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Review

Determinants of Fertility-Sparing Surgery Choice in Cervical Cancer: A Narrative Review

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Abstract

Objective: This review re-evaluates fertility-sparing surgery (FSS) in cervical cancer, synthesizing advancements in surgical precision, evolving indications, and sociodemographic factors influencing care access. It emphasizes the importance of multidisciplinary collaboration and equitable access to optimize both reproductive and survival outcomes for young patients. **Mechanism**: A systematic search was performed across PubMed, Embase, and Web of Science for studies published in the past ten years, using key terms related to cervical cancer, FSS, oncologic and obstetric outcomes, and social determinants of health. Due to heterogeneity in study designs and outcome reporting, a narrative synthesis was conducted to analyze trends in surgical techniques, oncologic safety, obstetric outcomes, and sociodemographic disparities. **Findings in Brief**: FSS encompasses procedures such as conization, radical trachelectomy (vaginal, abdominal, or minimally invasive), and neoadjuvant chemotherapy (NACT)- facilitated surgery, tailored to the tumor stage, size, and histology. Sentinel lymph node (SLN) mapping minimizes invasiveness during staging, while ovarian transposition (OT) preserves endocrine and reproductive function during pelvic radiotherapy. Multidisciplinary teams (MDTs) consider tumor biology, nodal status, and patient preferences to guide treatment decisions. **Conclusions**: FSS offers cervical cancer patients with oncologic safety and fertility preservation, but its success relies on a multidisciplinary approach. Factors like surgical expertise, patient characteristics, and social determinants-like insurance coverage and access to care-significantly influence outcomes. Future research should prioritize improving multidisciplinary care and addressing disparities to enhance fertility preservation for all patients.

Keywords: cervical cancer; fertility preservation; radical trachelectomy; neoadjuvant chemotherapy; medical decision

1. Introduction

Cervical cancer ranks as the fourth most common cancer among women globally, with a notably younger age of onset compared to many other malignancies. Approximately 42% of cervical cancer patients are diagnosed before the age of 45 [1,2]. With the rising trend of delayed childbearing, many women are diagnosed with cervical cancer before completing their family plans [3]. Despite concerns about infertility, many cancer survivors still wish to preserve their ability to have children, underscoring the growing demand for fertility-sparing treatment options [4,5].

Since Dargent *et al*. [6] first reported radical trachelectomy (RT) with pelvic lymphadenectomy for early invasive uterine cervical cancer in 1987, fertility-sparing surgery (FSS) has become a viable option for women desiring to preserve their fertility. FSS offers a promising approach, allowing women with early-stage cervical cancer to retain fertility while maintaining oncological safety comparable to radical hysterectomy [7]. This includes procedures such as cone resection (excision of a cone-shaped cervical segment to remove precancerous or microinvasive lesions), simple trachelectomy, vaginal radical trachelectomy (VRT), abdominal radical trachelectomy (AbRT), robotic or laparoscopic radical trachelectomy (surgical removal of the cervix, upper vagina, and parametrium with uterine preservation) and surgeries following neoadjuvant chemotherapy (NACT), defined as preoperative platinum-based chemotherapy to downstage tumors and minimize surgical radicality. The aim of FSS is not only to preserve the ability to conceive but also to minimize the risks of preterm birth and miscarriage [8]. Beyond the surgical and oncological aspects, the decision to undergo FSS is also influenced by broader social and cultural factors. Traditional fertility expectations, familial roles, economic disparities, and healthcare accessibility can significantly shape patient preferences and clinical decisions. In low-resource settings, limited access to specialized surgical expertise and inadequate insurance coverage may restrict FSS availability, creating disparities in treatment options [9,10].

Despite significant advancements in fertility-preserving cervical cancer treatments, critical gaps remain in understanding the multifactorial determinants influencing patient selection and optimizing outcomes for

Table 1. Determinants of fertility-sparing surgery (FSS)* in cervical cancer (FIGO 2018).

Cervical cancer stage	Surgical approach	Obstetric outcomes [11]	Additional influencing factors
IA1	• Conization	• Pregnancy rate: 56%	• Patient factors: age, fertility and obstetric outcomes
	• Simple trachelectomy	• Live birth rate: 74%	• Medical institution factors: surgical expertise and hospital resources, standardization and multidisciplinary care
		• Preterm birth: 15%	• Societal factors: insurance, ethnic disparities, Access to ART (e.g., geographic disparities)
IA2–IB1	• RT (vaginal/abdominal/MIS) + lymph node evaluation (SLN/PLND)	• Pregnancy rate: 44–65% • Live birth rate: 67–78% • Preterm birth: 39–57%	
IB2	• NACT + RT (vaginal/abdominal/MIS) + PLND	• Pregnancy rate: 77% • Live birth rate: 76% • Preterm birth: 15%	
Selected IB2 or IIA1 patients (tumors ≤4 cm with upper 2/3 vaginal involvement)	• NACT with trachelectomy	• Evolving understanding of safety	

*FSS should not be performed in patients with nodal involvement; small cell neuroendocrine carcinoma, gastric-type adenocarcinoma, adenoma malignum; or when the tumor is <5 mm from the internal os.

FSS, fertility-sparing surgery; SLN, sentinel lymph node; PLND, pelvic lymphadenectomy/pelvic lymph node dissection; NACT, neoadjuvant chemotherapy; RT, radical trachelectomy; ART, assisted reproductive technologies; FIGO, International Federation of Gynecology and Obstetrics; MIS, minimally invasive surgery.

diverse patient groups. This review integrates the latest surgical techniques, oncologic and obstetric outcomes, and sociocultural considerations to provide a comprehensive perspective for clinical decision-making. By systematically evaluating the safety and efficacy of FSS and highlighting emerging trends in personalized treatment (Table 1, Ref. [11]), this article aims to guide clinicians in balancing cancer survival with reproductive aspirations, ultimately enhancing patient-centered care in cervical cancer management.

2. Literature Search Strategy

A systematic search was performed across PubMed, Embase, and Web of Science databases for studies published in the past ten years, using key terms related to cervical cancer, fertility-sparing surgery, neoadjuvant chemotherapy, and various outcomes such as oncologic safety, recurrence rates, pregnancy rates, obstetric outcomes, and sociodemographic factors (Fig. 1). Boolean operators (AND/OR) were employed to refine the search, e.g., (“Uterine Cervical Neoplasms” [MeSH Terms] OR “Cervical Cancer” [Title/Abstract]) AND (“Fertility Preservation” [MeSH Terms] OR “fertility-sparing surgery” [MeSH Terms]). Studies were further identified through manual screening of reference lists in relevant systematic reviews. The eligibility of studies was initially assessed based on titles and abstracts, applying predefined inclusion and exclusion criteria to exclude irrelevant articles. Non-original studies, non-human studies, and publications in languages other than English or Chinese were excluded. The remaining studies were reviewed independently by researchers SZ and MMZ. Due to heterogeneity in study designs and outcome reporting, a narrative synthesis approach was used to analyze trends in surgical techniques, oncologic safety, obstetric outcomes, and sociodemographic disparities (Table 2, Ref. [3,12–16]).

3. Current FSS in Cervical Cancer

Over 60% of cervical cancer cases are diagnosed at a localized stage, for which surgery offers curative potential [17]. Fertility-sparing treatment (FST) comprises a variety of surgical procedures, differing in the extent of paracervical tissue removal and surgical techniques, each of which can lead to distinct perinatal outcomes [11,18]. The selection of the surgical approach should invariably prioritize optimal oncological outcomes whilst ensuring the preservation of adequate functional cervical tissue, a fundamental prerequisite for successful pregnancy [11,19–21].

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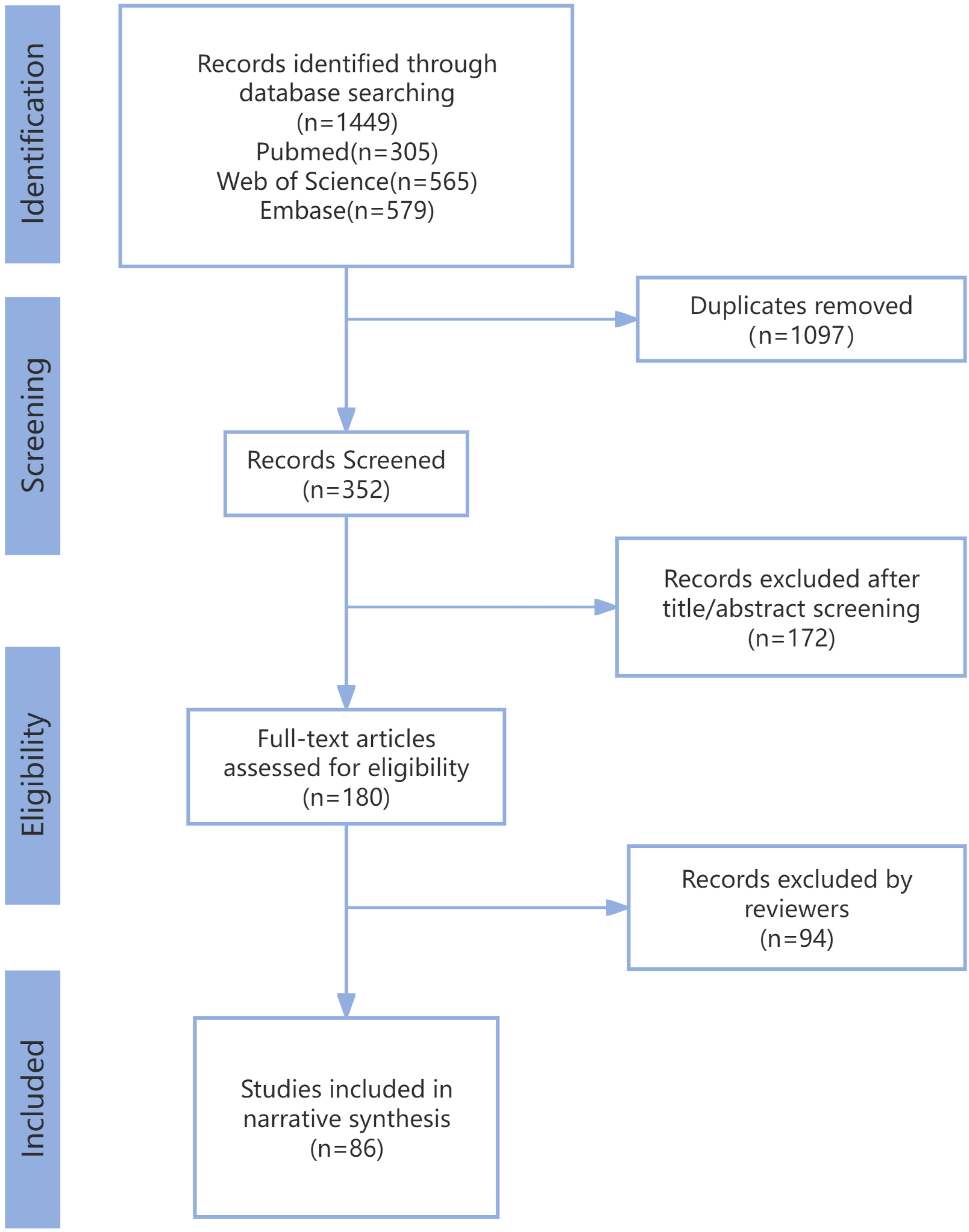

Fig. 1. Flow diagram of study selection process.

3.1 Surgical Approaches and Indications

Surgical management of cervical cancer varies depending on the stage and extent of the disease, with both non-radical and radical approaches offering different benefits and challenges. Non-radical surgical approaches for early-stage cervical cancer are focused on preserving the patient's fertility and minimizing complications, with two primary techniques being conization and simple vaginal trachelectomy (SVT). Conization or SVT are less radical options for select patients, including those with stage IA1 disease with lymphovascular space invasion (LVSI) and IB1 disease with tumors $\leq$2 cm [22]. With less invasive com-

Table 2. Summary of key studies on oncologic safety, obstetric outcomes, and sociodemographic influences.

Study (author/year)	Methodology	Sample size	Key findings
Wright *et al*. (2010) [12]	Retrospective cohort study	1409	Women ≥35 years were 78% less likely to undergo conization (OR = 0.22, 95% CI: 0.23–1.47) despite equivalent survival.
Cui *et al*. (2018) [13]	Retrospective cohort study	15,150	Younger women and those more recently diagnosed were more likely to undergo trachelectomy while Medicaid recipients (RR = 0.39; 95% CI: 0.28–0.54) and the uninsured (RR = 0.67, 95% CI: 0.45–1.00) were less likely to undergo trachelectomy.
Markt *et al*. (2018) [14]	Retrospective cohort study	13,698	Insurance status and cancer treatment mediate the association between race/ethnicity and cervical cancer survival.
Machida *et al*. (2020) [15]	Retrospective cohort study	393	Less-ideal candidates had approximately four-fold higher recurrence risk and cancer mortality compared with ideal candidates*.
Jorgensen *et al*. (2023) [16]	Retrospective cohort study	4521	Fertility-sparing treatment was more likely among young patients overall, and of those in racial and ethnic minority groups. ART use was low and was associated with non-Hispanic White race and ethnicity, younger age (18–35 years), and private insurance.
Slama *et al*. (2023) [3]	Retrospective cohort study	733	Nonradical fertility-sparing cervical procedures were not associated with a higher recurrence risk compared to radical procedures for tumors ≤2 cm. However, the recurrence risk was significantly higher for fertility-sparing procedures in tumors >2 cm.

*Ideal candidates were defined to have a tumor size of ≤2 cm, no lymph node metastasis, no deep stromal invasion, and no high-risk histology. Less-ideal candidates were defined to have any one of these four characteristics.

OR, odds ratio; RR, relative ratio; CI, confidence interval.

pared to more radical procedures, they are associated with a lower risk of complications like cervical stenosis and preterm birth [23], thus being a favorable option for patients with limited disease.

Radical vaginal cervix removal is typically recommended for tumors in the IA2 to IB1 (tumors ≤2 cm) stages, as more invasive than non-radical approaches but offers a higher chance of disease control. This procedure entails the removal of the cervix along with surrounding tissue, including the upper portion of the vagina. It can be performed through vaginal, abdominal, laparoscopic, or robotic-assisted techniques. A study comparing minimally invasive surgery (MIS) and AbRT found no significant difference in overall survival rates (MIS 99.0% vs. open surgery 99.2%) [24], suggesting that MIS can be a viable alternative, offering benefits like reduced recovery time. A systematic review of 47 studies reported a 53.6% clinical pregnancy rate after radical trachelectomy, with vaginal radical trachelectomy (VRT) demonstrating the highest reproductive success compared to abdominal approaches [25]. Additionally, a systematic review, which included 47 articles reporting on 2566 women, showed recurrence rates of 3.8% for VRT, 3.3% for AbRT, and 0% for laparoscopic RT (LRT) [26], highlighting similar oncological outcomes across surgical methods. Despite these similarities, clinical pregnancy rates were notably higher in the AbRT group, likely due to a more extended follow-up period compared to LRT.

3.2 Lymph Node Assessment and Sentinel Lymph Node Mapping

For stage IA2 and more advanced cervical cancers, radical trachelectomy should include lymph node assessment, as lymph node involvement is a significant prognostic factor and can influence treatment decisions [27]. Sentinel lymph node (SLN) mapping has revolutionized surgical staging by minimizing invasiveness while maintaining diagnostic accuracy, particularly for tumors ≤2 cm (detection rate: 88–94%) [28–30]. Current guidelines reflect evolving practices: the National Comprehensive Cancer Network (NCCN) endorses SLN biopsy is recommended instead of full pelvic lymphadenectomy for International Federation of Gynecology and Obstetrics (FIGO) 2018 stage IA1 (with LVSI) and IA2–IB1 disease [1,28], whereas European Society of Gynaecological Oncology (ESGO) 2023 recommends pelvic lymph node dissection even with negative SLNs in stage IB1 cases [31]. Prospective data from SENTICOL I/II trials (an international validation study of sentinel node biopsy in early cervical cancer) suggest comparable recurrence rates when omitting pelvic lymphadenectomy in stage IA–IIA patients with bilateral negative SLNs, though long-term validation remains pending [32]. For early-stage tumors (≤2 cm), SLN-guided strategies demonstrate clinical feasibility: Nica *et al*. [33] reported no recurrences after 44 months in 93% of SLN-negative patients, while those with micrometastases underwent completion lymphadenectomy without adverse outcomes. Despite the higher recurrence risk associated with LVSI (7.1%

vs. 2.4%, $p < 0.001$), its presence should not categorically exclude fertility preservation, provided multidisciplinary teams (MDT) rigorously assess tumor biology and nodal status [34].

3.3 Role of Neoadjuvant Chemotherapy

For patients with locally advanced cervical cancer (tumors >2 cm, stage IB2) desiring fertility preservation, NACT serves as a strategic bridge to enable FSS. By reducing tumor volume, NACT expands eligibility for cervical conization or radical trachelectomy in tumors initially measuring 2–4 cm, achieving recurrence rates comparable to standard radical hysterectomy [28,35]. However, recurrence risk stratification remains nuanced: a systematic review reported an 8.3% overall recurrence rate post-NACT/trachelectomy, escalating to 13.2% in IB2 cases [34], while other cohorts demonstrated lower rates (6.1–7.6%) [36]. A retrospective study of 60 patients with high-grade neuroendocrine carcinoma (HGNEC), a rare and aggressive subtype, found no survival benefit with NACT compared to primary surgery (overall survival (OS): p = 0.82; disease-free survival (DFS): p = 0.78), despite comparable feasibility [37]. Furthermore, NACT was associated with a non-significant trend toward higher intraoperative transfusion rates (45.5% vs. 10%, p = 0.052), underscoring the importance of histology-specific risk-benefit evaluation [37]. Beyond oncologic outcomes, this approach offers superior obstetric potential, with 74.5% of patients achieving pregnancy and 78.7% culminating in live births [34]. Notably, the global pregnancy rate following NACT/trachelectomy (31%) surpasses those of abdominal radical trachelectomy (AbRT: 16%) and vaginal radical trachelectomy (VRT: 24%), underscoring its reproductive advantages despite unresolved safety concerns regarding concurrent assisted reproductive technology (ART) integration. To address these gaps, the ongoing prospective CoNteSSA trial (NCT04016389) is evaluating 3-cycle NACT followed by conservative surgery in FIGO 2018 IB2 tumors (2–4 cm), with endpoints encompassing both oncologic safety and fertility metrics [38].

3.4 Ovarian Transposition (OT)

For patients with locally advanced cervical cancer (LACC), the standard treatment includes external beam radiation therapy (EBRT) ± brachytherapy ± chemotherapy [28,39]. However, the ovarian toxicity of EBRT is profound, as the standard radiation dose for cervical cancer is lethal to ovarian follicles, leading to ovarian failure and permanent infertility [40]. Given these consequences, OT can be performed before initiating radiation therapy to preserve ovarian endocrine function and reproductive potential.

For patient's ineligible for uterine preservation, fertility preservation relies on integrated approaches combining OT and ART to safeguard endocrine function and future reproductive potential [41,42]. Surgically relocates ovaries ≥3 cm beyond the radiation field, OT preserves ovarian endocrine function with a 90% success rate in limited randomized trials [43,44]. However, technical limitations persist: scattered radiation may still compromise transposed ovaries, particularly if displacement is suboptimal, and age-related declines in ovarian reserve amplify failure risks (effective sterilizing doses decrease with advancing age) [45,46]. Even minimal pelvic radiation (2 Gy) destroys 50% of primordial follicles, while 5–10 Gy induces amenorrhea in postpubertal patients [47]. To address these challenges, combined approaches—such as unilateral OT with contralateral ovarian cryopreservation—are advocated for patients undergoing chemoradiation, balancing hormonal preservation with future ART options [48]. Emerging techniques like magnetic resonance imaging (MRI)-guided brachytherapy further refine precision, sparing the uterine corpus and reducing off-target ovarian exposure [35]. Although ovarian stimulation and oocyte retrieval remain viable, successful pregnancies often require gestational surrogacy due to radiation-induced uterine fibrosis [43,49], a pathway restricted by legal barriers in regions like China.

3.5 Tumor Safety in FSS by Histological Type

The oncological safety of FSS varies by histological subtype. A retrospective study by Zusterzeel *et al.* [50] (n = 132) reported divergent recurrence rates: 20% for adenosquamous carcinoma (ASC), 12.5% for adenocarcinoma (AC), and 4.2% for squamous cell carcinoma (SCC) after VRT, with a median recurrence time of 21 months. In contrast, a multicenter cohort study (n = 733) with a median follow-up of 72 months found no significant association between histology (70% SCC, 24% AC) and recurrence, identifying tumor size >2 cm as the sole independent risk factor [3]. These discrepancies may reflect variations in tumor biology, surgical selection bias, or molecular heterogeneity within AC subtypes (e.g., gastric-type AC and adenoma malignum, which are contraindications for FSS) [51].

Current guidelines permit FSS for SCC, AC, ASC, and clear-cell carcinoma, provided lymph node (LN) status is negative [31]. However, neuroendocrine carcinomas, adenoma malignum cell types, LN-positive tumors, and rare variants (e.g., gastric-type AC) are excluded due to aggressive behavior and poor prognosis [51]. While some studies suggest heightened vigilance for AC/ASC cases—particularly those with LVSI or deep stromal invasion—the absence of prospective subtype-specific data necessitates individualized risk-benefit assessments by MDT. Emerging molecular profiling (e.g., human papillomavirus (HPV) integration patterns, programmed death-ligand 1 (PD-L1) expression) may refine selection criteria, enabling histology-agnostic approaches tailored to tumor microenvironment dynamics [52,53].

4. Factors Influencing Decision-Making and Prognosis

4.1 Obstetric Outcomes and Challenges

FSS enables pregnancy in approximately 55% of stage I cervical cancer patients, with live birth rates reaching 70% across surgical modalities [11]. However, FSS significantly elevates obstetric risks. The risks of different fertility and pregnancy-related complications are affected by the heterogeneity of women after FSS, the radicality of the procedure, and the amount of damage done to paracervical tissue and uterine artery ligation. Hence, the incidence of preterm birth and miscarriage varies significantly with surgical radicality, with reported preterm birth rates ranging from 38% to 76.5% and early miscarriage rates between 20%–23% [11,54]. While first-trimester miscarriage rates post-FSS (8%–10%) remain comparable to the general population [55,56], second-trimester miscarriage rates after radical vaginal trachelectomy (RVT) double this baseline (8%–10% vs. 4%–5%) [55,57]. A population-based study linking the California Cancer Registry with birth and hospital discharge data revealed that among 4087 women diagnosed with cervical cancer, only 118 (2.9%) conceived following FSS, highlighting the impact of treatment on fertility. Notably, squamous cell carcinoma accounted for 63.2% of these cases, followed by adenocarcinoma at 30.8%. Compared to both the general population and cervical cancer patients who conceived before their diagnosis, FSS patients exhibited significantly higher odds of preterm birth before 37 weeks, with rates of 21.5% versus 9.3% (OR: 2.66, 95% CI: 1.38–5.10) and 12.7% (OR: 1.88, 95% CI: 1.01–3.57), respectively, while the risk of preterm birth before 32 weeks did not significantly increase. Furthermore, neonatal morbidity was notably higher in FSS patients than in cervical cancer controls (15.9% vs. 6.9%, OR: 2.53, 95% CI: 1.16–5.54), although no significant differences were observed in fetal growth restriction, stillbirth, cesarean delivery, or maternal morbidity. The Fertility Sparing Surgery in cervical cancer patients outside controlled trials (FERTISS study), encompassing 44 centers in 13 countries, revealed stark disparities between non-radical and radical FSS: pregnancy success rates were 63.2% for non-radical procedures versus 25.7% for radical trachelectomy ($p < 0.001$), though live birth rates remained similar (86% vs. 83%, $p = 0.767$) [58]. Radical trachelectomy is associated with higher preterm birth rates (76.5% vs. 57.7% for non-radical FSS, $p = 0.150$) [21]. Prophylactic cervical cerclage reduces mid-trimester fetal loss to 20% but increases cervical stenosis risk [58]. And outcomes vary by technique: VRT and simple trachelectomy yield comparable pregnancy rates, whereas laparoscopic approaches reduce fertility to 40% [59].

NACT may reduce surgical invasiveness by shrinking tumor volume, thereby minimizing cervical/uterine isthmus resection and lowering preterm birth risk compared to upfront radical surgery [25]. However, its gonadotoxic potential necessitates careful ovarian reserve assessment pretreatment [48]. Pre-treatment oocyte/embryo cryopreservation is advised to mitigate gonadal toxicity, though ovarian stimulation carries theoretical risks of cancer dissemination [45,60]. For patients requiring hysterectomy, gestational surrogacy—achieving 66.7% ongoing pregnancy rates—remains the sole option in regions permitting it [61]. Ovarian tissue cryopreservation (OTC) is limited by malignancy recurrence risks, particularly in non-squamous histology (e.g., stage IIB adenocarcinoma) [62].

Post-FSS complications including cervical stenosis, cervical incompetence, and diminished ovarian reserve affect 25–50% of patients. Nevertheless, subsequent ART demonstrates favorable reproductive outcomes [16], with 53% of women achieving at least one pregnancy through interventions such as cervical dilation, intrauterine insemination, or *in vitro* fertilization, necessitating pre-surgical counseling by reproductive endocrinologists and high-risk obstetricians [11,25,26,63–65]. To better evaluate post-FSS pregnancy outcomes and guide clinical counseling, a Japanese study established a clinical prediction model, the Subsequent Pregnancy Index (SPI) score—a stratification tool incorporating age, marital status, and ART utilization—to evaluate expected pregnancy efficacy following fertility-sparing trachelectomy [66]. Despite established guidelines and emerging advances in pregnancy outcome prediction models, inadequate preoperative counseling persists, highlighting the urgent need for standardized MDT protocols to address anatomical, hormonal, and psychosocial barriers.

4.2 Grasping Surgical Indications

FSS achieves survival outcomes equivalent to radical hysterectomy in rigorously selected early-stage cervical cancer patients, but deviations from strict eligibility criteria exponentially increase recurrence risks, necessitating precise multidisciplinary evaluation. A study of 1409 IA1-stage patients demonstrated no survival difference between conization and hysterectomy (HR = 0.65, 95% CI: 0.23–1.47), with 40% undergoing conization [12]. Similarly, among IA2-IB2 stage patients in the U.S. National Cancer Database (2004–2014), trachelectomy and hysterectomy showed comparable 5-year survival (5.2% vs. 6.0% mortality; HR = 1.24, 95% CI: 0.70–2.22) [13]. However, a Japanese nationwide cohort (n = 393) stratified patients into ideal candidates (tumor $\leq$2 cm, node-negative, no deep stromal invasion; n = 284) and suboptimal candidates (any high-risk feature; n = 109), revealing a fourfold higher recurrence and mortality risk in the latter group [15]. These findings underscore that survival equivalence hinges on strict adherence to tumor size, histology, and nodal status. To mitigate risks, centralized implementation of FSS requires multidisciplinary infrastructure, including intraoperative frozen section analysis for margins/nodal assessment and collaboration between high-volume surgeons and specialized pathologists, ensuring eligibility is adjudicated through consensus rather than compromise.

4.3 Surgical Expertise and Technical Considerations

The success of fertility-sparing surgery (FSS) and patient decision-making are shaped by a complex interplay of institutional resources, surgical expertise, and individual preferences. A study showed that in centers ranked in the top 10% (performing 30% of cervical surgeries), the relative risk of short-term perioperative complications was reduced by 65% when cervical trachelectomy was performed, which may also influence the pregnancy outcomes of FSS [67]. Surgical approaches—vaginal, abdominal, or robotic—depend on patient-specific factors (e.g., anatomy, body habitus), surgeon proficiency, and institutional capabilities. Robotic trachelectomy, for instance, may offer advantages such as reduced blood loss and faster recovery [68], but its higher cost and limited accessibility often restrict its use to specialized centers, disproportionately affecting socioeconomically disadvantaged populations [69].

Patient preferences for FSS are further influenced by disparities in counseling quality and access to multidisciplinary care. While some patients prioritize uterine preservation despite higher obstetric risks, others may opt for definitive surgery due to concerns about recurrence or limited access to long-term surveillance. Notably, institutional experience with SLN mapping varies regionally: SLN biopsy is preferred in high-resource settings, whereas full pelvic lymphadenectomy remains common where SLN expertise is limited [70]. These variations emphasize the imperative for standardized training programs and referral networks to ensure equitable access to advanced techniques. MDT must therefore integrate surgeon experience, institutional capabilities, and patient-specific factors (e.g., body habitus, tumor location) when tailoring FSS strategies, prioritizing referral to high-volume centers whenever feasible.

4.4 Additional Influencing Factors

The uptake of FSS and ART varies significantly across sociodemographic groups, reflecting complex interactions between age, insurance status, race/ethnicity, and geographic accessibility [16]. In IA1-stage cervical cancer, women aged $\geq$35 years were 78% less likely to undergo conization than those $<$30 years (OR = 0.22, 95% CI: 0.16–0.30) despite equivalent survival outcomes (HR = 0.65, 95% CI: 0.23–1.47) [12]. For IA2–IB2 stage disease, Medicaid-insured (relative risk (RR) = 0.39, 95% CI: 0.28–0.54) and uninsured patients (RR = 0.67, 95% CI: 0.45–1.00) were significantly less likely to receive trachelectomy compared to privately insured counterparts, highlighting systemic financial barriers [13]. Paradoxically, racial/ethnic minority groups with cervical cancer showed higher odds of receiving FSS than non-Hispanic White patients—a contrast to prior studies on guideline-based treatment disparities [14]. This divergence may reflect cultural preferences or unequal access to definitive hysterectomy in underserved populations.

In contrast, ART utilization post-FSS reveals persistent racial inequities: minority patients face lower ART adoption rates, partly mediated by Medicaid's exclusion of fertility services (covering 30% of Black and 25% of Hispanic vs. 15% of White patients) [71]. Geographic disparities in ART access, prevalent nationally (30% lack local clinics), were absent in California due to high clinic density and state-mandated partial insurance coverage [72,73]. However, rural-urban gaps in FSS access remain mitigated by the feasibility of procedures like electrosurgical excision procedure (LEEP)/conization in low-resource settings [16]. These findings underscore that equitable fertility preservation requires addressing both structural inequities (insurance reform, ART clinic distribution) and cultural competence in counseling.

5. Conclusions

FSS has advanced significantly, offering cervical cancer patients a viable option to preserve fertility while ensuring oncologic safety. However, the success of FSS—encompassing both oncologic outcomes and reproductive prognosis—depends on a range of factors. Crucially, a multidisciplinary approach is essential, with comprehensive evaluation from gynecologic oncologists, pathologists, and fertility specialists ensuring the most appropriate treatment for each patient. Factors such as the surgeon's expertise, institutional resources, and the choice of surgical technique all influence obstetric outcomes, including preterm birth and miscarriage rates. Beyond the clinical and surgical aspects, patient-specific factors, such as age and individual health conditions, must also be considered in treatment planning. Furthermore, social determinants like ethnicity, insurance coverage, and geographic access to specialized care can create disparities in treatment outcomes. These factors highlight the need for coordinated efforts across medical, social, and policy levels. Future research should focus on optimizing multidisciplinary care, addressing healthcare access disparities, and improving fertility preservation strategies, to ensure that all women have equitable opportunities for successful fertility preservation after cervical cancer treatment.

Author Contributions

SZ conceptualized the study, developed the framework, and led the drafting and revising. MMZ contributed to conception of the work, literature research, writing, and revising. YYZ contributed to the literature research for this work, supervised the project, reviewed the manuscript, and ensured alignment with journal requirements. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

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The authors declare no conflict of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work the authors used ChatGpt-3.5 in order to check spell and grammar. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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