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**Optimization of the cosmetic appearance of skin scar after caesarean section — part I:
obstetric practice**

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ABSTRACT

Caesarean section (CS) is a surgical way of child delivery by cutting the abdomen and uterus. Although compared to natural childbirth, it carries a greater risk of complications, the percentage of performed cuts is still increasing. The consequence of this procedure is the surgical skin scar. The appearance of this scar depends on many factors, including appropriate pre- and intraoperative procedure, operator skills and experience. The aim of the work is to present actions aimed at increasing the aesthetics of the skin scar after CS including pre-, intra- and postoperative procedures.

Key words: skin scar; caesarean section; wound healing

INTRODUCTION

The surgical wound after a caesarean section is a cut wound, leaving a linear scar. Initially, a sterile wound is surgically sutured with edges of the wound placed close together, healing by primary intention. Wounds with infection or significant tissue loss heal by secondary intention, resulting in larger scars. Scars differ in appearance and structure from skin, and changes in their appearance reflect remodeling and maturation processes. Immature

scars are characterized by a disorganized collagen fiber system and the presence of blood vessels (up to 6 months after injury). They are red, slightly raised scars. Mature scars are characterized by a pale color (usually lighter than the surrounding tissue), lack of pigmentation, lack of hair, and less elasticity (replacement of type III collagen with type I collagen - thicker fibers arranged in an orientation corresponding to the lines of skin tension). The maturation process of scars leads to a significant increase in mechanical strength. It can last up to 12 months after injury or even up to 2 years. Despite these intense remodeling processes, scars never reach the strength of unharmed skin [1, 2]. Maturation disorders can lead to uncontrolled scar growth, which becomes hard, thickened, less elastic and strongly reddened (keloid, hypertrophic scar) or lack of filling the entire tissue defect (the bottom of the scar lies below the skin surface — atrophic scar). Such forms of scars not only disfigure, but can also provoke pain, burning and can lead to body deformities. Women with hypertrophic skin scars and depressed hypopigmented scars are more likely to have adhesions in the abdominal region [3, 4]. The process of proper wound healing depends on many factors: the patient's age, nutritional status, the presence of diabetes (weakened expression of cytokines, delayed epithelialization), the presence of obesity [healing disorders with a body mass index (BMI) > 30–35 kg/m² or subcutaneous tissue thickness > 3 cm], smoking, individual tendencies to keloid scars. Factors that are independent of the patient include the technique used for the procedure, the duration of the procedure, and postoperative care that includes wound care [5, 6].

Disturbed wound healing after CS can be result of partial or total wound dehiscence, hematoma within the wound, tissue necrosis due to ischemia, increased abdominal pressure or wound infection. A common complication that significantly affects cosmetic appearance of the scar is surgical site infection (SSI). This results in abnormal wound healing, often accompanied by separation of wound edges. It prolongs hospitalization and can be the cause of re-suturing the wound. There are significant differences in the frequency of SSI after CS (1.8–11.3% even up to 15%), as well as wound dehiscence (0.4–1.2%) [2]. Based on 3-year observations conducted in five Polish hospitals, the frequency of SSI was determined to be 0.5% (differences between facilities ranging from 0.1% to 1.8%), with a predominance of deep infections (61.5%) [7]. Delayed wound healing is observed more frequently in case of emergency CS [8]. Preventing SSI requires implementing appropriate perioperative procedures. Postoperative factors have been considered to play a relatively minor role in causing SSI. The aims of this review were to appraise actions aimed at increasing the cosmetic appearance of the skin scar after CS with regard to pre-, intra- and postoperative

procedures. To identify the risk factors and preventive strategies, a literature search with no date restrictions was conducted using the terms: scar, wound care, wound management, surgical site infections, C-section.

Table 1. Procedures aimed at optimizing wound healing process and postoperative skin scar cosmetic appearance (compiled by this review authors)

Preoperative care	Intraoperative care	Postoperative care
<ul style="list-style-type: none"> • Proper hygiene (shower, bath) • Prohibition of shaving pubic hair 7 days before surgery • Shaving pubic hair with clippers as close to the surgery as possible • Giving up or limiting smoking (at least 30 days before surgery) • Providing single-use hospital underwear during surgery • Antibiotic prophylaxis 	<ul style="list-style-type: none"> • Skin preparation (chlorhexidine) • Preoperative vaginal irrigation (optional) • Maintaining appropriate body temperature and saturation • Glucose control • Localization and length of the incision • Subcutaneous tissue suturing in case of thickness above 2 cm • Skin closure (non-absorbable sutures), avoiding excessive tension on the wound edges • Dressing application 	<ul style="list-style-type: none"> • Dressing removal after 24-48 hours following the procedure • Proper hygiene and wound care • Appropriate ways of changing body position (without tensing the abdominal muscles) • Stabilizing the wound during activities that cause abdominal pressure (coughing, sneezing, laughing, pushing) • Wound healing process evaluation

PREOPERATIVE CARE

Preoperative care aims to minimize risk of wound infection by implementing procedures to protect the continuity of skin, and the and reduce the bacterial flora present on the patient's skin. It is not recommended to shave or remove pubic hair at least one week before the surgery, as it may cause skin microdamage. If hair removal is required, it is recommended to use an electric clipper with a single-use head, and shaving should be done as

close to the procedure as possible, but outside the operating room [5, 9]. Using a razor increases the risk of SSI [10]. At the latest, the day before the surgery and on the day of the surgery, it is recommended to wash the entire body, including head, with special attention to areas characterized by significant bacterial colonization (skin folds, armpits, navel, groin, and perineum). Using mild, regular soap, wiping patient's body with a fresh towel, and avoiding moisturizers or oily cosmetics is a common practice. There are no recommendations for shower or bath optimal time, and the amount or type of cleaning agents used [8]. It is acceptable to use soap and antiseptic solution, usually chlorhexidine. However, there is no evidence of their greater effectiveness in reducing SSI [5, 11, 12]. Heavy smokers are also advised to quit or reduce smoking at least 30 days before the procedure [10]. Smoking increases the risk of complications after surgical procedures. Nicotine impairs blood flow through tissues, which disrupts the wound healing process.

An important element of preoperative prevention is antibiotic therapy. According to the guidelines in every case of CS (elective, emergency), a single dose of cefazolin in a dose adjusted to the patient's body weight (80 kg — 1 g, above 80 kg — 2 g) should be administered within 30 minutes before skin incision. Prolonging perioperative prophylaxis beyond 24 hours does not reduce the risk of infectious complications but may increase the risk of antibiotic resistance and side effects. Prophylactic antibiotic therapy in women undergoing CS reduces the frequency of wound and endometrium infections and serious infectious complications by 60–70% [13, 14]. However, this method of drug administration raises concerns due to their potential impact on the newborn (disruption of intestinal microflora formation, disruption of immune system development, development of antibiotic resistance, masking of infections). In both methods of administration Jyothirmay et al. [15] found no differences in the condition of newborns. The long-term impact of antibiotics administered before CS on the child's body has not yet been analyzed.

INTRAOPERATIVE CARE

Intraoperative care aimed at minimizing the risk of SSI includes skin disinfection, ensuring hemostasis, avoiding prolonging anesthesia, avoiding hypothermia (maintaining body temperature above 36°C), controlling blood glucose levels in patients with diabetes (< 11 mmol/L) [5, 6, 9, 16]. Operator- related factors: experience and technical ability are essential for wound healing process. The skin scar aesthetics also depend on the choice of incision localization, tools and suture materials selection and appropriate suturing technique. World Health Organization recommends using alcohol solutions of antiseptic preparations

based on chlorhexidine for skin preparation [17]. Their effectiveness is compared to preparations with povidone-iodine. In the case of CS, the most effective method of skin preparation has not yet been determined, and the results of studies are varied. There are also no guidelines regarding the methods and time of antiseptic agents application. Skin should be prepared at the surgical site immediately before the incision. The antiseptic solutions should dry in the air [9, 17, 18]. Caissutti et al. [19] recommend vaginal cleansing before CS (sponge stick preparation of povidone-iodine 10% for at least 30 seconds). This procedure has not been shown to decrease the frequency of postoperative wound infections in elective cases [20]. It mainly counteracts postpartum endometrial infection, especially in patients who had a rupture of the fetal membranes. Due to short time of the procedure and low cost, it can be considered for routine practice [20, 21].

Different types of skin incisions of the abdominal wall can be used for CS. For better cosmetic appearance transverse abdominal incision in accordance with the course of Langer's lines is recommended. Incision made transversely to Langer's lines (vertical incision), is associated with postoperative wound dehiscence, postoperative hernia development, and formation of scar contractures. The Pfannenstiel incision („bikini incision”, „smiley incision”) is an 8–12 cm curved incision made at a distance of the thickness of two fingers above the pubic symphysis, ending 2–3 cm medially from the anterior superior iliac spine. It provides good surgical access and satisfactory cosmetic results. The Joel-Cohen incision is a 15–17 cm straight incision, about 3 cm below the line connecting the anterior superior iliac spines, made more cranially compared to the Pfannenstiel incision. The Pfannenstiel incision is used in Pfannenstiel-Kerr method and the modified Misgav-Ladach method. The Joel-Cohen incision is used in the Joel-Cohen and Misgav-Ladach method [4, 22–24]. When comparing CS techniques with regard to skin scar appearance, it is assumed that better cosmetic effects are obtained with the Pfannenstiel incision [22]. In the case scar is located lower, often hidden in a natural skin depression, may partly be covered by pubic hair, and its length is shorter. On the other hand, the Joel-Cohen technique brings other benefits such as shorter operation time, fewer occurrences of fever and pain, and reduced blood loss. Preparation of tissues with blunt technique reduces the risk of nerve and blood vessel damage, which affects the healing rate of the wound [25, 26]. Therefore, chronic pain in skin scar area is more commonly reported in patients after the Pfannenstiel incision [27]. Less invasive CS performed using the Joel-Cohen technique and its modifications are associated with shorter procedure time, and better postoperative patient's condition, but or worse cosmetic appearance. The results of research

comparing the type of abdominal incision technique with the healing of the postoperative wound are inconsistent [23–28].

The length of incision is important for scar aesthetics, but it must be sufficient for the quick and safe delivery of the baby. The minimum length of the incision with the Pfannenstiel method is 150 mm, and the Allis forceps of the same length can be used to determine it (the "Allis test") [29]. Ulubay et al. [29] among the important factors affecting length of the incision, mention operator's experience (residents: 159.5 ± 13.1 mm; min–max, 132–195 mm, specialists 154.5 ± 14.8 mm; min–max, 127–195 mm) and the patient's BMI. Sutton [30] analyzed the relationship between length of the incision and postoperative wound complications. The average and median lengths of incision were similar (15.3 cm and 15 cm). Longer incisions were not associated with an increased risk of postoperative complications. They were more frequent in overweight patients.

Excessing tension on the wound increases the risk for dehiscence, and decreasing perfusion to the healing wound. Mechanical forces (stretching, compression, hydrostatic pressure and osmotic pressure) acting on a healing wound can also disrupt the scar formation process and lead to the formation of keloids or hypertrophic scars. The risk of pathological scarring is reduced by the use of fascia sutures (deep and superficial fascia). Natural, and tension-free wound adhesion is achieved by bringing the edges of deeper structures together [31].

Absorbable and non-absorbable sutures, staples, surgical tapes, and tissue adhesives are used for skin closure after CS. An optimal method is still being sought (fast, technically easy, without any complications, and with good cosmetic results). The choice of type for skin closure potentially influences the risk of wound infection and complications. No guidelines have been developed in this area yet. The selection of skin closure method depends on the operator's preferences. It is recommended to suture the subcutaneous tissue if its thickness is greater than 2 centimeters. This is associated with a lower rate of wound complications, specifically infection and wound separation. Routine subcutaneous tissue drainage and re-disinfection of the skin before suturing is not recommended [32–35]. Studies evaluating different methods of skin closure analyze the frequency and type of complications (SIS, wound separation), pain and cosmetic effect. Metal staples and absorbable sutures are the two methods most commonly used and compared. Routine staple skin closure is not recommended, although staples significantly reduce time of skin closure [6, 33]. In Aabake et al. [35] research half of the skin incision was closed with subcuticular sutures and the other half was closed with staples. Significantly more women preferred the stapled side in terms of

cosmetic effect and reported staples as their preferred technique. Tissue adhesive is a more expensive and less commonly used method. The efficacy of tissue adhesive is comparable to conventional suture. No differences were noted in blood loss, surgical site infection, length of postpartum hospitalization, or wound disruption. Tissue adhesive can be used safely and effectively for skin closure after CS [36, 37]. Although absorbable sutures are recommended in areas that require a good aesthetic effect (plastic surgery, gynecology), from personal observations, a better result is achieved using non-absorbable sutures.

The surgical incision should be covered with an appropriate interactive dressing at the end of the operation [9]. In case of patients with a risk of abnormal wound healing (*e.g.* obese — BMI > 45 kg/m²), prophylactic postoperative use of vacuum dressings might be considered [38].

POSTOPERATIVE CARE

In this stage, standard aseptic and antiseptic principles should be followed to prevent SIS. Because wound infections typically appear after leaving the hospital (postoperative days 4–7), patient education about wound healing, recognizing signs of infection, hygiene as well as care at home are very important [39, 40]. Additional measures to prevent wound separation and the formation of postoperative hernias include proper ways of changing positions and stabilizing the operated area with hands during activities that involve the abdominal muscles (coughing, sneezing, pushing, changing positions). The dressing is usually removed after 24–48 hours after the procedure. The results of studies evaluating the effects of earlier dressing removal are inconsistent. Kilic et al. [41] compared dressing removal 24 hours versus 48 hours after surgery. At the six-week follow-up, the wound score (the ASEPSIS score system) was significantly less in the 48-hour group, indicating better wound healing in this group. On the other hand, Peleg et al. [42] did not observe any differences in the wound healing process in the group with dressing removal 6 hours after CS versus 24 hours. The wound should be kept clean and dry, without any dressing. Frequent hand washing is recommended, particularly before and after using the toilet and before touching the wound. Soaking the wound is not recommended. Showers with pouring water over the wound area are advised. Soap, including chlorhexidine soap, is allowed, but skin should not be scrubbed. Wearing cotton, breathable underwear and loose clothing, is also recommended. Depilation or pubic area shaving is not recommended within 3–4 weeks after CS [6, 9, 38].

CONCLUSIONS

Caesarean Section is one of the most commonly performed major abdominal operations. With the increasing percentage of CS being performed women's awareness of the adverse health consequences of this procedure is growing. Proper pre-, intra-, and post-operative management combined with patient education are important for wound healing and cosmetic appearance of skin scar.

Conflict of interest

All authors declare no conflict of interest.

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