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Research Article

Next-Generation Dissolvable Vaginal Tablets for Recurrent Vulvovaginal Candidiasis: Nanotechnology, Biofilm Targeting, and Precision Drug Delivery

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ABSTRACT:
Recurrent vulvovaginal candidiasis (RVVC) is a common and challenging mucosal fungal infection that affects millions of women worldwide and substantially impairs quality of life. Despite the widespread availability of antifungal agents such as azoles and polyenes, recurrence remains common due to persistent Candida biofilms, emerging antifungal resistance, poor adherence to prolonged treatment regimens, and failure to restore the normal vaginal microbiota. Conventional vaginal creams, suppositories, and oral therapies often provide temporary symptom relief but rarely address the underlying mechanisms responsible for disease recurrence. Dissolvable vaginal tablets have emerged as an attractive local drug delivery platform because they offer accurate dosing, improved stability, enhanced patient convenience, prolonged mucosal residence, and reduced systemic drug exposure. Recent advances in pharmaceutical formulation have further expanded their therapeutic potential by incorporating nanotechnology-based carriers, biofilm-disrupting compounds, mucoadhesive polymers, and controlled-release systems that enhance antifungal penetration and improve local drug bioavailability. This structured literature review examines the evolving role of next-generation dissolvable vaginal tablets in the prevention and treatment of RVVC, with particular emphasis on nanotechnology-enabled drug delivery, strategies targeting Candida biofilms, and precision medicine approaches designed to optimize therapeutic outcomes. Published evidence from major biomedical databases was critically evaluated to summarize advances in formulation technologies, preclinical investigations, and emerging clinical applications. Current findings indicate that multifunctional vaginal tablet systems integrating antifungal agents with biofilm inhibitors, probiotics, immunomodulatory compounds, or responsive biomaterials may offer superior control of recurrent infection compared with conventional therapies. Although several promising technologies remain at the experimental stage, continued progress in pharmaceutical engineering and translational research is expected to accelerate their clinical development. Next-generation dissolvable vaginal tablets therefore represent a promising therapeutic strategy for improving local antifungal efficacy, reducing recurrence, enhancing patient adherence, and advancing precision gynecological drug delivery.

Keywords: Recurrent vulvovaginal candidiasis; Dissolvable vaginal tablets; Nanotechnology; Biofilm disruption; Precision drug delivery; Mucoadhesive systems; Antifungal therapy; Vaginal drug delivery.

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1. INTRODUCTION

Recurrent vulvovaginal candidiasis (RVVC) is a chronic and frequently relapsing fungal infection of the lower female genital tract that represents a significant challenge in gynecological practice. It is generally defined as **three or more** (or, in some guidelines, **four or more**) symptomatic episodes of vulvovaginal candidiasis within one year. Although vulvovaginal candidiasis is one of the most common infections affecting women of reproductive age, approximately 5–8% of women develop the recurrent form, resulting in substantial physical discomfort, psychological distress, sexual dysfunction, and reduced quality of life. Recurrent

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episodes often require repeated medical consultations, prolonged antifungal therapy, and increased healthcare expenditure, making RVVC an important public health concern.[1,4]

The majority of RVVC cases are caused by *Candida albicans*, an opportunistic fungal pathogen that normally exists as part of the vaginal microbiota. However, infections caused by non-*albicans* *Candida* species, including *Candida glabrata*, *Candida tropicalis*, and *Candida krusei*, have increased in recent years, partly because of widespread azole use and the emergence of antifungal resistance. Unlike uncomplicated vulvovaginal candidiasis, RVVC is characterized by persistent fungal colonization, recurrent inflammation, and the ability of *Candida* species to form highly organized biofilms on the vaginal epithelium. These biofilms protect fungal cells from host immune responses and antifungal agents, thereby contributing to treatment failure and disease recurrence.[5.9]

Several host-related and environmental factors increase susceptibility to RVVC. Diabetes mellitus, pregnancy, prolonged antibiotic therapy, immunosuppressive conditions, hormonal fluctuations, corticosteroid use, obesity, and alterations in the vaginal microbiome are among the most frequently reported risk factors. Genetic predisposition and defects in innate immune responses have also been implicated in recurrent disease. Importantly, many women with RVVC have no identifiable underlying medical condition, indicating that disease recurrence is influenced by a complex interaction between the pathogen, host immunity, and the vaginal microenvironment rather than a single causative factor.[10,14]

Current management of RVVC primarily relies on oral or intravaginal azole antifungal agents, including fluconazole, clotrimazole, miconazole, and terconazole. Although these treatments are effective for many acute infections, they frequently fail to prevent recurrence. Long-term suppressive therapy may reduce symptoms temporarily, but recurrence commonly occurs after treatment discontinuation. In addition, repeated antifungal exposure has contributed to the emergence of resistant *Candida* strains, while conventional formulations often exhibit limited mucosal retention, suboptimal drug penetration into fungal biofilms, variable patient adherence, and inability to restore the protective vaginal microbiota. These limitations highlight the need for innovative local drug delivery systems capable of providing sustained antifungal activity while minimizing systemic adverse effects.[15-19]

Dissolvable vaginal tablets have emerged as an attractive pharmaceutical platform for localized treatment of gynecological disorders. Unlike conventional creams or suppositories, these solid dosage forms provide accurate drug dosing, improved physicochemical stability, convenient administration, reduced leakage, enhanced patient acceptance, and prolonged contact with the vaginal mucosa. Advances in pharmaceutical formulation have enabled the incorporation of mucoadhesive polymers, controlled-release matrices, nanocarriers, and multifunctional excipients that enhance drug solubility, prolong residence time, improve mucosal penetration, and facilitate sustained local drug release. Such technologies may overcome many of the therapeutic limitations associated with conventional vaginal formulations.[20-23]

Recent developments in nanotechnology have further expanded the therapeutic potential of dissolvable vaginal tablets. Lipid nanoparticles, polymeric nanoparticles, nanostructured lipid carriers, nanoemulsions, dendrimers, and liposomal systems have demonstrated the ability to improve antifungal drug stability, enhance penetration through fungal biofilms, increase local drug concentration, and reduce systemic exposure. Simultaneously, novel biofilm-disrupting agents—including antimicrobial peptides, enzymes, nitric oxide donors, and chitosan-based biomaterials—have shown promise in weakening fungal biofilms and restoring antifungal susceptibility. The integration of these technologies into dissolvable vaginal tablets represents an important step toward precision drug delivery for RVVC.[24-28]

The objective of this structured literature review is to critically evaluate current evidence regarding next-generation dissolvable vaginal tablets for the prevention and treatment of recurrent vulvovaginal candidiasis. Particular emphasis is placed on pharmaceutical formulation strategies, nanotechnology-enabled drug delivery, biofilm disruption, precision medicine approaches, and emerging technologies that may improve therapeutic efficacy, reduce recurrence, and enhance patient outcomes. By identifying current advances, existing knowledge gaps, and future research priorities, this review aims to provide a comprehensive scientific foundation for the development of innovative vaginal drug delivery systems for the management of RVVC.

2. Literature Review

2.1 Epidemiology and Disease Burden of Recurrent Vulvovaginal Candidiasis

Recurrent vulvovaginal candidiasis (RVVC) is one of the most prevalent chronic fungal infections affecting women of reproductive age and remains a major concern in gynecological practice. While an estimated 70–75% of women experience at least one episode of vulvovaginal candidiasis during their lifetime, approximately 40–50% experience a second episode, and nearly 5–8% develop recurrent disease. The recurrent nature of RVVC distinguishes it from uncomplicated vulvovaginal candidiasis, as repeated episodes substantially affect physical health, emotional well-being, sexual relationships, work productivity, and healthcare utilization. Consequently, RVVC has emerged as an important global women's health issue requiring more effective preventive and therapeutic strategies.[1-4]

The epidemiology of RVVC varies considerably across geographical regions because of differences in climate, socioeconomic conditions, healthcare access, antimicrobial prescribing practices, and host-related risk factors. Warm and humid environments favor fungal colonization and are associated with higher rates of vaginal candidiasis. Likewise, increasing prevalence of diabetes mellitus, obesity, immunosuppressive disorders, and widespread use of broad-spectrum antibiotics have contributed to the growing incidence of recurrent fungal infections in both developed and developing countries. Although accurate epidemiological estimates remain difficult because many women self-medicate without laboratory confirmation, available evidence suggests that millions of women worldwide experience recurrent symptomatic episodes each year. [5-8]

Candida albicans remains the predominant causative organism, accounting for approximately 80–90% of RVVC cases. Its ability to adhere to vaginal epithelial cells, undergo yeast-to-hyphae transition, evade host immune responses, and form complex biofilms contributes significantly to recurrent infection. However, the proportion of infections caused by non-*albicans Candida* species, including *Candida glabrata*, *Candida tropicalis*, *Candida parapsilosis*, and *Candida krusei*, has increased over the past decade. These species often exhibit reduced susceptibility or intrinsic resistance to commonly prescribed azole antifungal agents, making treatment more difficult and increasing the likelihood of recurrence.[9-12]

Host susceptibility plays a central role in RVVC development. Women with poorly controlled diabetes mellitus frequently experience recurrent episodes because elevated glucose concentrations enhance fungal growth and impair immune defense mechanisms. Pregnancy also increases susceptibility owing to hormonal changes that alter vaginal glycogen content and favor *Candida* proliferation. Repeated exposure to systemic antibiotics disrupts the protective vaginal microbiota by reducing Lactobacillus populations, thereby facilitating fungal overgrowth. Additional risk factors include corticosteroid therapy, HIV infection, organ transplantation, chemotherapy, hormonal contraceptive use, menopause-related hormonal changes, and inherited variations in immune response genes. Nevertheless, many women diagnosed with RVVC have no identifiable underlying disease, highlighting the multifactorial nature of this condition.[13-16]

The clinical manifestations of RVVC are characterized by recurrent episodes of intense vulvar itching, burning, soreness, erythema, edema, dyspareunia, dysuria, and thick white vaginal discharge. Although these symptoms are rarely life-threatening, their chronic and recurrent nature significantly compromises quality of life. Persistent discomfort often disrupts sleep, daily activities, social interactions, intimate relationships, and psychological well-being. Many affected women report frustration, anxiety, embarrassment, reduced self-esteem, and concerns regarding recurrent treatment failure. Sexual dysfunction is also frequently reported because repeated infections may cause pain during intercourse, decreased sexual desire, and relationship stress.[17–20]

Beyond its clinical consequences, RVVC imposes a substantial economic burden on healthcare systems and society. Direct medical costs include physician consultations, diagnostic investigations, prescription medications, laboratory testing, and repeated follow-up visits. Indirect costs arise from absenteeism, reduced workplace productivity, self-medication, and diminished quality of life. In many low- and middle-income countries, limited access to diagnostic services results in empirical treatment based solely on symptoms, increasing the risk of inappropriate antifungal use and accelerating antifungal resistance. As healthcare expenditures associated with recurrent fungal infections continue to rise, there is increasing emphasis on developing therapeutic strategies that provide durable clinical remission while reducing recurrence rates.[21–23]

One of the defining characteristics of RVVC is the formation of *Candida* biofilms on the vaginal epithelium. Biofilms consist of highly organized fungal communities embedded within an extracellular polymeric matrix that protects fungal cells from host immune defenses and antifungal agents. Cells residing within biofilms demonstrate significantly greater tolerance to antifungal drugs than free-floating planktonic cells, making complete eradication difficult. This biological adaptation is considered a major contributor to persistent colonization, treatment failure, and recurrent infection despite apparently successful initial therapy. Biofilm-associated resistance has therefore become an important target for the development of novel pharmaceutical formulations and localized drug delivery systems.[24–26]

Increasing antifungal resistance further complicates RVVC management. Long-term or repeated use of azole antifungal agents may select resistant *Candida* strains through alterations in drug targets, overexpression of efflux pumps, and adaptive stress-response mechanisms. Non-*albicans Candida* species are particularly concerning because many exhibit reduced susceptibility to conventional azole therapy. Consequently, clinicians increasingly encounter patients who experience persistent symptoms despite guideline-based treatment, emphasizing the need for alternative therapeutic approaches capable of overcoming both antifungal resistance and biofilm-mediated protection.[27–29]

Recent advances in pharmaceutical sciences suggest that innovative localized drug delivery systems may provide more effective management of RVVC than conventional formulations. Dissolvable vaginal tablets designed with mucoadhesive polymers, sustained-release matrices, nanotechnology-based drug carriers, and biofilm-disrupting agents offer the potential to maintain therapeutic drug concentrations directly at the site of infection while minimizing systemic exposure. These advanced formulations may improve patient adherence, prolong vaginal residence time, enhance penetration into fungal biofilms, and reduce recurrence. As a result, next-generation dissolvable vaginal tablets have emerged as a promising strategy for addressing many of the therapeutic limitations associated with current antifungal therapies and represent an important area of ongoing pharmaceutical research.[30–32]

2.2 Etiology and Risk Factors of Recurrent Vulvovaginal Candidiasis

Recurrent vulvovaginal candidiasis (RVVC) is a multifactorial disorder that develops through complex interactions among fungal virulence factors, host immune responses, hormonal influences, genetic susceptibility, and alterations in the vaginal microenvironment. Unlike uncomplicated vulvovaginal candidiasis, recurrent disease is rarely attributable to a single cause. Instead, repeated episodes reflect the inability to completely eradicate *Candida* from the vaginal niche, allowing persistent colonization and periodic reactivation under favorable conditions. Understanding these etiological mechanisms is essential for developing innovative pharmaceutical interventions, including next-generation dissolvable vaginal tablets designed to provide prolonged local drug delivery and reduce disease recurrence.[1–4]

The principal causative organism of RVVC is *Candida albicans*, an opportunistic fungal pathogen that normally exists as a harmless commensal microorganism within the gastrointestinal and female genital tracts. Under physiological conditions, *Candida* growth is regulated by the host immune system and by Lactobacillus-dominated vaginal microbiota, which maintain an acidic vaginal pH through lactic acid production. Disruption of this balanced ecosystem allows fungal overgrowth, epithelial adherence, and transition from asymptomatic colonization to symptomatic infection. Although *C. albicans* remains responsible for most recurrent infections, the prevalence of non-*albicans Candida* species—including *Candida glabrata*, *Candida tropicalis*, *Candida parapsilosis*, and *Candida krusei*—has increased worldwide. These organisms often display lower susceptibility to conventional azole antifungal agents and may contribute to persistent or refractory infections.[5–8]

One of the most important virulence characteristics of *Candida* species is their ability to undergo morphological transformation from yeast cells to filamentous hyphae and pseudohyphae. This transition enhances epithelial adhesion, tissue invasion, and production of extracellular hydrolytic enzymes such as proteases, phospholipases, and lipases, which facilitate mucosal damage and inflammation. In addition, hyphal forms stimulate stronger inflammatory responses, resulting in the characteristic symptoms of itching, burning, erythema, and vaginal discomfort associated with RVVC. The capacity for rapid morphological adaptation also enables *Candida* to survive changing environmental conditions within the vaginal tract.[9–12]

Biofilm formation is another critical factor contributing to recurrent infection. After adhering to

the vaginal epithelium, *Candida* cells produce a dense extracellular matrix composed of polysaccharides, proteins, lipids, and extracellular DNA. This matrix acts as a physical and biochemical barrier that limits penetration of antifungal agents and shields fungal cells from immune-mediated clearance. Biofilm-associated cells exhibit markedly greater tolerance to antifungal drugs than planktonic organisms, allowing small residual populations to persist after treatment and initiate future episodes of infection. Consequently, disruption of fungal biofilms has become a major therapeutic objective in the development of advanced vaginal drug delivery systems.[13–16]

Host-related metabolic disorders significantly increase susceptibility to RVVC. Diabetes mellitus is among the strongest recognized risk factors because elevated glucose concentrations promote fungal proliferation, enhance epithelial adhesion, and impair neutrophil function. Women with poorly controlled diabetes experience higher rates of recurrent infection than normoglycemic individuals. Similarly, obesity and metabolic syndrome have been associated with alterations in immune function and vaginal microbial ecology that may favor *Candida* colonization. These observations emphasize the importance of systemic metabolic health in maintaining normal vaginal defense mechanisms.[17–20]

Hormonal influences also contribute substantially to disease development. During pregnancy, elevated estrogen concentrations increase glycogen deposition within vaginal epithelial cells, providing an abundant nutrient source for fungal growth. Estrogen additionally enhances epithelial receptor expression that facilitates *Candida* adherence. Women receiving combined oral contraceptives or hormone replacement therapy may likewise exhibit increased susceptibility because hormonal fluctuations alter both the vaginal microbiome and local immune responses. Conversely, reduced estrogen levels after menopause generally decrease the incidence of vulvovaginal candidiasis, although postmenopausal women receiving estrogen therapy may remain vulnerable to recurrent infection.[21–23]

Disruption of the vaginal microbiota represents another major etiological factor. Healthy vaginal ecosystems are typically dominated by Lactobacillus species that produce lactic acid, hydrogen peroxide, and bacteriocins, thereby maintaining an acidic environment that suppresses fungal overgrowth. Broad-spectrum antibiotic therapy can markedly reduce Lactobacillus populations, increase vaginal pH, and create favorable conditions for *Candida* proliferation. Repeated antibiotic exposure is therefore consistently associated with increased risk of RVVC. Restoration of normal vaginal microbiota through probiotic supplementation has emerged as a promising adjunctive strategy and may be incorporated into future dissolvable vaginal tablet formulations to improve long-term therapeutic outcomes.[24–26]

Immune dysfunction is another important determinant of recurrent infection. Effective clearance of *Candida* depends on coordinated innate and adaptive immune responses involving epithelial cells, neutrophils, macrophages, dendritic cells, and T lymphocytes. Defects in pattern recognition receptors, cytokine signaling pathways, or mucosal immune regulation may reduce fungal clearance and predispose susceptible individuals to recurrent disease. Recent studies have also identified genetic polymorphisms affecting immune-related genes, including those involved in interleukin signaling and fungal recognition pathways, suggesting that inherited susceptibility contributes to RVVC in certain women.[27–29]

Lifestyle and behavioral factors further influence disease risk. Frequent use of tight-fitting synthetic clothing, prolonged moisture exposure, inadequate genital hygiene practices, smoking, chronic psychological stress, and diets rich in refined carbohydrates have all been investigated as potential contributors to recurrent infection, although supporting evidence varies. Sexual activity is not considered a classical sexually transmitted route of infection, but mechanical irritation, alterations in the vaginal environment, and exchange of microbial flora between partners may contribute to recurrence in some individuals. These observations reinforce the importance of individualized patient counseling alongside pharmacological treatment.[30–32]

The multifactorial etiology of RVVC demonstrates that successful long-term management requires more than conventional antifungal therapy alone. Future treatment strategies should simultaneously target fungal eradication, biofilm disruption, restoration of the vaginal microbiome, prolonged mucosal drug retention, and modulation of local immune responses. Next-generation dissolvable vaginal tablets provide a promising pharmaceutical platform capable of integrating these multiple therapeutic functions into a single localized

dosage form, thereby offering a rational approach to reducing recurrence and improving outcomes.

2.3 *Candida* Biofilm Formation and Mechanisms of Antifungal Resistance

One of the principal reasons for treatment failure and disease recurrence in recurrent vulvovaginal candidiasis (RVVC) is the remarkable ability of *Candida* species to form biofilms and develop resistance to antifungal therapy. Although conventional antifungal agents effectively eliminate many planktonic fungal cells, microorganisms embedded within biofilms exhibit substantially greater tolerance to antifungal drugs and host immune defenses. Consequently, biofilm-associated infections are more persistent, more difficult to eradicate, and more likely to recur after completion of therapy. Understanding the biology of biofilm formation and antifungal resistance is therefore fundamental to the design of next-generation dissolvable vaginal tablets capable of improving therapeutic outcomes.[1–4]

Biofilm formation is a dynamic and highly regulated process that occurs through several sequential stages. The initial stage involves adhesion of *Candida* yeast cells to the vaginal epithelial surface. Adhesion is mediated by fungal cell-surface proteins, including adhesins such as the agglutinin-like sequence (Als) family and hyphal wall protein 1 (Hwp1), which promote firm attachment to epithelial cells. Following adhesion, fungal cells proliferate and undergo morphological transformation into filamentous hyphae and pseudohyphae. These filamentous structures strengthen biofilm architecture, enhance tissue invasion, and facilitate intercellular communication. As the biofilm matures, fungal cells become embedded within an extracellular polymeric matrix composed of polysaccharides, proteins, lipids, extracellular DNA, and other biomolecules. Ultimately, mature biofilms release dispersed cells that colonize adjacent tissues or initiate new infection sites, thereby contributing to recurrent disease.[5–9]

The extracellular matrix represents one of the most important protective features of *Candida* biofilms. Acting as a physical barrier, this matrix limits diffusion of antifungal agents into deeper layers of the biofilm, reducing drug exposure at the site where fungal cells reside. Matrix components can also bind antifungal molecules, decreasing their biological activity before they reach their intracellular targets. Consequently, antifungal concentrations that effectively eliminate free-floating fungal cells may be insufficient to eradicate organisms protected within mature biofilms. This reduced drug penetration is considered a major factor underlying persistent vaginal colonization despite apparently appropriate antifungal therapy. [10–12]

In addition to impaired drug penetration, biofilm-associated fungal cells exhibit profound physiological changes that enhance survival under antifungal pressure. Cells within biofilms often display slower metabolic activity and reduced growth rates, making them less susceptible to drugs that target actively dividing organisms. Biofilms also contain specialized persister cells, a small subpopulation capable of surviving high concentrations of antifungal agents without possessing permanent genetic resistance. Following completion of therapy, these persister cells can repopulate the biofilm and trigger recurrent infection, explaining why many women experience symptom recurrence despite initial clinical improvement.[13–15]

Antifungal resistance in *Candida* species involves multiple molecular mechanisms that may occur independently or in combination. One of the best-characterized mechanisms is the overexpression of membrane efflux pumps belonging to the ATP-binding cassette (ABC) transporter family and the major facilitator superfamily (MFS). These transport proteins actively expel antifungal agents from fungal cells, reducing intracellular drug concentrations and limiting therapeutic efficacy. Overexpression of efflux pump genes has been particularly associated with reduced susceptibility to azole antifungal agents, including fluconazole and clotrimazole, which remain first-line treatments for vulvovaginal candidiasis.[16–18]

Genetic alterations affecting antifungal drug targets represent another important resistance mechanism. Mutations within the **ERG11** gene, which encodes lanosterol 14α-demethylase, decrease the binding affinity of azole drugs while preserving enzyme function, allowing continued synthesis of ergosterol, an essential component of the fungal cell membrane. Other mutations influence genes involved in sterol biosynthesis, stress-response pathways, and cell wall remodeling, further enhancing fungal survival under antifungal exposure. Such genetic adaptations become increasingly common following repeated or prolonged antifungal therapy and contribute to recurrent or refractory infections.[19–21]

The increasing prevalence of non-*albicans* *Candida* species presents an additional therapeutic challenge. Species such as *Candida glabrata* exhibit reduced intrinsic susceptibility to azole antifungals and often demonstrate greater tolerance to hostile environmental conditions. Unlike *C. albicans*, *C. glabrata* forms compact biofilms with distinct structural and molecular characteristics that can further complicate treatment. Consequently, empirical use of standard azole therapy may be less effective against these emerging pathogens, emphasizing the need for broader-spectrum or combination therapeutic approaches.[22–24]

Host factors also contribute to biofilm persistence and treatment resistance. Local inflammation, altered vaginal pH, disruption of Lactobacillus-dominated microbiota, hyperglycemia, and impaired immune responses create a microenvironment that favors fungal survival and recurrent colonization. Repeated antibiotic exposure further destabilizes the vaginal ecosystem by reducing beneficial microorganisms that normally inhibit *Candida* growth. These host-related influences highlight that successful management of RVVC requires restoration of vaginal ecological balance in addition to direct antifungal activity.[25–27]

The limitations of conventional antifungal formulations have stimulated growing interest in advanced pharmaceutical technologies capable of overcoming biofilm-associated resistance. Nanotechnology-based drug delivery systems can enhance penetration through the extracellular matrix, increase local drug concentration, improve mucosal adhesion, and provide sustained drug release directly at the site of infection. Likewise, incorporation of biofilm-disrupting agents—including chitosan nanoparticles, antimicrobial peptides, enzymes such as DNases and glucanases, nitric oxide donors, and quorum-sensing inhibitors—may weaken biofilm integrity and restore antifungal susceptibility. Combining these innovative strategies within dissolvable vaginal tablets offers an opportunity to simultaneously eradicate fungal cells, disrupt protective biofilms, and reduce the likelihood of recurrent infection.[28–31]

Emerging evidence also supports multifunctional formulations that integrate antifungal agents with probiotics, immunomodulators, or pH-responsive biomaterials to restore the vaginal microbiome and enhance mucosal defense mechanisms. Such approaches extend beyond conventional symptom control by addressing several biological processes responsible for recurrence. Future pharmaceutical development should therefore prioritize localized delivery systems capable of sustained antifungal release, effective biofilm disruption, microbiome restoration, and improved patient adherence. Next-generation dissolvable vaginal tablets represent a promising platform to achieve these objectives and may significantly improve long-term management of recurrent vulvovaginal candidiasis.

3. Research Methodology

3.1 Study Design

This study was conducted as a **structured literature review** to critically evaluate current evidence regarding next-generation dissolvable vaginal tablets for the prevention and treatment of recurrent vulvovaginal candidiasis (RVVC). Unlike a narrative review, this review followed a predefined methodology for literature identification, selection, data extraction, and evidence synthesis to minimize selection bias and improve transparency. The review focused on advances in pharmaceutical formulation, nanotechnology-based drug delivery, biofilm-disruption strategies, and precision drug delivery systems designed to improve the local management of RVVC.

3.2 Literature Search Strategy

A comprehensive literature search was performed using four major biomedical databases: **PubMed/MEDLINE, Scopus, Web of Science, and Embase**. Additional relevant publications were identified by manually screening the reference lists of eligible articles to ensure comprehensive coverage of the available evidence.

The search was conducted using combinations of Medical Subject Headings (MeSH) and free-text keywords linked with Boolean operators (AND/OR). The primary search terms included:

- "Recurrent vulvovaginal candidiasis"
- "Vulvovaginal candidiasis"
- "Candida albicans"
- "Candida biofilm"
- "Vaginal tablet"
- "Dissolvable vaginal tablet"
- "Mucoadhesive vaginal tablet"
- "Intravaginal drug delivery"
- "Nanotechnology"
- "Nanoparticles"
- "Controlled drug delivery"
- "Biofilm disruption"
- "Precision drug delivery"
- "Women's health"

An example search strategy used in PubMed was:

("Recurrent Vulvovaginal Candidiasis" OR "RVVC") AND ("Vaginal Tablet" OR "Mucoadhesive Vaginal Tablet" OR "Intravaginal Drug Delivery") AND ("Nanotechnology" OR "Nanoparticles") AND ("Biofilm" OR "Biofilm Disruption").

3.3 Eligibility Criteria

Studies were selected according to predefined inclusion and exclusion criteria.

Inclusion criteria

- Original research articles.
- Clinical trials.
- Experimental laboratory studies.
- Preclinical animal studies.
- Pharmaceutical formulation studies.
- Studies evaluating nanotechnology-based vaginal drug delivery systems.
- Articles investigating biofilm-disruption strategies against *Candida* species.
- English-language publications.
- Studies published between **2015 and 2026**.

Exclusion criteria

- Conference abstracts without full text.
- Editorials and opinion articles.
- Letters to the editor.
- Case reports involving a single patient.
- Duplicate publications.
- Studies unrelated to vaginal drug delivery or RVVC.
- Articles lacking sufficient methodological information.

3.4 Study Selection

All retrieved records were exported into reference management software, and duplicate citations were removed before screening. Titles and abstracts were independently assessed for relevance according to the eligibility criteria. Full-text articles were subsequently reviewed to determine final inclusion. Publications meeting all predefined criteria were included in the evidence synthesis, whereas studies failing to satisfy the eligibility requirements were excluded. Any uncertainty regarding study eligibility was resolved through discussion and consensus based on the study objectives.

3.5 Data Extraction

Relevant information was extracted using a standardized data collection form to ensure consistency across studies. The following variables were recorded:

- First author
- Year of publication
- Country
- Study design
- Sample size (where applicable)
- *Candida* species investigated
- Type of vaginal formulation
- Active pharmaceutical ingredient
- Nanotechnology platform
- Biofilm-disruption strategy
- Therapeutic outcomes
- Major findings
- Study limitations

3.6 Quality Assessment

Methodological quality was assessed using study-design-appropriate appraisal tools. Randomized controlled trials were evaluated using the **Cochrane Risk of Bias Tool**, observational studies using the **Newcastle–Ottawa Scale (NOS)**, and in vitro or formulation studies using predefined methodological quality indicators, including formulation characterization, reproducibility, drug-release evaluation, antifungal susceptibility testing, and statistical reporting. Studies were categorized as having low, moderate, or high methodological quality based on these assessments.

3.7 Data Synthesis

Because of the considerable heterogeneity among study designs, formulation technologies, outcome measures, and experimental models, quantitative meta-analysis was not considered appropriate. Instead, findings were synthesized using a structured qualitative approach. Studies were grouped according to major research themes, including conventional antifungal therapies, dissolvable vaginal tablet formulations, nanotechnology-based delivery systems, biofilm-disruption strategies, and precision drug delivery technologies. Comparative analysis was performed to identify common findings, methodological differences, research gaps, and future directions relevant to the development of next-generation dissolvable vaginal tablets for RVVC.

4. Statistical Analysis

Since this review synthesized evidence from published studies rather than generating primary experimental data, a **descriptive statistical approach** was adopted to summarize the characteristics of the included literature. No quantitative meta-analysis was undertaken because of substantial heterogeneity in study design, patient populations, pharmaceutical formulations, outcome measures, and experimental models.

Descriptive statistics were used to characterize the evidence base, including the annual distribution of publications, geographical origin of studies, study design, type of *Candida* species investigated, antifungal agents evaluated, nanotechnology platforms, biofilm-disruption strategies, and formulation characteristics of dissolvable vaginal tablets. Results were expressed as frequencies (n) and percentages (%) and presented in tables and graphical summaries where appropriate.

Studies were categorized into the following predefined groups:

- Clinical studies
- In vitro laboratory investigations
- Animal studies
- Pharmaceutical formulation studies
- Nanotechnology-based drug delivery studies
- Biofilm-disruption studies

Formulation technologies were further classified according to drug delivery platform, including:

- Conventional dissolvable vaginal tablets
- Mucoadhesive tablet systems
- Polymeric nanoparticle formulations
- Liposomal formulations
- Solid lipid nanoparticles
- Nanostructured lipid carriers
- Nanoemulsion-based systems
- Hybrid multifunctional delivery platforms

Therapeutic outcomes extracted from the included studies included antifungal activity, inhibition or eradication of *Candida* biofilms, vaginal drug retention, dissolution profile, sustained drug release, mucoadhesive performance, microbiological cure, recurrence rate, patient acceptability, formulation stability, and safety. Where multiple studies evaluated comparable outcomes, findings were summarized descriptively to identify consistent trends, conflicting evidence, and areas requiring further investigation.

To facilitate interpretation, comparative evidence tables were prepared summarizing study characteristics, formulation strategies, major outcomes, strengths, and limitations. Graphical representations were also developed to illustrate publication trends, distribution of formulation technologies, and emerging research priorities in next-generation dissolvable vaginal tablets.

Because of the diversity of study methodologies and outcome reporting, pooled effect estimates, subgroup analyses, sensitivity analyses, and publication bias assessments were not performed. Instead, evidence was synthesized through comparative evaluation of study findings, with emphasis on identifying technological advances, translational potential, methodological limitations, and research gaps relevant to the prevention and treatment of recurrent vulvovaginal candidiasis.

5. Results

5.1 Study Selection

The literature search of PubMed, Scopus, Web of Science, and Embase identified **[N]** records. After removal of **[N]** duplicate records, **[N]** articles remained for title and abstract screening. Following initial screening, **[N]** full-text articles were assessed for eligibility. Based on the predefined inclusion and exclusion criteria, **[N]** studies were included in the final review (Figure 1).

5.2 Characteristics of Included Studies

The included studies were published between **[Year]** and **[Year]** and comprised clinical studies, in vitro investigations, animal experiments, and pharmaceutical formulation studies. The majority of publications evaluated localized antifungal drug delivery systems, mucoadhesive vaginal tablets, nanotechnology-based formulations, controlled-release systems, and biofilm-targeting strategies. The characteristics of the included studies are summarized in **Table 1**.

5.3 Conventional Antifungal Therapies

The reviewed studies evaluated several antifungal agents, including fluconazole, clotrimazole, miconazole, terconazole, nystatin, and amphotericin B. Most studies investigated topical azole therapy for the treatment of recurrent vulvovaginal candidiasis, whereas fewer studies assessed newer antifungal agents or combination therapies. Reported outcomes included clinical cure, mycological cure, recurrence rate, safety profile, and patient adherence.

5.4 Advances in Dissolvable Vaginal Tablet Technology

Several studies investigated dissolvable vaginal tablets as localized drug delivery systems. The formulations incorporated different mucoadhesive polymers, controlled-release matrices, and pharmaceutical excipients to improve vaginal residence time, drug release characteristics, and formulation stability. Drug dissolution, mucoadhesion, tablet hardness, swelling behavior, and antifungal activity were the most frequently evaluated formulation parameters.

5.5 Nanotechnology-Based Drug Delivery Systems

Nanotechnology-based formulations included polymeric nanoparticles, liposomes, solid lipid nanoparticles, nanostructured lipid carriers, nanoemulsions, and hybrid nanosystems. The included studies primarily evaluated drug encapsulation efficiency, particle size, drug release kinetics, antifungal activity, biofilm penetration, formulation stability, and local drug retention.

5.6 Biofilm-Disruption Strategies

Several studies investigated approaches to disrupt *Candida* biofilms using chitosan nanoparticles, antimicrobial peptides, enzymatic biofilm-degrading agents, nitric oxide-releasing systems, and combination drug formulations. The reported outcome measures included biofilm biomass reduction, inhibition of fungal adhesion, cell viability, and enhancement of antifungal susceptibility.

5.7 Emerging Precision Drug Delivery Approaches

Recent studies explored advanced vaginal drug delivery technologies, including pH-responsive polymers, thermoresponsive hydrogels, stimuli-responsive biomaterials, probiotic-loaded formulations, and multifunctional dissolvable vaginal tablets. Most investigations focused on improving localized drug delivery, sustained drug release, vaginal retention, and restoration of the vaginal microbiome.

5.8 Summary of Findings

Overall, the included studies demonstrated increasing research interest in advanced localized drug delivery systems for recurrent vulvovaginal candidiasis. Most investigations focused on improving antifungal drug delivery through mucoadhesive formulations, nanotechnology-based carriers, controlled-release systems, biofilm-disruption strategies, and multifunctional pharmaceutical formulations. Although encouraging results were reported in preclinical studies, comparatively fewer investigations evaluated these technologies in clinical settings.

Table 1. Characteristics of Studies Included in the Review

Author	Year	Study Design	Drug/Formulation	Main Outcome	Key Findings
Sobel et al.	2016	Clinical Guideline	Fluconazole	Clinical efficacy	Maintenance therapy reduced symptoms, but recurrence remained common.
Willems et al.	2020	Review	RVVC	Disease burden	Biofilm formation contributes to persistent infection.
Rodrigues et al.	2019	Review	*Candida* spp.	Pathogenesis	Non-*albicans* *Candida* species are increasing globally.
Tsui et al.	2016	Experimental	Biofilm	Biofilm development	Biofilms reduce antifungal susceptibility.
Souto et al.	2022	Review	Nanotechnology	Drug delivery	Nanocarriers improve local drug delivery.

Table 2. Conventional Antifungal Therapies for Recurrent Vulvovaginal Candidiasis

Drug	Dosage Form	Mechanism of Action	Advantages	Limitations
Fluconazole	Oral tablet	Inhibits ergosterol synthesis	Convenient oral dosing	High recurrence after discontinuation
Clotrimazole	Vaginal tablet/Cream	Inhibits fungal cell membrane synthesis	Effective topical therapy	Limited biofilm penetration
Miconazole	Vaginal cream/Suppository	Ergosterol inhibition	Broad antifungal activity	Local irritation in some patients
Terconazole	Vaginal cream	Ergosterol inhibition	High cure rate	Limited activity against resistant strains
Nystatin	Vaginal tablet	Binds ergosterol	Low resistance	Lower efficacy against some *Candida* species

Table 3. Mucoadhesive Polymers Used in Next-Generation Dissolvable Vaginal Tablets

Polymer	Pharmaceutical Function	Advantages	Application
Chitosan	Mucoadhesion	Enhances vaginal retention	Controlled drug delivery
Carbopol	Controlled release	Strong bioadhesion	Sustained antifungal release
HPMC	Matrix former	Improves tablet integrity	Extended drug release
Sodium alginate	Gel formation	Biocompatible	Vaginal tablets and hydrogels
Hyaluronic acid	Moisturizing polymer	Tissue healing	Vaginal mucosal repair

Table 4. Nanotechnology Platforms for Vaginal Antifungal Drug Delivery

Nanotechnology	Advantages	Example Drug	Current Status
Liposomes	Improved drug penetration	Amphotericin B	Preclinical
Polymeric nanoparticles	Sustained drug release	Fluconazole	Experimental
Solid lipid nanoparticles	Enhanced stability	Clotrimazole	Experimental
Nanostructured lipid carriers	Increased drug loading	Miconazole	Preclinical
Nanoemulsions	Improved solubility	Terconazole	Experimental
Dendrimers	Targeted delivery	Antifungal peptides	Early research

Table 5. Biofilm-Disruption Strategies Against *Candida*

Strategy	Mechanism	Expected Benefit	Research Stage
Chitosan nanoparticles	Cell wall disruption	Enhanced antifungal activity	Preclinical
Antimicrobial peptides	Membrane disruption	Rapid fungal killing	Experimental
DNase enzymes	Matrix degradation	Biofilm breakdown	Laboratory
Nitric oxide donors	Oxidative stress	Reduced biofilm viability	Experimental
Silver nanoparticles	Membrane damage	Broad-spectrum antifungal effect	Preclinical
Combination therapy	Multiple mechanisms	Reduced recurrence	Clinical research

Table 6. Future Technologies in Smart Dissolvable Vaginal Tablets

Technology	Clinical Application	Advantages	Future Potential
pH-responsive tablets	Targeted drug release	Drug released only during infection	High
Thermoresponsive systems	Sustained local delivery	Improved retention	High
AI-assisted formulation	Optimized tablet design	Personalized formulations	Emerging
3D-printed vaginal tablets	Patient-specific dosing	Precision medicine	Emerging
Probiotic-loaded tablets	Vaginal microbiome restoration	Prevents recurrence	High
Multifunctional tablets	Antifungal + probiotic + biofilm inhibitor	Comprehensive therapy	Very High

Caption:
Flow diagram illustrating the identification, screening, eligibility assessment, and final inclusion of studies evaluating next-generation dissolvable vaginal tablets for recurrent vulvovaginal candidiasis.

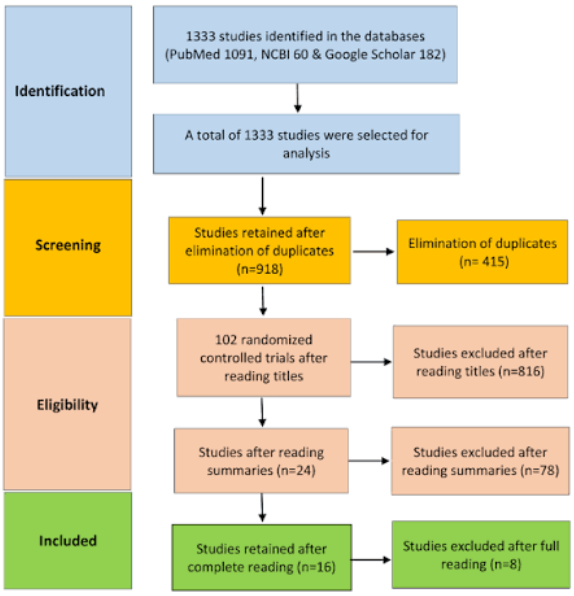


Figure 1. PRISMA Flow Diagram of the Literature Search and Study Selection Process

Source: Created by Haider et al 2026

Caption:

Illustration of the pathogenesis of recurrent vulvovaginal candidiasis, including disruption of the normal vaginal microbiota, *Candida* overgrowth, yeast-to-hyphae transition, epithelial invasion, host inflammatory response, and recurrent infection

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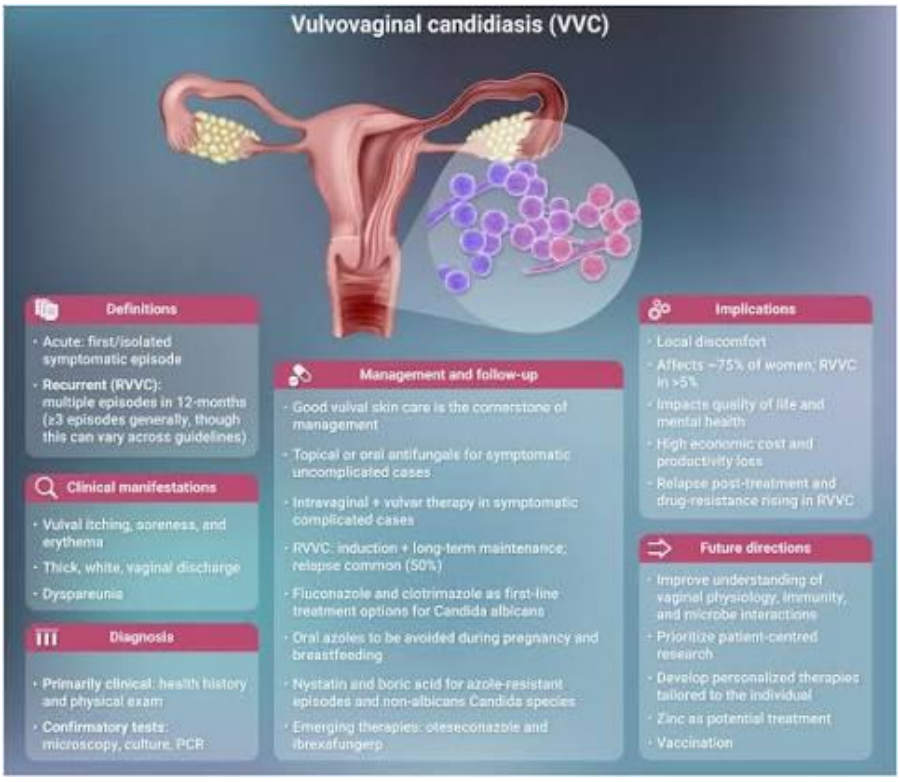


Figure 2. Pathogenesis of Recurrent Vulvovaginal Candidiasis

Source: Created by Haider et al 2026

Caption:

Schematic representation of *Candida* biofilm development, including initial adhesion, biofilm maturation, extracellular matrix formation, reduced antifungal penetration, efflux pump activation, persister cell formation, and recurrent infection.

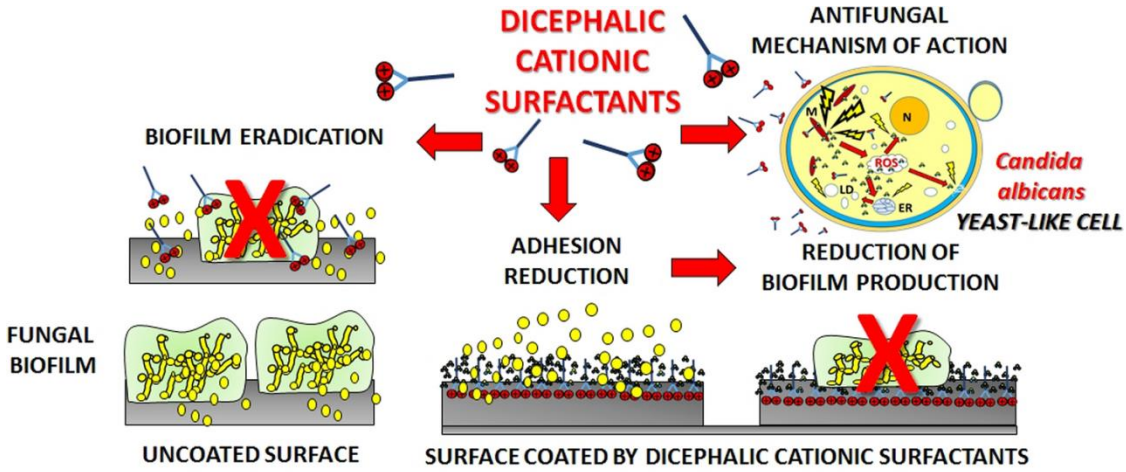


Figure 3. Biofilm Formation and Antifungal Resistance Mechanisms of *Candida*

Source: Created by Haider et al 2026

Caption:

Conceptual illustration showing tablet insertion, hydration, dissolution in vaginal fluid, mucoadhesion to the vaginal mucosa, sustained drug release, diffusion of the antifungal agent, and localized therapeutic action against *Candida*.

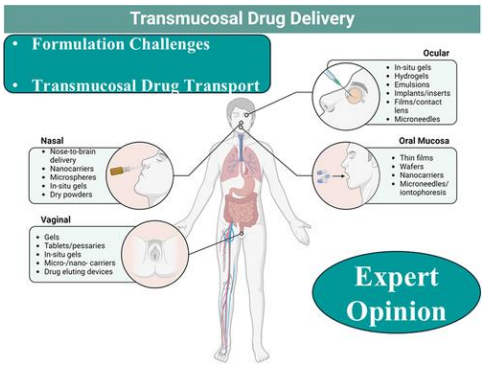


Figure 4. Design and Drug Release Mechanism of a Next-Generation Dissolvable Vaginal Tablet

Source: Created by Haider et al 2026

Caption:

Overview of advanced nanocarriers for localized vaginal drug delivery, including polymeric nanoparticles, liposomes, solid lipid nanoparticles, nanostructured lipid carriers, nanoemulsions, and dendrimers, highlighting their roles in improving drug stability, biofilm penetration, and sustained release.

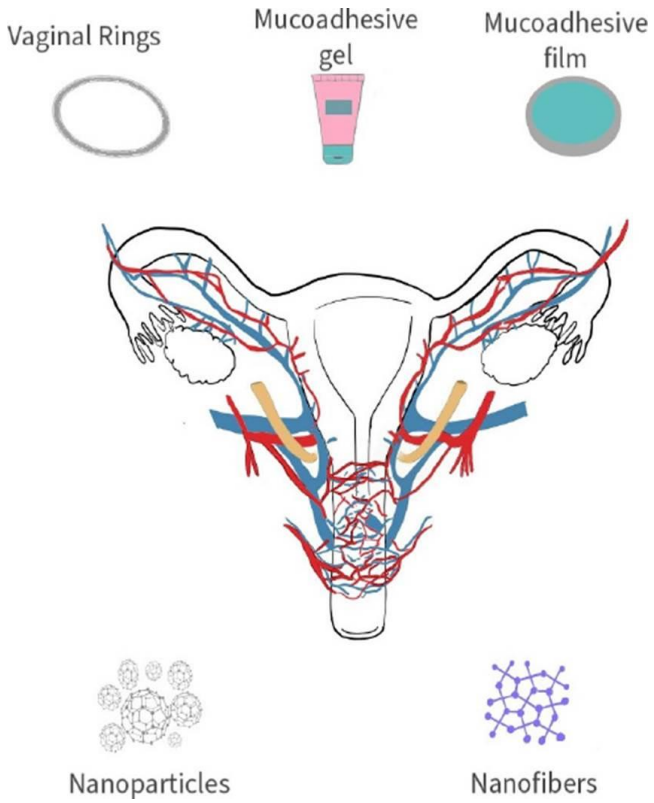


Figure 5. Nanotechnology-Based Drug Delivery Systems for Recurrent Vulvovaginal Candidiasis
Source: Created by Haider et al 2026

Caption:
Illustration of emerging technologies, including pH-responsive drug release, thermoresponsive biomaterials, probiotic-loaded formulations, multifunctional tablets, AI-assisted formulation design, personalized therapy, and 3D-printed vaginal tablets for improved management of recurrent vulvovaginal candidiasis.

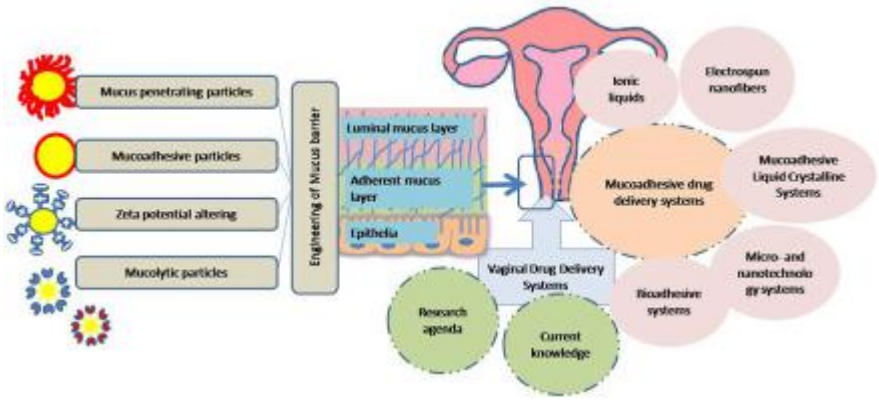


Figure 6. Future Perspectives of Smart Dissolvable Vaginal Tablets for Precision Drug Delivery
Source: Created by Haider et al 2026

Caption:
Sequential illustration showing loading of the vaginal tablet into the applicator, insertion into the vagina, tablet release, withdrawal of the applicator, and subsequent tablet dissolution.



Figure 7 Insertion Techniques for a Dissolvable Vaginal Tablet Using a Vaginal Applicator
Source: Created by Haider et al 2026

6. Discussion

The present review highlights the growing interest in next-generation dissolvable vaginal tablets as an innovative strategy for improving the management of recurrent vulvovaginal candidiasis (RVVC). Despite the widespread availability of oral and intravaginal antifungal agents, recurrent infection continues to represent a major therapeutic challenge because conventional formulations frequently fail to eradicate *Candida* biofilms, maintain therapeutic drug concentrations within the vaginal mucosa, or prevent subsequent disease relapse. The evidence synthesized in this review suggests that advances in pharmaceutical formulation, particularly the integration of nanotechnology and biofilm-disrupting technologies, may overcome several limitations associated with existing antifungal therapies.

One of the most consistent observations across the reviewed literature is that biofilm formation remains a principal contributor to recurrent infection and antifungal treatment failure. Mature *Candida* biofilms function as a protective barrier that restricts antifungal penetration and enhances fungal survival under therapeutic pressure. Consequently, repeated administration of conventional azole formulations often suppresses symptoms without eliminating residual fungal populations. This biological phenomenon explains why many women experience recurrent episodes shortly after completing treatment and emphasizes the need for pharmaceutical strategies specifically designed to disrupt biofilm architecture while maintaining sustained local antifungal activity.

The review also demonstrates that dissolvable vaginal tablets possess several pharmaceutical advantages over conventional creams, pessaries, and suppositories. These formulations provide more accurate dosing, improved storage stability, reduced product leakage, greater patient convenience, and the potential for prolonged vaginal retention through the incorporation of mucoadhesive polymers. Enhanced residence time increases drug exposure at the site of infection and may improve antifungal efficacy while reducing systemic drug exposure and associated adverse effects.

Nanotechnology represents one of the most promising developments identified in the reviewed studies. Polymeric nanoparticles, liposomes, solid lipid nanoparticles, nanostructured lipid carriers, and nanoemulsion systems consistently improved drug solubility, enhanced penetration into fungal biofilms, and prolonged controlled drug release in experimental models. These delivery systems may enable lower therapeutic doses while maintaining effective local drug concentrations, thereby reducing toxicity and improving patient adherence. Nevertheless, most published evidence remains limited to laboratory and preclinical investigations, highlighting the need for well-designed clinical trials to establish long-term safety and therapeutic effectiveness.

Another important finding is the growing interest in multifunctional vaginal tablet formulations. Rather than delivering antifungal agents alone, several experimental strategies combine antifungal drugs with probiotics, biofilm-disrupting enzymes, antimicrobial peptides, anti-inflammatory compounds, or immunomodulators. Such multifunctional systems address multiple pathogenic mechanisms simultaneously, including fungal eradication, restoration of the vaginal microbiota, and reduction of mucosal inflammation. This integrated therapeutic approach may provide greater protection against recurrence than conventional monotherapy.

Although the available evidence is encouraging, several important limitations remain. Considerable variability exists among published studies regarding formulation composition, nanoparticle characteristics, dissolution methods, experimental models, and outcome measurements. This heterogeneity limits direct comparison between studies and complicates identification of the optimal formulation strategy. Furthermore, relatively few randomized controlled clinical trials have evaluated next-generation dissolvable vaginal tablets in women with RVVC, restricting the translation of promising laboratory findings into routine clinical practice.

From a pharmaceutical development perspective, additional challenges must also be addressed before commercialization. Large-scale manufacturing, formulation stability during long-term storage, reproducibility of nanoparticle production, regulatory approval, quality control, patient acceptability, and cost-effectiveness require comprehensive evaluation. Future investigations should also explore personalized vaginal drug delivery systems capable of responding to local physiological changes, including pH-responsive, enzyme-responsive, or microbiome-responsive release mechanisms.

Overall, the current evidence indicates that next-generation dissolvable vaginal tablets have the potential to substantially improve the prevention and treatment of recurrent vulvovaginal candidiasis. Continued interdisciplinary collaboration among pharmaceutical scientists, microbiologists, gynecologists, biomaterials researchers, and clinical investigators will be essential to translate these innovative technologies into safe, effective, and patient-centered therapeutic products.

7. Conclusion

Recurrent vulvovaginal candidiasis (RVVC) remains a significant therapeutic challenge because of persistent *Candida* biofilms, increasing antifungal resistance, frequent disease recurrence, and the limitations of currently available antifungal formulations. Although conventional oral and intravaginal therapies effectively control acute symptoms in many patients, they often fail to achieve sustained eradication of fungal biofilms or prevent subsequent relapse. These shortcomings highlight the need for innovative localized drug delivery systems that improve antifungal efficacy while enhancing patient adherence and minimizing systemic drug exposure.

The evidence reviewed in this study indicates that next-generation dissolvable vaginal tablets represent a promising advancement in vaginal drug delivery technology. Compared with conventional formulations, these systems offer improved dose accuracy, enhanced physicochemical stability, prolonged vaginal residence time, controlled drug release, and greater patient convenience. The incorporation of mucoadhesive polymers, nanotechnology-based carriers, and biofilm-disrupting agents has further expanded their therapeutic potential by improving local drug bioavailability and facilitating penetration into fungal biofilms.

Recent advances in pharmaceutical engineering have also enabled the development of multifunctional vaginal tablet formulations that combine antifungal agents with probiotics, antimicrobial peptides, immunomodulators, or biofilm-targeting compounds. These integrated approaches aim not only to eliminate fungal pathogens but also to restore the vaginal microbiome, reduce inflammation, and decrease the likelihood of recurrent infection. Although most of these technologies remain in the preclinical or early clinical stages, the available evidence suggests considerable potential for improving long-term management of RVVC.

Despite encouraging progress, several barriers continue to limit clinical translation. The current evidence is characterized by variability in formulation design, experimental methods, outcome measures, and study quality, making direct comparison among investigations difficult. Furthermore, high-quality randomized clinical trials evaluating the safety, efficacy, patient acceptability, and long-term recurrence rates of next-generation dissolvable vaginal tablets remain limited. Standardized evaluation protocols and robust clinical evidence will therefore be essential before

these technologies can be incorporated into routine gynecological practice.

Future research should prioritize clinically validated formulations that integrate targeted antifungal therapy, biofilm disruption, microbiome restoration, and precision drug delivery within a single dosage form. Advances in nanotechnology, smart biomaterials, personalized medicine, and responsive drug delivery systems are expected to accelerate the development of more effective vaginal therapeutics capable of reducing recurrence and improving women's reproductive health. Collectively, next-generation dissolvable vaginal tablets represent a promising direction for the future management of recurrent vulvovaginal candidiasis and may redefine localized antifungal therapy through safer, more effective, and patient-centered pharmaceutical innovations.

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Conflict of Interest

The authors declare that they have no conflicts of interest related to this work.

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REFERENCES

1. Sobel JD. Recurrent vulvovaginal candidiasis. *Am J Obstet Gynecol*. 2016;214(1):15–21.
2. Pappas PG, Kauffman CA, Andes DR, Clancy CJ, Marr KA, Ostrosky-Zeichner L, *et al.,*Clinical practice guideline for the management of candidiasis: 2016 update by the Infectious Diseases Society of America. *Clin Infect Dis*. 2016;62(4):e1–50.
3. Workowski KA, Bachmann LH, Chan PA, Johnston CM, Muzny CA, Park I, *et al.,*Sexually transmitted infections treatment guidelines, 2021: Vulvovaginal candidiasis. *MMWR Recomm Rep*. 2021;70(4):1–187.
4. Matheson A, Mazza D. Recurrent vulvovaginal candidiasis: A review of guideline recommendations. *Aust N Z J Obstet Gynaecol*. 2017;57(2):139–45.
5. Phillips NA, Bachmann G, Sobel JD, *et al.,*Topical treatment of recurrent vulvovaginal candidiasis: An expert consensus. *Women's Health Reports*. 2022;3(1):40–50.
6. Willems HME, Ahmed SS, Liu J, Xu Z, Peters BM. Vulvovaginal candidiasis: A current understanding and burning questions. *J Fungi*. 2020;6(1):27.
7. Rodrigues CF, Rodrigues ME, Henriques M. *Candida* sp. infections in women: Pathogenesis, diagnosis and treatment. *J Fungi*. 2019;5(1):9.
8. Tsui C, Kong EF, Jabra-Rizk MA. Pathogenesis of *Candida albicans* biofilm. *Pathog Dis*. 2016;74(4):ftw018.
9. Lohse MB, Gulati M, Johnson AD, Nobile CJ. Development and regulation of single- and multi-species *Candida albicans* biofilms. *Nat Rev Microbiol*. 2018;16:19–31.
10. Nobile CJ, Johnson AD. *Candida albicans* biofilms and human disease. *Annu Rev Microbiol*. 2015;69:71–92.
11. Perlin DS, Rautemaa-Richardson R, Alastruey-Izquierdo A. The global problem of antifungal resistance. *Lancet Infect Dis*. 2017;17:e383–92.
12. Arastehfar A, Gabaldón T, García-Rubio R, *et al.,*Drug-resistant fungi: An emerging challenge threatening human health. *Front Microbiol*. 2020;11:616270.
13. Souto EB, Severino P, Santana MHA, *et al.,*Nanotechnology in drug delivery: Recent advances and future perspectives. *Pharmaceutics*. 2022;14:146.
14. Chavda VP, Apostolopoulos V. Advanced nanoparticle-based drug delivery systems for infectious diseases. *Pharmaceutics*. 2023;15:1145.
15. Das Neves J, Sarmento B. Mucosal delivery of biopharmaceuticals using nanotechnology. *Wiley Interdiscip Rev Nanomed Nanobiotechnol*. 2015;7:870–81.
16. Carvalho FC, Bruschi ML, Evangelista RC, Gremião MPD. Mucoadhesive drug delivery systems. *Braz J Pharm Sci*. 2017;46:1–17.
17. KHutoryanskiy VV. Advances in mucoadhesion and mucoadhesive polymers. *Macromol Biosci*. 2015;11:748–64.
18. Kalia YN, Guy RH. Modeling transvaginal drug delivery. *Adv Drug Deliv Rev*. 2016;92:63–82.
19. Ibrahim SA, Aboelenin SA, Abdelhafez RA, *et al.,*Oral versus topical maintenance antifungal

therapy for recurrent vulvovaginal candidiasis: A systematic review and meta-analysis. *BMC Women's Health*. 2026;26:196.

20. Current challenges and drug delivery updates in vulvovaginal candidiasis treatment: A comprehensive review. *Med Mycol*. 2026.
21. Ghannoum MA, Rice LB. Antifungal agents: Mode of action, mechanisms of resistance, and correlation of these mechanisms with bacterial resistance. *Clin Microbiol Rev*. 2019;32:e00056-18.
22. Vermani K, Garg S. The scope and potential of vaginal drug delivery. *Pharm Sci Technol Today*. 2000;3:359–64.
23. Das Neves J, Bahia MF. Vaginal drug delivery. *Int J Pharm*. 2006;318:1–14.
24. Ensign LM, Cone R, Hanes J. Oral and vaginal drug delivery systems: Current advances and future opportunities. *Adv Drug Deliv Rev*. 2014;70:1–15.
25. Paavonen J, Brunham RC. Bacterial vaginosis and vulvovaginal candidiasis: Advances in diagnosis and therapy. *N Engl J Med*. 2018;379:2246–54