

Advances in Obstetrics and Gynecology Research

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Advances in Obstetrics and Gynecology Research

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Table of Contents

- 1 Research on the Mechanism of Bionic Physical Microenvironment Combined with Plant-derived Signaling Molecules in Remodeling the Female Reproductive Tract Microbiota**
Shujuan Lu, Yan Zhang
- 8 Evolution and Emerging Hotspots in Continuous Labor Support: A CiteSpace-based Bibliometric Study**
Qiaowen Li, Chunqi Hu, Yinmei Huang
- 18 The Effect of Transcutaneous Electrical Acupoint Stimulation on Uterine Contraction Pain Induced by Breastfeeding in Women Undergoing Vaginal Delivery: A Randomized Controlled Study**
Yaqiu Guo, Xin Wang, Luyao Yang, Qingling Ma, Yunting Pang, Yanan Liang
- 27 Clinical Effect of Modified Continuous Locking Suture for Wound Reconstruction After Cold Knife Conization of the Cervix**
Jingbo Yang, Qing Yang, Jia Yang, Lingling Tong, Xinhui Jing

Research on the Mechanism of Bionic Physical Microenvironment Combined with Plant-derived Signaling Molecules in Remodeling the Female Reproductive Tract Microbiota

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Abstract: *Objective:* To explore the remodeling effect of a bionic physical microenvironment combined with plant-derived signaling molecules on the female reproductive tract microbiota. *Methods:* A total of 63 patients with female reproductive tract inflammation admitted to our hospital from June 2021 to June 2024 were selected and divided into an experimental group (32 patients, treated with bionic physical microenvironment combined with plant-derived signaling molecules) and a control group (31 patients, treated with Western medicine). The therapeutic effects of the two groups were compared. *Results:* After treatment, the clinical effectiveness rate, clinical symptom score, and quality of life score in the experimental group were significantly higher than those in the control group, while the incidence of adverse reactions between the two groups showed no significant difference. *Conclusion:* The treatment of female reproductive tract inflammatory diseases using a bionic physical microenvironment combined with plant-derived signaling molecules is highly effective, effectively alleviates related symptoms, improves patients' future quality of life, and exhibits relatively high safety.

Keywords: Bionic physical microenvironment; Plant-derived signaling molecules; Female reproductive tract inflammation; Remodeling of female reproductive tract microbiota

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1. Introduction

Female reproductive tract inflammation is a common disease that affects women of different ages and has a high recurrence rate. The bionic physical microenvironment can deliver antibiotics to the posterior vaginal fornix through perfusion, improving drug concentration in the pelvic region and optimizing local anti-infective effects^[1,2]. This method can disrupt the blood-pelvic barrier, allowing antibiotics to directly target

the lesion area, thereby rapidly relieving disease symptoms and eliminating pelvic adhesions and pelvic effusion. The bionic physical microenvironment can physically stimulate pelvic tissues, improving blood supply to the lesion through thermal effects and clearing inflammatory mediators in the pelvic cavity, thus achieving pelvic tissue repair. It can effectively relax pelvic floor muscles, alleviating discomfort such as pelvic pain. Additionally, the bionic physical microenvironment can reduce inflammatory exudation and promote effective absorption of pelvic effusion. Plant-derived signaling molecules are therapeutic agents extracted from natural Chinese herbal medicines, primarily Fuke Qianjin Capsules, which have strong heat-clearing, detoxifying, blood-nourishing, and dampness-resolving effects. Therefore, 63 patients with female reproductive tract inflammation were selected to investigate the effects of a bionic physical microenvironment combined with plant-derived signaling molecules.

2. Materials and methods

2.1. General information

A total of 63 patients with female reproductive tract inflammation admitted to our hospital from June 2021 to June 2024 were selected and divided into an experimental group and a control group by lottery. Their relevant data are shown in **Table 1**.

Table 1. Clinical data of the two groups

Group	Mean age (years)	Mean disease duration (months)
Experimental group (n=32)	37.52 ± 2.96	8.95 ± 1.26
Control group (n=31)	37.48 ± 3.01	9.01 ± 1.17
<i>P</i> value	> 0.05	> 0.05

2.2. Methods

The control group was treated with Western medicine, selecting cefotaxime sodium at a dosage of 2g mixed into 100ml of physiological saline and administered via intravenous drip twice daily. Additionally, levofloxacin was administered orally at a dosage of 500 mg once daily for one week.

The experimental group received a bionic physical microenvironment + plant-derived signaling molecules: 200 mL of tinidazole and 300 mL of ofloxacin were heated to 30–40°C, and 4000U of chymotrypsin and 5mg of dexamethasone were added. Puncture was performed at McBurney's point, located one-third of the way along the line connecting the umbilicus and the anterior superior iliac spine on the lateral side, and a trocar was inserted. When a sense of loss was felt, the needle core was removed, and the aforementioned drug solution was quickly poured in. The entire course of treatment was seven days, consisting of three courses. After the perfusion therapy, the patient was asked to lie flat, and bionic physical microenvironment treatment was initiated. The multifunctional pelvic physiotherapy instrument was connected to the circuit, the power was turned on, and the instrument's status was checked before appropriately adjusting the treatment temperature. The patient's lower abdominal skin was thoroughly cleaned, electrodes were attached, and bandages were securely fastened with appropriate tightness adjustments. The patient's external genitalia were disinfected, and an electrode sheath was placed over the intracavitary electrode rod. A small amount of paraffin oil was applied to the outside of the sheath, and it was then placed in the posterior vaginal fornix. The confirmation key was pressed to start the physiotherapy

process. A warm sensation in the vagina and abdomen was considered appropriate, with each physiotherapy session lasting between 30 and 60 minutes, once daily, for a total of ten days per course, and two consecutive courses were administered. For the selection of plant-derived signaling molecules, Fuke Qianjin Capsules were used, with a dosage of two capsules three times daily for one week.

2.3. Evaluation criteria

The clinical effective rate (marked effectiveness refers to the absence of disease symptoms, normal results from blood tests and vaginal secretion examinations, and imaging examinations showing two-thirds absorption of pelvic effusion; effectiveness refers to the presence of mild symptoms, slightly abnormal results from blood tests and vaginal secretion examinations, and imaging examinations showing one-third absorption of pelvic effusion; ineffectiveness refers to the presence of severe symptoms, abnormal results from blood tests and vaginal secretion examinations, and almost no absorption of pelvic effusion), clinical symptom scores (a 4-grade scoring system based on clinical symptoms such as lower abdominal pain or lumbosacral pain and fatigue, with 0-3 points indicating mild symptoms and higher scores indicating severe symptoms), and laboratory indicators (CRP test values, ηb values, ESR test values, FBG test values, and other hemorheological-related indicators) were compared between the two groups.

2.4. Statistical methods

The data from the study were analyzed using SPSS 23.0 software. For measurement data mean $\pm$ standard deviation [SD], a t-test was used, while for count data (%), a chi-square (χ^2) test was employed. A significant difference was indicated when $P < 0.05$.

3. Results

3.1. Comparison results of clinical effective rate between the two groups

As shown in **Table 2**, the clinical effective rate in the experimental group was higher than that in the control group ($P < 0.05$).

Table 2. Comparison results of clinical effective rates between the two groups (n/%)

Group	Number of markedly effective cases	Number of effective cases	Number of ineffective cases	Total effective
Experimental group (n = 32)	21	9	2	30 (93.8)
Control group (n = 31)	15	8	8	23 (74.2)
χ^2 value				4.509
P value				0.033

3.2. Comparison results of clinical symptom scores between the two groups

As shown in **Table 3**, after treatment, the clinical symptom scores of patients in the experimental group were significantly lower than those in the control group, with statistical significance ($P < 0.05$).

Table 3. Comparison results of clinical symptom scores between the two groups (mean $\pm$ SD)

Group	Lower abdominal and lumbosacral pain		Fatigue		Abnormal vaginal discharge		Menstrual abdominal pain	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Experimental group (n=32)	2.28 $\pm$ 0.41	0.84 $\pm$ 0.12	2.17 $\pm$ 0.33	0.75 $\pm$ 0.13	2.25 $\pm$ 0.36	0.69 $\pm$ 0.08	2.08 $\pm$ 0.41	0.75 $\pm$ 0.11
Control group (n=31)	2.32 $\pm$ 0.36	1.59 $\pm$ 0.36	2.24 $\pm$ 0.31	1.36 $\pm$ 0.44	2.19 $\pm$ 0.38	1.02 $\pm$ 0.31	2.12 $\pm$ 0.43	1.29 $\pm$ 0.35
<i>t</i> value	0.411	11.165	0.867	7.513	0.644	5.826	0.378	8.316
<i>P</i> value	0.683	0.000	0.389	0.000	0.522	0.000	0.707	0.000

3.3. Comparison results of quality of life scores between the two groups

As shown in **Table 4**, after treatment, the quality of life scores in the experimental group were higher than those in the control group ($P < 0.05$).

Table 4. Comparison results of laboratory indicators between the two groups (mean $\pm$ SD)

Group	CRP (mg/L)		η b (mPa·s)		ESR (mm/h)		FBG (g/L)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Experimental group (n=32)	8.71 $\pm$ 1.59	5.11 $\pm$ 0.72	2.55 $\pm$ 0.42	1.60 $\pm$ 0.38	39.46 $\pm$ 3.74	18.26 $\pm$ 2.81	4.66 $\pm$ 0.59	3.10 $\pm$ 0.50
Control group (n=31)	8.75 $\pm$ 1.60	6.27 $\pm$ 0.83	2.57 $\pm$ 0.44	2.02 $\pm$ 0.43	39.51 $\pm$ 3.77	25.93 $\pm$ 2.94	4.69 $\pm$ 0.55	4.18 $\pm$ 0.51
<i>t</i> value	0.100	5.931	0.185	4.111	0.053	10.587	0.209	8.487
<i>P</i> value	0.921	0.000	0.854	0.000	0.958	0.000	0.835	0.000

3.4. Comparison results of the incidence of adverse reactions between the two groups

During the treatment process, neither group experienced severe intolerable adverse reactions, and there was no significant difference between the two groups ($P > 0.05$).

4. Discussion

The study revealed statistically significant differences between the bionic physical microenvironment combined with plant-derived signaling molecules and conventional Western medicine in terms of clinical efficacy, improvement of clinical symptoms, normalization of important laboratory indicators, and enhancement of quality of life in the treatment of female reproductive tract inflammation. In the experimental group, the overall clinical effectiveness rate after treatment was 93.8% (30 cases out of a total of 32 cases), while in the control group, it was 74.2% (23 cases out of a total of 31 cases). The chi-square value between the two groups was 4.509, with a *P*-value of 0.033. Regarding clinical symptom scores, there was a significant separation between the two groups after treatment. These data clearly indicate that the combined therapy has definite and extensive advantages in alleviating patients' suffering. The changes in experimental indicators also provide physiological evidence for the above effects. After treatment, the experimental indicators in the experimental group were better than those in the control group ($P < 0.001$). The significant improvement in these parameters not only reflects the potent inhibition of systemic and local inflammatory

responses but also indicates the restoration of pelvic and reproductive tract microcirculation. Additionally, no severe adverse reactions were recorded in either group during the treatment process, and no statistically significant difference in the incidence of adverse events was observed, suggesting that the safety of the combined therapy is comparable to that of conventional Western medicine. Based on all the collected data, the combined therapy exhibits characteristics of “high efficacy, strong improvement, and low risk”, providing a solid database for future research.

The remarkable efficacy observed in this study is fundamentally attributed to the multi-target, multi-level synergistic effects of the bionic physical microenvironment and plant-derived signaling molecules in altering the reproductive tract microbiota and restoring local homeostasis ^[3]. The therapeutic effect of the bionic physical microenvironment is first manifested in the disruption and reconstruction of pathological physical barriers. Percutaneous drug perfusion delivers a mixture of tinidazole, ofloxacin, chymotrypsin, and dexamethasone, preheated to 30-40°C, into the pelvic lesion area, effectively bypassing the blood-pelvic barrier. This targeted drug delivery method results in significantly higher drug concentrations in the pelvic region compared to conventional intravenous administration, facilitating the rapid elimination of pathogenic microorganisms and suppression of inflammatory cascades, achieving an efficient “first-round attack” ^[4]. Subsequently, multifunctional pelvic physiotherapy is employed, utilizing physical energy (such as thermal effects or specific frequencies of electromagnetic/vibrational stimulation) to intervene in tissue. The intracavitary electrode of the physiotherapy device is placed in the posterior vaginal fornix, while the abdominal electrode is positioned on the lower abdomen, creating an energy field environment that covers the lesion area. Thermal effects significantly dilate local blood vessels, optimizing blood supply to the lesion area, enhancing the delivery of oxygen and nutrients, and accelerating the clearance of metabolic waste and inflammatory mediators. This improvement in blood flow and substance exchange serves as the physical basis for the effective absorption of pelvic effusion and the resolution of tissue edema. Physical stimulation also adjusts the pelvic floor muscles and nerves, promoting the relaxation of spastic muscles and alleviating pelvic pain and a sensation of heaviness ^[5]. More importantly, this bionic, mild physical microenvironment can influence the activity and function of local immune cells, potentially promoting the secretion of anti-inflammatory cytokines and inhibiting the release of pro-inflammatory factors, creating a microenvironment conducive to tissue repair in terms of immunity ^[6]. The addition of the plant-derived signaling molecule, Fuke Qianjin Capsule, introduces precise “biochemical-level” interventions to this repair process. The various phytochemicals in Fuke Qianjin Capsule, which are natural signaling molecules, extend beyond simple antibacterial and anti-inflammatory effects. They can regulate the gut-vagina axis or directly influence the vaginal mucosal immune system, thereby affecting the differentiation and function of immune cells. These signaling molecules may act like prebiotics, selectively stimulating the growth and colonization of beneficial bacteria such as *Lactobacillus* ^[7]. They may also influence the expression of tight junction proteins in vaginal epithelial cells to improve mucosal barrier function, reducing the adhesion and invasion opportunities of pathogenic bacteria. Additionally, they can regulate local pH, compete with pathogenic bacteria, and even interfere with the expression of virulence factors and biofilm formation in pathogenic bacteria through quorum-sensing quenching. Thus, the bionic physical microenvironment creates an “external improved field” conducive to drug penetration, inflammation elimination, blood circulation, and tissue repair, while plant-derived signaling molecules exert effects from an “internal regulatory network” involving immune modulation, microbiota guidance, and barrier healing ^[8].

The combination of the two forms a complete intervention process from “physical clearance” to “chemical adjustment” and finally to “life reconstruction”, which is likely the fundamental reason for its superior efficacy compared to the antimicrobial drug control group alone. The remodeling effect of the combined therapy on the female reproductive tract microbiota is a crucial step in achieving long-term efficacy and reducing the risk of recurrence. It involves key aspects such as regulating microbiota structure, adjusting microbiota function, and modulating microbiota-host interactions. Conventional Western medicine antimicrobial therapy can rapidly kill sensitive pathogenic bacteria, but its broad-spectrum antibacterial properties often indiscriminately attack beneficial bacteria in the vagina, leading to dysbiosis and disrupting microecological balance. This is one of the reasons why the control group showed less improvement in some indicators compared to the experimental group, and in the long term, this treatment approach may even increase the risk of recurrence ^[9]. In contrast, the combined therapy demonstrates a more “intelligent” regulatory effect on the microbiota. The bionic physical microenvironment improves local blood circulation, oxygenation, and pH, creating favorable physicochemical conditions for the recovery and colonization of beneficial bacteria such as *Lactobacillus*. The plant-derived signaling molecule, Fuke Qianjin Capsule, contains numerous active ingredients such as flavonoids, polysaccharides, and alkaloids, which exhibit certain antibacterial and anti-biofilm activities. More importantly, they function like “prebiotics” and “quorum sensing regulators”, selectively stimulating the growth of beneficial bacteria without promoting or inhibiting the proliferation of conditional pathogens. Crucially, studies have shown that these plant signaling molecules can influence quorum sensing systems to interfere with the expression of virulence genes and biofilm formation in pathogenic bacteria, thereby weakening their pathogenicity without necessarily eradicating them. This approach facilitates the rapid formation of a healthy microbiota after the clearance of major pathogens, either by preserving or guiding the original microbiota.

5. Conclusion

In conclusion, the bionic physical microenvironment combined with plant-derived signaling molecules represents an effective and safe method for treating female reproductive tract inflammatory diseases. Its mechanism involves the combined effects of physical energy improving the local internal environment, targeted drugs directly exerting anti-inflammatory and antibacterial effects, and plant signals systematically regulating immunity and the microbiota. This combined therapy represents a paradigm shift from “antimicrobial to probiotic (promoting beneficial bacteria)” and from “anti-inflammatory to restoring homeostasis”, providing new insights for clinical practice. Subsequent research should focus on increasing the sample size for validation, extending the follow-up observation period, exploring more details of the microbiome-host interactions, and refining treatment parameters to promote the more precise and widespread application of this combined strategy.

Disclosure statement

The authors declare no conflict of interest.

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Evolution and Emerging Hotspots in Continuous Labor Support: A CiteSpace-based Bibliometric Study

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Abstract: *Background:* Continuous labor support (CLS)—provided by midwives, doulas, or birth companions—is universally recognized as a core component of high-quality intrapartum care. Despite growing clinical evidence, a macroscopic and quantitative evaluation of the global research landscape, collaborative networks, and thematic evolution in CLS remains lacking. *Objective:* This study aimed to conduct a comprehensive bibliometric and visual analysis of global CLS research from 2005 to 2025 to map its intellectual structure, developmental trajectories, and emerging hotspots. *Methods:* Publications related to CLS between 2005 and 2025 were retrieved from the Web of Science Core Collection (WoSCC). CiteSpace was utilized to perform network visualizations, including annual publication trends, co-authorship (authors and countries/regions), keyword co-occurrence, cluster analysis, and timeline evolution. *Results:* Annual publication volume exhibited a steady upward trend, peaking at 106 articles in 2025. China and the USA were the predominant country contributors, while authors such as Meghan A. Bohren and Declan Devane occupied core positions in the author network. However, low network densities among authors (0.0042) and countries (0.0313) reflected relatively dispersed international collaboration. Keyword cluster analysis identified 10 major thematic clusters (Modularity $Q = 0.8757$, Mean Silhouette $S = 0.8515$), with “#0 doula” being the largest cluster. High-frequency keywords (childbirth, women, labor, care) highlighted a strong focus on woman-centered intrapartum management. The timeline visualization revealed a clear paradigm shift: moving from foundational randomized clinical trials and psychological support (2005–2018) toward data-driven intelligent monitoring, artificial intelligence, and predictive modeling (2019–2025). *Conclusion:* Global research on continuous labor support has expanded rapidly over the past two decades. The research paradigm is evolving from traditional continuous companionship toward integrating smart healthcare and AI-assisted predictive decision-making into woman-centered intrapartum care. Strengthening international interdisciplinary collaboration and advancing intelligent intrapartum monitoring represent crucial directions for future research.

Keywords: Continuous labor support; Bibliometric analysis; Intrapartum care

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1. Introduction

Continuous labor support (CLS)—typically provided by midwives, doulas, partners, or family members—is universally recognized as a fundamental component of high-quality intrapartum care ^[1]. Over the past decade, accumulating clinical evidence has demonstrated that continuous emotional, informational, and physical support during childbirth yields substantial maternal and neonatal benefits ^[2]. Specifically, women receiving CLS are more likely to experience spontaneous vaginal births, shorter labor durations, and positive birth experiences, while presenting a reduced need for intrapartum analgesia and lower rates of cesarean sections ^[1, 3]. Recognizing these profound impacts, global health authorities have actively advocated for the integration of continuous labor companionship into routine maternity care to ensure respectful and patient-centered childbirth environments ^[4].

Despite the robust evidence and clinical guidelines supporting CLS, its practical implementation remains inconsistent across varying socio-cultural and healthcare contexts ^[3, 4]. In recent years, scholars have extensively investigated multiple dimensions of labor support, ranging from the comparative efficacy of different caregiver models (e.g., doula versus family care) to the mitigation of maternal psychological distress during public health crises such as the COVID-19 pandemic ^[2, 9]. Consequently, an overwhelming volume of literature has emerged in this domain. However, existing reviews and meta-analyses primarily focus on specific clinical outcomes or qualitative syntheses of maternal experiences ^[1, 3]. There remains a critical lack of macroscopic and systematic evaluation regarding the global research landscape, evolutionary trajectories, and emerging frontiers within the CLS field.

Bibliometric analysis serves as a robust quantitative methodology for deciphering the structural dynamics and thematic evolution of a specific academic discipline over time ^[5]. Compared to traditional systematic reviews, bibliometrics—coupled with advanced visualization software such as CiteSpace—enables researchers to visually map complex collaboration networks among countries, institutions, and authors ^[6, 7]. Furthermore, it facilitates the identification of critical knowledge hubs, foundational references, and potential future hotspots through keyword co-occurrence and burst detection ^[8]. Recently, CiteSpace-based bibliometrics has been widely and successfully applied in various medical and obstetrical sub-fields, providing researchers with clear developmental trajectories and evidence-based insights for future investigations ^[8, 10].

Therefore, to address the current knowledge gap, this study aims to conduct a comprehensive bibliometric and visual analysis of the literature related to continuous labor support published between 2005 and 2025, based on the Web of Science Core Collection (WoSCC). By systematically mapping annual publication trends, collaboration networks, and key thematic clusters using CiteSpace, this research intends to elucidate the intellectual structure and trace the developmental milestones of CLS. Ultimately, the findings of this study will provide researchers, clinicians, and healthcare policymakers with a panoramic visualization of the current research status and emerging hotspots, thereby guiding future investigations and optimizing evidence-based intrapartum care practices.

2. Method

2.1. Data source

The literature data for this bibliometric study were obtained from the Web of Science Core Collection database. A comprehensive search was conducted using the following topic search strategy: TS = (“continuous

labor support” OR “continuous labor support” OR “continuous support during labor” OR “continuous support during labor”). The search period was set from January 1, 2005, to December 31, 2025, and only articles published in English were included. The literature search was conducted on March 1, 2026. Two researchers independently screened all retrieved records based on predefined inclusion and exclusion criteria. Studies directly related to continuous labor support during childbirth were included, whereas irrelevant articles, duplicate records, conference abstracts, and non-research publications were excluded. Any discrepancies between the reviewers were resolved through discussion or consultation with a third researcher. Finally, the eligible publications were exported for subsequent bibliometric analysis.

2.2. Research methods

The retrieved records were exported from the Web of Science Core Collection in plain text format with full records and cited references and subsequently imported into CiteSpace (version 6.4.R1) for bibliometric visualization and knowledge mapping. This bibliometric investigation systematically analyzed annual publication trends, collaboration networks among authors and countries/regions, as well as keyword co-occurrence, clustering, and evolutionary trends. For the collaboration analysis, the time span was set from 2005 to 2025 with a one-year time slice, selecting “Author” and “Country” as node types. The selection criterion was set to Top N = 50 per slice, while other parameters remained at default settings. For the keyword analysis, “Keyword” was selected as the node type with a one-year time slice, extracting the top 50 high-frequency keywords per slice. Keyword co-occurrence analysis was performed to identify major research themes, followed by keyword clustering analysis to reveal the knowledge structure of the field. The reliability and consistency of the clustering results were evaluated using the Modularity Q value and Mean Silhouette value. Furthermore, keyword timeline views were generated to illustrate the temporal evolution and dynamic trends of research topics. To enhance network readability and eliminate redundant connections, the “Pathfinder” and “Pruning sliced networks” algorithms were applied. All remaining parameters were kept at the default.

3. Result

3.1. Annual publication numbers and trends over the past decade

As shown in **Figure 1**, the annual number of publications generally exhibited an upward trend, despite minor fluctuations, from 2005 to 2025. In the early period (2005–2011), publication output remained relatively low and stable, fluctuating between 10 and 15 articles per year. The output experienced a slight increase starting in 2012, maintaining a plateau of around 20 publications per year through 2016. From 2017 onward, a more pronounced growth pattern emerged. After rising to 29 in 2017 and remaining stable around 31 through 2019, the volume surged significantly in subsequent years. Although slight dips occurred in 2021 (38) and 2023 (49), the overall momentum remained strongly positive, ultimately peaking at 106 publications in 2025. These results indicate that research in this field has expanded steadily, with scholarly interest accelerating rapidly over the past decade.

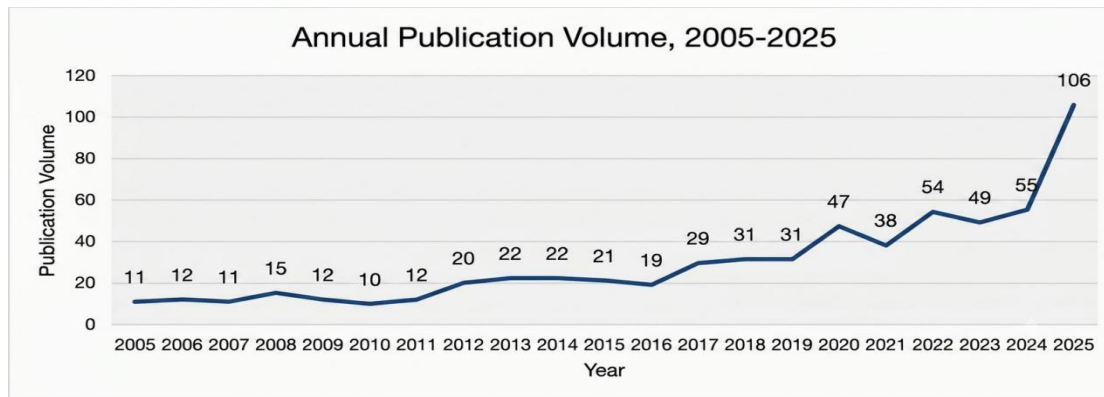


Figure 1. Annual number of publications on continuous labor support from 2005 to 2025.

3.2. Analysis of author collaboration network

Figure 2 presents the author co-occurrence network generated by CiteSpace. The resulting network comprised 647 nodes and 875 links, with a density of 0.0042, reflecting a relatively low density and a dispersed overall structure. Among the visible authors, Bohren, Meghan A, Devane, Declan, Brocklehurst, Peter, and Cuthbert, Anna emerged as the most prominent nodes, indicating their substantial contribution and central role in this research area. Other key active contributors included Crowther, Caroline A, Hofmeyr, G Justus, Tuncalp, Ozge, and Caughey, Aaron B. Although several localized, small-scale collaborative clusters have formed, the low network density (0.0042) suggests that inter-team collaborations and cross-regional academic exchanges remain modest. Broadening collaborative networks across different institutions and research group partnerships will be essential for further pushing this field forward.

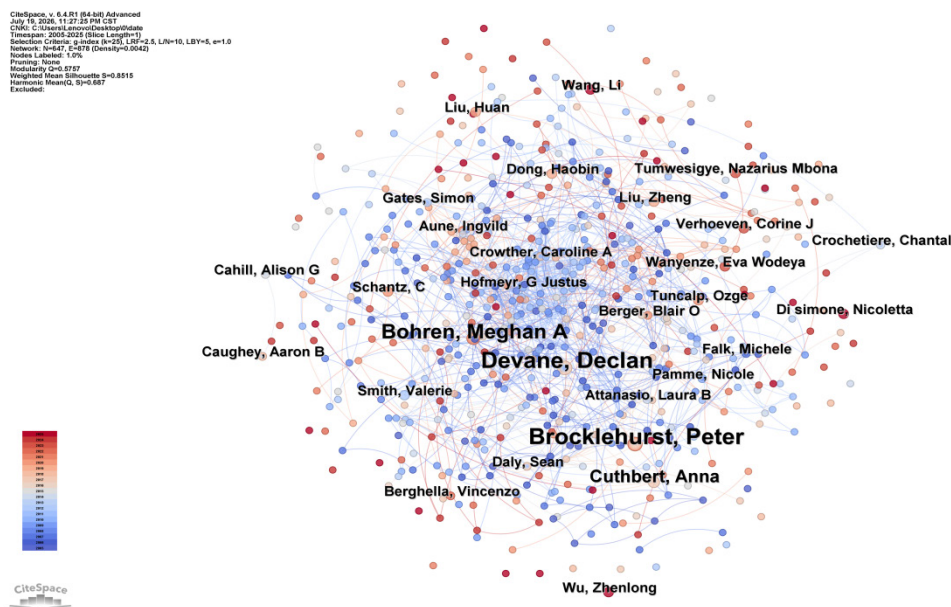


Figure 2. Author collaboration network in continuous labor support research.

3.3. Country/Region co-occurrence analysis

Figure 3 displays the country/region co-occurrence network generated by CiteSpace. The network consists

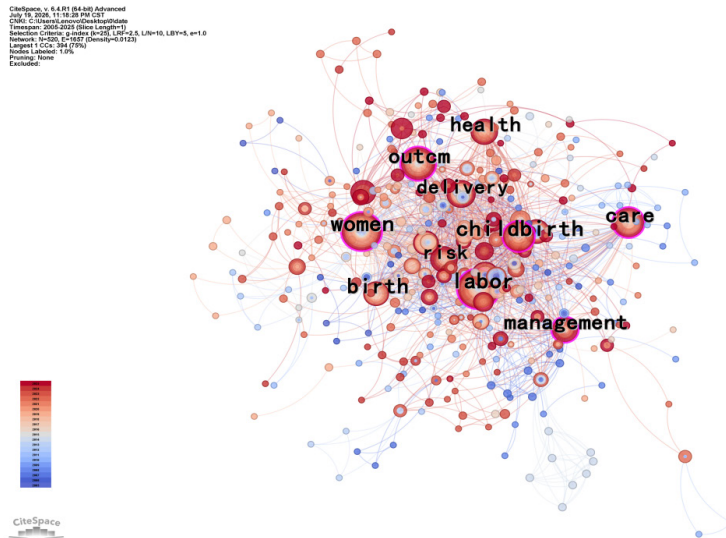


Figure 4. Keyword co-occurrence network in continuous labor support research.

3.5. Keyword clustering analysis

Figure 5 demonstrates the keyword cluster analysis generated by CiteSpace. A total of 10 major clusters were identified, including #0 doula, #1 labor, #2 artificial intelligence, #3 second-stage pushing, #4 asphyxia, #5 randomized controlled trial, #6 postpartum hemorrhage, #7 predictive modeling, #8 bg-sentinel, and #9 epidural analgesia. The network yielded a modularity Q value of 0.8757 (well above 0.3) and a weighted mean silhouette S value of 0.8515 (exceeding 0.7), confirming a robust modular structure and high clustering credibility. Among these, #0 doula emerged as the largest cluster, directly reinforcing the central theme of continuous labor support provided by professional birth companions or nurses. Overall, these clusters map out the multi-dimensional focus of current research, spanning non-pharmacological labor support (doula, second-stage pushing), maternal-neonatal safety and clinical outcomes (asphyxia, postpartum hemorrhage), methodological rigor (randomized controlled trial), and emerging intelligent technologies (artificial intelligence, predictive modeling).

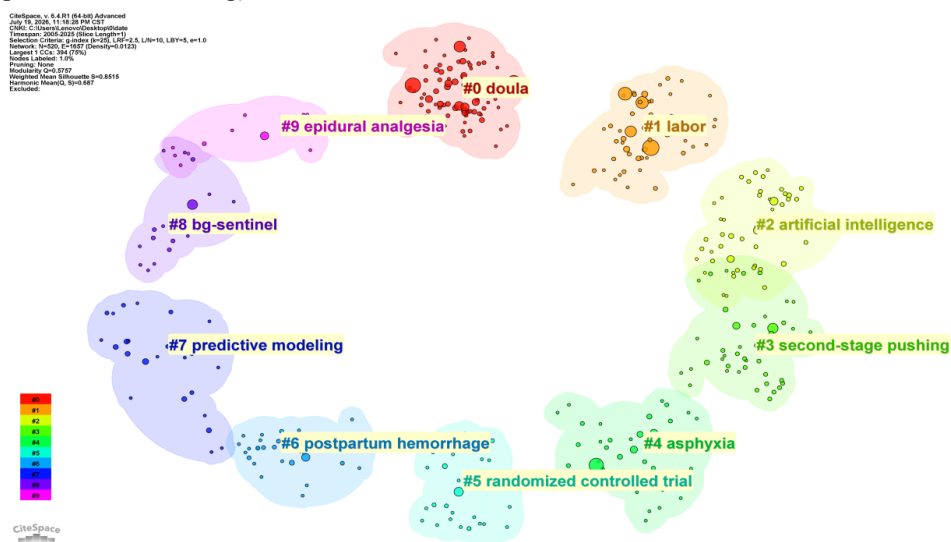


Figure 5. Keyword clustering network in continuous labor support research.

3.6. Timeline visualization and evolutionary trends of keywords

Figure 6 illustrates the timeline view of keyword co-occurrence clusters from 2005 to 2025, mapping the temporal evolution and research trajectories in continuous labor support. The 10 major clusters are arranged vertically according to their size, with horizontal axes depicting the developmental course of each research topic over time. In the early phase (2005–2010), foundational topics such as #0 doula, #1 labor, and #5 randomized controlled trial emerged with high-frequency nodes including childbirth, labor support, emotional support, continuous support, and women. This indicates that early research primarily established the clinical efficacy and psychological benefits of continuous labor support through clinical trials. Over the middle period (2011–2018), research expanded toward broad health management and maternal experiences, highlighted by emerging nodes like social support, anxiety, depression, experience, and maternity care across clusters #0 and #1. In recent years (2019–2025), a distinct dynamic shift toward digital healthcare and intelligent decision-making has taken shape. Clusters #2 artificial intelligence and #7 predictive modeling show high active density in recent time slices, with prominent nodes such as machine learning, classification, diagnosis, and strategy. Concurrently, persistent clinical focus remains evident in maternal and neonatal safety topics (#3 second-stage pushing and #6 postpartum hemorrhage). Overall, the timeline view reveals a paradigm evolution from foundational continuous care and psychological support toward data-driven intelligent monitoring and refined labor management.

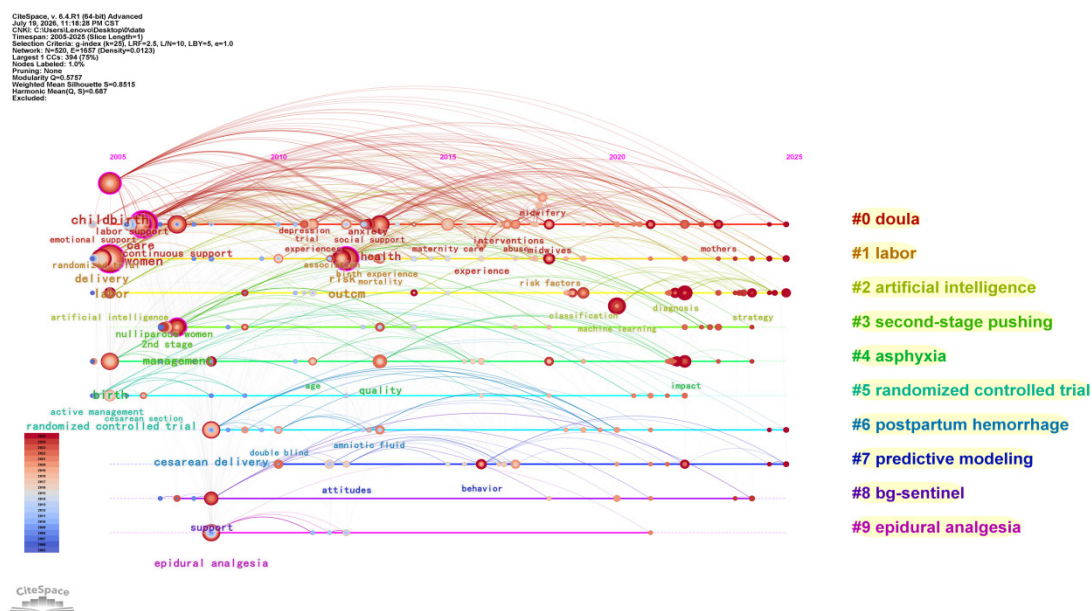


Figure 6. Keyword timeline visualization and thematic trajectories in continuous labor support research.

4. Discussion

This bibliometric analysis provides a comprehensive and macroscopic overview of the research landscape concerning continuous labor support (CLS) over the past two decades. Our findings reveal a steady and significant upward trajectory in publication volume, peaking notably in recent years, which underscores a growing global consensus on the indispensability of non-pharmacological intrapartum support ^[11]. The country collaboration network indicates that while the USA and China dominate the publication output and

act as core knowledge hubs, the overall network density remains relatively low (0.0313). This structural dispersion highlights a critical gap in cross-regional academic exchanges ^[12]. Given the varying socio-cultural contexts, healthcare resources, and midwifery policies worldwide, isolated regional research may limit the global standardization of CLS practices. Therefore, establishing robust, multi-center international partnerships is imperative to develop culturally adaptable and universally applicable labor companionship guidelines ^[13].

The keyword co-occurrence and clustering analyses further confirm that the core paradigm of this domain firmly revolves around woman-centered care, with “doula”, “labor”, and “randomized controlled trial” forming the foundational clusters. The prominence of terms such as childbirth, women, and care reflects a widespread academic transition from purely medicalized birthing models to holistic, humanized maternity care ^[14]. Specifically, the emergence of the largest cluster (#0 doula) reinforces the clinical significance of continuous physical and emotional support provided by dedicated companions, which has been shown to significantly enhance positive birth experiences and mitigate intrapartum anxiety ^[15]. Furthermore, the sustained focus on specific clinical topics, such as “second-stage pushing” and “postpartum hemorrhage”, indicates that current researchers are not only evaluating subjective maternal satisfaction but are also rigorously investigating how continuous companionship directly optimizes critical obstetric outcomes and maternal-neonatal safety ^[16].

Notably, the timeline visualization uncovers a transformative evolutionary trajectory in CLS research, transitioning from foundational psychological support toward data-driven, intelligent labor management. Over the past five years, emerging clusters such as #2 artificial intelligence and #7 predictive modeling have shown remarkable activity and high density. This paradigm shift strictly aligns with the rapid integration of digital healthcare and machine learning algorithms in modern obstetrics ^[17]. Advanced predictive models are increasingly being utilized alongside continuous labor support to dynamically assess intrapartum risks, such as fetal asphyxia or severe bleeding, thereby facilitating precise and timely clinical interventions ^[18]. By combining the empathetic, human-centric nature of traditional doula care with cutting-edge intelligent monitoring strategies, future intrapartum care can achieve an unprecedented balance between maternal comfort, personalized support, and clinical safety ^[19].

Despite providing robust visual insights into the CLS field, this study has several inherent limitations. First, literature retrieval was strictly restricted to the Web of Science Core Collection (WoSCC) database; thus, relevant publications in other databases (e.g., PubMed, Scopus) or in non-English languages may have been omitted, potentially introducing language and selection biases. Second, the reliance on quantitative bibliometric algorithms means that the nuanced qualitative findings of individual clinical trials might be underrepresented. Future research should integrate systematic qualitative reviews with quantitative bibliometrics to provide a deeper understanding of specific CLS implementation models. Ultimately, our study maps the multidimensional evolution of continuous labor support, highlighting its transition toward intelligent, technology-assisted intrapartum management. Strengthening international multidisciplinary collaboration and embracing AI-driven predictive technologies will be the crucial next steps in optimizing woman-centered childbirth care ^[20].

5. Conclusion

Over the past two decades, global research on continuous labor support has witnessed sustained

rapid growth, with China and the United States standing as the core contributors to relevant publications. Nevertheless, the low density of author and national collaboration networks reveals fragmented academic communication across regions and research teams. This bibliometric mapping confirms that woman-centered care constitutes the persistent core logic of this field, with doula companionship, clinical obstetric safety indicators, and randomized controlled trials forming the foundational research framework. The temporal evolution of research themes manifests an obvious paradigm shift: early studies focused on verifying the clinical value and psychological benefits of traditional continuous labor support, while recent research has gradually integrated artificial intelligence, predictive modeling, and intelligent monitoring technologies into intrapartum service systems. To further advance the development of continuous labor support worldwide, future scholars ought to break cross-national and interdisciplinary communication barriers to build stable international cooperative research platforms. Meanwhile, more empirical studies are required to explore the synergistic application of humanized continuous companionship and intelligent obstetric technology, so as to deliver safer, more personalized and high-quality childbirth care for women globally.

Disclosure statement

The authors declare no conflict of interest.

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The Effect of Transcutaneous Electrical Acupoint Stimulation on Uterine Contraction Pain Induced by Breastfeeding in Women Undergoing Vaginal Delivery: A Randomized Controlled Study

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Abstract: *Background:* Postpartum uterine contraction pain (afterpains) is common after vaginal delivery and often worsens during breastfeeding, which may adversely affect rest, mood, and breastfeeding experience. Safe and breastfeeding-friendly nonpharmacological analgesic options are needed. This study evaluated the analgesic effect of transcutaneous electrical acupoint stimulation (TEAS) on breastfeeding-evoked uterine contraction pain after vaginal delivery. *Patients and Methods:* In this parallel-group clinical trial, women after vaginal delivery were assigned to a TEAS group (T, n = 92) or a control group (C, n = 97). Pain intensity was assessed using a 0–100 mm numerical rating scale (NRS) at the first breastfeeding session within 24 hours postpartum (pre-feeding baseline, and 5 and 10 minutes after latch). Secondary outcomes included the number of days with breastfeeding-related pain > 40 mm (NRS > 40), 24-hour postpartum blood loss, analgesia satisfaction (1–5), and adverse events. Between-group comparisons were performed using non-parametric tests for continuous variables and Fisher's exact test for categorical variables. *Results:* Baseline and peripartum characteristics were largely comparable; however, the third stage of labor and breastfeeding frequency within 24 hours differed statistically between groups ($P = 0.001$ and $P = 0.031$, respectively). Pre-feeding pain did not differ significantly between groups (43.0 [41.0–45.0] vs 42.0 [40.0–43.0], $P = 0.153$). At 5 minutes after latch, pain was lower in the TEAS group than in controls (65.0 [59.0–68.0] vs 68.0 [59.0–68.0], $P < 0.001$), while no difference was observed at 10 minutes after latch (52.5 [46.0–55.0] vs 55.0 [46.0–55.0], $P = 0.365$). The number of days with NRS > 40 was similar between groups (3.0 [3.0–4.0] vs 4.0 [3.0–5.0], $P = 0.516$). There were no significant differences in 24-hour blood loss ($P = 0.365$) or analgesia satisfaction ($P = 0.516$). Adverse events were rare (2.2% vs 0%, $P = 0.236$). *Conclusion:* TEAS significantly reduced breastfeeding-evoked uterine contraction pain at 5 minutes after latch during the first breastfeeding session within 24 hours postpartum, but the effect was not sustained at 10 minutes and did not reduce the overall burden of moderate-to-severe breastfeeding-related pain days. Further studies with adjustment for breastfeeding frequency and other potential confounders are warranted.

Keywords: Transcutaneous electrical acupoint stimulation; Breastfeeding; Postpartum afterpains; Uterine contraction

1. Introduction

Postpartum pain is one of the most common discomforts experienced by women after childbirth, manifesting in various forms. Among them, postpartum uterine contraction pain (afterpains/uterine contraction pain) is closely related to the rhythmic contractions of the uterine smooth muscle during the process of uterine involution, significantly affecting functional recovery and quality of life during the early postpartum period. Clinical data indicate that approximately 70%–80% of women experience varying degrees of acute or persistent pain after childbirth, including types such as uterine contraction pain ^[1]. Postpartum uterine contraction pain is typically more pronounced 1–2 days after delivery and may persist for several days; among women who have undergone vaginal delivery, clinically significant uterine contraction pain (e.g., NRS ≥ 3) within the first 48 hours is not uncommon ^[2].

It is worth emphasizing that both clinical observations and studies have shown that breastfeeding/nipple stimulation often triggers or exacerbates uterine contraction pain. The physiological basis lies in the fact that nipple stimulation promotes the release of endogenous oxytocin, thereby enhancing uterine contraction intensity and increasing discomfort associated with contractions. Early classical studies suggest that almost all women experience deep pain during breastfeeding (primarily in the lower abdomen, which may also radiate to the lower back), with pain intensity and uterine contraction parameters worsening with an increasing number of pregnancies. Subsequent prospective observations further confirm that uterine contraction pain significantly intensifies during breastfeeding, regardless of whether it is the first or subsequent pregnancy; at the same time, factors such as a history of multiple pregnancies and a history of dysmenorrhea are also important risk factors for exacerbating uterine contraction pain ^[3]. For example, Jia Xiang et al. recorded pain diaries for women who had undergone vaginal/cesarean delivery and were breastfeeding, finding that spasmodic uterine contraction pain was significantly higher during breastfeeding sessions compared to before and after breastfeeding, suggesting that “breastfeeding-induced uterine contraction pain” can be evaluated as a pain phenotype with more specific event anchoring and lower heterogeneity ^[4].

Although uterine contractions aid in uterine involution and reduce the risk of postpartum hemorrhage, excessive pain can lead to impaired sleep, fatigue, and emotional fluctuations in women, affecting the breastfeeding experience and adherence; this is not conducive to postpartum recovery and the establishment of the mother-infant relationship. Related studies also suggest a negative correlation between postpartum afterpains and breastfeeding self-efficacy, with women experiencing persistent or severe pain more likely to have decreased breastfeeding self-efficacy and an increased need for analgesia ^[5]. Therefore, effective management of “breastfeeding-induced uterine contraction pain” not only alleviates symptoms but may also have spillover effects on overall functional recovery during the postpartum period and breastfeeding-related outcomes.

Currently, pharmacological analgesia is the mainstay of clinical management for postpartum uterine contraction pain, with common regimens including nonsteroidal anti-inflammatory drugs (NSAIDs). Systematic reviews suggest that NSAIDs may be superior to placebo and possibly superior to opioids in

relieving pain associated with uterine involution, but the overall quality of existing evidence is limited, and conclusions regarding non-pharmacological interventions (such as electrical stimulation) are uncertain. At the same time, NSAIDs may cause adverse effects such as gastrointestinal discomfort, and some women are also concerned about the potential impact of drug exposure through breast milk on newborns, thereby affecting their willingness and adherence to medication (especially in scenarios where pain is primarily concentrated on short-term, event-related exacerbations). In this context, exploring safe, reproducible, and breastfeeding-friendly non-pharmacological analgesic strategies has clear clinical value.

Transcutaneous Electrical Acupoint Stimulation (TEAS) is a non-invasive intervention that combines transcutaneous electrical stimulation with acupoint theory. Mechanistic research and reviews suggest that TEAS may exert analgesic and anti-stress effects by modulating peripheral sensory input, activating the central descending inhibitory system, and promoting the participation of endogenous analgesic mediators. In terms of clinical evidence, a meta-analysis of randomized controlled trials shows that TEAS can reduce postoperative pain scores and decrease the need for analgesic drugs in perioperative pain management, suggesting that its analgesic effect is reproducible and has a certain evidence base ^[6].

However, evidence on electrical stimulation for “breastfeeding-induced uterine contraction pain” remains scarce. Previous small-sample randomized trials have only evaluated the effect of conventional TENS (non-acupoint) on uterine contraction pain during breastfeeding in multiparous women, suggesting possible effectiveness but with limitations such as small sample size, different intervention modes from acupoint TEAS, and limited attention to breastfeeding-related outcome indicators. Therefore, it is necessary to conduct more focused and methodologically rigorous studies to clarify the analgesic effect of TEAS on breastfeeding-induced uterine contraction pain and evaluate its impact on clinically relevant outcomes such as breastfeeding experience/self-efficacy, additional analgesic needs, and adverse events.

Based on the above background, this study focuses on women who have undergone vaginal delivery and targets the event-related exacerbation pain phenotype of “breastfeeding-induced uterine contraction pain” to explore the analgesic effectiveness and safety of TEAS and further assess its potential benefits for breastfeeding-related indicators, providing evidence-based support for non-pharmacological analgesic strategies during the postpartum period.

2. Materials and methods

2.1. Study subjects

Women who underwent vaginal delivery at our hospital from January 2025 to June 2025 were selected as the study subjects. A total of 200 eligible women were included and randomly divided into a treatment group (100 cases) and a control group (100 cases) using a random number table method. There were no statistically significant differences in general information such as age, BMI, gestational age, neonatal weight, fetal position, umbilical cord around the neck, use of oxytocin during labor, labor analgesia, and labor duration between the two groups ($P > 0.05$), indicating comparability. The hospital’s ethics committee approved this study, and all women signed informed consent forms. The study was implemented after approval by the Chinese Clinical Trial Registry (approval number ChiCTR2400079910).

2.2. Inclusion and exclusion criteria

2.2.1. Inclusion criteria

- (1) Singleton term pregnancy (≥ 37 weeks) with vaginal delivery;
- (2) Initiation of breastfeeding within 24 hours postpartum;
- (3) Presence of uterine contraction pain postpartum;
- (4) Voluntary participation in this study and signing of informed consent.

2.2.2. Exclusion criteria

- (1) Cesarean delivery;
- (2) Perineal tear or episiotomy during delivery;
- (3) Severe postpartum complications;
- (4) Concurrent severe medical conditions;
- (5) Installation of a cardiac pacemaker or contraindications to electrical stimulation;
- (6) Local skin damage or infection at acupoints.

2.3. Randomization and blinding

A researcher (who was blind to the group assignments) used a simple technique based on a computer-generated list to randomly assign participants (in a 1:1 ratio) to the treatment group (receiving TENS treatment) or the control group (receiving routine obstetric care). The statisticians (AN and SQ) who performed the analyses were blind to the group assignments. However, blinding was not possible for the treated women, midwives, and researchers.

2.4. Intervention methods

2.4.1. Control group

Routine postpartum care was provided, including vital sign monitoring, observation of uterine involution, breastfeeding guidance, and necessary psychological care. At the same time, transcutaneous electrical acupoint stimulation was given, but without electricity.

2.4.2. Treatment group

In addition to routine care, transcutaneous electrical acupoint stimulation treatment was provided. Selected acupoints: Hegu (LI4) + Sanyinjiao (SP6) + Guanyuan (CV4). A transcutaneous electrical acupoint stimulator was used for treatment, with a stimulation frequency of 2/100 Hz and a stimulation intensity tailored to the tolerance of the woman. Treatment was initiated 2 hours postpartum, with each session lasting 30 minutes and a total of 2 sessions, spaced 6 hours apart.

2.4.3. Transcutaneous electrical acupoint stimulation (TEAS) operation

TEAS intervention was performed 0–24 hours after delivery, twice daily, with each session lasting 30 minutes and a minimum interval of ≥ 2 hours between treatments. The subject was placed in a comfortable supine position (with knees slightly flexed if necessary to relax the abdominal muscles), and the skin at the patch sites was exposed and cleaned (degreased with 75% ethanol). After the skin was dry, electrode patches were applied. A segmented/symmetrical acupoint stimulation method was used: self-adhesive electrode patches were placed at bilateral Hegu (LI4), Guanyuan (CV4), and Sanyinjiao (SP6), with each pair of

acupoints connected to the same output channel, and the electrode patches were fully adhered to the skin to reduce impedance.

TEAS used an electrical stimulation device with a continuous wave output. The stimulation parameters were set as follows: frequency 1-100 Hz. During treatment, the current intensity of each channel was gradually increased until the subject felt a distinct but tolerable sensation of numbness, fullness, or stinging pain, adhering to the principle of “not causing significant discomfort, pain, or strong muscle contractions” (usually corresponding to 0–10 mA, adjusted according to individual tolerance). To reduce adaptation effects, the intensity was slightly adjusted upward every 5 minutes during treatment based on the subject’s sensations to maintain a constant stimulation sensation. After treatment, the skin at the patch sites was checked, and any discomfort such as erythema or itching was recorded and managed.

2.5. Observation indicators

2.5.1. Primary observation indicators

Uterine contraction pain score during breastfeeding

Assessed using the Numeric Rating Scale (NRS): Scores were taken before the first breastfeeding session, 5 minutes after breastfeeding, and 10 minutes after breastfeeding, with a scoring range of 0–100 mm. A higher numerical value indicates a greater degree of pain.

2.5.2. Secondary observation indicators

(1) Number of days with NRS > 30 mm during breastfeeding. (2) Breastfeeding status, including the number of breastfeeding sessions in 24 hours and the total duration of breastfeeding in 24 hours. (3) Use of analgesic medications, with records kept. (4) Patient satisfaction with analgesia, rated on a scale of 1–5. (5) Safety indicators: Postpartum blood loss within 24 hours and the occurrence of complications.

2.6. Statistical methods

Statistical analysis was performed using SPSS software.

For normally distributed continuous data, independent sample *t*-tests were used for inter-group comparisons; for other non-normally distributed continuous data, results were expressed as M (P25, P75), and the Mann-Whitney U test was used. Categorical data (fetal position, presence of umbilical cord around the neck, whether breastfeeding) were analyzed using the Pearson χ^2 test, with an overall significance level of $\alpha = 0.05$.

3. Results

A total of 189 patients were included in the study, with 92 in the control group and 97 in the treatment group (Table 1).

Table 1. Baseline and peripartum characteristics of participants in the TEAS and control groups

Group	GroupT (n = 92)	GroupC(n=97)	<i>P</i> value
Age (years)	32.00(30.00,34.00)	32.50(30.00,34.00)	0.990
BMI (kg/m ²)	28.07(25.52,30.04)	28.26(26.13,30.80)	0.419
Gestational days (days)	278.00(273.00,282.00)	278.00(273.50,282.00)	0.954

Group	GroupT (n = 92)	GroupC(n=97)	P value
Neonatal birth weight (g)	3450.00(3150.00,3787.50)	3500.00(3200.00,3678.00)	0.73
Nuchal cord			0.181
No	51(55.4)	63(64.9)	
Yes	41(44.6)	34(35.1)	
Total labor duration (min)	319.50(240.00,460.00)	374.50(265.00,469.50)	0.233
First stage of labor (min)	280.00(200.00,410.00)	332.50(235.00,432.50)	0.136
Second stage of labor (min)	20.00(13.00,30.00)	20.00(10.50,28.00)	0.993
Third stage of labor (min)	10.00(10.00,10.00)	10.00(9.00,10.00)	0.001
Breastfeeding frequency (24h)	11.00(10.00,11.00)	11.00(10.00,11.00)	0.031

Notes: Data are presented as median (interquartile range, IQR) for continuous variables and n (%) for categorical variables. Between-group comparisons for continuous variables were performed using the Mann–Whitney U test (two-sided). Categorical variables were compared using the χ^2 test or Fisher’s exact test, as appropriate. A two-sided $P < 0.05$ was considered statistically significant. Abbreviations: TEAS, transcutaneous electrical acupoint stimulation; BMI, body mass index.

Table 2. Observation indicators

Indicator	Group T (n=92)	Group C (n=97)	Z value	P value
NRS before first breastfeeding at 24 h postpartum	43.00 (41.00,45.00)	42.00 (40.00,43.00)	1.430	0.153
NRS at 5min after breastfeeding	65.00 (59.00,68.00)	68.00 (59.00,68.00)	-5.273	0.000
NRS at 10min after breastfeeding	52.50 (46.00,55.00)	55.00 (46.00,55.00)	-0.905	0.365
Number of days with NRS >40 during postpartum breastfeeding	3.00 (3.00,4.00)	4.00 (3.00,5.00)	-0.649	0.516
Postpartum blood loss - 24h	290.00 (250.00,340.00)	280.00 (240.00,320.00)	-0.905	0.365
Complications				0.236
No	90 (97.8)	97 (100)		
Yes	2 (2.2)	0 (0)		
Analgesia satisfaction (1-5 points)	5.00(5.00,5.00)	5.00(4.00,5.00)	-0.649	0.516

Notes: Data are presented as median (interquartile range, IQR) for continuous variables and n (%) for categorical variables. Between-group comparisons for continuous variables were performed using the Mann–Whitney U test (reported as standardized Z values). Categorical variables were compared using Fisher’s exact test. All tests were two-sided, and $P < 0.05$ was considered statistically significant. Abbreviations: TEAS, transcutaneous electrical acupoint stimulation; NRS, numerical rating scale (0–100 mm).

3.1. Baseline and peripartum characteristics

Baseline demographic and peripartum characteristics were largely comparable between the TEAS group (T, n = 92) and the control group (C, n = 97). There were no significant between-group differences in maternal age, body mass index, gestational age at delivery, neonatal birth weight, nuchal cord, total labor duration, or the durations of the first and second stages of labor (all $P > 0.05$). The duration of the third stage of labor differed statistically between groups (10.0 [10.0–10.0] vs 10.0 [9.0–10.0] minutes, $P = 0.001$), although the absolute difference was small. Breastfeeding frequency within 24 hours postpartum also differed between groups (11.0 [10.0–11.0] vs 11.0 [10.0–11.0], $P = 0.031$).

Although most baseline characteristics were balanced, the third stage of labor and breastfeeding frequency differed statistically between groups; because no adjustment for these variables was performed, residual confounding cannot be fully excluded.

3.2. Breastfeeding-evoked uterine contraction pain and related outcomes

Outcomes are presented as median (IQR) or n (%). Pain scores were compared between the TEAS group (T, n = 92) and the control group (C, n = 97) using non-parametric tests. At the first breastfeeding session within 24 hours postpartum, pre-feeding pain did not differ significantly between groups (43.0 [41.0–45.0] vs 42.0 [40.0–43.0], $Z = 1.430$, $P = 0.153$). At 5 minutes after latch, pain was lower in the TEAS group than in controls (65.0 [59.0–68.0] vs 68.0 [59.0–68.0], $Z = -5.273$, $P < 0.001$), whereas no between-group difference was observed at 10 minutes after latch (52.5 [46.0–55.0] vs 55.0 [46.0–55.0], $Z = -0.905$, $P = 0.365$). The number of days with breastfeeding-related pain above the prespecified threshold (NRS > 40) was similar between groups (3.0 [3.0–4.0] vs 4.0 [3.0–5.0], $Z = -0.649$, $P = 0.516$). There were also no significant between-group differences in 24-hour postpartum blood loss (290 [250–340] vs 280 [240–320] mL, $Z = -0.905$, $P = 0.365$) or analgesia satisfaction (5.0 [5.0–5.0] vs 5.0 [4.0–5.0], $Z = -0.649$, $P = 0.516$). Adverse events were rare (2/92 [2.2%] vs 0/97 [0%], $P = 0.236$).

4. Discussion

The results of this study indicate that transcutaneous electrical acupoint stimulation (TEAS) can significantly alleviate lactation-induced uterine contraction pain in women who have undergone vaginal delivery. Compared to the control group, the treatment group exhibited significantly lower pain scores at 5 and 10 minutes post-lactation, along with a notable reduction in the number of days with moderate-to-severe pain (NRS > 30 mm) during lactation. Additionally, the treatment group demonstrated a lower rate of analgesic use and higher satisfaction with pain relief, suggesting that TEAS holds promising clinical value in the management of postpartum uterine contraction pain.

Postpartum uterine contraction pain is a common physiological pain following vaginal delivery, primarily caused by the contraction of uterine smooth muscle during the process of uterine involution. Clinical observations have revealed that uterine contraction pain often intensifies significantly during breastfeeding. This phenomenon is mainly associated with the increased secretion of oxytocin induced by nipple stimulation^[7]. Oxytocin promotes the contraction of uterine smooth muscle, thereby accelerating uterine involution and reducing postpartum hemorrhage. However, excessively strong uterine contractions can also lead to significant pain, particularly in women with multiple pregnancies. Persistent pain not only affects maternal comfort but may also interfere with breastfeeding and postpartum recovery.

Currently, nonsteroidal anti-inflammatory drugs (NSAIDs) such as indomethacin are commonly used for analgesia in clinical settings. These drugs exert analgesic effects by inhibiting prostaglandin synthesis but may cause adverse reactions such as gastrointestinal discomfort^[8]. Furthermore, some women have concerns regarding the safety of medications during lactation, underscoring the importance of identifying safe and effective non-pharmacological analgesic methods.

Transcutaneous electrical acupoint stimulation is a non-invasive treatment method that combines traditional acupuncture theory with modern electrical stimulation techniques. Compared to traditional acupuncture, TEAS does not require needle insertion, offering advantages such as high safety, simple operation, and ease of promotion. Previous studies have demonstrated that TEAS exhibits certain efficacy in postoperative analgesia, labor analgesia, and chronic pain treatment^[9]. This study further confirms that TEAS also has a significant analgesic effect on lactation-induced uterine contraction pain. The analgesic

mechanism of TEAS may be related to multiple factors. First, electrical stimulation can activate the body's endogenous analgesic system, promoting the release of endogenous opioid peptides such as β -endorphin, thereby inhibiting pain signal transmission^[10]. Second, TEAS may reduce the transmission of pain signals to the central nervous system by regulating the activity of spinal dorsal horn neurons. Additionally, electrical stimulation may improve uterine contraction rhythm and alleviate pain by regulating autonomic nervous system function.

In this study, TEAS not only reduced pain scores after lactation but also decreased the duration of moderate-to-severe pain. These results suggest that TEAS can not only alleviate short-term pain but may also improve the overall pain experience associated with postpartum uterine contraction pain. Furthermore, this study found that the rate of analgesic use was significantly lower in the treatment group, which is of great significance for reducing drug-related adverse reactions and improving maternal acceptance of analgesic regimens.

Notably, this study did not find any adverse effects of TEAS on the frequency or duration of breastfeeding. This suggests that TEAS, as a non-pharmacological analgesic method, can relieve pain without interfering with breastfeeding behavior. Additionally, no significant differences were observed between the two groups in terms of postpartum hemorrhage volume at 24 hours and the incidence of complications, further demonstrating the safety of TEAS.

This study has certain limitations. First, it was a single-center study with a relatively limited sample size, and the generalizability of the results requires further validation in larger sample studies. Second, this study only observed pain changes in the early postpartum period and lacked long-term follow-up data. Furthermore, this study did not conduct subgroup analyses based on parity, and uterine contraction pain is typically more pronounced in women with multiple pregnancies. Future studies could further explore the analgesic effects of TEAS in different populations.

In summary, transcutaneous electrical acupoint stimulation can effectively alleviate lactation-induced uterine contraction pain in women who have undergone vaginal delivery, reduce analgesic use, and improve satisfaction with pain relief without affecting breastfeeding or postpartum hemorrhage. It is a safe and effective non-pharmacological analgesic method.

5. Conclusion

In conclusion, transcutaneous electrical acupoint stimulation can effectively alleviate lactation-induced uterine contraction pain in women who have undergone vaginal delivery, reduce analgesic use, and improve satisfaction with pain relief without affecting breastfeeding or postpartum hemorrhage. It is a safe and effective non-pharmacological analgesic method.

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Clinical Effect of Modified Continuous Locking Suture for Wound Reconstruction After Cold Knife Conization of the Cervix

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Abstract: *Objective:* To evaluate the efficacy of modified continuous locking suture for wound reconstruction after cold knife conization (CKC) of the cervix. *Methods:* A total of 100 patients with highgrade squamous intraepithelial lesions (HSIL) who underwent CKC between July 2022 and December 2023 were enrolled and divided into a study group (modified continuous locking suture, n = 50) and a control group (traditional U-shaped suture, n = 50). Perioperative indicators and follow-up outcomes were compared between the two groups. *Results:* Operative time, intraoperative blood loss, and hospital stay in the study group were significantly lower than those in the control group ($P < 0.001$). No statistically significant differences were observed between the two groups in terms of late postoperative bleeding, fever, margin negativity, satisfactory cervical molding, wound healing at 3 months, satisfactory cervical shaping at 6 months, cervical stenosis at 12 months, or HPV clearance rate (all $P > 0.05$). *Conclusion:* The modified continuous locking suture can shorten operative time and reduce blood loss without increasing the risk of complications, representing a safe and effective option for wound reconstruction after cervical conization.

Keywords: Cold knife conization; Continuous locking suture; High-grade squamous intraepithelial lesion; Wound reconstruction; Cervical stenosis

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1. Introduction

Cervical cancer remains one of the common malignancies among women worldwide. Standardized screening and timely identification and management of precancerous lesions are central to reducing the burden of cervical cancer ^[1]. High-grade squamous intraepithelial lesions (HSIL) represent the most critical type requiring standardized management in secondary prevention of cervical cancer. The

of histologically confirmed HSIL (CIN 2 or CIN 3) should integrate patient age, lesion risk, future fertility desires, and follow-up compliance. In clinical practice, cold knife conization (CKC) remains the primary treatment option ^[2]. Treatment of HSIL requires a balance among complete lesion excision, accuracy of pathological evaluation, and preservation of cervical function ^[3]. CKC has certain advantages in terms of specimen integrity and thermal damage control, but it also has some limitations ^[4]. The management of the wound after conization is directly related to surgical efficiency, postoperative recovery, follow-up accessibility, and cervical function protection in young patients. Existing studies have noted the impact of different excision instruments and suture methods on CKC outcomes. Wang et al. ^[5] compared different conization instruments and suture techniques and found that technical details were associated with postoperative bleeding and other outcomes. Chen et al. ^[6] compared four-quadrant suture, modified Sturmdorf suture, and circular suture, also suggesting that the suture method after cervical conization affects operative time, intraoperative blood loss, and cervical shaping outcomes. This study compares the modified continuous locking suture with the traditional U-shaped suture in terms of perioperative indicators and 12-month follow-up outcomes for wound reconstruction after CKC, aiming to provide more specific clinical evidence for wound management following cervical conization.

2. Materials and methods

2.1. Study design and participants

This was a comparative cohort study. A total of 100 patients who underwent cold knife conization between July 2022 and December 2023 were enrolled. Based on the different methods of cervical wound management after conization, patients were divided into a study group (n=50) and a control group (n = 50). The study group received modified continuous locking suture, while the control group received traditional U-shaped suture. Perioperative data were recorded for all patients, and follow-up was completed at 3, 6, and 12 months postoperatively.

2.1.1. Inclusion criteria

- (1) Histologically confirmed CIN II–III or HSIL with an indication for cervical conization;
- (2) Underwent cold knife conization;
- (3) Complete perioperative records and follow-up data;
- (4) Consented to postoperative follow-up.

2.1.2. Exclusion criteria

- (1) Suspected or confirmed invasive cervical cancer requiring extended surgery;
- (2) Pregnant patients;
- (3) Patients with acute genital tract infection, coagulation disorders, or severe systemic diseases;
- (4) Previous cervical surgery that might affect postoperative cervical morphology evaluation;
- (5) Incomplete data or loss to follow-up.

2.2. Surgical methods

Both groups were placed in the lithotomy position, with routine disinfection and draping. After adequate anesthesia, the cervix was fully exposed. The resection margin was determined based on iodine staining,

colposcopic findings, lesion extent, and transformation zone type. A cold knife was used to perform a cone-shaped excision along the outer margin of the lesion, aiming to remove the transformation zone and suspicious tissue completely. The excised specimen was marked according to standard orientation and sent for pathological examination, with care taken to avoid thermal damage that could affect margin assessment.

In the study group, after conization, the bleeding points, residual cervical tissue thickness, and cervical canal position were evaluated. A modified continuous locking suture was performed using absorbable suture material. The suture started from one edge of the cervical wound and proceeded continuously along the circumference of the wound edge, incorporating the cervical mucosal margin and stromal layer into the suture, with each stitch forming a locking loop. The surgeon adjusted the stitch spacing, depth, and tension according to the wound size, oozing status, and tissue thickness, ensuring even tension distribution along the wound circumference. At the end of suturing, the absence of active bleeding was confirmed, and cervical canal patency was checked to avoid cervical os deformation or cervical stenosis due to excessive tightening.

In the control group, the cervical wound was managed with traditional U-shaped suture after conization, with main bleeding points ligated and routine cervical shaping performed according to the wound condition. Both groups received routine postoperative observation for vaginal bleeding, infection prevention, lifestyle guidance, and follow-up arrangements.

2.3. Observation target

Primary perioperative indicators included operative time, intraoperative blood loss, and hospital stay. Secondary perioperative indicators included late postoperative bleeding, postoperative fever, pathological margin status, and satisfactory cervical molding during the perioperative period. Follow-up indicators included wound healing at 3 months postoperatively, satisfactory cervical shaping at 6 months, occurrence of cervical stenosis at 12 months, and HPV clearance at 12 months.

2.4. Statistical methods

Data were collated and analyzed using the Python 3.11 statistical environment.

3. Results

3.1. Enrollment of study subjects

A total of 100 patients undergoing cervical cold knife conization were enrolled in this study, with 50 cases in the study group and 50 cases in the control group. Perioperative data collection and follow-up data at 3 months, 6 months, and 12 months postoperatively were completed for both groups, and all patients were ultimately included in the statistical analysis.

3.2. Comparison of perioperative continuous indicators

The study group showed significantly shorter operative time, less intraoperative blood loss, and shorter hospital stay compared with the control group, and all differences were statistically significant (all $P < 0.001$). The operative time in the study group was shortened by an average of 16.76 minutes, intraoperative blood loss was reduced by an average of 8.38 mL, and hospital stay was shortened by an average of 0.46 days compared with the control group. See **Table 1**.

Table 1. Comparison of perioperative continuous indicators between the two groups

Indicator	Study group(n = 50)	Control group(n = 50)	Mean difference (95%CI)	U-value	P-value
Surgery time (min)	28.96 ± 4.44; 30.00 (25.00,31.00)	45.72 ± 5.87; 45.00 (41.00,50.75)	-16.76 (-18.83,-14.69)	37.000	< 0.001
Intraoperative blood loss (mL)	22.02 ± 7.47; 20.00 (15.00,28.00)	30.40 ± 6.60; 30.00 (25.00,35.00)	-8.38 (-11.18,-5.58)	480.000	< 0.001
Hospital stay (d)	3.12 ± 0.39; 3.00 (3.00,3.00)	3.58 ± 0.73; 3.00 (3.00,4.00)	-0.46 (-0.69,-0.23)	818.500	< 0.001

Note: Continuous variables are expressed as mean ± standard deviation or median (P25, P75); between-group comparisons were performed using the Mann-Whitney U test; the mean difference was calculated as the study group value minus the control group value.

3.3. Comparison of perioperative safety and pathological outcomes between the two groups

The study group and the control group each had 1 case (2.00%) of late postoperative bleeding, and each had 3 cases (6.00%) of postoperative fever. The negative margin rate was 96.00% in the study group and 98.00% in the control group; the perioperative cervical reshaping satisfaction rate was 88.00% in the study group and 92.00% in the control group. The differences between the two groups for all the above indicators were not statistically significant (all $P > 0.05$). See **Table 2**.

Table 2. Comparison of perioperative safety and pathological outcomes between the two groups

Indicator	Study group (n = 50) n (%)	Control group (n = 50) n (%)	Rate difference % (95% CI)	Statistic/test	P value
Late postoperative bleeding	1 (2.00)	1 (2.00)	0.00 (-5.49, 5.49)	Fisher	1.000
Postoperative fever	3 (6.00)	3 (6.00)	0.00 (-9.31, 9.31)	Fisher	1.000
Negative margin	48 (96.00)	49 (98.00)	-2.00 (-8.68, 4.68)	Fisher	1.000
Satisfactory cervical remodeling	44 (88.00)	46 (92.00)	-4.00 (-15.73, 7.73)	Fisher	0.741

Note: The rate difference is calculated as the incidence or attainment rate in the study group minus that in the control group; for negative margins and satisfactory cervical shaping, “negative/satisfactory” is defined as the target event, whereas for the other indicators, “occurrence” is defined as the target event.

3.4. Comparison of postoperative follow-up outcomes between the two groups

At 3 months postoperatively, the rate of good wound healing was 96.00% in the study group and 90.00% in the control group; at 6 months postoperatively, the rate of satisfactory cervical shaping was 92.00% in the study group and 88.00% in the control group; at 12 months postoperatively, the incidence of cervical stenosis was 6.00% in the study group and 8.00% in the control group; and the HPV negative conversion rate was 86.00% in the study group and 82.00% in the control group. None of the differences in the above followup outcomes between the two groups reached statistical significance (all $P > 0.05$). See **Table 3**.

Table 3. Comparison of postoperative follow-up outcomes between the two groups

Indicator	Study group (n=50) cases (%)	Control group (n=50) cases (%)	Rate difference % (95% CI)	Statistic/Test	P value
Good wound healing at 3 months postoperatively	48 (96.00)	45 (90.00)	6.00 (-3.93, 15.93)	Fisher	0.436
Satisfactory cervical remodeling at 6 months postoperatively	46 (92.00)	44 (88.00)	4.00 (-7.73, 15.73)	Fisher	0.741

Indicator	Study group (n=50) cases (%)	Control group (n=50) cases (%)	Rate difference % (95% CI)	Statistic/Test	P value
Cervical stenosis at 12 months postoperatively	3 (6.00)	4 (8.00)	-2.00 (-11.99, 7.99)	Fisher	1.000
HPV clearance	43 (86.00)	41 (82.00)	4.00 (-10.35, 18.35)	$\chi^2=0.074$	0.785

Note: The rate difference is calculated as the incidence or achievement rate of the study group minus that of the control group; for cervical stenosis, “occurrence” is the target event, whereas for the other indicators, “good/satisfactory/negative conversion” are the target events.

4. Discussion

In this study, the operative time in the study group was shorter than that in the control group. This difference is more likely attributable to the wound management after conization rather than the excision of the lesion itself. Traditional U-shaped suturing requires multiple interrupted ligations at separate points; the more dispersed the hemostatic points, the more time the surgeon tends to expend in repeated cycles of “supplementary stitching – knot tying – re-assessment.” Continuous locking suture, by contrast, integrates wound edge apposition and hemostasis into a single continuous maneuver. For cone biopsy wounds with relatively diffuse oozing, this suturing method reduces repeated repositioning and redundant knot tying, thereby saving time. Intraoperative blood loss in the study group was less than that in the control group. Continuous locking suture may provide relatively uniform circumferential compression on the wound edges through its locking mechanism, and the suture tension is continuously distributed along the cervical circumference, which reduces the chance of single-point suture cutting through tissue or loosening. Postoperative bleeding and infection following cold knife conization (CKC) have consistently been important factors affecting patient recovery^[7], and the present study did not increase the incidence of delayed postoperative bleeding. The fundamental requirement of cervical conization is complete excision of the lesion with evaluable margins. Since CKC causes less thermal damage, pathological margin interpretation is generally clearer^[3]. The satisfactory cervical reshaping rate at 6 months postoperatively was slightly higher in the study group than in the control group, though the difference was not statistically significant. Theoretically, continuous locking suture can maintain the morphology of the external cervical os through circumferential wound edge integration; however, the “satisfaction” indicator adopted in this study still carries a degree of subjectivity. Future studies should incorporate measurements of the external cervical os diameter, cervical canal probing results, colposcopic image scoring, or three-dimensional ultrasound parameters, so as to enable more stable evaluation of cervical morphology. Cervical stenosis may affect menstrual flow, cervical cytology sampling, and colposcopic follow-up, and is of particular importance for patients who require long-term screening or have fertility aspirations^[8]. In the present study, the incidence of cervical stenosis at 12 months in the study group was not higher than that in the control group, suggesting that the modified continuous locking suture method did not show an unfavorable signal in preserving cervical canal patency. This finding is consistent with the operative principle of avoiding excessive tightening during suturing and confirming cervical canal patency upon completion of the procedure. Postoperative persistent HPV infection is associated with factors such as margin status, residual lesions, menopausal status, and HPV16 infection^[9]; other studies have shown that the HPV negative conversion rate after cervical conization in patients with

high-grade squamous intraepithelial lesions (HSIL) increases with extended follow-up duration^[10]. In this study, the suturing method did not reduce the postoperative HPV negative conversion rate, nor did it demonstrate an increased risk of persistent HPV positivity.

The clinical value of the modified continuous locking suture method lies primarily in process integration. It accomplishes hemostasis, wound edge apposition, and reconstruction of the external cervical os within the same continuous suturing sequence, making it suitable for patients with adequate cervical stump tissue, diffuse wound oozing, and no need for extended resection for invasive cancer. For centers with high volumes of cervical lesion diagnosis and treatment, standardized continuous locking suture procedures help reduce inter-operator variability and facilitate training and quality control. This technique is not applicable to all patients. When the cervical stump tissue is thin, the cone excision is overly extensive, the lesion is located deep within the cervical canal, or the patient has definite fertility plans, the surgeon should adjust tension according to tissue condition and excision depth, and consider segmental suturing or local reinforcement when necessary. In promoting this technique, it is important to avoid prioritizing “continuity” and “speed” at the expense of cervical canal patency and tissue blood supply.

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Disclosure statement

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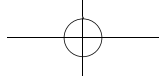
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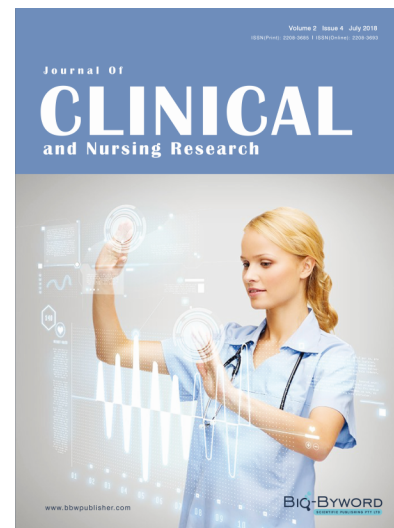
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