Suture Compared With Staple Closure of Skin Incision for High-Order Cesarean Deliveries

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OBJECTIVE: To compare wound complication rates in tertiary or higher-order cesarean delivery based on wound closure technique.

METHODS: We performed a retrospective cohort study of all tertiary or higher-order cesarean deliveries performed by one group practice in a large academic medical center from 2005 to 2017. We excluded patients with a vertical skin incision. Although the study was not randomized, wound closure type was relatively uniform in this practice and based on time period: before 2011, the preferred closure was staple closure; after 2011, subcuticular suture closure was preferred. All patients received preoperative antibiotics and closure of subcutaneous tissue 2 cm deep or greater. The primary outcome was a wound complication, defined as a wound infection requiring antibiotics or a wound separation requiring wound packing or reclosure any time up to 6 weeks after delivery. Regression analysis was used to control for any significant differences at baseline between the groups.

RESULTS: There were 551 patients with tertiary or higher-order cesarean delivery, 192 (34.8%) of whom had staple closure and 359 (65.2%) of whom had suture closure. Suture closure was associated with a significantly lower rate of wound complication (4.7% [17/359, 95% CI 3.0%–7.5%] vs 11.5% [22/192, 95% CI 7.7%–16.7%], P=.003). On regression analysis controlling for the number of prior cesarean deliveries and the participation of a resident in the closure, suture closure remained independently associated with a lower risk of a wound complication (adjusted odds ratio 0.44, 95% CI 0.23–0.86).

CONCLUSION: For women undergoing their third or higher-order cesarean delivery, suture closure is associated with a lower rate of wound complications.

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Most often, the skin incision for cesarean delivery is a transverse incision in the lower abdomen, also known as a Pfannenstiel incision. At the end of the operation, closure of the skin incision usually involves either surgical clips (staples) or a continuous subcuticular suture. Several prospective randomized studies have compared these two skin closure types for cesarean delivery and most studies[1–3] as well as a recent meta-analysis[4] have demonstrated that closure with subcuticular suture is associated with a lower rate of wound complications, specifically infection and wound separation. However, most patients randomized in these studies were undergoing their first or second cesarean delivery. Higher-order cesarean deliveries tend to be more technically challenging and are associated with a higher rate of complications.[5,6] Also, with several prior abdominal incisions, the underlying scar tissue has more collagen and is more avascular, which could affect wound healing in this population. It is currently unknown whether closure type has a similar effect on the rate of wound complications in women with several prior cesarean deliveries.

In our practice, we perform many high-order cesarean deliveries with relatively uniform surgical technique. We are a private practice, currently with 10 delivering doctors and a delivery volume of approximately 1,000 deliveries per year. We deliver our

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patients at a large, academic, tertiary care hospital, most often with resident physicians involved. As best as possible, we try to standardize care across the practice, including surgical technique. Before 2011, our standard technique for skin closure was staples. Starting in the spring of 2011, as a result of growing evidence that suture closure was preferable in women undergoing their first and second cesarean deliveries, we began closing these skin incisions, including those in women with two or more prior cesarean deliveries, with subcuticular suture. Therefore, our surgical experience allows for retrospective analysis of the two skin closure types.

The objective of this study was to compare wound complication rates in women undergoing tertiary or higher-order cesarean delivery based on wound closure technique.

MATERIALS AND METHODS

After Biomedical Research Alliance of New York institutional review board approval was obtained, we reviewed the charts of all patients undergoing cesarean delivery by a single practice between July 2005 (when our computerized medical record was created) and September 2017. We reviewed the outpatient medical records, operative reports, anesthesia records, hospital inpatient records, and discharge summaries for each patient to record the maternal baseline characteristics, delivery information, operative details, and intraoperative and postoperative complications. For this study, we included patients undergoing tertiary (third) or higher cesarean delivery. We excluded any patient who had a vertical skin incision and any patient who had skin closure performed by another surgical service (general surgery, plastic surgery).

Over the course of the study period, every patient undergoing tertiary or higher cesarean delivery in this practice had at least one of the seven authors as a surgeon. The second surgeon was another author, another attending physician, or an obstetrics and gynecology resident at Mount Sinai Hospital, which is a large, tertiary, academic medical center in New York City. The decision for who was the second surgeon was not standardized over the course of the study period and was usually based on patient preference, physician scheduling, and labor floor coverage at the time of the operation. In our practice, patients undergoing tertiary or higher cesarean delivery are delivered at approximately 37–39 weeks of gestation, earlier in the setting of preterm labor or as indicated (for example, in the case of preeclampsia or fetal growth restriction). The decision regarding exact timing of delivery was individualized based on clinical circumstances and contemporary management guidelines.

In our practice, for all patients undergoing cesarean delivery, we routinely close all layers if technically possible, including the parietal peritoneum, rectus muscles, and fascia. If the depth of the subcutaneous tissue is 2 cm or more, we close the subcutaneous space with interrupted absorbable sutures without drain placement.[7] All patients receive prophylactic antibiotics 30 minutes before skin incision per hospital protocol and have intermittent compression boots in place starting preoperatively until the patient is ambulatory.[8] Select patients with body mass indexes (calculated as weight (kg)/[height (m)]^2) greater than 40 receive postoperative subcutaneous heparin as well. These surgical techniques, antibiotic prophylaxis, and thromboembolism prophylaxis were uniform over the course of the study period.

The decision whether to close the skin with staples or suture was left to the surgeon. However, before 2011, the preferred skin closure type was with staples; starting in 2011, the preferred closure type was subcuticular suture. For patients with staple closure, the staples were typically removed on postoperative day 4–7, either in the hospital or as an outpatient, and then wound closure strips were applied to the wound for 2 weeks. For patients with suture closure, the skin was closed with a running subcuticular suture of either 3-0 poliglecaprone or 4-0 polyglactin suture as well as wound closure strips, which were typically removed 2 weeks later. The sutures were left to resorb and were not removed. All patients had a sterile dressing applied to the wound that was typically removed on postoperative day 2, at which time patients could shower. All patients are routinely seen at 6 weeks postpartum for examination. If the patient suspects any complications prior, she is seen in the office at that time. We typically have a 100% follow-up rate for postpartum visits, but if patients move out of town or do not attend their visit, they are contacted by one of our nursing staff to inquire about any complications since discharge from the hospital.

The primary outcome for this study was a wound complication before 6 weeks postpartum. A wound complication was defined as wound separation requiring packing or reclosure or a wound infection (diagnosed clinically requiring antibiotics). Secondary outcomes included operative time, clinical endomyometritis, transfusion of blood products during or after delivery, postoperative day 1 hematocrit, and length of stay in the hospital before discharge.

χ^2 testing was used to compare parametric categorical variables and Fisher exact test for nonparametric categorical variables. Student *t* test was used to compare continuous variables that were normally distributed and Mann Whitney *U* test was used for continuous variables that were not normally distributed. We performed a planned regression analysis to control for any differences at baseline that were significant at $P<.05$ using SPSS for Windows 22.0. To have 80% power with an α error of 5% to detect a difference in wound complication from 12% to 5%, a total of 500 patients would be needed.

RESULTS

Over the course of the study period, 574 patients underwent tertiary or higher cesarean delivery in our practice. We excluded 17 patients who had vertical skin incision and six patients whose skin incisions were closed by a general surgeon or plastic surgeon, leaving 551 patients for analysis. Records and follow-up were available for all patients. Skin closure was with staples in 192 (34.8%) patients and with suture in 359 (65.2%) patients. Before March 2011, 88.4% (176/199) women had staple closure; starting in March 2011, 95.5% (336/352) women had suture closure.

Baseline characteristics of the two groups are shown in Table 1. The suture group had significantly more prior cesarean deliveries and was more significantly likely to have two attending surgeons as opposed to one attending and one resident. Otherwise, there were no significant differences in baseline characteristics between the two groups. Suture closure was associated with a significantly lower rate of wound complication (4.7% vs 11.5%, $P=.003$, relative risk 0.39, 95% CI 0.20–0.75) (Table 2). Operative time was approximately 10 minutes longer in the suture group (66 vs 56 minutes, $P<.001$). There were no differences in rates of transfusion, postoperative hematocrit, or postoperative endomyometritis. The suture group had a shorter postoperative stay in the hospital (3 vs 4 days, $P<.001$).

On regression analysis controlling for the number of prior cesarean deliveries and the participation of a resident in the closure, suture closure remained independently associated with a lower risk of a wound complication (adjusted odds ratio [OR] 0.44, 95% CI 0.23–0.86). The number of prior cesarean deliveries (adjusted OR 2.0, 95% CI 0.98–4.2) and the participation of a resident (adjusted OR 1.0, 95% CI 0.41–2.5) were both not independently associated with the likelihood of a postoperative wound complication. Subgroup comparisons were performed based on the number of prior cesarean deliveries and resident participation and the results are shown in Table 3. Suture closure remained significantly associated with a lower wound complication rate in all women with two prior cesarean deliveries regardless of resident involvement. For women with three or four prior

Table 1. Baseline Characteristics of the Women Undergoing Their Third or Higher Cesarean Delivery Based on Skin Closure Type

Characteristic	Staples (n=192)	Suture (n=359)	*P*
Total prior cesarean deliveries			.002
2	113 (58.9)	163 (45.4)	
3	45 (23.4)	99 (27.6)	
4 or more	34 (17.7)	97 (27.0)	
Maternal age (y)	34.2±5.2	35.1±5.1	.069
Maternal BMI at the time of surgery (kg/m^2)	31.1±6.0	31.0±5.8	.971
Gestational age at delivery (wk)	37.5± 2.3	37.3±2.1	.399
In vitro fertilization	10 (5.3)	28 (7.8)	.279
White race	186 (96.9)	335 (93.3)	.079
Anticoagulation	17 (8.9)	24 (6.7)	.346
Diabetes (pregestational or gestational)	13 (6.8)	41 (11.5)	.081
Chronic hypertension	5 (2.6)	11 (3.1)	.759
Prior myomectomy	3 (1.6)	9 (2.5)	.469
Labored (planned or unplanned)	21 (11.1)	33 (9.2)	.493
Preeclampsia	5 (2.6)	3 (0.9)	.103
Preoperative hematocrit (mean %)	34.1±2.7	34.0±3.3	.473
Surgeons			<.001
2 attendings	86 (44.8)	234 (65.2)	
1 attending, 1 resident	106 (55.5)	125 (34.8)	

BMI, body mass index.
Data are n (%) or mean±SD unless otherwise specified.

Table 2. Surgical Outcomes of the Women Undergoing Their Third or Higher Cesarean Delivery Based on Skin Closure Type

Outcome	Staples (n=192)	Suture (n=359)	*P*
Wound infection or separation	22 (11.5)	17 (4.7)	.003
Operative time (min)	56 (46–67)	66 (56–79)	<.001
Endomyometritis	5 (2.6%)	12 (3.4%)	.798
Transfusion of blood products	9 (4.7%)	11 (3.1%)	.346
Postoperative day 1 hematocrit (mean %)	29.4±3.4	29.1±3.9	.473
Postoperative days in hospital	4 (4–4)	3 (3–4)	<.001

Data are n (%), median (interquartile range), or mean±SD unless otherwise specified.

cesarean deliveries, the results were no longer significant, but we were underpowered for these subgroup analyses.

DISCUSSION

In this study, we found that for women undergoing a third or higher cesarean delivery, suture closure is significantly associated with a lower rate of wound separation or infection. The reduction seen was greater than 50% and this remained significant after controlling for potential confounding variables. Prior studies have shown a similar effect of suture closure on wound complications in women undergoing cesarean delivery, but mostly for women undergoing their first or second cesarean delivery.[1–4] It is unclear whether results from those studies could be reliably extrapolated to women undergoing higher-order cesarean deliveries. In our study, the risk reduction associated with suture closure was an adjusted risk of 0.44 (95% CI 0.23–0.86). This benefit is similar in magnitude to the risk reduction seen in a recent meta-analysis of patients mostly undergoing their first or second cesarean delivery, which was 0.49 (95% CI 0.28–0.87).[4] Therefore, our results in tertiary or higher cesarean deliveries are comparable with the existing literature on primary and repeat cesarean deliveries.

The participation of a resident physician was not significantly associated with the primary outcome nor did it affect the association between closure type and the primary outcome. We have published this finding previously.[9] Also, in this study we had 131 (24%) patients with four or more prior cesarean deliveries, and we did not find an association between this many prior cesarean deliveries and a wound complication. Therefore, it appears that the closure type has a greater effect on the rate of wound complication than the number of prior cesarean deliveries or resident involvement. However, although wound closure technique remained independently associated with wound complications on regression analysis, in several of our subgroup analyses, the results were not significant. Further studies could be performed in more patients to increase the power to find a difference in these subgroups.

Although we did report differences in operative time and length of stay, we believe these differences seen were not solely the result of wound closure technique. In regard to operative time, our hospital changed the timing of the final surgical count in 2012 from after skin closure to before skin closure. The final count usually takes 2–3 minutes. In our study, suture closure was associated with a longer operative time of approximately 10 minutes. However, it is likely that 2–3 minutes of this time was the result of

Table 3. Subgroup Analysis of Wound Complication Rates in Women Undergoing Tertiary or Higher Cesarean Delivery Based on Wound Closure Type

No. of Prior Cesarean Deliveries	Resident Involvement	n	Wound Complications With Staple Closure	Wound Complications With Suture Closure	*P*
2	No	99	4/37 (10.8)	1/62 (1.6)	.043
2	Yes	177	13/76 (17.1)	7/101 (6.9)	.034
3	No	106	1/23 (4.3)	3/83 (3.6)	.870
3	Yes	38	3/22 (13.6)	0/16 (0.0)	.249
4 or more	No	115	1/26 (3.8)	5/89 (5.6)	.721
4 or more	Yes	16	0/8 (0.0)	1/8 (12.5)	.999

Data are n/N (%) unless otherwise specified.

the surgical count being performed before skin closure in later years, which were the same years we preferred suture closure. It is interesting to note that in a recent meta-analysis comparing suture with staple closure, suture closure was associated with a longer operative time of 7 minutes.[4] Therefore, assuming the surgical count was 2–3 minutes, our finding of 10 additional minutes is very similar to the results found in the meta-analysis.

We also found that suture closure was associated with a shorter hospital stay (3 vs 4 days). However, we believe this difference is mostly the result of changes in hospital practices. Starting in 2013, patients were encouraged by the hospital to go home on postoperative day 3 instead of day 4. Therefore, we anticipated that the suture group, which was the more contemporary group in our study, would also have shorter inpatient hospital stays. It is important to note that this would be another reason to prefer suture over staple closure. An earlier meta-analysis concluded that staple removal on postoperative day 3 was associated with a higher rate of wound separation,[10] which is plausible as well. Because it is most convenient to remove staples before discharge, if patients were to go home on postoperative day 3, staple removal on that day could increase the risk of wound complications further. Delaying staple removal to a later date would necessitate an additional outpatient visit, which could be inconvenient for the patient. Therefore, as contemporary practices evolve to discharge patients home earlier after cesarean delivery, the benefit seen with suture closure could increase.

Our study has several strengths. Although our study design was retrospective, because patients before 2011 had predominantly staple closure and patients 2011 and later had predominantly suture closure, the selection was primarily based on the time period. Another strength of this study was that all the operations were performed by one of the seven authors, so we are confident that surgical technique was similar across the entire study period as were other perioperative interventions, including antibiotic prophylaxis.

Our study is limited by its retrospective design, which introduces potential selection bias and confounding variables. Because the two cohorts were cared for in nonoverlapping time periods, it is possible that other features of the population or their care changed as well. We controlled for measurable and known confounders, but there could still be unmeasured variables that confounded our results. Ultimately, the surgeon decided how to close the skin incision, so this could introduce selection bias as well. Ideally, this study would be repeated in a prospective, randomized trial. However, given the large sample size needed (500 patients), this would likely need to be a multicenter study, which would then introduce bias in regard to surgical technique and perioperative management differences across different institutions. Although we had follow-up for 100% of patients, we acknowledge that it is possible a patient was seen elsewhere between discharge and her postpartum visit for a complication and did not report this to us. Because our practice patients are somewhat homogenous, our findings are also limited in their ability to be extrapolated to other populations.

One final limitation of the study is that we were unable to control for the type of skin preparation (povidone–iodine vs chlorhexidine–alcohol-based), because the operative reports did not specify this detail. Chlorhexidine became the preferred method in our practice in recent years, but several years after we started routine suture closure. Therefore, it is possible this influenced our results. However, a recent prospective, randomized trial of chlorhexidine–alcohol as compared with povidone–iodine for cesarean skin preparation in 932 patients showed no difference in the rates of surgical site infection within 30 days of delivery (6.3 vs 7.0%, P=.38).[11] Therefore, we believe the lack of data on specific skin preparation likely did not affect our results.

In conclusion, for women undergoing their third or higher-order cesarean delivery, suture closure is associated with a lower rate of wound complications. Given these data and the results of randomized trials in women undergoing primary and secondary cesarean delivery, suture closure should be the preferred method of skin closure for all cesarean deliveries.

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