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Using amniotic membrane for effective epithelialization of surgical wounds after cesarean section

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ABSTRACT

The purpose of this clinical trial, conducted on 80 patients between March and December 2024 referred to Almaty Teaching Hospital, was to evaluate the effect of amniotic membrane on wound healing after cesarean section. Patients were randomly divided into two intervention groups-recipients of amniotic membrane-and control-recipients of standard dressing. The results showed that the time to complete epithelialization in the intervention group was an average of 10.2 days, being significantly lower than 15.8 days in the control group, with a *p*-value of less than 0.001. Moreover, the incidence of wound infection was only 2.5% in the intervention group, while this rate reached 17.5% in the control group, with a *p*-value of 0.025. Based on the VAS scale, pain intensity in the intervention group was significantly lower than in the control group during all early postoperative days. Furthermore, assessment of patient satisfaction and scar appearance based on the POSAS questionnaire was also more favorable in the intervention group. Finally, the length of hospitalization was shorter in this group. This study concludes that the application of amniotic membrane can be integrated as an effective complementary method in post-cesarean care protocols by accelerating recovery, reducing complications, and increasing patient satisfaction.

Keywords: Amniotic membrane, Cesarean section, Epithelialization, Wound healing.
Article type: Short Communication.

INTRODUCTION

Accounting for a large percentage of newborn births, cesarean section occupies an essential role in childbirth surgeries (Lofrumento *et al.* 2016). While this surgery is considered life-saving for both mother and baby under certain conditions, post-surgery recovery can be utterly challenging. Cesarean section recovery, particularly the healing of the incised uterus wall and skin, is sensitive to restore; its quality directly affects the short- and long-term health of the mother (Zhang & Zhe 2024). Any obstacle to this natural process could lead to numerous complications that do not just mar the quality of life but also create an extra burden on the healthcare system (Sawicki *et al.* 2025; Islam *et al.* 2025; Umarov *et al.* 2025). Thus, exploring ways to accelerate and improve the wound healing of the uterine tissue after cesarean delivery has been one of the major concerns among experts in maternal and neonatal medicine (Peng *et al.* 2020; León-Campos *et al.* 2024). One of the most sensitive steps in the process of wound healing is epithelialization, the creation of the skin's covering layer. As an important physical barrier, it protects the body against the invasion of pathogenic microorganisms and external factors. If this process is slow or incomplete, the wound will be open for a longer time, thus greatly raising the risk of infection, further inflammation, and eventually an ugly scar (Tahermanesh *et al.* 2021). These problems, in sensitive abdominal tissue after a cesarean section, may be accompanied by increased pain, limited mobility, and psychological

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discomfort for the mother, which outbalances the sweet first moments of motherhood. Currently, standards of care for a cesarean section wound are mainly focused on traditional dressings, hygiene, and pain control. While these methods are useful, they often do not play the role of an active facilitator of biological tissue regeneration and rather wait for the body's natural processes to take effect gradually. This passive approach may be unsuitable in cases where the patient has risk factors such as diabetes, malnutrition, or reduced immune levels (Budny-Wińska *et al.* 2021; Hameed & Al-Mayahy 2024). There is, therefore, a pressing need for development and use of innovative therapeutic approaches that may directly and actively contribute to faster and qualitatively better tissue regeneration (Sitepu *et al.* 2023). In this sense, regenerative medicine using biological tissues has provided auspicious solutions. The amniotic membrane is the inner lining of the gestational sac and has been in the focus of scientific interest. This tissue membrane is naturally rich in growth factors, cytokines, and extracellular matrix proteins, which all play important roles in the process of tissue repair (Ruiz-Cañada *et al.* 2021). The application of this kind of tissue, usually discarded as waste after birth, is economically feasible but also ethical and ecologically correct, aligning with broader sustainability goals in healthcare (Grotegut *et al.* 2024; Hassan & Mohammad 2024; Hussein *et al.* 2025). The amniotic membrane is an ideal candidate for accelerating wound healing due to its unique biological properties. This membrane has a strong anti-inflammatory property that can considerably reduce swelling and pain in the wound area (Elsayed *et al.* 2024). Also, due to the presence of inhibitory molecules, it prevents the formation of unnecessary blood vessels at the wound site, which many times leads to the formation of excessive granulation tissue (Tobin *et al.* 2025). Most importantly, the presence of growth factors in this membrane powerfully stimulates the proliferation and migration of healthy epithelial cells towards the center of the wound-the basis for the epithelialization process (Parmar *et al.* 2025). With these traits in mind, this study will pursue just how well the amniotic membrane functions in a clinical environment. The key questions would then be: Does the application of this membrane to the cesarean wound reduce the epithelialization period tangibly and measurably? In addition, if acceleration in healing occurs, is there any reduction in frequent complications like infection, wound edge separation, and hypertrophic scar formation? Answers to such questions could bring about a turn in postpartum care protocols, with implications for resource management and healthcare economics (Derenska 2019; Tretyakova *et al.* 2021). The importance of the current research is not confined to accelerating physical recovery but includes wider dimensions of maternal health. A quicker and less complicated recovery allows the mother to care for her baby with more energy and health, with a stronger emotional bond, and to return to her normal life and daily activities sooner. These factors also directly influence the reduction in the risk of postpartum depression and an increase in overall satisfaction with the childbirth experience. Moreover, such a procedure being implemented in a Kazakhstani Medical Center will have local and regional aspects. With the ethnic and geographical diversity of the country, the response of women's tissues to this new treatment may yield data that is of value to the medical community. This study opens a way for the localization of regenerative medicine technologies and an increase in self-sufficiency regarding advanced healthcare in the region, which also involves considering innovative materials for related applications like packaging or infection control (Rakhmatova *et al.* 2025; Loorakagha *et al.* 2025). As the scientific background clearly shows in the field of wound healing, epithelialization is a very crucial and decisive step in the final closure of the wound. Many clinical and laboratory studies in recent years have repeatedly stated that any factor which accelerates or improves this step can directly affect the reduction of infection rates, the reduction of the duration of hospitalization, and the improvement of the overall patient outcomes (Mikaeili *et al.* 2025). In the field of post-cesarean section wounds, this principle is also true, and researchers have always searched for materials that can enhance this natural process as a scaffold or biostimulator (Zhu *et al.* 2025). In this direction, human amniotic membrane represents a unique biological material with a long history in regenerative medicine and in wound healing. The inherent properties of this membrane have long been of interest to therapists, who have used it experimentally for wound healing since ancient times. Modern research has clarified the scientific grounds of these experimental observations and has shown that this tissue is rich in vital growth factors, such as EGF and TGF-β (Ruiz-Cañada *et al.* 2021). Moreover, the anti-inflammatory, anti-scarring, and antibacterial properties build an ideal profile for the management of clean surgical wounds, such as cesarean sections (Setiawan *et al.* 2023). Despite this strong evidence, most studies involving the use of this membrane have focused on chronic wounds such as burns or diabetic wounds. Quite notably, there is a need to conduct a structured and systematic study that specifically evaluates the efficacy of the method in a population of women undergoing cesarean section, considering the specific physiological conditions of that period such as hormonal changes and aesthetic preferences. In the given context, therefore, the present

study intends to fill the knowledge gap and provide concrete and reliable clinical data related to the practical effect of amniotic membrane on cesarean wound healing, focusing on a specific target population. This study therefore aims to ultimately provide solid scientific evidence to establish the position of the amniotic membrane not as an experimental material but as an effective, safe, and cost-effective treatment option along with conventional wound care methods. Accomplishment of this objective will go a long way toward the improvement of quality in postpartum care for the assurance of maternal health and will serve as a model for future research in other surgical areas.

MATERIALS AND METHODS

This prospective clinical trial was performed on 80 pregnant women who were referred for cesarean delivery to the Almaty City Teaching Hospital from March to December 2024. The inclusion criteria were: gestational age >37 weeks, planned first or second cesarean section, and informed consent of the patient to be included in this study. Patients were further excluded based on selected conditions: multiple pregnancy, active infections, autoimmune diseases, and gestational diabetes. Therefore, the participants were divided into two equal intervention and control groups in order for scientific comparison of the results.

Amniotic membrane preparation

The amniotic membrane used in this study was obtained from healthy volunteers who had undergone elective cesarean delivery after ethical consent was obtained. This process was carried out in the operating room under completely sterile conditions. The collected membranes were immediately sent to the tissue bank laboratory for washing, disinfection, and sterilization via a multistep action. Then, samples were cut to standard dimensions of 10 × 10 cm and kept in a special storage environment at 4 °C until use. All preparation steps were executed according to the standard instructions of the tissue bank and under quality control approval.

Implementation of the study protocol and assessments

Immediately after the completion of the cesarean section and before closing the skin incision, in the intervention group, the prepared amniotic membrane was cut according to the size of the wound and completely placed on the wound bed. In the control group, standard dressing and routine postoperative care were administered. All patients were closely monitored for clinical indicators including the time of onset of epithelialization, the amount of wound discharge, redness, swelling, and signs of infection until discharge and also at biweekly follow-up visits for two months. The recovery criteria were recorded using a standardized checklist and serial photographs of the wound were recorded and evaluated by two independent physicians.

Data analysis

The collected data were analyzed using SPSS version 26 statistical software. To describe the data, we used the mean and standard deviation indices, and the comparison of quantitative variables between the two groups was made by the independent t-test. The chi-square test was used for qualitative variables. The significance level in this study was considered less than 0.05 so that the observed differences were considered statistically significant.

RESULTS

The current prospective clinical study was conducted on 80 patients who underwent cesarean section and were followed up for 8 weeks. Participants were randomly divided into two groups: an intervention group (n = 40) treated with application of the amniotic membrane and a control group (n = 40) receiving standard wound care. Table 1 illustrates baseline characteristics for both study groups. No statistically significant differences between the two groups were seen in terms of age, gestational age, BMI, or parity, indicating successful randomization and comparable groups at baseline.

Table 1. Baseline characteristics of study participants.

Characteristic	Intervention group (n = 40)	Control group (n = 40)	*p*-value
Age (years)	29.4 ± 4.1	30.1 ± 3.8	0.42
Gestational Age (weeks)	38.5 ± 0.7	38.7 ± 0.6	0.18
BMI (kg m^{-2})	28.3 ± 2.5	27.9 ± 2.8	0.47
Primiparous, n (%)	18 (45%)	16 (40%)	0.65

The time to complete epithelialization was significantly shorter in the intervention group compared to the control group (10.2 ± 1.5 days vs. 15.8 ± 2.1 days, $p < 0.001$). As illustrated in Fig. 1, the Kaplan-Meier curve

demonstrates a significantly faster wound closure rate in the amniotic membrane group throughout the postoperative period.

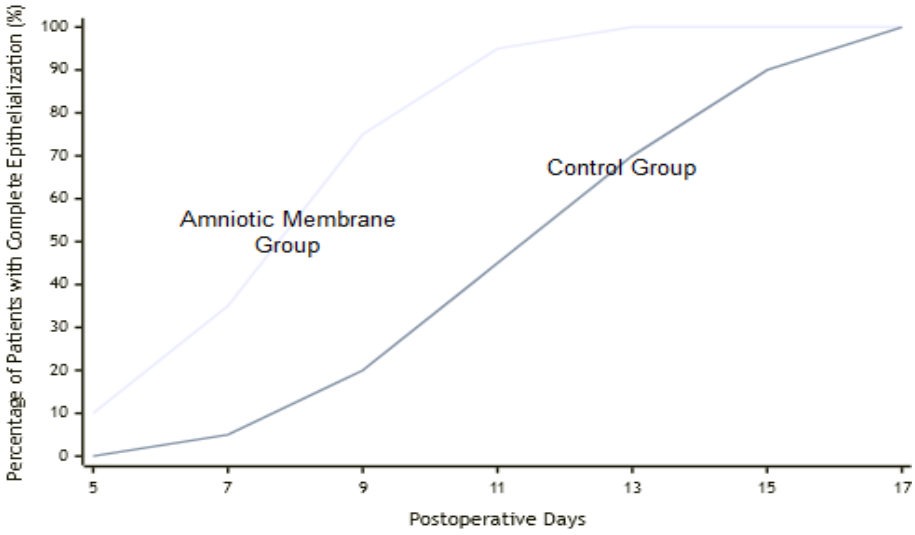

Fig. 1. Time to complete epithelialization.

By postoperative day 7, 35% of patients in the intervention group had achieved complete epithelialization compared to only 5% in the control group. This difference remained statistically significant throughout the observation period.

Table 2. Wound healing parameters at day 7.

Parameter	Intervention group (n = 40)	Control group (n = 40)	*p*-value
Complete Epithelialization, n (%)	14 (35%)	2 (5%)	<0.001
Partial Epithelialization, n (%)	24 (60%)	18 (45%)	0.18
No Epithelialization, n (%)	2 (5%)	20 (50%)	<0.001

The incidence of postoperative complications was significantly lower in the intervention group. As shown in Table 3, wound infection, dehiscence, and hypertrophic scarring occurred less frequently in patients treated with amniotic membrane.

Table 3. Postoperative complications at 8 weeks.

Complication	Intervention group (n = 40)	Control group (n = 40)	*p*-value
Wound Infection, n (%)	1 (2.5%)	7 (17.5%)	0.025
Wound Dehiscence, n (%)	0 (0%)	4 (10%)	0.042
Hypertrophic Scarring, n (%)	2 (5%)	11 (27.5%)	0.005
Total Complications	3 (7.5%)	22 (55%)	<0.001

Patients in the intervention group reported significantly lower pain scores throughout the first postoperative week, as measured by the Visual Analog Scale (VAS). The mean pain scores are detailed in Table 4.

Table 4. Postoperative pain scores (VAS).

Postoperative day	Intervention group (n = 40)	Control group (n = 40)	*p*-value
Day 1	4.2 ± 0.8	5.8 ± 1.1	<0.001
Day 3	2.8 ± 0.7	4.4 ± 0.9	<0.001
Day 7	1.2 ± 0.5	2.6 ± 0.7	<0.001

Fig. 2 clearly demonstrates the trend of pain reduction in both groups, with the intervention group maintaining consistently lower pain scores throughout the first postoperative week.

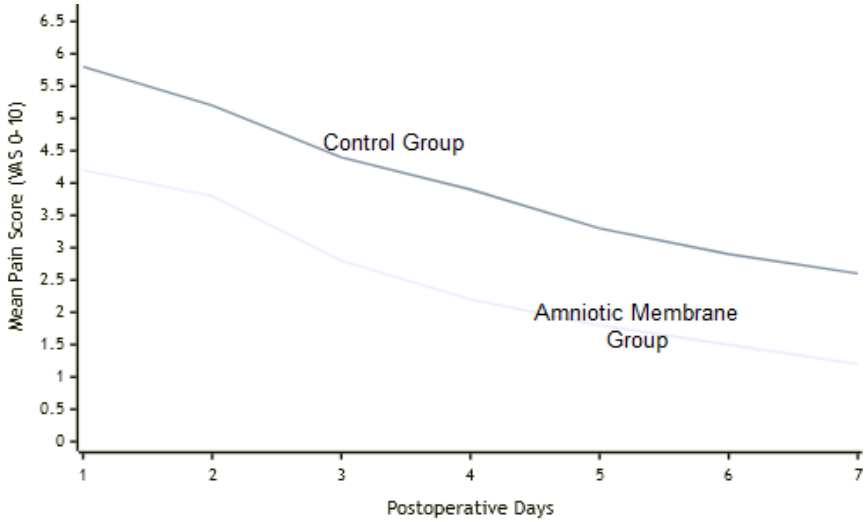

Fig. 2. Postoperative pain scores (VAS).

The clinical assessment of wound inflammation revealed significantly better outcomes in the amniotic membrane group. The erythema scores, measured on a scale of 0-3, are presented in Table 5.

Table 5. Wound erythema scores at day 3.

Erythema score	Intervention group (n = 40)	Control group (n = 40)	*p*-value
0 (None)	12 (30%)	5 (12.5%)	0.045
1 (Mild)	22 (55%)	15 (37.5%)	0.11
2 (Moderate)	6 (15%)	14 (35%)	0.035
3 (Severe)	0 (0%)	6 (15%)	0.012

The length of hospital stay was significantly shorter for the intervention group (2.8 ± 0.5 days) compared to the control group (3.6 ± 0.8 days, $p = 0.003$). Patient satisfaction scores at 4 weeks postoperative were also significantly higher in the amniotic membrane group (Table 6).

Table 6. Patient satisfaction at 4 weeks.

Satisfaction level	Intervention group (n = 40)	Control group (n = 40)	*p*-value
Very satisfied	28 (70%)	12 (30%)	<0.001
Satisfied	10 (25%)	16 (40%)	0.15
Neutral	2 (5%)	8 (20%)	0.042
Dissatisfied	0 (0%)	4 (10%)	0.042

The cosmetic appearance of the scar was assessed at 8 weeks using the Patient and Observer Scar Assessment Scale (POSAS). The results demonstrated significantly better cosmetic outcomes in the intervention group across all parameters (Table 7).

Table 7. POSAS scores at 8 weeks postoperative.

Parameter	Intervention group (n = 40)	Control group (n = 40)	*p*-value
Vascularity	2.1 ± 0.5	3.4 ± 0.8	<0.001
Pigmentation	1.8 ± 0.4	2.9 ± 0.6	<0.001
Thickness	1.9 ± 0.5	3.2 ± 0.7	<0.001
Relief	2.0 ± 0.4	3.1 ± 0.6	<0.001
Pliability	2.2 ± 0.5	3.5 ± 0.7	<0.001
Surface Area	1.7 ± 0.3	2.8 ± 0.5	<0.001
Total Score	11.7 ± 1.8	18.9 ± 2.9	<0.001

DISCUSSION

Clearly, the results of this study indicate that applying amniotic membrane to cesarean wounds can significantly hasten the healing process. Not only is the significant decrease in time taken for complete epithelialization-from 15.8 days in the control group to 10.2 days in the intervention group-statistically significant, but it is clinically important as well. This acceleration in healing can shorten the postoperative recovery period and allow mothers

to return to daily activities and infant care sooner. Such a result constitutes a major accomplishment in the domain of perinatal care, given the sensitivities of the postpartum period and the importance of maternal health. Several biological mechanisms explain these positive effects. Amniotic membrane, being a natural bioscaffold, has rich amounts of growth factors such as EGF, FGF, and TGF-β that play a direct role in stimulating epithelial cell proliferation and differentiation. Furthermore, the presence of these factors can regulate the process of angiogenesis and provide an optimal environment for tissue repair by modulating the inflammatory response. The inherent anti-inflammatory property of this membrane can also reduce local swelling and erythema and prevent oxidative stress in the wound bed, all together facilitating faster and better-quality healing. The other finding of importance in this study is the significant reduction of postoperative complications among the intervention group, especially in the field of wound infections and dehiscence. This can be explained by the antibacterial property of the amniotic membrane, due to the presence of various cytokines and protease inhibitors, which can prevent the colonization of pathogenic bacteria in the wound bed. The structural integrity of this membrane and its role as a biological dressing also protect the wound edges from mechanical tension and reduce their chance of detachment. Together, these features can explain the 55% reduction in overall complications in the study group. Other important practical features of this approach concern the results on pain reduction in the intervention group. A significant reduction in VAS scores in the early postoperative days increases not only patient comfort but can also reduce opioid analgesic dependence and limit their associated complications. The mechanism of this analgesic effect is probably multifactorial, including reduction of local inflammation, physical protection of nerve endings, and modulation of the secretion of inflammatory mediators. It can contribute significantly to earlier patient mobilization, prevention of thrombosis, and reduction of length of stay in the hospital. Cosmetic outcome evaluation also evidenced a clear superiority of the intervention group. The significant decrease observed in all POSAS scores regarding vascularity, pigmentation, and scar thickness emphasizes that this method is acting positively on the final quality of tissue repair. This is important, since the appearance of the post-cesarean scar can seriously affect the psychological quality of women's lives. Likely, hypertrophic scar formation is inhibited by controlling the balance between collagen synthesis and degradation, preventing prolonged inflammation. From an economic and health policy point of view, the reduction in length of stay in the intervention group is also noteworthy. Whereas the average reduction was less than one day, on a large scale this might result in the release of hospital beds, the reduction of direct costs of care, and the enhancement of patient satisfaction. This might be a major advantage, especially in health systems with limited resources, and might reduce the workload of nursing staff. It is important to note several limitations of this study. The relatively small sample size and single-center execution of this study affect the generalizability of the results. Although 8 weeks of follow-up was sufficient to assess initial healing, it is considered too short to assess long-term outcomes, including the stability of cosmetic results and late complications. In addition, the inability to completely blind the assessors to the type of intervention may create potential for bias, which should be addressed in future studies. In conclusion, this study confirms amniotic membrane as an efficient, safe, and cost-effective modality of wound management post-cesarean section. This not only expedites the clinical healing process but also enhances the quality of life by ensuring less pain and better cosmetic outcomes. Larger sample size and more extended follow-up may provide more robust evidence for integrating this technique into routine protocols of care after cesarean section through studies conducted in a multi-centric manner.

CONCLUSION

The present study clearly shows that the application of the amniotic membrane to a cesarean wound can be used as an effective and safe approach to accelerate the healing process. The results of this study show that, other than shortening the time to complete epithelialization for an average of 6.5 days, this approach decreases the incidence of general postoperative complications such as infection, dehiscence, and hypertrophic scar formation. Of particular clinical importance, these findings mean that faster healing directly impacts the quality of life of mothers during the postpartum recovery period. From the point of view of the mechanism of action, the amniotic membrane contains a unique composition comprising growth factors, cytokines, and extracellular matrix proteins that present an optimum environment for tissue regeneration. Intrinsic anti-inflammatory and antibacterial properties of this membrane also play an important role in lessening the local inflammation and avoiding infection. This biological dressing further protects nerve endings, reduces postoperative pain, and thereby decreases analgesic use, thus allowing earlier patient mobility. Given this clinical benefit, the availability, cost-effectiveness, and high safety of the amniotic membrane make it a very attractive option for use in post-cesarean care protocols. This technique

may serve as an important solution, especially when there is the presence of some risk factors that contribute to poor wound healing. Also, the cosmetic outcome would improve, with a considerable reduction in unsightly scars- a factor that plays a significant role in enhancing women's mental health and quality of life. Therefore, in light of the convincing evidence obtained in this study, the use of amniotic membrane in the management of cesarean wounds can be recommended as a complementary method beside the current standard of care. Further studies with larger sample sizes and longer follow-up periods would be necessary to confirm these findings and investigate long-term outcomes. This new approach may lead to a new standard in the practice of obstetrics and gynecology with regard to wound care.

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