic, 53 TLH). Outcomes stratified only by suture-type, not robotic assistance.				
							N	33	34		Count
							Suture time (min)	3.2 (1.1)	7.6 (2.7)	<0.001	Mean (SD)
							Post-op dyspareunia (N) [of x 3 mo intercourse]	1/9 (11%)	4/9 (44%)	NR	Count
							Granulation (N)	0 (0%)	2 (5.9%)	NR	Count
							Dehiscence (N)	0 (0%)	1 (1.9%)	NR	Count
							Cost (material)	22	7.17		Value
							Cost (closure) \$22/min	\$92.4 (24.2)	\$180.8 (65.1)	<0.001	Mean (SD)
Tillmanns TD, et al., 2016²¹	United States	RCT	GYN	Hys	V-Loc 180 (2-0)	Vicryl (2-0)	Cost (closure) \$62/min	\$220.4 (68.2)	\$484.8 (173.1)	<0.001	Mean (SD)
							Cost (closure) \$133/min	\$444.4 (145.2)	\$1,016 (362.1)	<0.001	Mean (SD)
							OR costs assessed at low, mid, high estimates of \$22, \$62 and \$133/min				
							"From another perspective, physicians performing 3 of these surgeries per day could gain 15 extra non-OR minutes in their days."				

Reference	Country	Study type	Group	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							"Although Lapra-Ty may decrease vaginal cuff closure time, this suture is likely to be cost-prohibitive, as it requires two VICRYL sutures (\$5 each) and two Lapra-Ty clips (\$183 each) for a total of \$376."				
Zhou Y, et al., 2014 ³³	United States	Retro cohort	GYN	TLH	V-Loc 180	Polyglactin 910	N	49	44		Count
							Operative time (min)	220.2 (58.3)	272.8 (80.6)	0.00	Mean (SD)
							Intra-op blood loss (ml)	163.2 (137.2)	274.9 (299.5)	0.02	Mean (SD)
							Length of stay (d)	1.8 (1.0)	2.6 (3.0)	0.11	Mean (SD)
							Granulation tissue (N)	4 (8.2%)	12 (27.3%)	0.03	Count
							Dehiscence (N)	1 (2.0%)	0 (0.0%)	1.00	Count
							Post-op bleeding (N)	7 (14.3%)	10 (22.7%)	0.42	Count
							Number of clinic visits	2.6 (0.8)	2.9 (1.5)	0.2	Mean (SD)
							Healing time (weeks)	7.7 (3.4)	8.5 (4.1)	0.32	Mean (SD)
		Retro	GYN	Hys			N	118	323		Count

Reference	Country	Study type	Group	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Drudi L, et al., 2013⁵¹	Canada				V-Loc (NR)	Vicryl or Vicryl + Biosyn	Dehiscence (N)	1	6	NR	Count
							N	76	58	Count	
							Bowel obstruction (N)	0 (0%)	0 (0%)	NR	Count
							Dehiscence (N)	0 (0%)	0 (0%)	NR	Count
							Cost (material)	\$26.00	\$376.00	NR	Value
Neubauer NL, et al., 2013⁴⁹	United States	Retrospective	GYN	TH	V-Loc 180 (2-0)	Monofil (2-0)	"At the study institution, the average cost of using 2-0 monofilament synthetic absorbable suture (US \$5.00 each; on average, 2 sutures per case) and absorbable suture clips (\$183.00 each; on average, 2 per case) is greater than that associated with using only a single 2-0 absorbable welded-loop barbed suture (\$26.00 each)				
							"After 1 year, all attending surgeons switched over to the welded-loop method of vaginal cuff closure owing to its ease of use."				
							"Of the 2 techniques, we now prefer knotless vaginal cuff closure. The unidirectional barb of this suture precisely secures the tissue at numerous points, evenly distributing the closure forces and enabling a fast and safe knot-free vaginal cuff closure during robotic hysterectomy."				
							"this closure technique works well in an academic environment, where surgeons range in skill level (resident physician, fellow, attending surgeon), and eliminates dependence of the cuff closure on robotic tying."				
		GYN		TLH		Vicryl	N	69	133		Count

Reference	Country	Study type	Group	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
Nawfal AK, et al., 2012³⁴	United States	Retro cohort			V-Loc 180		Operative time (min)	135 (30-299)	175 (80-625)	< 0.001	Median (range)
							Intra-op blood loss (ml)	50 (10-300)	75 (10-1000)	<0.001	Median (range)
							Length of stay (d)	1 (1-9)	1 (1-14)	0.01	Median (range)
							Length of stay >1d (Odds Ratio)	0.37 [0.18, 0.76]			Ratio [95%CI]
Sammon J, et al., 2011⁴⁴	United States	Consec	URO	PN	V-Loc 180	Polyglactin	N	15	15		Count
							Warm ischemia time (min)	18.5 (5.3)	24.7 (6.6)	0.008	Mean (SD)
							Operative time (min)	227.5 (66.7)	275 (49.2)	0.49	Median (SD)
							Intra-op blood loss (ml)	150 (119.3)	150 (99.6)	0.35	Median (SD)
							Length of stay (d)	2.0 (0.7)	2.0 (1.3)	0.86	Median (SD)
							Cost (material) 3 cm defect	\$158.80	\$146.25	NR	Mean
							"We think a \$12.55 increase in cost per case is negligible, given the increases in efficiency gained. The collective decrease in warm ischemia time or operative time over multiple cases could also contribute to cost savings. Also there are potential cost benefits to society of a reduction in				

Reference	Country	Study type	Group	Proc	Device	Comp details	Outcome	V-Loc data	Comp data	Sig	Measure
							warm ischemia time in terms of preservation of renal function."				

95%CI, 95% confidence interval; ANOVA, analysis of variance (simultaneous multiway comparisons); BMI, body mass index; Comp, comparator; Complic, complications; Consec, consecutive patients; d, days; Fisher, Fisher's exact test' GYN, gynecology; h, hours; Hys, hysterectomy; Intra-op, intra-operative; IQR, interquartile range; N, number of patients; NR, not reported; OR, operating room; PN, partial nephrectomy; Post-op, post-operative; Proc, (surgical) procedure; Prosp, prospective (data collection); RCT, randomized controlled trial; Retro, retrospective; SD, standard deviation; Sig, (measure of) significance (p-value when reported or calculable); TLH, total laparoscopic hysterectomy; URO, urology.

In the study of Tillmanns²¹ the outcome reporting dyspareunia were presented as the number of patients who experienced the complication as a fraction of the number of patients who had resumed intercourse within 3 months (x). The study of Brown 2016³² includes both robotic and non-robotic procedures (respective patient numbers for V-LocTM and conventional suture, robotic and non-robotic are indicated).

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8. Structured literature search details

8.1. Searches performed

Structured searches were performed to identify literature reporting on V-Loc™ wound closure device data in non-clinical and clinical settings for indicated procedures in PubMed (Table 8-1) and EMBASE (Table 8-2). Searches were performed 06 September 2017.

Table 8-1 Structured searches in PubMed to identify relevant V-Loc™ wound closure device data

Index	Aim	Search string	Hits
#01	V-Loc™-specific barbed suture	("V Loc"[tw] OR V-Loc[tw] OR Vloc[tw] OR V-Loc*[tw] OR VLoc*[tw] OR V-Loc180*[tw] OR V-Lock[tw] OR Vlock[tw] OR V-Lock*[tw] OR VLock*[tw] OR V-Lok[tw] OR Vlok[tw] OR V-Lok*[tw] OR VLoc*[tw])	255
#02	Generic barbed suture description	((barb[tw] OR barbs[tw] OR barbed[tw] OR knotless[tw] OR knot-less[tw] OR selfretain*[tw] OR "self retaining"[tw] OR self-retain*[tw]) AND (sutures[tw] OR sutur*[tw] sutures[MeSH] OR stitches[tw] OR stitch*[tw] OR oversew[tw] OR over-sew[tw] OR "over sew"[tw] OR thread*[tw]))	350
#03	Competitor barbed suture	(Stratafix*[tw] OR (Quill*[tw] AND (sutures[mh] OR sutur*[tw])))	65
#04	10-year search window	"2007/01/01"[pdat]:"2018/12/31"[pdat]	10,007,977
#05	Article types to exclude	("Case Reports" [ptyp] OR "Clinical Conference" [ptyp] OR "Comment" [ptyp] OR "Editorial" [ptyp] OR "Letter"[ptyp] OR "Retracted Publication"[ptyp] OR "Congresses"[ptyp] OR "Duplicate Publication"[ptyp] OR "case report"[tw] OR "case study"[tw])	3,404,625
#06	Publications with explicit reference to animal models or studies (clinical vs non-clinical stratification)	Animal model/experimentation terms ⁶⁵	6,407,756
#07	Publications of experimental applications	("Cadaver"[MeSH] OR cadaver[tw] OR deceased[tw] OR "ex vivo"[tw] OR "Nontherapeutic Human Experimentation"[MeSH])	128,414
#08	Anastomoses	("Anastomosis, Surgical"[MeSH] OR anastomosis[tw] OR anastomoses[tw])	120,930
#09	Hernia	(Hernia[MeSH] OR Hernia[tw] OR mesh[tw] OR fascia[tw])	123,630
#10	(Putative) Clinical barbed suture, exclude non-indicated	((#01 OR #02 OR #03) AND #04 NOT (#05 OR #08 OR #09)) NOT (#06 OR #07)	205

	procedures and publication types		
#11	(Putative) Non-clinical barbed suture, exclude non-indicated procedures and publication types	((#01 OR #02 OR #03) AND #04 NOT (#05 OR #08 OR #09)) AND (#06 OR #07)	83

Table 8-2 Structured search in EMBASE to identify use of V-Loc™ devices

Index	Aim	Search string	Hits
#01	Named V-Loc™ wound closure device	(V NEXT/1 (Loc OR Loc180 OR Loc90 OR LocPBT OR Lock OR Lock90 OR Lock180 OR Lok OR Lok180 OR Lok90 OR LokPBT) OR V-Loc OR Vloc OR V-Loc* OR VLoc* OR V-Loc180* OR VLoc180* OR V-Loc90* OR VLoc90* OR V-LocPBT* OR VLocPBT* OR V-Lock OR Vlock OR V-Lock* OR VLock* OR V-Lock180* OR VLock180* OR V-Lock90* OR VLock90* OR "V LockPBT" OR V-LockPBT* OR VLockPBT* OR V-Lok OR Vlok OR V-Lok* OR VLoc* OR V-Lok180* OR VLoc180* OR V-Lok90* OR VLoc90* OR V-LokPBT* OR VLocPBT*):ab,ti,kw,de,dn AND (sudur* OR stitch* OR 'wound closure' OR 'suture'/exp OR 'wound closure'/exp) OR (((barb:ab,ti,kw,de OR barbs:ab,ti,kw,de OR barbed:ab,ti,kw,de OR knotless:ab,ti,kw,de OR 'knot-less':ab,ti,kw,de OR selfretain*:ab,ti,kw,de OR 'self retaining':ab,ti,kw,de OR 'self-retaining':ab,ti,kw,de OR oversew:ab,ti,kw,de) AND (sudur*:ab,ti,kw,de OR stitch*:ab,ti,kw,de OR 'wound closure':ab,ti,kw,de OR 'suture'/exp OR 'wound closure'/exp) OR 'barbed suture'/exp) AND (covidien* OR Medtronic*):ab,ti,kw,de,df)	548
#02	Generic barbed suture description	((barb OR barbs OR barbed OR knotless OR 'knot-less' OR selfretain* OR 'self retaining' OR 'self-retaining' OR oversew):ab,ti,kw,de AND (sudur*:ab,ti,kw,de OR stitch*:ab,ti,kw,de OR 'wound closure':ab,ti,kw,de OR 'suture'/exp OR 'wound closure'/exp)) OR 'barbed suture'/exp	1,320
#03	Competitor products	stratafix*:ab,ti,kw,de,dn OR (quill*:ab,ti,kw,de,dn AND (sudur*:ab,ti,kw,de OR stitch*:ab,ti,kw,de OR 'wound closure':ab,ti,kw,de OR 'suture'/exp OR 'wound closure'/exp))	186
#04	Limit to 10 years	[2007-2018]/py	13,081,467

#05	Non-targeted publication types	'conference abstract'/exp OR 'conference paper'/exp OR 'conference review'/exp OR 'editorial'/exp OR 'letter'/exp OR 'note'/exp OR 'short survey'/exp OR 'retracted article'/exp OR 'abstract report'/exp OR 'case report'/exp OR 'case report':ab,ti,kw OR 'case study':ab,ti,kw	8,171,877
#06	Animal studies	Animal model/experimentation terms ⁶⁵	7,220,693
#07	Experimental procedures	'cadaver'/exp OR 'in vitro study'/exp OR 'ex vivo study'/exp OR 'ex vivo':ti,ab,kw,de OR 'in vitro':ti,ab,kw,de OR cadaver:ti,ab,kw,de OR deceased:ti,ab,kw,de	5,450,177
#08	Anastomoses	'anastomosis'/exp OR anastomosis:ab,ti,kw,de OR anastomoses:ab,ti,kw,de	208,565
#09	Hernia and fascia	'hernia'/exp OR 'fascia'/exp OR ((hernia:ab,ti,kw,de OR surgical:ab,ti,kw,de) AND mesh:ab,ti,kw,de)	127,212
#10	(Putative) Clinical barbed suture, exclude non-indicated procedures and publication types	((#01 OR #02 OR #03) AND #04 NOT (#05 OR #08 OR #09)) NOT (#06 OR #07)	363
#11	(Putative) Non-clinical barbed suture, exclude non-indicated procedures and publication types	((#01 OR #02 OR #03) AND #04 NOT (#05 OR #08 OR #09)) AND (#06 OR #07)	144

In both databases, searches were identically structured. The technology was searched first by name using field codes and features specific to each database, then by generic terms, and finally by specific names of competitor products. Data are restricted to a 10-year time window to retain relevance; V-Loc™ was approved for clinical use in 2009, however earlier publications may exist referencing barbed suture in non-clinical applications and these were to be excluded. As indicated in Section 2.4, articles were excluded from these searches not indicated for V-Loc™ wound closure device usage. Finally, as a putative discriminant between non-clinical and clinical applications, terms describing animal studies⁶⁵ and ex vivo or cadaver experiments were used to mutually-exclusively divide the results for screening against criteria described in Section 8.2.

8.2. Screening literature results

Results from the two searches were exported from their respective databases as search strings (PubMed) and .RIS files (EMBASE) for integration into the *Sourcerer* software utility for literature screening and review. Duplicate articles returned from the different sources were removed resulting in 419 clinical and 161 non-clinical articles. Articles were subjected to title/abstract-level screening to identify those potentially relevant to V-Loc™ devices using criteria listed in Table 8-3. Where the barbed suture technology was ambiguous at abstract level, the full text of the article was reviewed to determine relevance to V-Loc™ wound closure devices.

Table 8-3 Description of exclusion criteria

Criterion	Explanation
Articles with no abstract	At top level screening, no informed decision regarding evidence or quality can be made without an abstract
Not targeted publication type	Articles that are commentaries or letters responding to other articles are not included for evidence recovery. Also included are basic science publications that are unrelated to suturing (such as “V Loci” in molecular biological studies that were captured by the search terms but not relevant to suturing).
Not targeted procedure	Exclude publications which unambiguously refer to non-indicated procedures or non-indicated use (such as knot tying).
Not suture-focused	Studies which make only incidental reference to V-Loc™ or other suturing in describing a method, with no relevant comparison of outcomes between changes in suturing types.
*Fewer than 10 patients	Applicable to the clinical screening only, exclude studies with fewer than 10 subjects in each study arm.
Not V-Loc™	From generic terminology for barbed suture searches, articles where there are clearly no V-Loc™-relevant data.
†No comparison and non-V-Loc™	Pre-clinical studies which are single arm or veterinary where no suture-related comparison is performed or the barbed suture is identified as not V-Loc™.

*Applicable only to clinical publication screening

†Applicable only to non-clinical publication screening

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