Between 1996 and 2007, the cesarean delivery rate in the United States increased from just over 20% to more than 31%. The increased cesarean rate has been attributed to the use of electronic fetal monitoring, decreased use of forceps, and decreased vaginal deliveries of breech fetuses. In the 1970s, data supported trial of labor after previous cesarean delivery (TOLAC) as a reasonable approach in certain pregnancies. Thus, the overall cesarean delivery rate decreased to approximately 20% by 1996; however, because of increased rates of TOLAC in the 1970s, rates of uterine rupture and other complications also increased. These adverse outcomes have resulted in a reversal of TOLAC, with a decrease in rates of vaginal birth after cesarean delivery (VBAC) and an increase in rates of cesarean delivery. By 2004, the VBAC rate had decreased to 9.2%. Currently, the overall total cesarean delivery rate is 32.0%, a slight decrease from recent years. The cesarean delivery rate has generally increased along with the rate of rare complications such as cesarean scar ectopic pregnancy. A 2004 case series estimated an incidence of 1:2226 of all pregnancies, with a rate of 0.15% of cesarean scar ectopic pregnancies in women with a previous cesarean delivery and a rate of 6.1% of all ectopic pregnancies in women who had at least 1 cesarean delivery.

Cesarean scars pose a unique set of risks for women who have had previous cesarean deliveries. Between 1996 and 2007, the rate of trial of labor after previous cesarean delivery increased, along with reported rates of uterine rupture and other complications. Consequently, trial of labor after previous cesarean delivery and resultant vaginal birth after cesarean delivery have decreased and cesarean delivery has increased. With nearly one-third of women having cesarean delivery, the rate of rare complications such as cesarean scar ectopic pregnancy has also increased. An integration of osteopathic manipulative treatment techniques into the management of cesarean deliveries and cesarean scars has yet to be defined. The author presents 4 cases of cesarean delivery in which osteopathic manipulative treatment was integrated with successful outcomes.
Methods
A literature search was performed using MEDLINE, PubMed, Google Scholar, and JAOA.org for 1950 to 2015 to assess the available literature regarding cesarean delivery,\(^8\) cesarean scar ectopic pregnancy,\(^9\) TOLAC,\(^10\) uterine rupture,\(^11,12\) relevant osteopathic concepts and treatments,\(^13,14\) and other studies that incorporated OMT in the prenatal care of pregnant women.\(^15-17\) All appropriate institutional approvals and patient informed consent were obtained before treatment. The treatment algorithm (Figure 1) that was created by the author and implemented in these cases was devised using evidence-based OMT techniques from the identified sources\(^8-17\) to reduce tension on the previous cesarean scar (in the cases of TOLAC and repeated cesarean deliveries); to restore balance and hemostasis to areas of somatic dysfunction; and to heal dysfunctions of the viscera and related anatomical structures caused by previous surgical procedures, vaginal and cesarean delivery, and gravid uterus changes. The inclusion criteria for the 4 patients in the current article were based on their indications: (1) a patient who had no previous abdominal surgery or cesarean delivery, (2) a patient who had at least 1 cesarean delivery previously through a low transverse skin and uterine incision, (3) a patient who had at least 1 previous cesarean delivery through a low transverse skin and uterine incision and desired TOLAC, and (4) a patient who had a previous cesarean delivery through a low transverse skin and uterine incision and became pregnant with the sac implanted into the old cesarean scar and was a candidate for methotrexate treatment.

Scars and Somatic Dysfunction
Cesarean scars have direct links to the perineal fascia and its connection with the transversalis fascia. These scars can interfere with fascial load distribution, which create adhesions to neighboring tissues.\(^25\) The abdominal and pelvic viscera and surrounding anatomical structures are then potentially disrupted, causing inadequate nutrition and inappropriately distributed tension among the various structures affected. This concept becomes important during TOLAC and when treating cesarean scar ectopic pregnancies.

Although low transverse incisions are more common, scars from other incisional methods are made at the uterine isthmus. During healing, scars in this area primarily attach to the sacrum and the lumbar spine via the abdominal and pelvic musculature and fascial compartments.\(^25,26\) The sacrum is connected to the uterus via the uterosacral ligament and the broad ligament to which the ovarian and uterine arteries are associated. The lumbar spine has connections with muscles of the pelvis and neurovascular structures that supply the uterus primarily at spinal level L1. If these connections are disrupted, the function and nutrition of the uterus can be compromised. Substantial restriction and somatic dysfunction of the sacrum and lumbar spine disrupts the function of the pelvis, the corresponding visceral structures innervated by the lumbar and pelvic splanchnic nerves in the lumbar and sacral foramina, and the neurovascular components of the broad ligament. Thus, somatic dysfunction of these areas can be managed before delivery, after delivery, and during labor in the case of TOLAC.
Figure 1.
Algorithm for management of cesarean scars for primary cesarean deliveries, repeated cesarean deliveries, and trial of labor after previous cesarean delivery (TOLAC). *Although this protocol can only be recommended for other cases using a Pfannenstiel incision, it is theoretically applicable to any incision type. Abbreviations: MFR, myofascial release; OMT, osteopathic manipulative treatment; OSE, osteopathic structural examination; VBAC, vaginal birth after cesarean delivery.
Outcome Measures
For cases of primary cesarean delivery, the outcome was considered successful if blood loss was less than or equal to 1000 mL as determined by estimated blood loss; pre- and postpartum hemoglobin levels were between 12.0 and 15.5 g/dL; pre- and postpartum hematocrit was between 37% and 48%; meconium-stained amniotic fluid (MSAF) was absent; at the 2-week follow-up appointment the cesarean scar (subcuticular suture closure) showed full-thickness and was intact and healed; and no other postpartum complications occurred. For repeated cesarean deliveries, the outcome was considered successful with the same criteria for primary cesarean deliveries in addition to lack of uterine rupture (especially in patients with 4 or more cesarean deliveries, when such a risk is increased27). For TOLAC, the outcome was considered successful if blood loss was less than or equal to 500 mL as determined by estimated blood loss; pre- and postpartum hemoglobin levels were between 12.0 and 15.5 g/dL; pre- and postpartum hematocrit was between 37% and 48%; MSAF was absent; uterus did not rupture; and no other postpartum complications occurred. For cesarean scar ectopic pregnancies, the outcome was considered successful if β-human chorionic gonadotropin (hCG) levels decreased and the ectopic pregnancy was resolved without complications, such as ectopic pregnancy rupture or need for additional methotrexate administration.

Case Studies
Case 1: Primary Cesarean Delivery
A 23-year-old woman (gravida 1, para 0) with a gestational age of 39 weeks presented to the Department of Labor and Delivery for a scheduled cesarean delivery because of fetal malpresentation. The patient’s prenatal course was unremarkable. She had a history of hypothyroidism and had not undergone any surgical procedures. Results of bedside abdominal ultrasonography and Leopold maneuvers indicated a fetal weight of 3200 g and a complete breech fetal position. Vital signs were found to be stable, and the patient had a body mass index (BMI) of 19. Complete blood cell count revealed hemoglobin and hematocrit levels to be 12.1 g/dL and 36.8%, respectively. An osteopathic structural examination (OSE) revealed that L1-5 were neutral, rotated right, sidebent left, and the sacrum was rotated left on the left oblique axis. Two Chapman points were found: 1 on the right between the posterior superior iliac spine and the transverse process of L5 and 1 below the greater trochanter on the right.

Myofascial release was performed on the planned Pfannenstiel incision site until strain was released, and the Chapman points were managed with rotary movement for 60 seconds. The patient was prepared for cesarean delivery with cefazolin for antibiotic prophylaxis, sequential compression devices for deep vein thrombosis prophylaxis, and citric acid for gastrointestinal prophylaxis. In the operating room, a Pfannenstiel incision was made. The amniotic sac was incised and the fluid was noted to be clear. A 3290-g neonate was successfully delivered, with Apgar scores of 9/9 at 1 and 5 minutes without complication. The uterus was closed with a 2-layer closure technique; the peritoneum, muscle, and fascial layers were sutured; and the skin incision was closed using a subcuticular stitch. Estimated blood loss was 800 mL.

Osteopathic manipulative treatment techniques consisting of rib raising, paraspinal inhibition, and pectoral retraction were performed postoperatively. No uterine Chapman points were identified at this time. Postpartum hemoglobin and hematocrit levels were 10.8 g/dL and 30.5%, respectively. Two weeks later, this patient presented for postpartum follow-up with her newborn. Her incision was noted to be completely intact and healing well, and the patient was without complaint. An OSE revealed that L1-5 were neutral, rotated right, and sidebent left, and the sacrum was rotated left on the left occiput anterior. No uterine Chapman points were identified. Myofascial release was applied to the cesarean scar and lumbar and sacral anchors until strain was released.
layers were then closed, and the skin incision was closed using a subcuticular stitch. Estimated blood loss was noted to be 1000 mL.

Rib raising, paraspinal inhibition, and pectoral retraction were performed postoperatively. No uterine Chapman points were identified at this time. Postpartum hemoglobin and hematocrit levels were 12.4 g/dL and 37.3%, respectively. Two weeks later, the patient presented for postpartum follow-up. Her incision was noted to be completely intact and healing well. An OSE revealed that L1-5 were neutral, rotated right, and sidebent left, and the sacrum was rotated right on the right oblique axis. No uterine Chapman points were identified. Myofascial release of the cesarean scar and lumbar and sacral anchors was performed until strain was released.

Case 3: TOLAC

A 25-year-old woman (gravida 2, para 1) with a gestational age of 41 weeks presented to the Department of Labor and Delivery with lower abdominal pain of 3 hours’ duration. The patient rated her pain as 8 on a scale of 1 to 10, with 10 being the most painful. A pelvic examination revealed an intact pregnancy, the cervix diated to 4 cm and 80% effaced, and a fetal station of −2. Results of bedside abdominal ultrasonography and Leopold maneuvers estimated a fetal weight of 3100 g and demonstrated a vertex fetal position. This patient’s prenatal course thus far had been unremarkable, and she had no notable medical or surgical history otherwise.

Results of bedside abdominal ultrasonography and Leopold maneuvers indicated a fetal weight of 4100 g, a vertex fetal position, and an amniotic fluid index of 15. Her vital signs were stable, and her BMI was 22. Complete blood cell count revealed hemoglobin and hematocrit levels to be 13.2 g/dL and 40.0%, respectively. An OSE found that L1-5 were neutral, rotated left, and sidebent right, and the sacral base was anterior. Chapman points were found bilaterally approximately 2 inches below the greater trochanters.

Myofascial release was performed on the previous cesarean scar and lumbar and sacral anchors until strain was released, and the Chapman points were managed with rotary movement for 60 seconds. The patient was prepared for cesarean delivery with cefazolin for antibiotic prophylaxis, sequential compression devices for deep vein thrombosis prophylaxis, and citric acid for gastrointestinal prophylaxis. In the operating room, a Pfannenstiel incision was made in the abdomen along the previous cesarean scar. Minor adhesions were lysed, and the incision was made in the uterus. The amniotic sac was incised, and the fluid was noted to be clear. The patient successfully gave birth to a 4210-g neonate, with Apgar scores of 9/9 at 1 and 5 minutes without complication. The uterus was closed with a 2-layer technique. The fallopian tubes were subsequently ligated using the Pomeroy technique. The peritoneum, muscle, and fascial layers were then closed, and the skin incision was closed using a subcuticular stitch. Estimated blood loss was noted to be 1000 mL.

Rib raising, paraspinal inhibition, and pectoral retraction were performed postoperatively. No uterine Chapman points were identified at this time. Postpartum hemoglobin and hematocrit levels were 12.4 g/dL and 37.3%, respectively. Two weeks later, the patient presented for postpartum follow-up. Her incision was noted to be completely intact and healing well. An OSE revealed that L1-5 were neutral, rotated right, and sidebent left, and the sacrum was rotated right on the right oblique axis. No uterine Chapman points were identified. Myofascial release of the cesarean scar and lumbar and sacral anchors was performed until strain was released.
performed and revealed that T10-12 were rotated right, sidebent left; L1-5 were rotated left, sidebent left; and the sacrum was rotated left on left occiput anterior. No Chapman points were identified. The patient’s β-hCG levels were 4909 mIU/mL. A complete blood cell count revealed hemoglobin and hematocrit levels of 9.6 g/dL and 28.6%, respectively.

Results from transvaginal ultrasonography (Figure 2) revealed an endometrial stripe of 1 cm in thickness without abnormal fluid or vascularity and an abnormally positioned ectopic gestational sac with the fetal pole and yolk sac in the lower uterine segment adherent to the previous cesarean scar. The mean diameter of the gestational sac was 0.79 cm, which corresponded to a gestational age of 5 weeks and 3 days; however, the fetal pole was 0.3 cm, which corresponded to a gestational age of 5 weeks and 6 days. The fetal heart rate was 92 beats/min. A magnetic resonance image without contrast (Figure 2) revealed an early gestational sac measuring 2.2×2.0 cm implanted in the anterior aspect of the lower uterine segment infiltrating into the previous cesarean scar.

Four weeks after delivery, the patient presented for postpartum follow-up with her husband and had no complaint. An OSE was performed and revealed that L1-5 were neutral, rotated right, sidebent left, and the sacrum was rotated right on the right occiput anterior. No uterine Chapman points were identified. Myofascial release of the cesarean scar and lumbar and sacral anchors was performed until strain was released.

**Case 4: Cesarean Scar Ectopic Pregnancy Managed With Methotrexate**

A 24-year-old woman (gravid 2, para 1) with an unconfirmed gestational age presented to the Emergency Department with complaints of vaginal bleeding and cramping. The patient denied passage of clots, severe abdominal and flank pain, dizziness, shortness of breath, or syncope. Her vital signs were stable, and she had a BMI of 22. A pelvic and speculum examination revealed approximately 2 mL of dark red blood in the vaginal vault with a closed cervical os. An OSE was performed and revealed that T10-12 were rotated right, sidebent left; L1-5 were rotated left, sidebent left; and the sacrum was rotated left on left occiput anterior. No Chapman points were identified. The patient’s β-hCG levels were 4909 mIU/mL. A complete blood cell count revealed hemoglobin and hematocrit levels of 9.6 g/dL and 28.6%, respectively.

Results from transvaginal ultrasonography (Figure 2) revealed an endometrial stripe of 1 cm in thickness without abnormal fluid or vascularity and an abnormally positioned ectopic gestational sac with the fetal pole and yolk sac in the lower uterine segment adherent to the previous cesarean scar. The mean diameter of the gestational sac was 0.79 cm, which corresponded to a gestational age of 5 weeks and 3 days; however, the fetal pole was 0.3 cm, which corresponded to a gestational age of 5 weeks and 6 days. The fetal heart rate was 92 beats/min. A magnetic resonance image without contrast (Figure 2) revealed an early gestational sac measuring 2.2×2.0 cm implanted in the anterior aspect of the lower uterine segment infiltrating into the previous cesarean scar without complete perforation of the uterus and no extension into the urinary bladder.

**Figure 2.** Imaging of cesarean scar ectopic pregnancy. In the ultrasonographic image (A), the abnormally positioned ectopic gestational sac is shown (arrow) with fetal pole and yolk sac in the lower uterine segment adherent to the previous cesarean scar. In the magnetic resonance image (B), an early gestational sac (arrow) was seen implanted in the anterior aspect of the lower uterine segment infiltrating into the previous cesarean scar.
For repeated cesarean deliveries, releasing tension of the incision site and the 2 anchors can potentially (1) reduce adhesions caused by previous surgery; (2) release tension of the myofascial layers to ensure more accurate identification of the anatomical structures during surgery; and (3) correct somatic dysfunction that may impair proper recovery. For a primary or repeated cesarean delivery, postoperative OMT techniques are the same because OMT is performed after cesarean delivery to ensure appropriate healing. Thus, postoperative OMT can provide improved lymphatic drainage and correction of hypersympathetic tone. Osteopathic manipulative treatment is repeated at postoperative follow-up to achieve the same goals.

For TOLAC, OMT aims to reduce tension on the previous cesarean scar to decrease the complication of uterine rupture. Although the rate of uterine rupture for low transverse incisions is 0.5% to 0.7%, the sequelae of this complication are severe, and measures to prevent it are important. Patients who have undergone TOLAC should have already had preoperative OMT, which would have released tension at the sacral and lumbar anchors and previous incision site. However, patients in labor will continue to have stress and pressure at the previous incision site because of regular uterine contractions during labor. Therefore, by continuing to release tension of the previous scar during the labor process, the overall stress on the previous scar and the likelihood of uterine rupture are potentially reduced. After successful VBAC, postoperative OMT techniques are similar to those performed after primary cesarean deliveries except that MFR of the incision site is repeated.

Inadequate blood flow to the cesarean scar site where an ectopic pregnancy has implanted could cause systemic methotrexate treatment to fail. The medicine may be unable to reach the implantation site because cesarean scars are inadequately vascular, and scar formation disrupts normal patterns of blood vessels. The goal of OMT techniques in this case is to ensure vascular access and subsequent delivery of methotrexate to its target area.

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Discussion
The OMT protocol used in the present cases was unique to each patient. For primary cesarean deliveries, MFR potentially releases the tension of the tissue layers that will be incised. In addition, MFR potentially relieves congestion or visceral somatic dysfunction of the uterus or broad ligament by targeting the uterine Chapman points. Because no previous incision site exists in these cases, the initial incision of the tissue layers (and later healing) will dictate the quality and subsequent structural alteration caused by the future scar. Cao et al found that when MFR was applied to 3-dimensional bioengineered tendons, inflammatory factors decreased and healing capacity increased. On the basis of in vitro MFR studies, wound healing and tension reduction of MFR was applied to the present clinical cases. Further studies of the protocol presented in the current article should include biopsies of the cesarean scar to evaluate wound healing in patients who receive OMT vs control patients who do not receive OMT.

These results along with the risks and benefits of various treatments were discussed with the patient, and she was treated with intramuscular methotrexate. Myofascial release was performed on the previous cesarean scar and lumbar and sacral anchors until strain was released, and 50 mg/m² of methotrexate was administered intramuscularly. The patient was instructed to return on treatment day 2 and treatment day 7 to check β-hCG levels. This patient did not return for follow-up on day 2, and her follow-up on day 7 revealed that her β-hCG level decreased less than 15%. The patient was without complaint. She was instructed to return for follow-up on a weekly basis to ensure appropriate decrease of her β-hCG level and monitor for any complications. She continued routine follow-up appointments for 2 months, at which point her β-hCG level was less than 5%. A levonorgestrel-releasing intrauterine device was subsequently placed per her request.
In all of the current cases, preoperative OMT was used to potentially avoid complications for the mother and the fetus. King et al demonstrated that prenatal OMT was shown to decrease the incidence of MSAF and preterm delivery. Accordingly, lack of MSAF was used as an outcome measure in the first 3 cases.

Limitations

Although the protocol was successfully used in the 4 cases, limitations exist. First, because Pfannenstiel incisions were used in these cases, any recommendation can apply only to this incision type. Additionally, each of the patients had a BMI of 22 or less; overweight and obese patients may have little to no benefit from these procedures. Nevertheless, experienced osteopathic physicians should be able to perform OMT on most patients.

The protocol must be subject to randomized controlled trials to make definitive conclusions regarding the risks and benefits of OMT for primary cesarean deliveries, repeated cesarean deliveries, TOLAC, and cesarean scar ectopic pregnancies that are managed with systemic methotrexate. Because of the limited sample size and insufficient numbers needed to treat, the successful outcomes may have been a coincidence. Further studies with a larger sample size and randomization are needed.

Conclusion

Cesarean scars pose a unique set of risks for women who have had previous cesarean deliveries. Although integrating OMT techniques into the management of cesarean scars has yet to be defined, the 4 present cases had successful outcomes when OMT was integrated into the treatment plan. Additional studies are required to refine this treatment approach and more clearly evaluate the potential risks and benefits in a randomized controlled trial.


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