

Effect of degree of cervical dilatation at time of cesarean section on postpartum isthmocele formation

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Cite this article as: Topcu Akduman A, Koç Tiske P, Köroğlu S, Sağlık K, Türkçapar AF, Özdemir Ö. Effect of degree of cervical dilatation at time of cesarean section on postpartum isthmocele formation. *Gulhane Med J*. [Epub Ahead of Print]

Date submitted:

16.06.2026

Date accepted:

25.08.2026

Epub:

27.10.2026

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Keywords: Cesarean section, cervical dilatation, cesarean scar defect, isthmocele, uterine niche

ABSTRACT

Aims: Isthmocele is a common long-term complication of cesarean delivery that causes various gynecological symptoms, primarily abnormal uterine bleeding. Although labor-related factors are believed to contribute to the etiology of isthmocele, the relationship between cervical dilation and isthmocele development remains controversial. This study aims to evaluate the relationship between the degree of cervical dilation during primary cesarean section and the occurrence of postpartum isthmocele.

Methods: This retrospective cohort study with prospective ultrasound assessment included women who underwent primary cesarean section between January 2023 and December 2024. Transvaginal ultrasonography performed 12 to 24 months postpartum assessed the presence of isthmocele and residual myometrial thickness. The primary endpoint was the presence of an isthmocele, defined as a notch at least 2 mm deep in the cesarean scar region. The relationship between the level of cervical dilation and isthmocele formation was evaluated using logistic regression analysis.

Results: A total of 127 women (median age: 26 years, interquartile range 23-31) were included in the study. Of these, 84 had cervical dilatation less than 4 cm and 43 had cervical dilatation 4 cm or greater at the time of cesarean section. Isthmocele was detected in 24 (28.6%) women in the less than 4 cm group and 20 (46.5%) women in the 4 cm or greater group ($p=0.070$). In univariate logistic regression analysis, each 1 cm increase in cervical dilatation was associated with higher odds of isthmocele formation [odds ratio: 1.20, 95% confidence interval (CI): 1.05-1.38; $p=0.007$]. However, this association was not significant after adjustment for potential confounders (adjusted odds ratio: 1.19, 95% CI: 0.97-1.45; $p=0.087$).

Conclusions: A higher prevalence of isthmocele was observed among women with cervical dilatation of 4 cm or more at the time of primary cesarean section. However, cervical dilatation was not independently associated with isthmocele formation after adjustment for potential confounders.

Introduction

Isthmocele (cesarean scar defect or uterine niche) is defined as an anatomical defect resulting from insufficient myometrial healing at the hysterotomy line after cesarean section (1). Cesarean section is one of the most frequently performed surgical procedures worldwide, and isthmocele, a late complication of this procedure, is attracting increasing attention (1,2). In addition to being associated with gynecological problems such as prolonged menstrual bleeding in the form of postmenstrual spotting and other abnormal bleeding, dysmenorrhea, chronic pelvic pain, and secondary infertility, isthmocele is also linked to serious obstetric complications that may occur in subsequent pregnancies, such as cesarean scar pregnancy, placenta accreta spectrum, and uterine rupture (3). However, despite a growing understanding of its clinical significance, the pathophysiological mechanisms underlying isthmocele development and its associated risk factors are not yet fully understood.

Regarding isthmocele development, patient-related factors such as maternal age, body mass index (BMI), history of previous cesarean section, and uterine position; surgical factors such as surgical experience, operation time, suture material, continuous or locked suture technique, single or double-layer closure of the myometrium, and whether the endometrial layer is included in the suture line; and labor-related factors such as cervical dilation, labor augmentation, premature membrane rupture, and fetal head level during cesarean section have been investigated (3-5). Among these factors, the level of cervical dilation is particularly noteworthy, as it reflects the degree of labor progress and can also influence the anatomical placement of the hysterotomy line.

While the effect of modifying surgical factors on the formation of cesarean scar defects is well known, a better understanding of labor-related factors may also be clinically important. Especially when cesarean delivery is performed during labor, adapting surgical strategies to intrapartum conditions can help reduce the development of isthmoceles and related long-term complications. Recent systematic reviews have reported that labor-related factors such as advanced cervical dilation, premature rupture of membranes, and a fetal presenting part located below the pelvic inlet may be associated with isthmocele development. Furthermore, cesarean deliveries performed during advanced labor and low-level hysterotomy may increase the risk of scar defects (3,4). It is suggested that opening the hysterotomy line at a lower level during advanced labor and including cervical tissue in the incision may contribute to the development of isthmocele because cervical tissue has different healing properties than myometrial tissue (4). It is also suggested that prolonged labor may contribute to the development of cesarean scar defects by negatively affecting tissue perfusion and wound healing through mechanisms such as thinning and stretching of the lower uterine segment, increased tissue edema, and a higher

risk of infection (3,4,6-8). However, the underlying mechanisms of this relationship have not been fully clarified, and much of the current evidence comes from observational studies.

The aim of this study was to evaluate the effect of cervical dilation level during primary cesarean section on postpartum isthmocele formation and cesarean scar healing.

Methods

Study design and participants

This study was conducted at the Department of Obstetrics and Gynecology, University of Health Sciences Türkiye, Gülhane Training and Research Hospital, a tertiary care referral center. Women who underwent primary cesarean section between January 2023 and December 2024 were identified from hospital records and assessed for eligibility. Eligible women were subsequently invited for a standardized transvaginal ultrasonography examination 12-24 months after delivery to evaluate cesarean scar healing and isthmocele formation. Of these, 77 women could not be contacted for follow-up and 15 did not meet the eligibility criteria. Therefore, 127 women were included in the final analysis.

Ethical considerations

The study protocol complied with the ethical guidelines outlined in the 1975 Declaration of Helsinki and its revisions (most recently in 2013).

Approval for the evaluation and publication of the collected data was obtained from the University of Health Sciences Türkiye, Gülhane Training and Research Hospital Clinical Research Ethics Committee (approval number: 2024/15, dated: September 12, 2024). The ethics approval covered both the retrospective review of medical records and the prospective ultrasonographic follow-up of eligible participants. Written informed consent was obtained from all participants before the follow-up transvaginal ultrasonographic examination and study participation.

Inclusion and Exclusion Criteria

The study included women aged 18 years and older who had their first delivery by cesarean section at 37 weeks of gestation or later, had complete medical records, and agreed to undergo transvaginal ultrasonography evaluation.

Women were excluded if they had a history of previous uterine surgery or cesarean section, multiple pregnancies, fetal death, congenital uterine malformations, uterine fibroids, intrauterine devices, or incomplete medical records.

Cesarean section

In all women, cesarean delivery was performed by the responsible obstetrician using a transverse Pfannenstiel incision for laparotomy and a transverse Monroe-Kerr incision

for hysterotomy. The uterine incision was repaired with a standardized double-layer closure technique using absorbable suture material. The first layer was closed with a locking continuous suture technique using 1 Vicryl sutures, including the endometrial layer in the suture line. The second layer was closed with a non-locking continuous suture technique using 1 Vicryl suture. Parietal peritoneal repair was performed in all cases. All patients received a routine 30 IU oxytocin infusion in the postoperative period. Cesarean section was performed in accordance with contemporary intraoperative care recommendations for cesarean section (9).

Radiological assessment

Ultrasonographic examinations were performed between January 2025 and December 2025 and were conducted 12-24 months postpartum. A single experienced physician (A.T.A.), who was blinded to intraoperative details, performed all assessments. During the assessment, uterine position, presence of isthmocele, total myometrial thickness, residual myometrial thickness (RMT), and isthmocele depth were recorded. All measurements followed predefined criteria. Additionally, all patients were asked about symptoms potentially associated with isthmocele, including cesarean scar pain, spotting-type bleeding lasting more than five days, intermenstrual spotting, and brown discharge following heavy menstrual bleeding. For statistical analysis, patients reporting one or more of these symptoms were classified as having a symptomatic isthmocele.

Isthmocele is characterized by a hypoechoic area within the myometrium of the lower uterine segment at the site of a previous cesarean section scar and is defined as an indentation at least 2 mm deep in the scar region (10). RMT was measured perpendicular to the endometrial line at the level of the cesarean scar. When an isthmocele was present, the measurement was taken as the distance between the apex of the isthmocele and the serosal surface. In the sagittal plane, uterine length was measured as the distance from the uterine fundus to the level of the cervical canal (Figure 1). All measurements were performed using a 2D transvaginal ultrasonography device (Voluson S8, GE Healthcare, Zipf, Austria) with an empty bladder and a 4-9 MHz transvaginal probe.

Clinical and obstetric data collection

Clinical and obstetric data potentially associated with isthmocele development were obtained from patients' medical records. Variables evaluated included maternal age, BMI, presence of comorbid diseases, obstetric history (gravida, parity, gestational age, and neonatal birth weight), presence of premature rupture of membranes, use of oxytocin and dinoprostone for labor induction, presence of uterine contractions, cervical dilation at the time of cesarean section, and indication for cesarean section. Additionally, postpartum

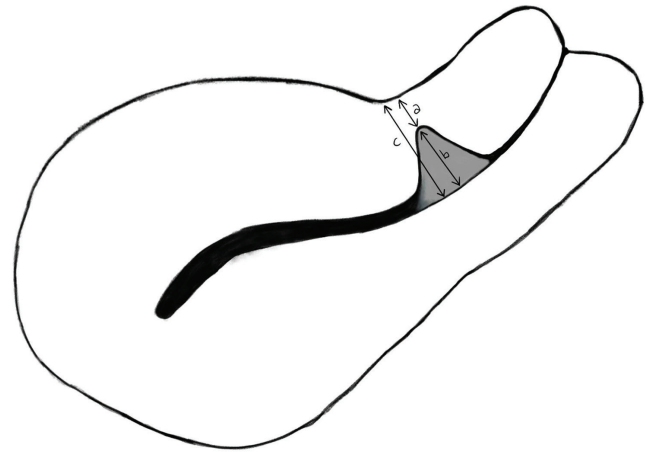


Figure 1. Schematic illustration of ultrasonographic measurements used for the assessment of cesarean scar healing. (a) Residual myometrial thickness, measured as the distance between the apex of the isthmocele and the serosal surface; (b) isthmocele depth; and (c) total myometrial thickness

6-hour complete blood count results, as well as history of postpartum hemorrhage and wound infection, were recorded.

Study groups and outcome measures

Women in the study were divided into two groups based on cervical dilation at cesarean section: One group with cervical dilation less than 4 cm and another with cervical dilation of 4 cm or more. The 4 cm threshold was chosen based on the traditional definition of active labor, as described in the National Institute for Health and Care Excellence Guideline and previous literature (11,12). Although contemporary labor management guidelines generally define active labor as beginning at approximately 6 cm cervical dilatation, the 4 cm cut-off was specified a priori during study design and retained to allow comparison with previous studies evaluating cesarean scar healing and isthmocele formation. The groups were compared for maternal characteristics, obstetric variables, and ultrasonographic findings. The primary outcome was the presence of isthmocele. Secondary outcomes included RMT, total myometrial thickness, isthmocele depth, uterine position, and the presence of symptoms associated with isthmocele.

Statistical Analysis

Research data were analyzed using the SPSS 23.0 Statistical Package (IBM Corp., Armonk, NY, USA). Categorical variables were presented as numbers and percentages, while continuous variables were presented as mean $\pm$ standard deviation or median (interquartile range), depending on their distribution. The normality of continuous variables was assessed

using visual methods (histograms and probability plots) and the Kolmogorov-Smirnov or Shapiro-Wilk tests. Independent samples t-tests were used to compare two independent groups with normal distributions, while the Mann-Whitney U test was used for variables without normal distributions. The Pearson chi-square test or, when appropriate, the Fisher's exact test was used to compare categorical variables. Univariate logistic regression analyses were first performed to identify factors associated with isthmocele development. Variables with $p < 0.25$ in univariate analyses and those considered clinically significant were included in the multivariate logistic regression model. Before multivariable logistic regression analysis, multicollinearity among independent variables was assessed using variance inflation factor (VIF) values. A VIF value > 5 was considered indicative of significant multicollinearity. Statistical significance was set at $p < 0.05$.

An a priori sample size calculation was performed using G*Power (version 3.1.9.7). Based on an effect size of 0.51, $\alpha = 0.05$, and 95% power, a minimum sample size of 166 participants was estimated for the original three-group design (0-4 cm, 5-8 cm, and 9-10 cm cervical dilatation). Due to the limited number of women with advanced cervical dilatation, the final analysis was conducted using two groups (< 4 cm and ≥ 4 cm), including 127 women.

Results

A total of 127 women who underwent primary cesarean section were included in the analysis, comprising 84 women with cervical dilatation < 4 cm and 43 women with cervical dilatation ≥ 4 cm at the time of cesarean delivery. Baseline demographic, obstetric, and clinical characteristics of the study population are presented in Table 1. Women with cervical dilatation ≥ 4 cm had a significantly greater gestational age at delivery than those with cervical dilatation < 4 cm (39.42 ± 1.18 vs. 38.59 ± 1.19 weeks, $p < 0.001$). Significant differences were also observed in the indications for cesarean section ($p = 0.002$) and the mode of cesarean delivery ($p < 0.001$). Arrest of labor and cephalopelvic disproportion were more common among women with cervical dilatation ≥ 4 cm, while malpresentation and other elective indications were more frequent in the < 4 cm group. As expected, emergency cesarean section, presence of uterine contractions, oxytocin augmentation, and combined dinoprostone plus oxytocin use were significantly more frequent among women with cervical dilatation ≥ 4 cm (all $p \leq 0.005$). No significant differences were observed between the groups in maternal age, body mass index, smoking during pregnancy, parity, comorbidity status, diabetes mellitus, membrane status, fetal presentation, neonatal birth weight, hemoglobin levels, or dinoprostone induction alone.

As shown in Table 2, women with cervical dilatation ≥ 4 cm at the time of primary cesarean section tended to have a higher

rate of isthmocele formation than those with cervical dilatation < 4 cm, although this difference did not reach statistical significance (46.5% vs. 28.6%, $p = 0.070$). RMT, total myometrial thickness, isthmocele depth, uterine length, and postpartum uterine position were similar between the groups. However, surgical site infection was significantly more frequent among women with cervical dilatation ≥ 4 cm (11.6% vs. 2.4%, $p = 0.044$). The frequency of symptomatic isthmocele was low and did not differ significantly between the groups (8.3% vs. 7.0%, $p > 0.999$).

Table 3 shows the results of a logistic regression analyzing the associations between isthmocele and potential risk factors. The univariate logistic regression analysis found that cervical dilatation and gestational age at cesarean section were significantly associated with isthmocele formation. Each 1 cm increase in cervical dilatation was associated with higher odds of isthmocele formation [odds ratio (OR): 1.20; 95% confidence interval (CI): 1.05-1.38; $p = 0.007$]. Similarly, later gestational age at delivery was associated with increased odds of isthmocele formation (OR: 1.36; 95% CI: 1.01-1.84; $p = 0.045$). However, in the multivariable logistic regression analysis, after adjusting for maternal body mass index, parity, presence of uterine contractions, and type of cesarean section, no variable was independently associated with isthmocele formation. Although the effect estimate for cervical dilatation remained elevated, it did not reach statistical significance in the multivariable model (adjusted OR: 1.19; 95% CI: 0.97-1.45; $p = 0.087$).

Discussion

This study evaluated whether cervical dilatation, an indicator of active labor, is associated with postpartum isthmocele formation after primary cesarean section. The prevalence of isthmocele was higher in women with cervical dilatation ≥ 4 cm compared to those with dilatation < 4 cm (46.5% vs. 28.6%). In univariate analysis, greater cervical dilatation was associated with higher odds of isthmocele formation. However, this association was not significant after adjusting for potential confounding factors. These findings suggest that cervical dilatation may reflect other intrapartum processes accompanying active labor rather than serving as an independent determinant of isthmocele formation.

Active labor is considered an important intrapartum factor that can affect cesarean scar healing. In a prospective cohort study by Antila-Längsjö et al. (6), each additional hour of active labor independently increased the risk of developing a cesarean scar defect, while cervical dilation and fetal head station were not identified as independent determinants. Similarly, Gupta et al. (13) reported that prolonged active labor is associated with isthmocele development. Additionally, various cohort studies have shown that cesarean sections performed during active labor are associated with the scar being located closer to the internal os or within the endocervical canal, as well as with lower RMT (14,15). These findings suggest that changes occurring

Table 1. Baseline obstetric and clinical characteristics by cervical dilatation at the time of primary cesarean delivery

Characteristic	<4 cm (n=84)	≥4 cm (n=43)	p
Maternal age (year), mean ± SD	27.85±6.00	27.70±5.89	0.895
Maternal BMI (kg/m ²), mean ± SD	29.35±5.20	30.45±5.10	0.258
Smoking during pregnancy, n (%)	17 (20.2)	5 (11.6)	0.334
Parity			0.400
Nulliparous	64 (76.2)	29 (67.4)	
Multiparous	20 (23.8)	14 (32.6)	
Gestational age at delivery (weeks), mean ± SD	38.59±1.19	39.42±1.18	<0.001
Comorbidity, n (%)	30 (35.7)	13 (30.2)	0.675
Diabetes mellitus, n (%)	8 (9.5)	7 (16.3)	0.409
Hemoglobin (g/dL)	10.16±1.30	10.22±1.05	0.801
Main indication for CS, n (%)			0.002
Fetal distress	28 (33.3)	17 (39.5)	
Arrest of labor	14 (16.7)	15 (34.9)	
CPD	3 (3.6)	6 (14.0)	
Malposition	17 (20.2)	3 (7.0)	
Fetal macrosomia	5 (6.0)	0 (0.0)	
Other indications	17 (20.2)	2 (4.7)	
Membrane status n (%)			0.309
Intact	72 (85.7)	33 (76.7)	
PROM	12 (14.3)	10 (23.3)	
CS type			<0.001
Elective	31 (36.9)	1 (2.3)	
Emergency	53 (63.1)	42 (97.7)	
Presence of contractions	32 (38.1)	43 (100)	N/A
Dinoprostone induction	22 (26.2)	14 (32.6)	0.585
Oxytocin augmentation	6 (7.1)	27 (62.8)	<0.001
Dinoprostone + oxytocin	4 (4.8)	10 (23.3)	0.005
Presentation n (%)			0.092
Cephalic	67 (79.8)	40 (93.0)	
Breech	17 (20.2)	3 (7.0)	
Birth weight (g), mean ± SD	3200.74±563.11	3366.16±425.47	0.093

Data are presented as mean ± standard deviation or n (%). Student's t-test, Pearson chi-square test, and Fisher's exact test were used as appropriate. BMI: Body mass index, CS: Cesarean section, CPD: Cephalopelvic disproportion, PROM: Premature rupture of membranes, SD: Standard deviation

during active labor may affect cesarean scar healing and contribute to isthmocele development. Although the duration of active labor was not evaluated in our study, the presence of uterine contractions in all women with cervical dilation ≥4 cm suggests that this group largely represents women in active labor.

Given the potential effects of active labor on cesarean scar healing, cervical dilation has frequently been used as an indicator to assess this relationship. However, findings regarding the independent role of cervical dilation in isthmocele development are inconsistent. Osser et al. (16) reported that the risk of developing a large cesarean scar defect increased significantly as cervical dilation during cesarean section increased. While a

recent prospective cohort study reported that cervical dilation greater than 4 cm was an independent risk factor for isthmocele development (17), many studies have shown that cervical dilation does not remain an independent predictor in multivariate analyses (6,18). In contrast, Antila-Längsjö et al. (6) did not find an increased risk in women with cervical dilation ≥5 cm. Similarly, Kamel et al. (19) reported that advanced cervical dilation was associated with a lower scar location and a reduced frequency of niche formation. These differences between studies may be due to heterogeneity in study populations, definitions of isthmocele, imaging methods, timing of evaluation, and surgical practices. In our study, cervical dilation was also found to be associated with isthmocele development in univariate analysis, but it could not

Table 2. Postpartum sonographic and clinical outcomes by cervical dilatation at the time of primary cesarean delivery

Characteristic	<4 cm (n=84)	≥4 cm (n=43)	p
Isthmocele presence, n (%)	24 (28.6)	20 (46.5)	0.070
Symptomatic isthmocele, n (%)	7 (8.3)	3 (7.0)	>0.999
Residual myometrial thickness (mm)	5.32±1.48	4.86±1.46	0.311
Myometrial thickness (mm)	8.70±2.78	7.67±2.92	0.057
Isthmocele depth (mm)	5.02±1.22	4.92±1.95	0.841
Uterine length (mm)	56.12±7.77	55.92±10.92	0.905
Postpartum uterine position n (%)			0.489
Anteverted	71 (84.5)	39 (90.7)	
Retroverted	13 (15.5)	4 (9.3)	
Surgical site infection, n (%)	2 (2.4)	5 (11.6)	0.044
Postpartum hemorrhage, n (%)	5 (6.0)	1 (2.3)	0.663

Data are presented as mean ± standard deviation or n (%). Student's t-test, Pearson chi-square test, and Fisher's exact test were used as appropriate.

Table 3. Univariate and multivariate logistic regression analyses of factors associated with isthmocele formation after primary cesarean delivery

	Univariate LR		Multivariate LR	
	OR (95% CI)	p-value	aOR (95% CI)	p-value
Cervical dilatation (continuous)	1.20 (1.05-1.38)	0.007	1.19 (0.97-1.45)	0.087
BMI	1.02 (0.95-1.09)	0.509	1.01 (0.94-1.09)	0.639
Gestational age	1.36 (1.01-1.84)	0.045	1.24 (0.89-1.73)	0.196
Parity				
Nulliparous	Ref		Ref	
Multiparous	1.47 (0.65-3.30)	0.351	1.15 (0.47-2.79)	0.747
Presence of contractions				
No	Ref		Ref	
Yes	2.11 (0.97-4.60)	0.059	1.46 (0.47-4.52)	0.512
CS type				
Elective	Ref		Ref	
Emergency	1.01 (0.43-2.36)	0.970	0.42 (0.14-1.25)	0.123

Outcome variable: Isthmocele presence (yes/no)
 Variables with p<0.25 in univariate analyses and clinically relevant covariates were entered into the multivariable logistic regression model. BMI: Body mass index, CS: Cesarean section, CI: Confidence interval, OR: Odds ratio, aOR: Adjusted odds ratio, LR: Logistic regression

be shown as an independent risk factor in multivariate analysis. This finding suggests that cervical dilation may be an indicator of other intrapartum factors accompanying active labor rather than a sole determinant.

In our study, gestational age at cesarean section was associated with isthmocele formation in the univariate analysis, but this association did not remain significant in the multivariate analysis. In the literature, most studies evaluating the relationship between gestational age and the development of cesarean scar defects have not found a significant association (4). Only two studies have reported a significant relationship between gestational age and cesarean scar healing (18,20). Our findings suggest that gestational age alone may not be an independent factor in determining cesarean scar healing and that the observed relationship may be influenced by other intrapartum factors related to labor. Another notable finding was

the increased rate of surgical site infection among women with cervical dilation of 4 cm or greater. Although some suggest that infection may negatively affect wound healing and contribute to the development of cesarean scar defects, findings in the literature regarding infection as an independent risk factor are inconsistent (3,4,6). In our study, the primary objective of the multivariable analysis was to identify baseline and intrapartum predictors of subsequent isthmocele formation. Accordingly, postoperative surgical site infection was not included in the regression model.

The main strengths of this study are the inclusion of only women who had a primary cesarean section and the use of the standard double-layer uterine closure technique in all cases. This approach reduced potential confounding effects from previous cesarean sections and varying surgical techniques. Additionally, all ultrasonographic evaluations were performed

12-24 months postpartum by a single experienced researcher using a standard protocol and were blinded to intraoperative data. The combined assessment of cervical dilation, labor characteristics, and cesarean scar findings enabled a more comprehensive examination of the relationship between labor and cesarean scar healing.

Study Limitations

However, the study has some limitations. Because of its retrospective and single-center design, establishing a causal relationship was not possible. Additionally, the final sample size (n=127) was lower than the a priori calculated requirement (n=166), which may have reduced the statistical power of the study and increased the risk of a type II error. Therefore, the absence of a statistically significant association between cervical dilatation and isthmocoele formation in the adjusted analysis should be interpreted with caution, as a true association may have gone undetected because of insufficient statistical power. Some important intrapartum factors known to influence cesarean scar healing could not be evaluated due to the retrospective study design. These factors included labor duration, uterine contraction characteristics, fetal head station, hysterotomy level, and operative duration. The absence of these variables may have limited the interpretation of the relationship between labor characteristics and isthmocoele formation. Consequently, the possibility of residual confounding should be considered, as unmeasured intrapartum factors may have influenced the observed associations. Finally, isthmocoele assessment was performed at a single time point, and only women who attended follow-up examinations were included in the analysis. A substantial proportion of eligible women could not be contacted for follow-up, which may have introduced selection bias and limited the representativeness of the study population. Therefore, the generalizability of these findings should be interpreted with caution. Further multicenter prospective studies with larger sample sizes are needed to validate our findings.

Conclusion

A higher prevalence of isthmocoele was observed among women with advanced cervical dilatation at the time of primary cesarean section. However, cervical dilatation was not independently associated with isthmocoele formation after adjustment for potential confounding factors. These findings suggest that changes during labor may affect cesarean scar healing, but the observed relationship may reflect the combined effect of multiple intrapartum factors rather than cervical dilatation alone. Prospective studies with larger sample sizes are needed to clarify this relationship further.

Ethics

Ethics Committee Approval: Approval for the evaluation and publication of the collected data was obtained from the University of Health Sciences Türkiye, Gülhane Training and Research Hospital Clinical Research Ethics Committee (approval number: 2024/15, dated: September 12, 2024).

Informed Consent: Written informed consent was obtained from all participants before the follow-up transvaginal ultrasonographic examination and study participation.

Acknowledgments

For transparency, the authors note that an artificial intelligence-assisted language model (ChatGPT, OpenAI) was utilized to support language correction. This assistance was limited to linguistic refinement; all scientific content, critical analysis, and final editorial decisions were made exclusively by the authors. The authors would like to thank Hatice Büşra Akduman, a medical student, for her assistance in preparing the schematic illustration included in this manuscript.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.T.A., P.K.T., A.F.T., Ö.Ö., Concept: A.T.A., P.K.T., A.F.T., Ö.Ö., Design: A.T.A., P.K.T., A.F.T., Ö.Ö., Data Collection or Processing: A.T.A., P.K.T., S.K., K.S., Analysis or Interpretation: A.T.A., Ö.Ö., Literature Search: A.T.A., A.F.T., Writing: A.T.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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