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Role of Amniotic Fluid in Caesarean Section Scar Healing: Cosmetic Outcomes, Regenerative Potential, and Anti-Fibrotic Effects

Dr Aditi Hiralal Iche[1], Dr Sameer Chaudhari[2], Dr Hitesh Khatri[3], Dr Meenal Deshmukh Bawankar[4]

[1] Assistant Professor, Department of Obstetrics & Gynaecology, Dr. Rajendra Gode Medical College, Amravati
[2] Associate Professor, Department of General Medicine, Dr. Panjabrao Deshmukh Memorial Medical College, Amravati
[3] Assistant Professor, Department of Dermatology, Venereology & Leprosy, Dr. Panjabrao Deshmukh Memorial Medical College, Amravati
[4] MBBS DipGO ICMCH, MASTERS IN cosmetic gynaec, Fellowship in Psycosexual Medicine

Corresponding Author:

Dr Aditi Hiralal Iche

Assistant Professor, Department of Obstetrics & Gynaecology, Dr. Rajendra Gode Medical College, Amravati.

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ABSTRACT

Background: Caesarean section (CS) is one of the most frequently performed surgical procedures worldwide. The quality of postoperative scar healing significantly influences maternal satisfaction, cosmetic outcomes, and long-term wellbeing. Amniotic fluid is rich in growth factors, cytokines, stem cells, and bioactive molecules that possess regenerative, anti-inflammatory, and anti-fibrotic properties. These characteristics may contribute to improved wound healing and scar remodeling following caesarean delivery.

Aim: To evaluate the role of amniotic fluid in caesarean section scar healing with respect to cosmetic outcomes, regenerative potential, and anti-fibrotic effects.

Materials and Methods: This prospective observational study was conducted in the Department of Obstetrics and Gynaecology of a tertiary care hospital. A total of 148 women undergoing lower segment caesarean section were enrolled. Scar healing was assessed during postoperative follow-up using standardized scar evaluation parameters, including pigmentation, vascularity, pliability, scar height, and overall cosmetic appearance. Postoperative wound complications such as surgical site infection, wound dehiscence, hypertrophic scar formation, and patient satisfaction with scar appearance were also evaluated. The influence of amniotic fluid exposure on scar healing characteristics was analysed.

Results: Excellent cosmetic scar outcomes were documented in 62.2% of women, while 27.7% demonstrated good cosmetic outcomes. Hypertrophic scar formation occurred in 6.1% of participants, and poor scar healing was observed in 4.0%. Surgical site infection and wound dehiscence were noted in 3.4% and 1.4% of cases, respectively. Women with favorable scar healing exhibited improved scar pliability, reduced scar thickness, and higher cosmetic satisfaction scores. The findings suggest a positive association between amniotic fluid exposure and enhanced tissue regeneration with reduced fibrotic response.

Conclusion: Amniotic fluid may play a beneficial role in caesarean section scar healing through its regenerative and anti-fibrotic properties, contributing to improved cosmetic outcomes and reduced postoperative scar-related complications.

Keywords: *Amniotic fluid, Caesarean section, Scar healing, Cosmetic outcome.*

INTRODUCTION

Caesarean section is one of the most frequently performed surgical procedures globally. In the last three decades, CS increased from 6.7% to 19.1% globally.[1] Caesarean section (CS) is one of the most commonly performed surgical procedures worldwide, accounting for a substantial proportion of births in both developed and developing countries. While advances in surgical techniques and perioperative care have significantly improved maternal outcomes, postoperative wound healing and scar formation remain important determinants of maternal satisfaction and quality of life. Poor scar

healing may result in hypertrophic scars, keloids, chronic discomfort, cosmetic dissatisfaction, and psychological distress. Therefore, identifying factors that promote optimal wound healing and minimize fibrosis has become increasingly relevant in obstetric practice.[2,3]

Amniotic fluid is a biologically active substance containing numerous growth factors, cytokines, extracellular matrix components, stem cells, antimicrobial peptides, and anti-inflammatory mediators. These constituents play a critical role in fetal tissue development and scarless wound healing observed during intrauterine life. Experimental and clinical studies suggest that amniotic fluid possesses regenerative properties that facilitate tissue repair, enhance epithelialization, suppress inflammation, and reduce excessive collagen deposition during wound healing.[3]

The anti-fibrotic effects of amniotic fluid are attributed to its ability to modulate transforming growth factor-beta (TGF-β) signaling pathways, reduce fibroblast proliferation, and promote balanced extracellular matrix remodeling.[4,5] Additionally, the presence of mesenchymal stem cells and bioactive molecules contributes to accelerated tissue regeneration and improved scar quality.[6]

Despite increasing evidence regarding the regenerative potential of amniotic fluid in various surgical specialties, its role in caesarean section scar healing remains inadequately explored. The present study was conducted to evaluate the influence of amniotic fluid on scar healing following caesarean delivery, focusing on cosmetic outcomes, regenerative potential, and anti-fibrotic effects.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Obstetrics and Gynaecology of a tertiary care teaching hospital over a period of two years. A total of 148 women undergoing lower segment caesarean section (LSCS), either elective or emergency, were enrolled in the study after obtaining informed written consent. Women who were willing to participate and comply with postoperative follow-up visits were included. Patients with known connective tissue disorders, immunocompromised states, chronic steroid therapy, a previous history of keloid formation, or incomplete follow-up were excluded from the study.

Detailed demographic, obstetric, and perioperative data were collected for all participants. Postoperative scar healing was assessed during scheduled follow-up visits using modified Vancouver Scar Assessment parameters, which included evaluation of pigmentation, vascularity, pliability, scar height, and overall cosmetic appearance. Patient satisfaction regarding scar appearance was also documented. Scar healing outcomes were analyzed with particular emphasis on cosmetic results, regenerative characteristics, and evidence of anti-fibrotic effects.

The collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 26.0. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Comparative analyses were performed using appropriate statistical tests, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1. Baseline Characteristics of Study Participants (n=148)

	Variable	Frequency	Percentage (%)
Age Groups (Years)	<25 years	36	24.3
	25–30 years	72	48.6
	>30 years	40	27.1
Gravida	Primigravida	61	41.2
	Multigravida	87	58.8
LSCS Type	Elective LSCS	59	39.9
	Emergency LSCS	89	60.1

A total of 148 women who underwent lower segment caesarean section were included in the study. As shown in Table 1, the majority of participants (48.6%) belonged to the 25–30 years age group, followed by 27.1% who were older than 30 years and 24.3% who were younger than 25 years. The mean age of the study population was 27.8 ± 4.6 years. Multigravida women constituted 58.8% of the participants, while 41.2% were primigravida. Emergency caesarean sections were more common (60.1%) than elective procedures (39.9%).

Table 2. Cosmetic Scar Outcome Assessment

Cosmetic Outcome	Frequency	Percentage (%)
Excellent	92	62.2
Good	41	27.7
Fair	9	6.1

Poor	6	4.0
Total	148	100

Table 2 demonstrates the cosmetic scar outcomes following caesarean section. Excellent cosmetic outcomes were observed in 62.2% of women, while 27.7% had good scar appearance. Only 6.1% and 4.0% of participants exhibited fair and poor cosmetic outcomes, respectively, indicating generally favorable postoperative scar healing.

Table 3. Postoperative Scar Characteristics

Scar Characteristic	Frequency	Percentage (%)
Normal scar	133	89.9
Hypertrophic scar	9	6.1
Hyperpigmentation	12	8.1
Increased vascularity	8	5.4
Reduced pliability	10	6.8

In Table 3, it was observed that a normal scar was observed in 89.9% of women. Hypertrophic scar formation was noted in only 6.1% of cases. Hyperpigmentation, increased vascularity, and reduced scar pliability were observed in 8.1%, 5.4%, and 6.8% of participants, respectively, suggesting a low prevalence of adverse scar features.

Table 4. Postoperative Wound Complications

Complication	Frequency	Percentage (%)
Surgical site infection	5	3.4
Wound dehiscence	2	1.4
Seroma	3	2.0
Hematoma	1	0.7
No complication	137	92.6

Table 4 summarizes postoperative wound complications. The majority of women (92.6%) experienced no complications. Surgical site infection was the most common complication, occurring in 3.4% of cases, followed by seroma formation in 2.0% and wound dehiscence in 1.4%. Hematoma was the least common complication, reported in only 0.7% of participants.

Table 5. Patient Satisfaction with Scar Appearance

Satisfaction Level	Frequency	Percentage (%)
Highly satisfied	88	59.5
Satisfied	42	28.4
Neutral	12	8.1
Dissatisfied	6	4.0

It is shown in Table 5 that most women were highly satisfied (59.5%) or satisfied (28.4%) with the cosmetic outcome of their scar. Only 8.1% reported neutral satisfaction, while dissatisfaction was reported by 4.0% of participants, reflecting a high level of overall acceptance of scar appearance.

Table 6. Scar Healing Parameters

Parameter	Favorable Outcome n (%)
Normal pigmentation	136 (91.9)
Normal vascularity	140 (94.6)
Good pliability	138 (93.2)
Scar height <2 mm	134 (90.5)
Excellent cosmetic appearance	92 (62.2)

In Table 6, it was observed that favorable outcomes were observed in the majority of women, with normal vascularity in 94.6%, good pliability in 93.2%, normal pigmentation in 91.9%, and scar height less than 2 mm in 90.5% of participants. Excellent overall cosmetic appearance was achieved in 62.2% of women, supporting the observation of effective scar healing and favorable tissue remodeling following caesarean section.

DISCUSSION

Wound healing is a complex biological process involving inflammation, proliferation, extracellular matrix deposition, and tissue remodeling. Excessive fibroblast activity and collagen deposition often lead to hypertrophic scar formation and poor cosmetic outcomes.[7]

The present study demonstrated favorable scar healing outcomes in the majority of women undergoing caesarean delivery. More than 89% of participants exhibited excellent or good cosmetic scar appearance, while hypertrophic scar formation remained uncommon.

These findings are consistent with previous studies suggesting that amniotic fluid contains numerous regenerative factors capable of promoting organized tissue repair. Koob et al. [8] reported that amniotic membrane-derived biological products possess anti-inflammatory and anti-scarring properties that enhance wound healing. Similar observations were documented by Niknejad et al. [9] who highlighted the ability of amniotic-derived tissues to accelerate epithelialization and suppress fibrosis.

The regenerative potential of amniotic fluid is largely attributed to the presence of epidermal growth factor (EGF), fibroblast growth factor (FGF), vascular endothelial growth factor (VEGF), transforming growth factor regulators, and mesenchymal stem cells. [10] These components contribute to angiogenesis, collagen remodeling, and balanced tissue regeneration.

Another important observation in the present study was the low incidence of surgical site infection and wound dehiscence. Amniotic fluid contains antimicrobial peptides and immunomodulatory proteins that may provide protection against microbial colonization and excessive inflammatory responses. [11]

Furthermore, fetal wound healing is characterized by minimal scar formation despite rapid tissue regeneration. Researchers have suggested that exposure to the intrauterine environment, including amniotic fluid, plays a crucial role in achieving scarless healing. [12] The favorable cosmetic outcomes observed in the present study may reflect similar biological mechanisms acting on maternal wound tissues exposed to amniotic fluid during caesarean delivery.

Although the findings are encouraging, larger multicentric studies incorporating molecular and histopathological evaluation of scar tissue are required to further elucidate the precise mechanisms underlying the regenerative and anti-fibrotic effects of amniotic fluid.

Enhanced scar pliability, reduced scar thickness, and improved patient satisfaction further support its potential role in optimizing postoperative wound healing. Future large-scale studies are warranted to validate these observations and explore therapeutic applications of amniotic fluid-derived biological products in obstetric wound management.

CONCLUSION

The present study demonstrated favorable cosmetic scar outcomes following caesarean section, with low rates of hypertrophic scar formation, surgical site infection, and wound dehiscence. The findings suggest that amniotic fluid may contribute positively to scar healing through its regenerative, anti-inflammatory, and anti-fibrotic properties.

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