Research Article / *Araştırma Makalesi*

Ege Journal of Medicine / *Ege Tıp Dergisi* 2026; 65 (3): 527-537

A novel approach to optimizing post-cesarean scar healing: A comparative study of the Haliscelik technique versus conventional double-layer uterine closure

Sezaryen sonrası skar iyileşmesini optimize etmeye yönelik yeni bir yaklaşım: Halisçelik tekniği ile geleneksel çift katlı uterin kapatmanın karşılaştırmalı çalışması

Mesut Ali Halisçelik Mesut Bala

Department of Gynecological Oncology, Gazi Yasargil Training and Research Hospital, Diyarbakır-Türkiye

ABSTRACT

Aim: This study aims to compare the Halisçelik technique, a novel modified double-layer uterine closure method, with the conventional double-layer non-locking suture technique in terms of postoperative scar healing following primary cesarean section, and to evaluate their effects on the anatomical and functional integrity of the uterine incision site through clinical and radiological parameters.

Materials and Methods: This retrospective cohort study included 98 patients who underwent primary cesarean section between January 2023 and January 2025. Participants were divided into two groups based on the uterine closure technique: the Halisçelik technique (Group 1, n=49) and the conventional double-layer non-locking method (Group 2, n=49). Demographic data, perioperative outcomes, and postoperative scar characteristics were analyzed. Residual myometrial thickness (RMT) and isthmocele incidence were assessed via transvaginal ultrasonography 6 months after surgery. Linear regression and ROC analyses were conducted to identify predictors of RMT and isthmocele.

Results: Although baseline characteristics such as age, BMI, parity, gravidity, gestational age, and neonatal birth weight did not significantly differ between the groups ($p>0.05$), the Halisçelik technique resulted in a significantly shorter operative time (median: 24 min vs. 27 min; $p=0.001$). At 6-month follow-up, the residual myometrial thickness (RMT) was significantly greater in Group 1 (median: 10 mm, IQR: 2) compared to Group 2 (median: 8 mm, IQR: 2; $p<0.001$). Isthmocele incidence was also significantly lower in the Halisçelik group (1/49) than in the conventional group (8/49; $p=0.014$). In the multiple linear regression model, both the surgical technique ($B = -2.038$, $p<0.001$) and postoperative hemoglobin drop (ΔHb) ($B=-0.298$, $p=0.001$) were independently associated with RMT. Exploratory ROC analysis showed that ΔHb had an AUC of 0.807 (95% CI: 0.622–0.992; $p=0.002$), with a preliminary cut-off of 1.75 g/dL (sensitivity 67%, specificity 90%), while operation duration had an AUC of 0.710 (95% CI: 0.536–0.884; $p=0.039$), with a preliminary cut-off of 25.5 minutes (sensitivity 89%, specificity 65%).

Conclusions: The Halisçelik technique appears to improve postoperative uterine healing by reducing operative time, preserving myometrial thickness, and lowering isthmocele incidence. These findings suggest that the Halisçelik technique may serve as a promising alternative to conventional methods for optimizing cesarean scar outcomes. However, further prospective studies with larger samples are warranted to confirm these results.

Keywords: Cesarean section, uterine closure, isthmocele, residual myometrial thickness, Halisçelik technique, scar healing

Corresponding author: Mesut Ali Halisçelik
Department of Gynecological Oncology, Gazi Yasargil Training and Research Hospital, Diyarbakır-Türkiye
E-mail: mesuthaliscelik@hotmail.com
Application date: 29.04.2026 Accepted: 17.06.2026

ÖZ

Amaç: *Bu çalışmanın amacı, primer sezaryen sonrası postoperatif skar iyileşmesi açısından yeni modifiye çift katlı uterin kapatma yöntemi olan Halisçelik tekniğini, konvansiyonel çift katlı kilitsiz sütür tekniği ile karşılaştırmak ve uterin insizyon hattının anatomik ve fonksiyonel bütünlüğü üzerindeki etkilerini klinik ve radyolojik parametreler aracılığıyla değerlendirmektir.*

Gereç ve Yöntem: *Bu retrospektif kohort çalışmaya, Ocak 2023 ile Ocak 2025 tarihleri arasında primer sezaryen operasyonu geçiren 98 hasta dahil edildi. Hastalar uygulanan uterin kapatma tekniğine göre iki gruba ayrıldı: Halisçelik tekniği uygulanan grup Grup 1 (n=49), konvansiyonel çift katlı kilitsiz sütür tekniği uygulanan grup ise Grup 2 (n=49) olarak tanımlandı. Demografik veriler, perioperatif sonuçlar ve postoperatif skar özellikleri analiz edildi. Rezidüel miyometriyal kalınlık (RMT) ve istmosel insidansı, cerrahiden 6 ay sonra transvajinal ultrasonografi ile değerlendirildi. RMT ve istmosel gelişiminin belirleyicilerini saptamak amacıyla lineer regresyon ve ROC analizleri yapıldı.*

Bulgular: *Yaş, vücut kitle indeksi, parite, gravida, gestasyonel hafta ve yenidoğan doğum ağırlığı gibi başlangıç özellikleri açısından gruplar arasında istatistiksel olarak anlamlı fark saptanmadı (p>0.05). Halisçelik tekniği grubunda operasyon süresi anlamlı olarak daha kısa bulundu (medyan: 24 dk ve 27 dk; p=0.001). Altıncı ay takip değerlendirmesinde, rezidüel miyometriyal kalınlık Grup 1'de Grup 2'ye göre anlamlı olarak daha yüksekti [medyan: 10 mm, çeyrekler arası aralık (IQR): 2 ve medyan: 8 mm, IQR: 2; p=0.001]. İstmosel insidansı da Halisçelik grubunda konvansiyonel gruba kıyasla anlamlı olarak daha düşüktü (1/49 ve 8/49; p=0.014). Çoklu lineer regresyon analizinde cerrahi teknik (B=-2.038, p<0.001) ve postoperatif hemoglobin düşüşü (ΔHb) (B=-0.298, p=0.001), RMT ile bağımsız olarak ilişkili bulundu. ROC analizinde ΔHb için eğri altında kalan alan (AUC) 0.807 (%95 GA: 0.622–0.992; p=0.002) olarak saptandı ve optimal kesim değeri 1.75 g/dL idi (duyarlılık %67, özgüllük %90). Operasyon süresi için AUC değeri 0.710 (%95 GA: 0.536–0.884; p=0.039) olarak bulundu ve optimal kesim değeri 25.5 dakika idi (duyarlılık %89, özgüllük %65).*

Sonuç: *Halisçelik tekniği, operasyon süresini kısaltması, rezidüel miyometriyal kalınlığı koruması ve istmosel insidansını azaltması nedeniyle postoperatif uterin iyileşmeyi olumlu yönde etkiliyor görünmektedir. Bu bulgular, Halisçelik tekniğinin sezaryen skar sonuçlarını optimize etmek amacıyla konvansiyonel yöntemlere alternatif olabilecek umut verici bir yaklaşım olduğunu göstermektedir. Bununla birlikte, bu sonuçların doğrulanması için daha geniş örneklemli prospektif çalışmalara ihtiyaç vardır.*

Anahtar Sözcükler: *Sezaryen, uterin kapatma, istmosel, rezidüel miyometriyal kalınlık, Halisçelik tekniği, skar iyileşmesi.*

INTRODUCTION

Cesarean delivery has become an integral component of obstetric practice, with its global prevalence steadily increasing. Although the World Health Organization (WHO) states that cesarean section rates exceeding 10–15% do not confer additional benefits for maternal and neonatal health, many countries have significantly surpassed this threshold (1). The rising incidence of cesarean deliveries has brought attention to the associated risks of both short- and long-term complications. Among these, factors affecting the healing quality of the uterine incision site are of particular importance (2, 3).

Uterine scar healing is of paramount importance, particularly in preventing obstetric morbidities such as uterine rupture and placental abnormalities in future pregnancies. The healing process of the uterine incision site is directly influenced by the closure technique employed (4). Although the conventional double-layer uterine closure method has been widely used for many years, its effectiveness and potential disadvantages have recently come under scrutiny (5). In this context, the need for new techniques aimed at optimizing scar healing has emerged.

Recent studies have shown that healing at the uterine incision site depends not only on the surgical technique but also on factors such as suture material, type of suturing, contact with the endometrial cavity, and the level of hemostasis achieved (6). In this context, there is a growing need for modified methods that may positively influence the healing process. The primary goals of these techniques are to enhance the

histological integrity of scar tissue, ensure restoration of the myometrial layer, and ultimately reduce the risk of severe complications such as uterine rupture (7).

The aim of this study is to compare the Halisçelik technique with the conventional double-layer uterine closure method in terms of post-cesarean scar healing, and to evaluate their effects on the anatomical and functional integrity of the uterine incision site by analyzing both clinical and radiological outcomes.

MATERIALS and METHODS

This retrospective cohort study was designed to compare the postoperative outcomes of two different uterine closure techniques in patients who underwent primary cesarean section at our clinic between January 2023 and January 2025. The Halisçelik technique was not applied prospectively as an experimental intervention within the scope of this study; rather, it had been used as a surgeon-preferred modified double-layer uterine closure technique in routine clinical practice during the study period. Therefore, the present study retrospectively evaluated data from patients who had already undergone either the Halisçelik technique or the conventional double-layer non-locking closure technique. In this study, a retrospective analysis was conducted to compare a newly developed modified double-layer non-locking closure method (Halisçelik technique, Group 1, n=49) with the conventional double-layer non-locking suture technique (Group 2, n=49). The two groups were analyzed to determine whether there were statistically significant differences in postoperative residual myometrial thickness and isthmocele incidence.

The study protocol was approved by the Ethics Committee of the Diyarbakır Gazi Yaşargil Training and Research Hospital (Decision No: 410/03). Data were retrospectively collected from patient records and analyzed in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethics committee approval was obtained for the retrospective review and analysis of anonymized clinical, perioperative, and ultrasonographic data. All cesarean procedures were performed according to standard institutional surgical and postoperative care protocols. Patients were informed preoperatively about the surgical procedure and postoperative follow-up process, and written informed consent for surgery and the use of anonymized clinical data for scientific purposes was obtained in accordance with institutional policy.

Women aged between 18 and 45 years with a body mass index (BMI) ranging from 15.5 to 34.9 kg/m², singleton pregnancies, and who underwent primary cesarean section at term (≥37 weeks of gestation) were included in the study. Exclusion criteria included multiple pregnancies, history of uterine scarring or previous cesarean delivery, history of dilation and curettage (D&C), thrombophilia, prior uterine surgery such as myomectomy, presence of fibroids or congenital anomalies in the lower uterine segment, emergency cesarean indications, preterm birth (<37 weeks), active labor (cervical dilatation ≥4 cm), placenta previa or abruption, chorioamnionitis, the need for postoperative reoperation, malnutrition, or connective tissue disorders that could negatively impact wound healing. Additionally, patients who underwent uterine incisions other than the Kerr incision (e.g., inverted T or extended transverse incisions), preterm premature rupture of membranes (PPROM), or labor induction were excluded.

Indications for cesarean section were defined as cephalopelvic disproportion (CPD), fetal anomaly, fetal distress, and malpresentation. CPD was diagnosed according to the institutional obstetric protocol, which was based on the American College of Obstetricians and Gynecologists (ACOG) and Society for Maternal-Fetal Medicine (SMFM) recommendations regarding labor dystocia and the prevention of primary cesarean delivery (8, 9). The diagnosis was not based solely on cervical dilatation; rather, it was determined by the attending obstetrician according to clinical evidence of fetopelvic disproportion, including inadequate labor progress despite appropriate uterine activity, lack of fetal head descent, fetal size–pelvic capacity mismatch, pelvic assessment, and overall obstetric examination findings. Patients with active labor and cervical dilatation ≥4 cm were excluded to minimize the potential effect of advanced labor on lower uterine segment morphology and scar healing.

Demographic data (age, body mass index (BMI)), obstetric history (gravidity, parity), gestational age, neonatal birth weight, presence of comorbid systemic diseases, postoperative 6th-hour visual analog scale (VAS) pain score, presence of postoperative endometritis, length of hospital stay,

duration of surgery, type of uterine flexion, need for additional sutures, and preoperative and postoperative 6th-hour hemoglobin levels were recorded for each patient.

Patient selection was performed by retrospectively screening the institutional cesarean delivery records between January 2023 and January 2025. Patients were included if they met all predefined eligibility criteria and had complete perioperative and postoperative ultrasonographic follow-up data. The study groups were formed according to the uterine closure technique already used in routine clinical practice during the index cesarean delivery. No additional intervention or allocation was performed for the purpose of this study. Patients with missing key clinical data, unavailable postoperative ultrasonographic assessment, or exclusion criteria that could potentially affect uterine scar healing were not included in the final analysis.

Surgical Procedure

All cesarean sections were performed under spinal anesthesia with the patient in a mild left lateral decubitus position, following standard surgical protocols. All cesarean sections in both groups were performed by the same experienced obstetric surgeon to minimize inter-surgeon variability and ensure procedural consistency. Antisepsis was achieved using 10% povidone-iodine and a 3 cm transverse Pfannenstiel incision was made in the suprapubic region. During the dissection phase, the rectus fascia was incised transversely, the rectus muscles were bluntly separated, and the peritoneum was opened using a combination of sharp and blunt dissections. A Kerr incision was made in the lower uterine segment, and after fetal extraction, the uterine cavity was carefully cleaned with gauze, without traumatizing the tissue. According to the 2018 "Intraoperative Care Guidelines for Cesarean Delivery" issued by the Enhanced Recovery After Surgery Society (ERAS), closing the hysterotomy using a double-layer technique may reduce the risk of uterine rupture (10). In this study, a double-layer non-locking suture technique was used for uterine closure, and patients were assigned to two groups based on the closure method: Group 1 (n = 49) underwent the Halisçelik technique, while Group 2 (n = 49) underwent the conventional double-layer non-locking suture technique.

Haliscelik Technique (Group 1)

In the study group, the suturing technique known as the “Halisçelik Technique” was applied, which is a two-layer, non-locking, continuous, single-step method (Figure-1). The procedure began at point A1, located 1 cm from the inferior edge of the incision line, and involved full-thickness passage through the visceral peritoneum, perimetrium, myometrium, and endometrium. The needle exits at point B1, which is located just below the inferior edge. It was then reinserted at point C1, corresponding to the mid-depth of the myometrial layer, angled inferiorly at 45°, and exits at point D1, approximately 1 cm medial to the original entry site, while also incorporating the visceral peritoneum. Similarly, the needle was inserted at point A2, located 1 cm from the superior edge of the incision line, and passed through the same anatomical layers, exiting point B2. It was then reinserted at point C2, corresponding to the upper half of the myometrial layer, angled superiorly at 45°, and exited at point D2, 1 cm medial to the original entry point, completing the suture while including the visceral peritoneum. Both incision edges were carefully aligned in their anatomical positions with the assistance of a surgical assistant, ensuring that neither inversion nor eversion occurred, and effective hemostasis was achieved. The suture was continued in a non-locking manner, and the knot was tied at the corner of the incision (Figure-1).

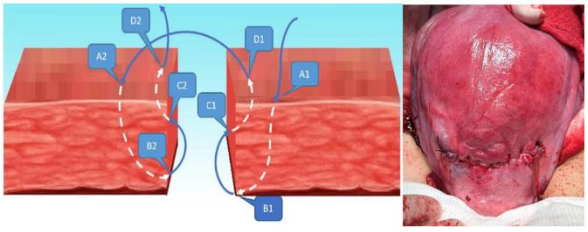

Figure-1. Schematic Representation of the “Halisçelik Technique” for Double-Layer Non-Locking Continuous Uterine Closure in Cesarean Section

Conventional Technique (Group 2)

In the control group, the uterine incision was closed using the classical double-layer continuous (non-locking) suture technique, encompassing all layers, including the endometrium and visceral peritoneum, after placing separate holding sutures at both corners. Additional hemostatic sutures were placed in both the groups to achieve hemostasis. In all cases, the parietal peritoneum was closed while preserving the anatomical integrity.

Operative and Postoperative Protocol

The duration of surgery was defined as the time from skin incision to closure based on anesthesia records. Uterine closure was performed for all cesarean procedures using synthetic absorbable No. 1 polyglactin sutures (Coated VICRYL® (polyglactin 910), Ethicon, NJ, USA).

A standardized postoperative protocol was applied to all patients, including intraoperative and postoperative intravenous infusion of 20 IU oxytocin, antibiotic prophylaxis with a first-generation cephalosporin (1–2 g IV), and analgesia with paracetamol (1 g IV every 8 h).

Ultrasonographic Evaluation

The diagnosis of isthmocele was based on the presence of a depression larger than 2 mm in the cesarean scar region, as detected by transvaginal ultrasonography (11). During follow-up examinations, transvaginal ultrasonography was performed using a high-frequency 5–6 MHz probe (SAMSUNG RS85, serial no: 1017929923). The uterine cavity with an empty bladder was evaluated during the follicular phase of the menstrual cycle (days 6–10). The presence of isthmocele, residual myometrial thickness (RMT), and the anatomical position of the uterus were assessed. Patients with suspected isthmocele or related symptoms were further evaluated using sonohysterography (SIS). As the maturation process of cesarean scar tissue requires at least six months (12), postoperative ultrasonographic evaluations performed routinely between 6 and 18 months were retrospectively reviewed from patient records (Figure-2). Residual myometrial thickness was measured at a right angle to the endometrial stripe at the level of the cesarean section scar. In cases where an isthmocele was detected, the measurement was taken as the shortest distance from the apex of the defect to the uterine serosal surface (Figure-2). Ultrasonographic assessments were performed by an operator who was not involved in the surgeries and was blinded to the uterine closure technique.

Although postoperative ultrasonographic evaluations were retrospectively available within a 6–18-month interval, the primary scar assessment was based on the first eligible standardized transvaginal ultrasonographic examination performed at or after 6 months, when cesarean scar maturation is expected to be more reliable. Follow-up time was reviewed for all included patients, and only examinations performed under standardized conditions during the follicular phase were considered for analysis.

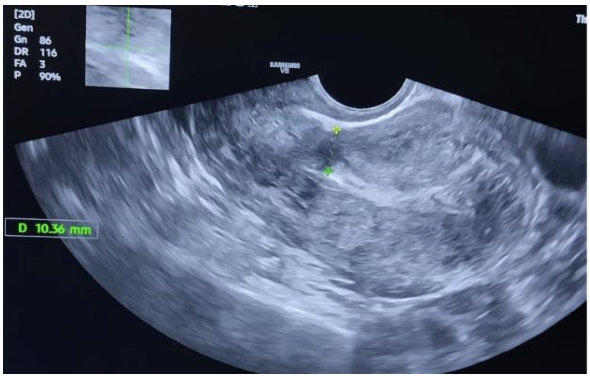

Figure-2. Transvaginal Ultrasonographic Assessment of the Uterine Scar and Residual Myometrial Thickness During the Follicular Phase (6–10 Days)

Statistical Analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS 24.0; SPSS Inc., Chicago, IL, USA). Data were expressed as mean ± standard deviation, median with interquartile range, or number and percentage, as appropriate. The distribution of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed variables were compared using Student's t-test, whereas non-normally distributed variables were analyzed using the Mann–Whitney U test. Categorical variables were compared using the chi-squared test. ROC analyses were performed to explore the discriminatory ability of ΔHb and operation duration for isthmocele formation; given the limited number of isthmocele cases, these analyses were considered exploratory. Multiple linear regression analysis was used to identify independent predictors of residual myometrial thickness, and model assumptions were evaluated using R^2, adjusted R^2, residual analysis, and multicollinearity diagnostics. Statistical significance was set at $p<0.05$.

RESULTS

In this study, 98 participants were divided into two groups: Group 1 (Halisçelik technique, n = 49) and Group 2 (standard double-layer non-locking suture technique, n = 49). The mean age of patients included in the study was 27.8 ± 5.5 years. When the baseline characteristics were compared between the groups, no statistically significant

differences were found in terms of mean age, body mass index, parity, gravidity, gestational age, comorbid conditions, indications for cesarean section, or neonatal birth weight (Table-1).

In the perioperative evaluation, no statistically significant differences were observed between the groups in terms of preoperative hemoglobin, postoperative hemoglobin, 6th-hour visual analog scale (VAS) scores, need for additional sutures, incidence of postoperative endometritis, or length of hospital stay (Table-2). Regarding the duration of surgery, the median time in Group 1 was 24 min (IQR: 3), while that in Group 2 was 27 min (IQR: 3). The standard double-layer non-locking technique significantly prolonged the operative time (Z: -4.496, p = 0.001).

At the 6-month postoperative evaluation, no significant difference was found between the groups in terms of uterine position (anteverted/retroverted) (p > 0.05). However, significant differences were observed in the residual myometrial thickness and isthmocele incidence. The median residual myometrial thickness in the Halisçelik technique group was 10 mm (IQR: 2 mm), which was significantly higher than that in the standard technique group (8 mm, IQR: 2 mm) (Z = -6.453, p < 0.001). Furthermore, in the assessment of isthmocele development, 1 patient in Group 1 and 8 patients in Group 2 were diagnosed with isthmocele, indicating a significantly higher incidence in the standard technique group (χ^2: 5.995, p = 0.014) (Table-3).

The area under the curve (AUC) was 0.807 for ΔHb and 0.710 for operation duration, indicating that both variables have predictive value, with ΔHb demonstrating a stronger discriminatory ability. The reference line (diagonal) represents the line of no discrimination. ΔHb achieved higher specificity, while operation duration showed higher sensitivity at their respective optimal cut-off values (Figure-3).

The area under the curve (AUC) for ΔHb was 0.807 (95% CI: 0.622–0.992, p = 0.002), indicating good discriminative ability. The optimal cut-off value for ΔHb was 1.75 g/dL, yielding a sensitivity of 67% and a specificity of 90%. For operation duration, the AUC was 0.710 (95% CI: 0.536–0.884, p = 0.039), with a cut-off value of 25.5 minutes, resulting in a sensitivity of 89% and a specificity of 65% (Table-4).

A linear regression analysis was conducted to identify predictors of residual myometrial thickness (RMT) measured at 6 months postoperatively. The surgical technique (Group) was a statistically significant predictor (B = -2.038, p < 0.001), indicating that patients who underwent the Halisçelik technique had significantly greater RMT compared to the conventional closure group. Additionally, hemoglobin drop (ΔHb) was negatively associated with RMT (B = -0.298, p = 0.001), suggesting that increased blood loss during surgery may adversely affect scar healing. Other variables, including BMI, age, preoperative hemoglobin level, and operation duration, were not significant predictors in this model (Table-5). The overall regression model was statistically significant [F(6,91) = 13.709, p < 0.001] and explained 47.5% of the variance in residual myometrial thickness (R^2 = 0.475, adjusted R^2 = 0.440). Multicollinearity diagnostics did not indicate a relevant collinearity problem among the independent variables, with VIF values ranging from 1.03 to 1.35.

Table-1. Comparison of Surgical Approaches According to Demographic and Clinical Characteristics

		Group 1 (n:49)	Group 2 (n:49)	t-Z-X^2	p
Age mean±sd		28.02±5.9	27.7±5.2	0.272	0.416
BMI mean±sd		27.86±1.936	27.9±1.96	-0.104	0.889
Parity median (IQR)		1 (1)	1 (1)	-0.298	0.766
Gravida median (IQR)		2 (1)	2 (1)	-0.184	0.854
Pregnancy week median (IQR)		40 (1)	39 (2)	-1.386	0.166
Additional disease	**Hypertension n (%)**	3 (3.1)	3 (3.1)	0.345	0.951
	Preeclampsia n (%)	1 (1)	2 (2)		
	DM n (%)	3 (3.1)	3 (3.1)		
	No n (%)	42 (42.9)	41 (41.8)		
	Fetal anomalies n (%)	3 (3.1)	3 (3.1)	0.000	1.00
	CPD n (%)	19 (19.4)	19 (19.4)		

Caesarean section indication	**Presentation anomalies n (%)**	16 (16.3)	16 (16.3)		
	Fetal distress n (%)	11 (11.2)	11 (11.2)		
Baby weight mean ± sd		3391±610	3445±636	-0.431	0.566

Group-1. Halisçelik technique; Group 2, double non-locking suture technique; SD, standard deviation; BMI: Body Mass Index, IQR, interquartile range; DM, diabetes mellitus; CPD, cephalopelvic disproportion; p<0.05 was considered statistically significant.

Table-2. Surgical Time, VAS, Hematocrit Values and Length of Hospitalization

		Group 1 (n:49)	**Group 2 (n:49)**	t-Z-X^2	p
Surgical Duration median (IQR)		24 (3)	27 (3)	-4.496	**0.001**
Preoperative Hgb mean ± sd		11.9±1.2	11.9±1.2	0.232	0.835
Postoperative Hgb median (IQR)		11.8 (1.9)	11 (2)	-1.386	0.166
Need for extra sutures	Yes n (%)	5 (5.1)	3 (3.1)	0.544	0.461
	No n (%)	44 (44.9)	46 (46.9)		
VAS 6th hour median (IQR)		4 (1)	4 (1)	0.0	1.00
Postoperative endometritis	Yes n (%)	3 (3.1)	3 (3.1)	0.0	1.00
	No n (%)	46 (46.9)	46 (46.9)		
Length of Stay median (IQR)		2 (0)	2 (0)	0	1.00

Group-1. Halisçelik technique; Group 2, double non-locking suture technique; SD, standard deviation; IQR, interquartile range; VAS, visual analog scale; p<0.05, considered statistically significant.

Table-3. Transvaginal ultrasound assessment and comparison at 6 months post-cesarean section

		Group 1 (n:49)	**Group 2 (n:49)**	X^2 / Z	p
Uterine shape	Antevert n (%)	39 (39.8)	38 (38.8)	0.061	0.806
	Retrovert n (%)	10 (10.2)	11 (11.2)		
Residual myometrium median (IQR)		10 (2)	8 (2)	-6.453	**<0.001**
Isthmocele	Yes n (%)	1 (1)	8 (8.2)	5.995	**0.014**
	No n (%)	48 (49)	41 (41.8)		

Group-1. Halisçelik technique; Group 2: double non-locking suture technique; IQR: interquartile range; p<0.05 was considered statistically significant.

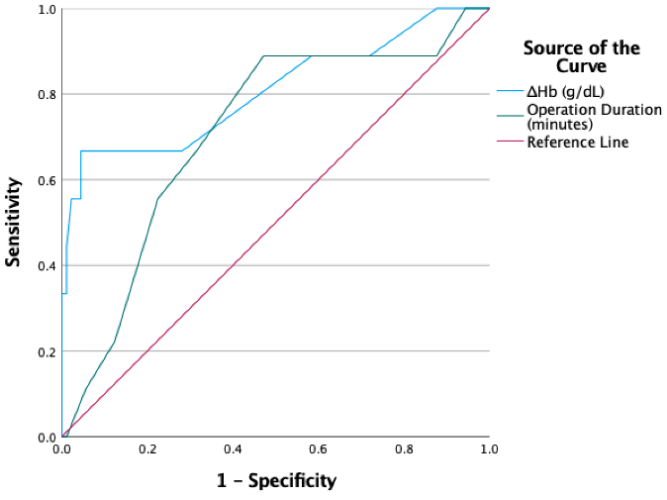

Figure-3. ROC Curves of ΔHb and Operation Duration for Predicting Isthmocele Formation

Table-4. ROC Curve Analysis of ΔHb and Operation Duration for Predicting Isthmocele Formation

	AUC	Sensitivity	Cut-off	Specificity	p value	Asymptotic 95% CI	
						Lower Bound	Upper Bound
ΔHb (g/dL)	0.807	67%	1.75	90%	**0.002**	0.622	0.992
Op. Duration	0.710	89%	25.5	65%	**0.039**	0.536	0.884

Table-5. Multiple Linear Regression Analysis for Predictors of Residual Myometrial Thickness at 6 Months Post-Cesarean

	Unst. Coeff.		St. Coeff.	t	p value	95% CI	
	B	St. Error	Beta			Lower Bound	Upper Bound
(Constant)	11.254	2.394		4.700	**<0.001**	6.498	16.010
Groups	-2.038	0.279	-0.631	-7.293	**<0.001**	-2.593	-1.483
BMI (kg/m²)	-0.021	0.064	-0.025	-0.319	0.750	-0.149	0.107
Age (years)	-0.002	0.023	-0.007	-0.089	0.929	-0.047	0.043
Preop Hb (g/	-0.015	0.106	-0.011	-.138	0.891	-0.224	0.195
ΔHb (g/dL)	-0.298	0.091	-0.266	-3.284	**0.001**	-0.478	-0.118
Op Duration	0.075	0.055	0.121	1.365	0.176	-0.034	0.184

DISCUSSION

In this study, significant differences were identified in certain postoperative parameters based on the surgical technique employed. The shorter operative time observed in cases managed with the Halisçelik technique suggests a potential improvement in surgical efficiency. Moreover, increased residual myometrial thickness and lower incidence of isthmocele in this group indicate that the newly developed technique may contribute positively to uterine scar healing. Regression analysis revealed that both the surgical technique and intraoperative hemoglobin loss were key determinants of scar quality. Furthermore, ROC curve analysis supported that hemoglobin drop and operation duration may serve as clinically relevant predictors for isthmocele development.

The global rise in cesarean delivery rates has raised concerns regarding both early and late complications, one of which is isthmocele—a uterine scar defect resulting from impaired hysterotomy healing (13-15) . Its pathogenesis is associated with mechanical stress in the lower uterine segment, leading to reduced perfusion and suboptimal tissue oxygenation, which impairs healing (10, 16). Proper closure technique plays a pivotal role in minimizing such complications (17).

To address these concerns, we compared the perioperative and postoperative outcomes of a novel technique—the Halisçelik technique—with the standard double-layer non-locking suture. No significant differences were observed between groups in terms of baseline clinical characteristics, such as age, BMI, parity, gestational age, comorbidities, and neonatal birth weight, ensuring the comparability of the two groups.

In the literature, BMI and diabetes are generally not considered major risk factors for isthmocele (16, 18, 19); however, some studies report associations with maternal obesity, gestational diabetes, multiple cesareans, active labor with cervical dilation >5 cm, and retroverted uterus (12, 14, 19-21). Despite conflicting findings on uterine position, most agree that it may contribute to defect formation (22).

Our study found no significant group differences in hemoglobin levels, pain scores, additional suturing, endometritis, or hospital stay. However, the Halisçelik technique was associated with significantly shorter operative time (24 vs. 27 min, p=0.001), supporting its efficiency (23). At 6-month ultrasound evaluation, although uterine position did not differ between groups, residual myometrial thickness (RMT) was significantly greater in the Halisçelik group (10 mm vs. 8 mm, p=0.001). This finding aligns with other modified techniques, such as parallel closure (24) and those reported by Kalem et al. (25), suggesting improved preservation of myometrial tissue.

Isthmoceles were significantly less frequent in Group 1 (1.0%) compared to Group 2 (8.2%, p=0.014), indicating the Halisçelik technique may reduce defect incidence. These findings contrast

with earlier studies (23), which evaluated isthmocele incidence as early as 6 weeks postpartum—before complete scar maturation (12). By assessing at 6 months, our study aimed for more accurate evaluation.

One of the strengths of our study was that all surgeries in both the study and control groups were performed by the same surgeon. This approach enhanced the reliability of the results by eliminating potential confounding factors related to technical variations among different surgeons. In addition, in accordance with the literature and considering the tissue healing process, transvaginal ultrasonography was performed six months postpartum in all patients, regardless of the presence of symptoms. For patients with symptoms or suspected isthmocele on imaging, further evaluation was conducted using sonohysterography (SIS) with informed consent, allowing for a more objective and definitive diagnosis based on stricter criteria.

However, this study has several limitations. The relatively small sample size in each group may limit the generalizability of the findings. In addition, patients with underlying etiological factors that could potentially contribute to uterine scar defects were excluded, which may have reduced clinical heterogeneity but also limits the applicability of the results to broader obstetric populations. Another important limitation is that subsequent pregnancy outcomes after the index cesarean delivery could not be evaluated, as these data were not available in the current retrospective dataset. Therefore, although the present study provides evidence regarding 6-month ultrasonographic scar healing parameters, residual myometrial thickness, and isthmocele formation, it does not allow conclusions to be drawn regarding long-term obstetric outcomes such as uterine dehiscence, uterine rupture, abnormal placentation, or delivery outcomes in subsequent pregnancies. Further prospective studies with larger cohorts and longer follow-up are warranted to assess the reproductive and obstetric safety of the Halisçelik technique. The ROC findings should be interpreted with caution because of the limited number of isthmocele cases. Accordingly, the cut-off values for ΔHb and operation duration should be regarded as preliminary and exploratory findings rather than definitive clinical thresholds. Larger prospective studies are needed to validate these results and determine their clinical applicability.

In this study, the Halisçelik technique was used to optimize tissue alignment while minimizing the risks of inversion and eversion and providing balanced hemostasis and tissue perfusion. This approach supported healing without creating excessive tension, and contributed to the prevention of both short- and long-term complications. It was found to be particularly more effective than standard techniques in preserving residual myometrial thickness and reducing the incidence of isthmocele. These findings highlight the critical role of the surgical technique in post-cesarean uterine repair and suggest that the Halisçelik technique may be advantageous in maintaining myometrial integrity and minimizing complications. However, large-scale, prospective studies with long-term follow-up are needed to more clearly assess the clinical validity of these results.

CONCLUSION

In conclusion, the Halisçelik technique was associated with shorter operative time, greater residual myometrial thickness, and a lower incidence of isthmocele compared with the conventional double-layer non-locking uterine closure technique after primary cesarean section. These findings suggest that this modified closure method may contribute to improved uterine scar healing by supporting better myometrial approximation and preserving scar integrity. Although the results are promising, they should be interpreted in light of the retrospective design and limited sample size. Further prospective, randomized, and large-scale studies with longer follow-up are required to confirm the clinical effectiveness and reproducibility of the Halisçelik technique.

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Diyarbakır Gazi Yaşargil Training and Research Hospital for the retrospective review of anonymized patient data (Decision No: 410/03). All procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent for the cesarean procedure, postoperative follow-up, and the use of anonymized clinical data for scientific purposes was obtained from all participants in accordance with institutional policy.

Consent for publication: Not applicable.

Availability of data and materials: The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request

Acknowledgement: Not applicable

Competing interests: The authors declare no conflict of interest.

Funding: This research received no funding.

References

1. Wladimiroff J, Tsiapakidou S, Mahmood T, Velebil P. Caesarean section rates across Europe and its impact on specialist training in Obstetrics: A qualitative review by the Standing Committee of Hospital Visiting Programme for Training Recognition of the European Board and College of the Obstetrics and Gynaecology (EBCOG). Eur J Obstet Gynecol Reprod Biol. 2025;304:77–83.
2. Kulshrestha V, Agarwal N, Kachhawa G. Post-caesarean Niche (Isthmocele) in Uterine Scar: An Update. J Obstet Gynaecol India. 2020;70(6):440–6.
3. Budny-Wińska J, Zimmer-Stelmach A, Pomorski M. Impact of selected risk factors on uterine healing after cesarean section in women with single-layer uterine closure: A prospective study using two- and three-dimensional transvaginal ultrasonography. Adv Clin Exp Med. 2022;31(1):41–8.
4. Shabnam K, Begum J, Singh S, Mohakud S. A prospective study on risk factors associated with the development of isthmocele after caesarean section. J Ultrasound. 2024;27(3):679–88.
5. Pecorella G, Licchelli M, Panese G, Morciano A, Sparic R, Kosmas I, et al. Laparoscopic repair of uterine rupture after delivery: A comprehensive evaluation of the uterine rupture management, with a proposal surgical method. Int J Gynaecol Obstet. 2025.
6. Başbuğ A, Doğan O, Ellibeş Kaya A, Pulatoğlu Ç, Çağlar M. Does Suture Material Affect Uterine Scar Healing After Cesarean Section? Results from a Randomized Controlled Trial. J Invest Surg. 2019;32(8):763–9.
7. Verberkt C, Stegwee SI, Van der Voet LF, Van Baal WM, Kapiteijn K, Geomini P, et al. Single-layer vs double-layer uterine closure during cesarean delivery: 3-year follow-up of a randomized controlled trial (2Close study). Am J Obstet Gynecol. 2024;231(3):346.e1–.e11.
8. Caughey AB, Cahill AG, Guise JM, Rouse DJ. Safe prevention of the primary cesarean delivery. Am J Obstet Gynecol. 2014;210(3):179–93.
9. First and Second Stage Labor Management: ACOG Clinical Practice Guideline No. 8. Obstet Gynecol. 2024;143(1):144–62.
10. Caughey AB, Wood SL, Macones GA, Wrench IJ, Huang J, Norman M, et al. Guidelines for intraoperative care in cesarean delivery: Enhanced Recovery After Surgery Society Recommendations (Part 2). Am J Obstet Gynecol. 2018;219(6):533–44.
11. Vervoort AJ, Uittenbogaard LB, Hehenkamp WJ, Brölmann HA, Mol BW, Huirne JA. Why do niches develop in Caesarean uterine scars? Hypotheses on the aetiology of niche development. Hum Reprod. 2015;30(12):2695–702.
12. Antila-Långsjö RM, Mäenpää JU, Huhtala HS, Tomás EI, Staff SM. Cesarean scar defect: a prospective study on risk factors. American journal of obstetrics and gynecology. 2018;219(5):458. e1–. e8.
13. Sung S, Mahdy H. Cesarean section. StatPearls [Internet]: StatPearls Publishing; 2023.
14. Ofili-Yebovi D, Ben-Nagi J, Sawyer E, Yazbek J, Lee C, Gonzalez J, et al. Deficient lower-segment Cesarean section scars: prevalence and risk factors. Ultrasound Obstet Gynecol. 2008;31(1):72–7.
15. Sholapurkar SL. Etiology of Cesarean Uterine Scar Defect (Niche): Detailed Critical Analysis of Hypotheses and Prevention Strategies and Peritoneal Closure Debate. J Clin Med Res. 2018;10(3):166–73.
16. Osser OV, Jokubkiene L, Valentin L. High prevalence of defects in Cesarean section scars at transvaginal ultrasound examination. Ultrasound Obstet Gynecol. 2009;34(1):90–7.
17. Hofmeyr JG, Novikova N, Mathai M, Shah A. Techniques for cesarean section. Am J Obstet Gynecol. 2009;201(5):431–44.
18. van der Voet LF, Bij de Vaate AM, Veersema S, Brölmann HA, Huirne JA. Long-term complications of caesarean section. The niche in the scar: a prospective cohort study on niche prevalence and its relation to abnormal uterine bleeding. Bjog. 2014;121(2):236–44.
19. Hayakawa H, Itakura A, Mitsui T, Okada M, Suzuki M, Tamakoshi K, et al. Methods for myometrium closure and other factors impacting effects on cesarean section scars of the uterine segment detected by the ultrasonography. Acta Obstet Gynecol Scand. 2006;85(4):429–34.
20. Wang CB, Chiu WW, Lee CY, Sun YL, Lin YH, Tseng CJ. Cesarean scar defect: correlation between Cesarean section number, defect size, clinical symptoms and uterine position. Ultrasound Obstet Gynecol. 2009;34(1):85–9.
21. Tower AM, Frishman GN. Cesarean scar defects: an underrecognized cause of abnormal uterine bleeding and other gynecologic complications. Journal of minimally invasive gynecology. 2013;20(5):562–72.

22. Park IY, Kim M, Lee H, Gen Y, Kim M. Risk factors for Korean women to develop an isthmocele after a cesarean section. BMC Pregnancy and Childbirth. 2018;18:1–9.
23. Turan C, Büyükbayrak EE, Yilmaz AO, Karsidag YK, Pirimoglu M. Purse-string double-layer closure: a novel technique for repairing the uterine incision during cesarean section. J Obstet Gynaecol Res. 2015;41(4):565–74.
24. Alper E, Aksakal E, Usta I, Urman B. The Novel Parallel Closure Technique Compared to Single-Layer Closure of the Uterus After Primary Cesarean Section Decreases the Incidence of Isthmocele Formation and Increases Residual Myometrial Thickness. Cureus. 2024;16(5).
25. Kalem Z, Kaya AE, Bakırarar B, Basbug A, Kalem MN. An Optimal Uterine Closure Technique for Better Scar Healing and Avoiding Isthmocele in Cesarean Section: A Randomized Controlled Study. J Invest Surg. 2021;34(2):148–56.