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Closing the Gap:

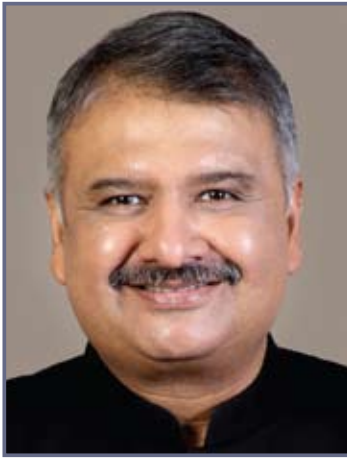
Expert opinion on advanced wound closure strategies in cesarean section

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Preface



Dr Jaydeep Tank



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Closing the gap: Expert opinion on advanced wound closure strategies in cesarean section

Cesarean section (C-section) remains one of the most common surgical procedures worldwide, performed for a variety of maternal and fetal indications. As surgical techniques continue to evolve, there has been a growing interest in improving surgical efficiency, reducing postoperative complications, and enhancing wound healing. One such innovation is the use of barbed sutures, which have gained attention in obstetric surgery, including C-section procedures. Barbed sutures, with their self-locking design, are becoming increasingly popular in cesarean sections due to their ability to streamline the procedure and improve efficiency. These sutures eliminate the need for knot-tying, allowing for faster closure of both the uterine and abdominal incisions. Benefits may include reduced operative time, less tension on the wound, and improved wound security. However, while promising, ongoing research is needed to fully assess their impact on postoperative outcomes and complications.

Best wishes!

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CLOSING THE GAP:

**Expert opinion on advanced wound closure
strategies in caesarean section**

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Dr Mukesh Gupta**

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Overview of cesarean sections

The rate of Cesarean section (CS) deliveries has risen in recent years, primarily due to precious pregnancies and those conceived through IVF. Additional contributing factors include either maternal, fetal, or placental abnormalities. CS, like all surgical procedures, are associated with inherent risks, including hemorrhage, infection, delayed wound healing, potential challenges in establishing breastfeeding and skin-to-skin contact, as well as an elevated risk of complications in subsequent pregnancies.¹

An optimal skin closure technique should prioritize safety, efficiency, cost-effectiveness, and patient comfort, offering minimal follow-up requirements, low risk of wound complications, and favorable cosmetic outcomes.² Identifying effective techniques to reduce the risk of complications following CS is imperative.³ Choice of suture materials and suturing techniques have shown potential to reduce wound dehiscence rates and lower related treatment costs following CS, making them a valuable option for postoperative wound management, and long-term outcomes for the mother.³

Objective

The purpose of this consensus document is to provide updated expert opinion for standardizing CS closure techniques across Indian healthcare systems. Based on expert panel discussions and clinical evidence, the document outlines practices for bleeding control and wound healing following CS procedures.

Expert panel and consensus process

The task force comprised of experts in the field of Obstetrics and Gynaecology. The task force reviewed the existing literature and developed consensus statements based on published literature, their individual clinical experience, and focused discussion amongst the experts. The consensus statements developed by task force were presented to larger group consisting of eminent experts in the field of Obstetrics and Gynaecology. There was deliberation on each consensus point and later

accepted or deleted. Thus, this document provides much-required insights and useful, practical, and accurate feasible guidance that aids a practicing clinician across the country.

Surgical goals for wound closure and hemostasis during CS

The objectives of wound management involve recognizing the various stages of wound healing and applying appropriate treatments at each stage. In cesarean closure, the primary aim is to achieve hemostasis, prevent infection, prevent untoward injuries, encourage tissue regeneration and healing, and achieve an improved cosmetic result.^{4,5}

Immediate concerns

Minimizing blood loss

- The reported average blood loss in cesarean delivery is approximately 500 to 1000 mL.⁶
- There has been an agreement amongst clinicians that a faster closure of uterine incision can reduce the blood loss associated with cesarean delivery.⁷ Therapeutic measures should be targeted at stabilizing the patient and controlling the cause of bleeding.⁸

Reducing adhesions

- The incidence of adhesions following a primary cesarean delivery has been reported to range from 24% to 73%.⁹ This variation may be attributed to differences in surgical techniques, with the type of uterine incision, the method used for closing the hysterotomy, and particularly whether the peritoneum is closed or left open. Regardless of the technique employed, studies indicate that adhesions are common after cesarean delivery, and that the incidence increases with each subsequent CS.⁹
- Abdominal adhesions are associated with several complications such as bowel obstruction, secondary infertility, and chronic pelvic pain, and may complicate subsequent pelvic surgeries. Hence, prevention of adhesion formation following cesarean delivery is essential.⁹

Reducing the risk of Surgical Site Infections (SSI)

- Surgical site infections (SSIs) are a common complication after CS, with an incidence ranging from 3% to 15%.¹⁰ They impose mental, physical and economic burden on the mother and are linked to maternal mortality. As the global rate of CS continues to rise, the occurrence of SSIs is expected to increase, highlighting their clinical importance.¹⁰
- Surgical suture is one of the factors involved in the onset of SSIs. Use of anti-microbial coated sutures can inhibit viable adhered microbes and prevent biofilm formation thereby preventing suture-associated SSIs.¹¹

Late concerns

Secure tissue closure

- The choice of material and surgical technique used to close an abdominal wall incision are key factors influencing the risk of wound dehiscence and incisional hernia development. The closure techniques of uterine incision can influence the incidence of scar ectopics, isthmocele, and vaginal birth after CS. Optimizing the closure of these incisions can prevent incisional hernias and result in significant healthcare cost savings.¹²

Improved cosmetic outcomes

Postoperative scar formation is an unavoidable consequence of surgery and may have significant impacts on both the physical and psychological well-being of the patient.¹³

The aesthetic appearance of repaired skin incisions is very important to patients undergoing CS and is especially significant for women undergoing elective cesarean births.¹⁴ An appropriate wound closure technique can help to achieve better cosmetic results, for example, the use of absorbable sutures for deeper wounds can decrease the tension and better approximate the wound edges. This allows for a lower risk of wound dehiscence and a more aesthetically pleasing outcome. Further, care should be taken to have more cosmetically appealing results providing greater tensile strength and less risk of injuring cutaneous circulation.⁴

Long-term morbidity due to pain and numbness/paresthesia

Severe adhesions and nerve entrapment can cause significant long-term distress for women.¹⁵ Employing proper suturing techniques and choice of materials can help minimize these complications.¹⁶

EXPERT OPINION

Experts agree that surgical goals for wound closure and hemostasis in CS should include: achieving faster closure of the uterine incision to minimize blood loss, preventing adhesion formation, to reduce the risk of SSIs, optimizing abdominal wall closure to prevent incisional hernias, and attaining cosmetically favorable outcomes, good surgical technique suture material can help achieve these goals .

Step-by-step guide to wound closure and bleeding management in CS

Step 1: Uterine incision and closure

A low transverse incision is a typically performed opening on the uterus that follows delivery of the baby, and removal of the placenta, with gentle cord traction and uterine massage.¹⁷ The fear of scar rupture is a specific risk factor involved in a post-cesarean pregnancy.¹⁸ Appropriate suturing techniques can address other concerns like scar dehiscence, scar ectopics, scar endometriosis, isthmocele, and morbidly adherent placentation.¹⁹ A uterine incision taken very low and late in labor by 5 cm dilation has been associated with a higher rate of isthmocele.²⁰

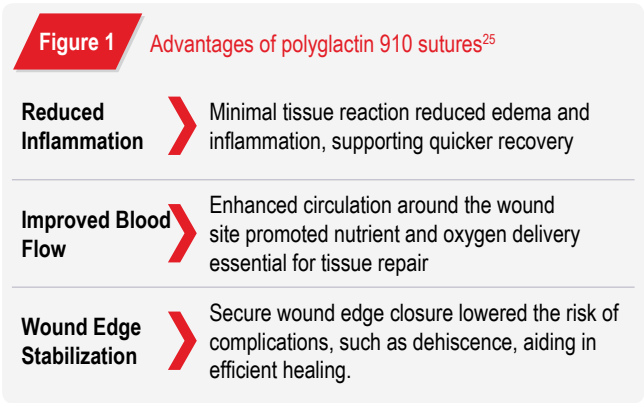
Incidence of scar endometriosis increases when same intrauterine mop is used. It is advisable to avoid use of the swab inside the uterine cavity, but if it is used it should be discarded immediately after use to decrease the incidence of scar endometriosis.²¹

Therefore, a key step in CS is the closure of the uterine incision. It is, therefore, necessary to employ an optimal surgical technique and an anatomically proper closure of the incision on the uterus to minimize the morbidity in the existing pregnancy and prevent uterine scar dehiscence in future pregnancies.¹⁸

The Enhanced Recovery after Surgery Society (ERAS) guideline for intraoperative care in cesarean delivery recommends a blunt expansion of a transverse uterine incision to reduce surgical blood loss.²²

An Indian survey of 253 obstetricians has shown that polyglactin 910 Sutures have replaced catgut for uterine closure in CS. Nearly half of the obstetricians (43.88%) have switched over to the use of polyglactin 910 sutures in preference to catgut.²³

Polyglactin 910 suture is a commonly preferred suturing material for its tensile strength and its resistance to breakage during the tying process with minimal tissue reaction.²⁴ A key advantage of polyglactin 910 suture is to promote faster wound healing and other advantages are shown in Figure 1.²⁵



Single-layer vs. double-layer uterine closure

Research has shown that single-layer uterine closures were associated with several advantages such as significant reductions in operative time.²⁶ The effect on future childbearing needs to be considered since higher rates of subsequent uterine ruptures were reported in women who had a single-layer uterine closure in the previous cesarean.²⁷ Single-layer closure is also associated with a higher risk of postmenstrual spotting and possibly subfertility after a CS. These complications can be prevented with double-layer unlocked closure, which is considered safe, as it results in thicker residual myometrium, especially when non-locking sutures are applied.²⁸

The ERAS guideline for intraoperative care in cesarean delivery recommends that closure of the hysterotomy in two layers can lower the rate of uterine rupture.²²

Suturing technique for uterine incision closure

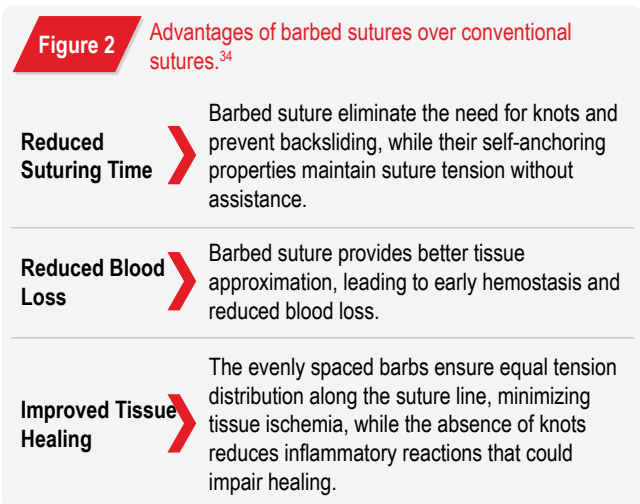
The uterine incision is closed using an absorbable braided suture.²⁹ Braided sutures, like triclosan

coated polyglactin 910—a synthetic absorbable suture made from a glycolide-lactide polymer. They are easy to handle and offer favorable knot-tying properties due to their coating of glycolide, lactide, and calcium stearate.³⁰ Triclosan coated Polyglactin 910 sutures offer improved patient outcomes for uterine closure during CS due to their antibacterial properties, ease of handling, minimal tissue reaction, and provide smooth passage through tissue.³¹ The suture is completely absorbed within 56 to 70 days.³²

A meta-analysis and trial sequential analysis were performed to assess the existing evidence on the effectiveness of Triclosan coated sutures (TCS) in preventing SSIs. The results indicated that TCS significantly reduced the incidence of SSIs compared to uncoated sutures (relative risk [RR] 0.72, 95% Confidence interval [CI]: 0.60 to 0.86; $p < 0.001$). With an estimated risk of 138 SSIs per 1,000 procedures, TCS use reduced this by 39 cases (95% CI: 19 to 55). Trial sequential analysis further supported a 15% relative risk reduction with TCS usage.³³

Knotless Barbed sutures for uterine closures

Conventional smooth sutures require knotting, leading to uneven tension distribution, reduced tensile strength (by 35%-95% at the knot site), and an increased risk of suture failure due to knot slippage. The knot's size and number also contribute to an increased inflammatory response. Barbed sutures have been widely used in gynecological surgeries and in obstetrics for CSs, due to their ability to reduce suturing time and blood loss. Other advantages are listed in figure 2.³⁴



Barbed sutures are commonly preferred over conventional sutures due to their benefits, including

improved tissue approximation, hemostasis, and strength, and eliminating the need for knot tying and reducing operative time. A meta-analysis was conducted to assess the efficacy and safety of barbed suture with conventional suture. It was found that:³⁵

- Barbed sutures reduced uterine repair time by 110.6 seconds (95% CI 93.8–127.4 seconds), total surgical time by 1.9 minutes (95% CI 0.03–3.80 minutes), and the need for additional hemostatic sutures (risk ratio 0.391, 95% CI 0.282–0.541).
- Both groups showed similar findings in other outcomes including estimated blood loss (mean difference [MD] 46.2 mL, 95% CI 13.55–105.89 mL) or combined postoperative morbidity.
- Barbed sutures provided a suitable alternative to conventional sutures for uterine closure, offers reduced repair and surgical times, with no increase in blood loss or maternal morbidity.

A retrospective cohort study was conducted to compare knotless barbed and conventional synthetic suture use for uterine closure in different settings of CS. Knotless barbed sutures were associated with lower mean operating room time, mean estimated blood loss, and complication rates compared to conventional synthetic suture across all uterine closure scenarios.³⁶

EXPERT OPINION

- A double-layer continuous non-locking closure should be preferred over a single-layer closure, as it is considered a safe option providing efficient uterine closure and scar strength.
- The experts recommend use of bidirectional knotless barbed sutures due to their associated advantages, such as reduced suturing time, decreased blood loss, and improved tissue healing compared to traditional continuous or interrupted sutures.
- If braided sutures are used then triclosan coated sutures should be preferred.

Step 2: Peritoneum Closure

The standard procedure involves closing the peritoneum by suturing the two layers of tissue that

line the abdomen and cover the internal organs, in order to restore anatomical integrity.³⁷

Visceral Peritoneum Closure

A Cochrane Database of systematic reviews including 21 trials (17,276 women) was conducted to assess the effects of non-closure as an alternative to closure of the peritoneum at CS on intraoperative and immediate-and long-term postoperative outcomes. When trials involving non-closure of visceral peritoneum only versus closure of both peritoneal surfaces were analyzed, reduction in operative time, postoperative days in hospital, and wound infection was observed. Further, a reduction in all the major urinary symptoms of frequency, urgency, and stress incontinence was reported when the visceral peritoneum was left unsutured.³⁷ Adhesion Prevention Barrier (ORC) can be placed over the raw area at lower uterine segment to help in adhesion prevention.

Parietal Peritoneum Closure

Closure of the parietal peritoneum is usually performed using absorbable or delayed absorbable sutures, and can be done with interrupted or continuous sutures.³⁸

A Cochrane Database of Systematic Reviews analyzed the effects of non-closure of parietal peritoneum only versus closure of both peritoneal layers. It was found that there was a reduction in operative time and postoperative pain with no difference in the incidence of postoperative pyrexia, and postoperative duration of hospital stay and wound infection.³⁷

Another research has shown that parietal peritoneal closure at primary cesarean delivery was 5-fold protective against all adhesions (odds ratio [OR] 0.20, 95% CI 0.08-0.49), and 3-fold protective against dense adhesions (OR 0.32, 95% CI 0.13-0.79).³⁹

Step 3: Muscle approximation with polyglactin 910 suture

Triclosan coated Polyglactin 910 suture is a synthetic, absorbable, sterile, antibacterial coated suture made from a copolymer of 90% glycolide and 10% L-lactide.⁴⁰ It is designed for soft tissue approximation in cases where short-term wound support is sufficient, and where the rapid absorption of suture is advantageous.⁴¹

Rectus muscle reapproximation (RMR) during CS enhances muscle strength and core endurance in the early postoperative period. By improving physical fitness, RMR can help mothers more easily manage daily activities, particularly in the early stages of recovery.⁴²

In CS patients who were sutured with three loose vertical midline interrupted polyglactin 910 size 2.0 sutures, the post-operative pain scores at 6 and 12 hours during mobilization was found to be significantly higher in the only parietal peritoneum closure group than in the group undergoing both, closure of the parietal peritoneum and reapproximation of the rectus muscle.⁴³ The approximation of the rectus muscle has been found to be of benefit in reducing the incidences of diastasis of recti.⁴⁴

EXPERT OPINION

- Non-closure of the visceral peritoneum is recommended as the preferred approach during cesarean section, due to its benefits, including reduced major urinary symptoms, urgency, stress incontinence, as well as shorter operative time and lower risk of wound infection. Closure of the visceral peritoneum at cesarean delivery may increase the risk of adhesions.
- The decision to close or not close the parietal peritoneum should be left to the discretion of the practicing clinician, taking into account the potential risk of adhesion formation with non-closure.
- Absorbable or delayed absorbable sutures can be used with interrupted or continuous sutures for closure of parietal peritoneum with an attempt to evert the parietal peritoneum raw surface area.
- If the parietal peritoneum is closed, the clinician can consider closure of the parietal peritoneum and reapproximation of the rectus muscle with three loose vertical midline interrupted polyglactin 910 size 2.0 sutures for improved outcomes (reduced postoperative pain and analgesia requirement).

Step 4: Rectus sheath closure

During a cesarean delivery, the rectus sheath overlying the rectus abdominis muscles is exposed after incising the skin and subcutaneous tissue. This fascia consists of two layers: one derived from the aponeurosis of the external oblique muscle, and a second fused layer formed by the aponeuroses of the transverse abdominis and internal oblique muscles.

⁴⁴The fascia provides strength to the whole wound. Inappropriately repaired rectus sheath may increase the risk of developing an incisional hernia.¹⁷

A delayed-absorbable suture in a running non-locking pattern can be used to close the rectus sheath as an alternative to the interrupted technique. To lower the risk of infection, an antibacterial coated monofilament suture is recommended, particularly for patients at higher risk of complications, instead of a braided suture. Using a monofilament suture may also help reduce the risk of hernia formation later on.⁴⁴

A study was conducted to compare Prolene and Polydioxanone sutures for abdominal rectus sheath closure. It was found that patients undergoing closure with non-absorbable prolene experienced more pain (VAS score 8) and it lasted for around 72 hours in majority of cases (44.1%) as compared to Polydioxanone where average VAS score was 4 and pain lasted maximally till 48 hours. Wound discharge, wound dehiscence and burst abdomen were more in the Prolene group compared to the polydioxanone suture group. Further, at 3 months, more number of patients from Prolene suture group developed incisional hernia.⁴⁵

During a Pfannenstiel incision for Cesarean delivery, the nerves that supply the suprapubic region and lower abdomen may be damaged or entrapped if the incision extends beyond the lateral margins of the rectus sheath.⁴⁶

The European Hernia Society's guideline recommends using a continuous suture with a slowly absorbable monofilament thread for closing elective midline laparotomies, following the 'small bites' technique. This involves placing stitches 5–8 mm from the fascia edge, with 5 mm between stitches, and maintaining a suture-to-wound length ratio of at least 4:1.^{12,47}

The far-near-near-far technique has gained significant attention in recent years among the various rectus sheath closure methods. This approach introduces an innovative suturing pattern that evenly distributes tension, reducing the likelihood of wound dehiscence and incisional hernias, offering potential advantages over traditional closure techniques.⁴⁸

The most commonly used suturing agents during CS for rectus sheath closure includes synthetic absorbable monofilament or polyfilament suture material such as polydioxanone and barbed sutures.³⁵

Polydioxanone is a synthetic, absorbable monofilament suture and offers greater initial tensile strength.⁴⁹ It is reported to provide prolonged wound support throughout the healing process, exhibiting excellent pliability and handling characteristics, and was completely absorbed within 182 to 238 days following implantation. It is used to achieve secure closure in high-tension tissues such as fascia, providing support for up to six weeks.^{50, 51}

On the other hand, for over a decade, barbed sutures have been widely used in gynecological surgeries and later introduced in obstetrics for CS, due to their ability to reduce suturing time and blood loss.³⁴ Barbed sutures, commonly used in cesarean surgeries, include various commercial options. There are knotless tissue control devices that have features of both symmetrical and spiral designs. Additionally, its antibacterial coating enhances antimicrobial properties and reduces the risk of surgical site infections (SSIs).⁵² These knotless barbed sutures reduce suturing complexity, particularly in minimally invasive gynecological procedures, by enhancing tissue engagement and closure. Furthermore, it reduces operating time and minimizes knot-related complications.⁵³

The symmetric polydioxanone barbed suture, the only barbed suture for high-tension closures like fascia, featured a unique barb design for strong tissue approximation, combining the performance and absorption characteristics of polydioxanone

suture. Like polydioxanone plus suture, this device provided extended wound support for up to six weeks, making it suitable for applications such as fascial closure.⁵³

EXPERT OPINION

- The experts opined that during a cesarean delivery, the rectus sheath can be closed with delayed-absorbing monofilament antibacterial coated suture in a continuous non-locking pattern ending with Aberdeen's knot. Tying a knot with loop at rectus sheath creates a weaker scar.
- A monofilament suture should be preferred to minimize the risk of hernia and wound complications.
- An expert consensus indicates that polydioxanone and barbed sutures can be regarded as a suitable option for rectus sheath closure after a CS, as they are associated with reduced pain, fewer wound complications, and a lower risk of incisional hernia.
- Symmetric polydioxanone antibacterial coated barbed sutures can help in stronger tissue approximation and reduced suturing time and blood loss.

Step 5: Subcutaneous layer closure

Suture closure of the subcutaneous tissue has been reported to be effective in reducing wound complications, especially for wound thickness of >2 cm. Subcutaneous tissue suturing is also reported to lower the seroma rate, and decrease the incidence of postoperative hematoma and wound disruption, as well as SSIs.⁵⁴

Another research has shown that suture closure of subcutaneous fat during cesarean delivery resulted in a 34% decrease in risk of wound disruption in women with fat thickness greater than 2 cm. Therefore, suture closure of the subcutaneous dead space prevented wound complications after cesarean delivery.⁵⁵

The advantages of absorbable poliglecaprone-25 sutures are elaborated in Figure 3.

Figure 3 Advantages of absorbable poliglecaprone-25 sutures

Minimal tissue reaction, has good knot security and excellent handling characteristics because it lacks stiffness and has less memory vs. other synthetic absorbable sutures. ⁵⁶	A very smooth surface and passes through tissue with greater ease than catgut or braided absorbable sutures. Provides knot security, and superior knot tie-down, and stretch capacity. ⁵⁷	Lower incidence of swelling and induration, wound discharge, reduced wound dehiscence and requirement of resuturing vs. polyglactin suture. ⁵⁸
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EXPERT OPINION

- A monofilament absorbable antibacterial-coated Poliglecaprone suture is a preferred choice to approximate the subcutaneous superficial fascia, which can help in providing the tensile strength to the scar.
- It is recommended to suture the subcutaneous superficial fascia between the superficial and deep fatty layer during cesarean delivery to reduce the risk of wound complications and disruption.
- The use of synthetic absorbable monofilament suture is to be preferred over braided polyglactin 910 sutures for closing the subcutaneous layer, as it is associated with a lower incidence of wound complications following caesarean section.
- Unidirectional / bidirectional spiral barbed suture made of Poliglecaprone can provide superior closure with better scar, SSI and good cosmetic outcome
- Bidirectional spiral barbed suture can be used for subcutaneous closure while using the remaining half for subcuticular closure.

Step 6: Skin closure

Skin closure is an important step in cesarean delivery, affecting postoperative pain, wound healing, cosmetic results, for both surgeon and patient satisfaction.⁵⁹

The optimal skin closure technique should prioritize safety, efficacy, and cost-effectiveness, with a shorter application time, minimal patient

discomfort, and significantly aesthetically favourable results. Additionally, it should require minimal follow-up care and have a low incidence of wound-related complications.²

Skin closure in cesarean delivery can be performed using subcuticular sutures (under the skin), interrupted or continuous transcutaneous sutures (over the skin), or staples or tissue glue. The choice of suture material is influenced by its composition—either natural or synthetic—and may be absorbable or non-absorbable. Additionally, sutures may vary structurally, being either monofilament or braided, antibacterial coated or not. Staples offer the advantage of quicker application, making them a popular choice in clinical settings where time efficiency is prioritized.¹⁷ Advantages and disadvantages of types of sutures are listed in Table 1.^{2,60}

Table 1. Advantages and disadvantages of different types of sutures^{9,43}

	Staples	Nylon sutures	Subcuticular closure
Pros	Rapid and easy applicability	Tensile strength that ensures wound security.	Good cosmetic outcomes
Cons	Expensive May be associated with a higher rate of wound dehiscence Removal of staples can be painful ²	Difficulty in achieving good knot security. Because monofilaments have greater memory (the tendency to return to their packaged shape) than braided sutures, they tend to unravel if not tied correctly. ⁶⁰	Technique-dependent and therefore time-consuming. ²

A recent network meta-analysis (NMA) compared absorbable skin closure materials in cesarean delivery, focusing on time to skin closure, incidence of skin separation, and wound complications. In the skin separation NMA, pooled network OR values demonstrated that absorbable sutures (network OR: 0.37; 95% CI: 0.19 to 0.70) were superior to staples. Absorbable sutures significantly reduced the risk of skin separation after cesarean delivery without increasing the risk of wound complications.⁶¹

In a study by Verma et al, patients undergoing a first cesarean delivery with a low transverse incision who received nonabsorbable sutures experienced longer skin closure times and required more analgesics

compared to those in the absorbable suture group. Additionally, cosmetic outcomes were found to be better in the absorbable suture group among primary surgery patients.⁶²

For women undergoing CS, subcuticular sutures with absorbable material resulted in cosmetically superior scars and fewer wound complications compared to interrupted mattress sutures. Those who received subcuticular sutures also experienced less postoperative pain, improved wound healing, faster recovery, earlier hospital discharge, and overall better cosmetic outcomes than those with interrupted mattress sutures.⁶³

The ERAS guideline recommends using subcuticular sutures for skin closure in most cases, citing evidence that this approach reduces wound separation compared to staples removed within four days post-surgery.²²

Triclosan coated polyglecaprone suture, a monofilament suture, was utilized for skin and subcuticular closure following CS, providing antibacterial properties to reduce the risk of surgical site infection, favorable cosmetic results, and decreased postoperative pain.^{32, 64} It demonstrated easy handling, high knot security, and complete absorption within 91 to 119 days. Subcuticular skin closure with suture after cesarean has shown lower wound complication rates compared to staple closure. A randomized clinical study was conducted to compare the polyglecaprone and polyglactin sutures for subcuticular closure following CS. The study found that the rate of surgical site infection was comparable between the two suture types ($p=0.58$; adjusted OR, 1.23; 95% CI, 0.60-2.49).⁶⁵

The spiral polyglecaprone knotless tissue control device is made of barbed spiral suture material, featuring a surgical needle at one end and a fixation loop at the other. Its unidirectional barbs enable tissue approximation without requiring surgical knots. For subcuticular closure, the needle should be passed across the incision after at least one pass in reverse. Next, use a split-thickness bite to exit the skin perpendicular to the incision. For optimal use of the spiral polydioxanone knotless tissue control device subcutaneously, it should be placed as deeply as possible to minimize erythema and induration associated with absorption.⁶⁶

EXPERT OPINION

- The ideal skin closure technique should prioritize safety, efficacy, and cost-effectiveness, while minimizing application time, reducing patient, discomfort, and delivering aesthetically favourable results.
- Poliglecaprone monofilament absorbable suture material of size 3.0 with subcuticular suturing and preferably knots inside should be considered, so that there is no communication of inside to the outer skin.
- Subcuticular suturing with monofilament absorbable material polyglecaprone knotless device may help reduce application time and help achieve better aesthetic result.

Step 6: Dressing

Cyanoacrylate-based topical skin adhesives represent an innovative noninvasive skin closure system that combines the efficacy of 2-octyl cyanoacrylate with a self-adhering mesh. The mesh is placed directly over the wound, and 2-octyl cyanoacrylate is applied through a pen, forming a durable closure that should remain in place for at least 10 days post-surgery.⁶⁷

Cyanoacrylate-based topical skin adhesives offer several advantages, which includes eliminating the need for sutures or staples and the need for post-surgical dressings. They also form a flexible barrier against microbial penetration, which may help reduce the risk of SSIs.⁶⁸ *In vitro* studies have shown that Cyanoacrylate-based topical skin adhesives provided a superior microbial barrier compared with common pressure-sensitive adhesives. No penetration of bacterial pathogens into any of the cyanoacrylate topical skin adhesive samples at 72 hours was observed compared with 99% bacterial penetration of the pressure-sensitive adhesive samples.⁶⁸ Further, incisions closed with Cyanoacrylate-based topical skin adhesives were shown to be 33% stronger compared with staples ($p<0.01$) and 40% stronger compared with sutures ($p<0.01$).⁶⁹

In a retrospective cohort study, women were administered either Cyanoacrylate-based topical skin adhesives or Steri-strips for skin closure after CS. Use

of Cyanoacrylate-based topical skin adhesive was associated with a significant reduction in the frequency of wound separation ($p=0.03$) and a composite wound complications endpoint ($p=0.006$).⁷⁰

Cyanoacrylate-based topical skin adhesive was found to be associated with significantly lower rates of SSI ($p=0.011$) and wound complication ($p=0.036$) compared with skin closure using skin staples plus waterproof wound dressings in CS.⁷¹

Special considerations in CS wound closure and bleeding management

Management of bleeding at the uterine angle

If the uterine incision angles are extended or incompletely sutured, it can result in undetected bleeding from inadequately ligated vessels, causing postoperative vaginal bleeding if directed inward, or intra-abdominal bleeding if it extends to the peritoneal cavity or forms a broad ligament hematoma. The hemostatic sutures at the uterine angle with unilateral uterine artery ligation, will control bleeding.⁷²

Previous cesarean scars

Inadequate uterine healing following CS can lead to long-term issues, such as thinning of the muscle layer—observed in up to 60% of cases—and associated complications like isthmocele, ectopic scar pregnancies, placenta accreta spectrum (PAS), uterine rupture, intermenstrual bleeding, dysmenorrhea, pelvic pain, and infertility. Scar tissue during pregnancy poses significant obstetric challenges, with a prevalence of 1 in 2200 to 1 in 1800 pregnancies, which increases with cesarean rates. Diagnosis of cesarean scar pregnancies requires expertise and primarily done by vaginal ultrasound.⁷³ Efforts to improve CS scar outcomes with advanced suture techniques are ongoing. Barbed sutures show promising effects in CS due to their self-anchoring, tissue alignment, hemostatic properties, and durability. These advantages warrant further investigation for improving uterine scar outcomes.⁷⁴

EXPERT OPINION

- Experts agree that Cyanoacrylate-based topical skin adhesives are a preferred option over standard adhesives. They provide a stronger microbial barrier, lower the risk of surgical site infections (SSIs), reduce wound separation and complications, and offer greater strength.
- Appropriate SSI prevention protocol to be used and the operation theater dressing should preferably be removed after 2-3 days if no signs of wound infection.

Barbed vs. conventional sutures for cesarean uterine scar defects

A study was conducted to evaluate the effect of barbed versus conventional sutures in preventing myometrial defects and improving postpartum outcomes after cesarean delivery. Clinical and ultrasonographic outcomes showed:⁷⁴

- Barbed suture group had significantly smaller niche dimension- length (2.45 ± 1.65), depth, and width) and a greater residual myometrial thickness (RMT) compared to the conventional suture group ($p<0.001$ for all comparisons).
- No defects with an RMT <3 mm was found in the barbed suture group.
- Lower incidence of uterine niches in barbed and conventional sutures (29.1% vs. 68.2%), respectively.
- Secondary outcomes, including operative time and surgical complications, showed no significant differences between groups.

Double-layer barbed sutures may thus reduce CS scar defects and postoperative complications, supporting their use in cesarean delivery to prevent wound complications and enhance maternal recovery.

Preventive: Excluding the endometrium closure

Uterine incision closure techniques significantly affect the prevalence and size of post-cesarean niche formation. A study was evaluated to compare the niche formation based on closure techniques. Women were divided into two groups; Technique A (endometrium-free) and Technique B (routine, non-endometrium-free).⁷⁵

- Twenty niches were identified, five using Technique A, nine using Technique B with double-layer closure, and three using Technique B with single-layer closure.
- Technique B was associated with a six fold increase in clinically significant niche formation compared to Technique A (OR 6.0, 95% CI 1.6–22.6, $p=0.008$).
- Furthermore, average niche depth was significantly reduced with Technique A (2.4 mm) compared to Technique B's double-layer closure (4.9 mm, $p=0.005$).

Study showed that excluding the endometrium during closure may mitigate significant scar defects.

Obesity and wound closure

Maternal overweight and obesity have become increasingly common in obstetric practice, with over 50% of pregnant women in developed nations classified as overweight or obese.⁷⁶ Maternal obesity significantly elevates the risk of surgical wound complications following CS, including hematoma, seroma, abscess, dehiscence, and surgical site infections. Due to these increased risks, it is essential to implement preventive strategies for its management.⁷⁷

Recent findings have indicated that wound dehiscence rates are higher with increasing body mass index (BMI). According to a study conducted by Pergialiotis V et al., the relative risk of wound infection increases when the thickness of the subcutaneous tissue is greater than 3 cm.⁷⁸

In obese women, subcutaneous tissue closure is commonly employed to reduce the risk of wound complications. Closing this layer significantly lowers the incidence of postoperative hematoma and seroma by sealing dead space and effectively aligning wound edges. This also improves cosmetic outcomes by reducing strain on skin sutures.⁷⁹ A study was conducted to assess the effect of wound complications in women with a subcutaneous tissue thickness greater than 4 cm. The study found that subcutaneous closure significantly reduced wound complications.⁸⁰ In women with more than 2 cm of subcutaneous tissue, reapproximation of tissue should be performed to reduce wound

complication.²² These findings support the use of subcutaneous tissue closure in obese women following CS to lower the risk of wound complications.⁷⁷

1. Topical hemostatic agents

Topical hemostatic agents can aid hemostasis where suturing or electrocautery may be ineffective, such as bleeding from raw bone surfaces, solid organs, or soft tissues, or where these methods pose a risk to nearby structures.⁸¹ Topical hemostatic agents cannot be a substitute to good suturing techniques.

Oxidized regenerated cellulose

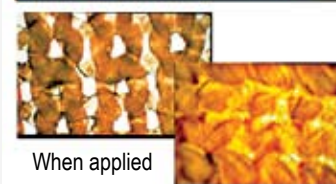
Oxidized regenerated cellulose (ORC), acts as a scaffold for clot formation and is available in customizable multilayered ORC materials. Its versatility allows it to be trimmed or molded to various shapes and sizes, making it suitable for various bleeding surfaces.⁸² ORC sheets exhibit strong hemostatic and antimicrobial properties due to its low pH. Compared to gelatin foams, ORC provides better handling characteristics; it does not adhere to instruments and can be easily held against bleeding tissues until hemostasis is achieved. ORC sheets with its cotton-like consistency, remains pliable when placed in a wound and typically dissolves within 2–6 weeks.⁸² Figure 4 demonstrates the application of oxidized regenerated cellulose sheet.

The new age ORCs are available in powdered form which ensure fast and durable hemostasis. Because of the powdered form the ORC reaches the bleeding source and acts fast.⁸³

Figure 4 Application of oxidized regenerated cellulose sheet

ORC - What is it

- Oxidized regenerated cellulose (ORC)
- Site Specific
- All cleared from body within 28 days
- Forms protective gel coat over raw surfaces
- Should be stored below 30°C
- Size: 7.6 cm x 10.2 cm (3 x 4 inches)



When applied

After 8 hours

EXPERT OPINION

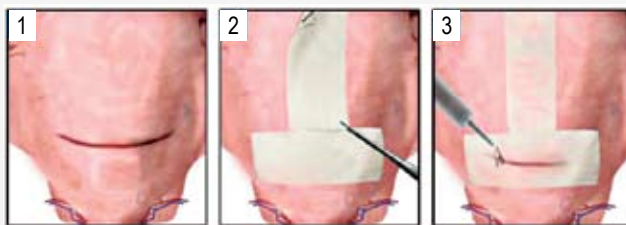
- ORC sheets and powder are an evolving option for controlling bleeding from soft tissue, solid organs, and bone surfaces when sutures or electrocautery are ineffective.

2. Adhesion prevention barrier in CS

Absorbable adhesion barrier has been shown in various gynecologic studies to:^{84,85}

- Significantly reduce the incidence of both new and reformed adhesions
- Be clinically effective across multiple gynecological procedures
- Be up to 2 times more effective than good surgical technique alone in achieving an adhesion-free outcome
- Forms a continuous protective coating during the critical 5-day to 7-day peritoneal healing period

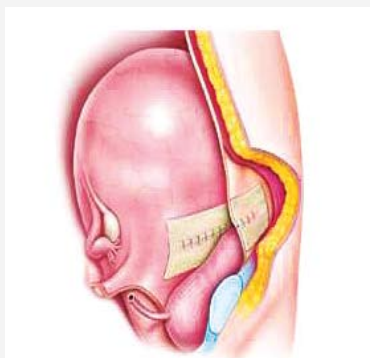
Figure 5 Steps for adhesion prevention barrier placement



1 Achieve meticulous hemostasis, remove all irrigation fluid and instillates from the peritoneal cavity, and cut the Adhesion barrier into two pieces.

2 Place one, dry, single layer on the uterine incision and then place the other layer over the anterior uterine serosa (perpendicular to the uterine incision).

3 Moisten the Adhesion barrier with 1 to 2 ml of irrigation solution to ensure adherence and conformity to the application site.



In a meta-analysis of 13 RCTs, use of absorbable adhesion barrier was associated with reduced incidence of de novo adhesions and re-formed adhesions vs no treatment.⁸⁵

A Cochrane Database of Systematic Reviews was conducted to assess the effect of physical barriers used during pelvic surgery in women of reproductive age on pregnancy rates, pelvic pain, or postoperative adhesion reformation. The findings indicated that absorbable adhesion barriers effectively reduced the incidence of adhesion formation after both laparoscopy and laparotomy.⁸⁶

3. Skin Closure Products

Absorbable Skin Staples

Disposable mechanical skin staplers offer a rapid and effective method for closing long incisions, reducing skin closure time by three to four times, though their postoperative removal may take longer.³⁰ The FDA-approved dermal stapler, made from a copolymer of polylactic and polyglycolic acid, maintains strength for 7 days before gradually degrading over 21 days, with complete hydrolysis in approximately 10 weeks.⁸⁷ Compared to metal staples, dermal stapler may reduce inflammation, pain, and improve cosmetic outcomes.^{30,88}

A randomized, controlled clinical study by Cross et al. showed that absorbable dermal staplers can lower operating room and anesthesia time, offering cost-effective, safe and consistent surgical benefits with cosmetically acceptable results.³⁰

Adhesive Skin Closure

The 2-Octyl Cyanoacrylate glue is a liquid monomer that forms a strong, waterproof tissue bond, providing additional strength and a protective barrier against bacteria.⁵⁹ A study compared wound complication rates, postoperative pain, and overall patient satisfaction between adhesive glue and subcuticular sutures after elective CS.⁸⁹

- The adhesive glue group was associated with significantly lower subjective pain scores on postoperative day 3 ($p=0.023$), shorter skin closure time (2.57 ± 0.67 vs. 3.2 ± 1.18 minutes, $p=0.001$), and lesser total operative time (39.52 ± 8.24 minutes vs. 42.1 ± 6.10 minutes, $p=0.054$) compared to the suture group.⁸⁹

Tissue adhesive is a valuable option for closing Pfannenstiel incisions after cesarean delivery. It offers several advantages, including reduced skin closure and operating time, decreased postoperative

pain, comparable cosmetic results and surgeon satisfaction without increasing the rate of wound complications.⁸⁹

EXPERT OPINION

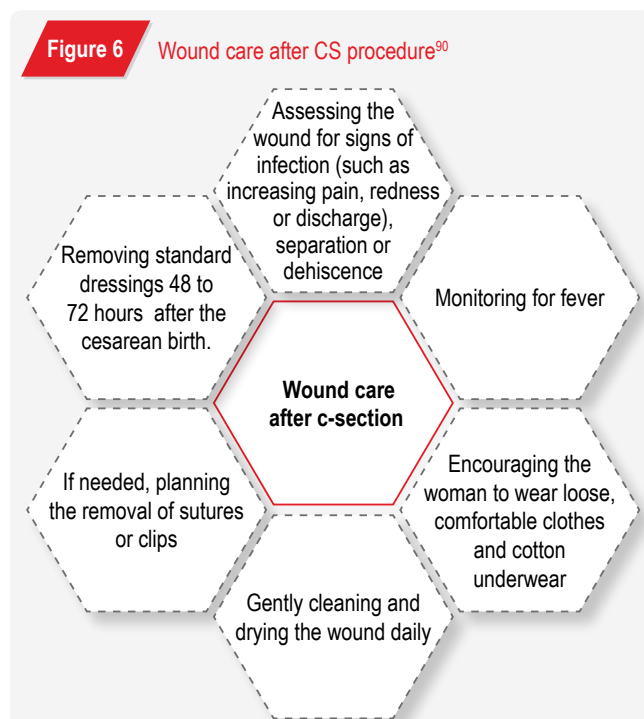
- Expert consensus suggests that topical skin adhesives are recommended for closing Pfannenstiel incisions. Their use has been shown to reduce skin closure and operating time, minimize postoperative pain, improve cosmetic outcomes, and enhance surgeon satisfaction, all without increasing the rate of wound complications.

Postoperative care and monitoring

Wound care protocols

National Institute of Health and Care Excellence (NICE) guidelines recommend measure for wound care after CS (Figure 6).⁹⁰

Figure 6 Wound care after CS procedure⁹⁰



Monitoring for Complications

Wound complications increase hospital stays, readmissions, time away from work, reduced infant bonding, and healthcare costs, highlighting the importance of early identification and management of patients at risk. Optimal skin closure reduces wound complication rates and follow-up needs after a CS.² Effective reduction of postoperative infections involves stabilizing patients with pre-existing medical conditions before surgery. A primary preventive measure is maintaining perioperative

glycemic control, and ensuring blood glucose levels remain below 200 mg/dL for diabetic and non-diabetic patients.⁹¹

Postoperative patient experience

The German Society of Gynaecology and Obstetrics (DGGG), the Austrian Society of Gynaecology and Obstetrics (ÖGGG) and the Swiss Society of Gynaecology and Obstetrics (SGGG) guidelines recommend daily temperature monitoring and wound infection assessment in the initial postoperative days, along with proper wound care education for patients following a CS. Both mother and infant require close monitoring by trained professionals, as cesarean delivery often necessitates more intensive care than vaginal birth. Observation rooms should be well-equipped with the appropriate technology to support optimal care.⁹²

The Centers for Disease Control and Prevention (CDC) guidelines for preventing SSIs recommend that a primarily closed surgical incision be covered with a sterile dressing for 24–48 hours. Research has indicated that removing the dressing earlier allows women to resume to wash or shower sooner and increases their satisfaction with their postoperative recovery.⁹³

EXPERT OPINION

- Once the dressing is removed, it is recommended that patients should gently clean and dry the wound daily.
- Women should wear loose and comfortable clothing to prevent the friction against incision.
- Measuring the patient's temperature daily during the first few postoperative days and monitor for signs of wound infection, while also informing women about proper wound care following a CS is important.
- Following a CS, both the mother and infant require close monitoring by trained medical professionals.
- Early oral feeding and mobilization after cesarean delivery is recommended to support quick recovery and optimize patient outcomes.

A study was conducted to compare early vs. delayed oral feeding post-cesarean. Women (n=140) were divided into groups and were started with a liquid diet at 2- or 8-hours post-surgery. Results showed significantly faster bowel movement return (7.8 ± 2.9 vs. 11.7 ± 5 hours, $p < 0.0001$) and earlier mobilization (10.7 ± 7.7 vs. 13.5 ± 5.9 hours, $p = 0.015$) in the early feeding group. Early oral feeding supported bowel function recovery without increasing complications, recommend diet initiation within 2 hours post-cesarean.⁹⁴

Early mobilization has been shown to enhance short-term postoperative outcomes, such as rapid bowel function recovery, reduced thrombosis risk, and shorter hospital stays.⁹⁵

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