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Buccal Tablets as an Effective Drug Delivery Platform: Advances and Challenges

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Abstract: *Buccal tablets have gained significant attention as a novel and effective platform for drug delivery, especially for therapeutics requiring rapid onset of action or protection from harsh gastrointestinal conditions. Administered via the buccal mucosa, these tablets allow direct absorption into the systemic circulation, bypassing first-pass hepatic metabolism and enhancing the bioavailability of many drugs. This route is particularly advantageous for peptides, proteins, and drugs with low solubility or stability in the gastrointestinal tract. The incorporation of mucoadhesive polymers, permeation enhancers, and controlled-release technologies has contributed to improved retention time, targeted delivery, and consistent drug absorption profiles. Additionally, patient compliance is generally high due to the non-invasive nature and ease of administration. Despite these benefits, several challenges limit the widespread adoption of buccal tablets. The buccal cavity has a relatively small surface area for drug absorption and is continuously exposed to saliva, which may dilute the drug and affect its bioavailability. Moreover, interpatient variability in mucosal permeability and potential for irritation or allergic reactions can complicate formulation and dosing strategies. Ensuring adequate adhesion, drug stability, and controlled release over time remains a critical area of ongoing research. Overall, buccal tablets present a promising alternative for targeted and systemic drug delivery, particularly for drugs that are unsuitable for oral or injectable routes. Continued advancements in polymer science, nanotechnology, and drug formulation are expected to overcome existing barriers and further establish buccal tablets as a versatile and reliable drug delivery system in clinical practice.*

Keywords: Buccal tablets, drug delivery, mucoadhesive polymers, bioavailability, controlled release, oral mucosa, systemic absorption

I. INTRODUCTION

Overview of Drug Delivery Systems

Drug delivery systems (DDS) have become a cornerstone of modern pharmacotherapy, enabling more efficient, safe, and targeted treatment of a wide range of diseases. A drug delivery system is a formulation or device that facilitates the introduction of a therapeutic substance into the body and modulates its release profile, absorption, distribution, and elimination to achieve desired therapeutic outcomes. The primary objective of DDS is to deliver the right amount of drug, at the right time, to the right location in the body, thereby maximizing efficacy while minimizing adverse effects.[1,2]

Traditional drug administration methods, such as oral ingestion or intravenous injection, often pose significant limitations. These may include poor drug solubility, degradation in the gastrointestinal tract, rapid clearance from the bloodstream, and a lack of specificity that can lead to systemic side effects. Consequently, there has been a growing demand for innovative drug delivery strategies that overcome these challenges and provide controlled, sustained, and site-specific delivery.

The field of drug delivery has seen rapid advancements over the past few decades, driven by progress in materials science, biotechnology, and nanotechnology. Modern DDS encompass a broad spectrum of technologies, including controlled-release formulations, transdermal systems, inhalers, injectables with sustained release properties, and

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advanced nanocarrier systems such as liposomes, micelles, dendrimers, and polymeric nanoparticles. These technologies not only enhance the pharmacokinetic and pharmacodynamic profiles of drugs but also contribute to improving patient adherence and quality of life.

Moreover, the emergence of personalized medicine has further fueled the development of smart and responsive drug delivery platforms that can adapt to individual patient needs, environmental triggers, or disease-specific markers. With the integration of biosensors, artificial intelligence, and precision diagnostics, the future of drug delivery is moving toward more intelligent and individualized therapeutic approaches.[3,4]

In summary, drug delivery systems represent a transformative evolution in the way therapeutic agents are administered. By ensuring that drugs are delivered in a controlled and targeted manner, DDS significantly improve treatment outcomes and play a crucial role in the ongoing advancement of modern medicine.[5]

Importance of Alternative Routes to Oral and Parenteral Delivery

While oral and parenteral routes remain the most commonly used methods for drug administration, they are not always ideal due to various physiological, pharmacokinetic, and patient-related limitations. Oral delivery, although convenient and non-invasive, can be hindered by poor bioavailability due to degradation in the gastrointestinal tract, first-pass metabolism in the liver, and variable absorption. Similarly, parenteral routes such as intravenous or intramuscular injections provide rapid systemic effects but are invasive, may cause pain or discomfort, and require skilled administration, making them less suitable for chronic therapies or self-administration.

To address these challenges, alternative delivery routes—such as transdermal, intranasal, pulmonary, ocular, buccal, sublingual, rectal, and vaginal—have gained significant attention. These methods offer several advantages, including improved patient compliance, avoidance of first-pass metabolism, targeted or localized drug action, and the potential for sustained or controlled drug release. For instance, transdermal patches can provide continuous systemic drug delivery over days, while inhalation routes allow for rapid onset of action and direct delivery to the lungs, which is particularly beneficial in respiratory diseases. Buccal and sublingual routes bypass hepatic metabolism and provide faster absorption compared to oral intake.

Moreover, alternative routes are especially important for drugs that are poorly soluble, unstable in the gastrointestinal environment, or require localized action. They also provide critical options for pediatric, geriatric, or unconscious patients who may struggle with swallowing pills or tolerating injections. With advancements in drug formulation technologies, these non-conventional routes are playing an increasingly vital role in optimizing therapeutic outcomes, enhancing convenience, and broadening the scope of treatable conditions.

Buccal drug delivery is an increasingly recognized alternative route for systemic drug administration, offering several advantages over conventional oral and parenteral routes. This method involves the placement of a drug formulation, typically in the form of a buccal tablet, in the buccal cavity (the inner lining of the cheek), where it adheres to the mucosal membrane and releases the drug for absorption. Buccal tablets are designed to remain in position, often using bioadhesive polymers, and provide controlled and sustained drug release directly through the mucosal tissue.

The buccal mucosa is a promising site for drug delivery due to its rich vascularization, relatively permeable epithelial surface, and ability to bypass the harsh conditions of the gastrointestinal tract and hepatic first-pass metabolism. Unlike sublingual delivery, which provides a rapid onset of action, buccal delivery is better suited for prolonged drug absorption. Additionally, the buccal route offers the potential for localized treatment as well as systemic delivery, depending on the drug and formulation.

Buccal tablets are especially beneficial for patients who experience difficulty swallowing, such as pediatric, geriatric, or critically ill individuals, and for drugs that degrade in the gastrointestinal environment or have poor oral bioavailability. With advancements in mucoadhesive materials, permeability enhancers, and controlled release technologies, buccal delivery systems have emerged as a valuable platform in modern pharmaceutical development.[6-10]

Aim and Scope of the Review

The primary aim of this review is to provide a comprehensive overview of buccal drug delivery systems, with a particular focus on buccal tablets. This article explores the anatomical and physiological characteristics of the buccal

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mucosa that make it suitable for drug delivery, discusses the formulation strategies and types of polymers used in buccal tablets, and evaluates their advantages, limitations, and clinical applications. Furthermore, the review highlights recent advances in the field, including novel bioadhesive materials, drug release technologies, and innovative approaches to enhance buccal permeability.

The scope of this review also extends to examining the regulatory aspects, challenges in formulation development, and future trends in buccal drug delivery. By summarizing current knowledge and ongoing research, the article aims to support further innovation and application of buccal tablets as a patient-friendly and effective drug delivery platform.

II. BUCCAL MUCOSA: ANATOMY AND PHYSIOLOGY

Structure and Characteristics of the Buccal Mucosa

The buccal mucosa is the inner lining of the cheeks and is a part of the oral mucosal system, which also includes the sublingual and gingival regions. Histologically, it is composed of a stratified squamous epithelium overlaying a connective tissue lamina propria. Unlike the keratinized epithelium found in regions like the gingiva and hard palate, the buccal mucosa is predominantly non-keratinized, making it more permeable to drug molecules. This epithelium is supported by a rich network of blood vessels in the underlying tissue, which plays a vital role in facilitating rapid drug uptake into the systemic circulation.

Permeability and Absorption Mechanisms

Drug absorption through the buccal mucosa occurs primarily via passive diffusion across the epithelial cell layers. The buccal epithelium allows for both transcellular (through cells) and paracellular (between cells) transport, although the transcellular route is generally more favorable for lipophilic drugs. The presence of tight junctions and the relatively thick epithelial layer can present resistance to drug permeation; however, these can be modulated through formulation strategies such as the inclusion of permeation enhancers, mucoadhesive polymers, or enzyme inhibitors. Once absorbed, the drug enters the local capillary network and is transported via the facial vein to the systemic circulation, effectively bypassing hepatic first-pass metabolism.

Advantages of the Buccal Route

One of the key advantages of the buccal route is the avoidance of first-pass hepatic metabolism, which significantly enhances the bioavailability of certain drugs that are extensively metabolized when taken orally. Additionally, the buccal route allows for controlled and sustained release of drugs, reducing dosing frequency and improving patient compliance. It is also non-invasive and suitable for self-administration, making it an attractive option for chronic therapies. Moreover, the accessibility of the buccal cavity enables easy monitoring and removal of the dosage form if necessary, providing an added layer of safety.

Limitations and Physiological Barriers

Despite its advantages, the buccal route presents several limitations. The buccal mucosa has a relatively limited surface area for drug absorption compared to other routes such as the gastrointestinal tract. Saliva secretion, involuntary swallowing, and mucosal turnover can affect the residence time of the dosage form and influence drug absorption. The permeability of the buccal tissue is also lower than that of the sublingual mucosa, making it less suitable for drugs requiring rapid onset of action. Furthermore, enzymatic activity within the oral cavity can degrade certain peptide and protein drugs, limiting their effectiveness via this route. Overcoming these barriers requires innovative formulation strategies, including the use of bioadhesive polymers, enzyme inhibitors, and nanoparticle-based delivery systems.[11-15]

III. BUCCAL TABLETS: CLASSIFICATION AND TYPES

Buccal tablets are solid dosage forms specifically designed for placement in the buccal cavity, where they adhere to the mucosal tissue and release the active pharmaceutical ingredient (API) for local or systemic absorption. The design of buccal tablets plays a crucial role in determining their performance, drug release behavior, and therapeutic efficiency. Based on their formulation approach and functional characteristics, buccal tablets can be classified in several ways.

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Bioadhesive vs. Non-Bioadhesive Tablets

Bioadhesivebuccal tablets are formulated using polymers that allow the dosage form to adhere to the buccal mucosa. These bioadhesive agents, such as carbopol, hydroxypropyl methylcellulose (HPMC), and chitosan, enable prolonged retention at the site of administration, enhancing drug absorption and minimizing the risk of accidental swallowing. Bioadhesive systems are preferred for sustained drug release and improved therapeutic efficacy, especially in cases where extended mucosal contact is needed.

In contrast, **non-bioadhesivebuccal tablets** do not possess mucoadhesive properties and are generally used for fast drug release. These tablets rely on rapid disintegration and dissolution in the buccal cavity, making them suitable for drugs requiring a quick onset of action. However, their shorter residence time may limit absorption efficiency for certain drugs.

Unidirectional vs. Multidirectional Release Tablets

Unidirectional buccal tablets are designed to release the drug in a single direction—toward the buccal mucosa—while minimizing drug loss into the oral cavity or saliva. This is achieved by incorporating an impermeable backing layer (e.g., ethyl cellulose, wax-based layers) on one side of the tablet. This targeted release enhances drug absorption and bioavailability while reducing drug wastage and potential side effects in other parts of the oral cavity.

On the other hand, **multidirectional buccal tablets** release the drug in all directions. While these tablets may be simpler to manufacture, they often result in lower efficiency due to drug dilution in saliva and swallowing, which can reduce systemic absorption and lead to first-pass metabolism.

Fast-Dissolving vs. Sustained-Release Buccal Tablets

Fast-dissolving buccal tablets are designed to disintegrate quickly in the buccal cavity, releasing the drug for immediate absorption. These are particularly useful for acute conditions where rapid therapeutic action is required, such as in pain relief or anti-emetic therapy. They offer convenience, especially for pediatric and geriatric patients who may have difficulty swallowing conventional tablets.

In contrast, **sustained-release buccal tablets** are formulated to slowly release the drug over an extended period, maintaining therapeutic levels in the bloodstream for a longer duration. These systems are ideal for chronic conditions that require consistent plasma concentrations and reduced dosing frequency. The inclusion of controlled-release polymers and matrix systems helps regulate the release kinetics, improving drug stability and therapeutic outcomes.

Each classification of buccal tablets serves specific clinical needs and therapeutic goals. The selection of a particular type depends on the nature of the drug, the desired release profile, the target patient population, and the intended route of absorption (local vs. systemic).[16-19]

IV. FORMULATION CONSIDERATIONS

Formulating an effective buccal tablet requires careful consideration of multiple factors that collectively influence the drug's bioavailability, mucoadhesion, release profile, and patient acceptability. These factors include the selection of suitable drug candidates, the choice of bioadhesive polymers, the inclusion of functional excipients, and the application of appropriate manufacturing technologies.

Selection of Drug Candidates

The success of buccal drug delivery largely depends on the physicochemical and pharmacokinetic properties of the drug. Ideal drug candidates for buccal administration should possess:

- **Low molecular weight** (typically <500 Da) to facilitate diffusion across the mucosal membrane.
- **Balanced lipophilicity and hydrophilicity** to enable membrane permeation and solubility in the buccal environment.
- **Potency at low doses**, as the buccal route provides limited surface area for absorption.
- **Stability in saliva**, avoiding degradation by enzymes or pH variations in the oral cavity.
- **Non-irritating and non-bitter** nature to ensure patient comfort and compliance.

Examples of drugs that meet these criteria include nitroglycerin, fentanyl, buprenorphine, and ondansetron.

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Mucoadhesive Polymers

Mucoadhesive polymers play a central role in buccal tablet formulation by enabling the dosage form to adhere to the mucosal surface and remain in place long enough to ensure efficient drug absorption. These polymers can be natural or synthetic:

- **Natural Polymers**
  - **Chitosan**: A biodegradable, biocompatible polymer derived from chitin with excellent mucoadhesive and permeation-enhancing properties.
  - **Sodium Alginate**: Extracted from seaweed, alginate forms viscous gels and provides good mucoadhesion when hydrated.
  - **Pectin** and **Guar Gum**: Also used for their biocompatibility and swelling behavior in aqueous environments.
- **Synthetic Polymers**
  - **Hydroxypropyl Methylcellulose (HPMC)**: A widely used semi-synthetic polymer with film-forming and controlled-release properties.
  - **Carbopol (Carbomer)**: A high-molecular-weight synthetic polymer with excellent bioadhesive and swelling characteristics, often used in combination with other polymers to enhance adhesion.
  - **Polyvinyl Alcohol (PVA)** and **Eudragit** are also employed to modify drug release and improve mechanical strength.

The selection and combination of polymers directly influence tablet hardness, drug release rate, mucoadhesion strength, and patient comfort.[20-25]

Excipients

In addition to the active drug and polymers, several functional excipients are incorporated into buccal tablet formulations to enhance performance:

- **Permeation Enhancers**: Compounds like surfactants (e.g., sodium lauryl sulfate), bile salts, and fatty acids (e.g., oleic acid) that temporarily disrupt mucosal barriers and improve drug transport.
- **Enzyme Inhibitors**: Agents such as aprotinin and bestatin help protect peptide or protein drugs from enzymatic degradation within the oral cavity.
- **Stabilizers**: Antioxidants, buffering agents, and pH modifiers help maintain drug stability and optimize the local environment for absorption.
- **Flavoring and Sweetening Agents**: Used to improve palatability and patient acceptance, especially in pediatric and geriatric formulations.

Technology and Techniques

Advancements in pharmaceutical manufacturing have enabled the development of more efficient, precise, and innovative buccal tablets. Key technologies include:

- **Direct Compression**: A widely used, cost-effective method where the drug and excipients are blended and compressed into tablets. It is suitable for heat-sensitive drugs.
- **Hot-Melt Extrusion (HME)**: Involves melting and mixing the drug with polymers under controlled heat and pressure, ideal for sustained-release formulations.
- **Spray Drying**: Converts drug-polymer mixtures into dry powders or granules, which can then be compressed into tablets or used for film coatings.
- **3D Printing**: An emerging technology that allows the creation of highly customized buccal tablets with complex geometries and multi-layer drug release profiles.
- **Freeze Drying (Lyophilization)**: Used particularly in the production of fast-dissolving buccal dosage forms that offer rapid onset of action.

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These technologies not only affect the drug release characteristics but also determine the tablet's physical integrity, stability, and ease of administration.

Overall, successful formulation of buccal tablets requires a multidisciplinary approach, integrating pharmaceutical sciences, material engineering, and patient-centric design principles to deliver effective and reliable drug therapy.[26-28]

V. MECHANISM OF DRUG ABSORPTION THROUGHBUCCAL ROUTE

Drug absorption through the buccal mucosa is a complex process influenced by both physiological and formulation-related factors. The buccal route offers a unique environment for systemic drug delivery, primarily due to its relatively permeable epithelium, high vascularization, and the ability to bypass hepatic first-pass metabolism. Understanding the mechanisms of absorption is critical for designing effective buccal formulations.

Passive Diffusion and Facilitated Transport

The primary mechanism of drug transport across the buccal mucosa is **passive diffusion**, where drug molecules move along a concentration gradient from the site of administration into the underlying blood vessels. This can occur through:

- **Transcellular (intracellular) pathway**, where lipophilic drugs pass through the lipid bilayers of epithelial cells.
- **Paracellular (intercellular) pathway**, where hydrophilic drugs navigate the aqueous pores between cells. This pathway is more restrictive due to tight junctions, thus limiting the absorption of large or polar molecules.

In some cases, **facilitated transport** mechanisms may play a minor role, especially for drugs that mimic naturally occurring substrates. These involve specific membrane-bound transport proteins that assist in the translocation of certain drugs across the mucosal barrier. However, such transport is less common in the buccal region compared to other parts of the body.

Role of pH, Saliva, and Enzymatic Activity

Several **physiological factors** within the oral cavity significantly influence drug absorption:

- **pH of the Buccal Cavity**: The pH in the buccal region typically ranges from 6.2 to 7.4. The degree of ionization of a drug at this pH affects its permeability. Non-ionized, lipophilic drugs are generally absorbed more readily. Hence, drugs with pKa values that allow for substantial unionized fraction at buccal pH are more suitable for this route.
- **Saliva**: Saliva maintains mucosal hydration, facilitates dissolution of buccal tablets, and acts as a vehicle for drug transport. However, it can also dilute and wash away drug particles, reducing residence time and absorption. The average saliva flow rate (0.5–2.0 mL/min) is a significant variable affecting drug contact with the mucosa.
- **Enzymatic Activity**: The buccal mucosa contains lower enzymatic activity compared to the gastrointestinal tract, but enzymes such as proteases and esterases can still degrade susceptible drugs (e.g., peptides and proteins). This degradation may reduce drug bioavailability and necessitate the inclusion of enzyme inhibitors in the formulation.[29-35]

Influence of Formulation on Release and Absorption

The design of a buccal tablet significantly affects how a drug is released and subsequently absorbed:

- **Drug Release Profile**: Formulations can be tailored to provide immediate, delayed, or sustained release, depending on therapeutic goals. Controlled-release formulations ensure prolonged drug contact with the mucosa, leading to enhanced absorption.
- **Mucoadhesion**: The use of mucoadhesive polymers ensures that the dosage form remains in close contact with the buccal mucosa, increasing the residence time and allowing more drug to permeate through the tissue.
- **Permeation Enhancers**: Formulations may include agents that temporarily modify the mucosal barrier to increase drug permeability. These can act by disrupting lipid bilayers, opening tight junctions, or increasing fluidity of cell membranes.

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- **pH Modifiers**: Some formulations incorporate buffering agents to locally adjust the pH, optimizing the drug's ionization state for better permeability.
- **Enzyme Inhibitors**: For sensitive drugs, inhibitors may be included to prevent enzymatic degradation at the site of administration.

Each of these formulation strategies can significantly impact the efficiency of buccal drug delivery, and their optimization is essential to overcome the inherent barriers of the buccal environment.

In summary, buccal drug absorption is primarily governed by passive diffusion, but can be modulated through intelligent formulation design. A thorough understanding of buccal physiology and the interplay between drug properties and excipients is essential for the development of effective buccal delivery systems.

VI. EVALUATION AND CHARACTERIZATION OF BUCCAL TABLETS

The successful development of buccal tablets requires comprehensive evaluation and characterization to ensure their safety, efficacy, and quality. Both **in vitro** and **in vivo** studies are essential to understand the performance of the dosage form in terms of drug release, mucoadhesion, absorption, and stability. These tests provide critical insights into the formulation's behavior in the buccal environment and help in predicting clinical outcomes.

In Vitro and In Vivo Studies

In vitro studies are performed under controlled laboratory conditions and are crucial for early-stage screening of buccal formulations. These include dissolution testing, mucoadhesion evaluation, and permeation studies using synthetic membranes or animal tissues. In vitro models help optimize formulations before proceeding to animal or human trials.

In vivo studies, typically conducted in animal models (e.g., pigs or rabbits) or human volunteers, provide data on the pharmacokinetics, bioavailability, and therapeutic efficacy of the buccal tablet. These studies assess parameters such as time to peak concentration (Tmax), maximum concentration (Cmax), and area under the curve (AUC), comparing them with other routes of administration. In vivo data is essential for regulatory approval and clinical translation.

Mucoadhesion Strength Tests

The mucoadhesive property of buccal tablets is one of their most critical attributes, determining the tablet's ability to remain in place and sustain drug delivery. Mucoadhesion strength can be evaluated by:

- **Texture analyzer** or **modified balance methods**, where the force required to detach the tablet from a mucosal surface (e.g., porcine buccal tissue) is measured.
- **Shear stress method**, which determines the force needed to slide the tablet along the mucosal surface.
- **Falling weight and tensile strength methods**, which assess the detachment force under vertical stress.

Higher mucoadhesion strength generally correlates with longer residence time and improved drug absorption.[36,37]

Drug Release and Permeation Studies

Drug release studies evaluate how the drug is released from the tablet into the surrounding environment. These are usually performed using USP dissolution apparatus, with appropriate simulated saliva or phosphate buffer solutions as the medium. The release profile helps classify the formulation as immediate, sustained, or controlled release.

Permeation studies assess how much of the drug can cross the buccal mucosa and reach systemic circulation. These are typically performed using:

- **Franz diffusion cells** with excised animal or human buccal tissue.
- **Artificial membranes** to simulate buccal absorption under standardized conditions.

Parameters such as permeability coefficient (P), flux (J), and lag time (Tlag) are calculated to understand drug transport kinetics. These studies are key in predicting **in vivo bioavailability** and optimizing formulation strategies.

Stability Studies

Stability is a critical quality attribute that determines the shelf life and effectiveness of buccal tablets. Stability testing is conducted under **ICH (International Council for Harmonisation)** guidelines and includes:

- **Physical stability**: Monitoring changes in appearance, hardness, and weight.
- **Chemical stability**: Assessed by quantifying the active drug content over time using methods like HPLC.

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- **Mucoadhesive stability**: Ensures the adhesive properties are retained during storage.
- **Microbiological stability**: Particularly important for formulations using natural polymers or moisture-sensitive excipients.

Tablets are stored under various environmental conditions (e.g., 25°C/60% RH and 40°C/75% RH) for extended periods (e.g., 3, 6, or 12 months) to simulate real-world storage.

A thorough evaluation of buccal tablets through in vitro, in vivo, and stability studies is essential for developing reliable and effective formulations. These assessments not only ensure compliance with regulatory standards but also support the consistent performance of buccal drug delivery systems throughout their shelf life.

VII. CLINICAL APPLICATIONS AND THERAPEUTIC AREAS

Buccal drug delivery systems have garnered increasing interest due to their ability to provide efficient and controlled drug release, bypassing the first-pass metabolism and improving patient compliance. A variety of drugs and formulations have been developed for buccal administration, targeting numerous therapeutic areas. These include pain management, hormone replacement therapy, antiemetics, and local treatments for oral conditions. Below is an overview of the current drugs and formulations on the market or under development in these areas.

Current Drugs/ Formulations on the Market

1. **Pain Management and Opioid Therapy**
   - **Fentanyl Buccal Tablets (Effentora)**: Fentanyl, a potent opioid analgesic, is available in a buccal tablet form for the treatment of breakthrough cancer pain. Effentora provides rapid onset of analgesic action, with fentanyl being absorbed directly through the buccal mucosa, bypassing the first-pass metabolism and providing faster relief than oral formulations.
   - **Buprenorphine (Subutex, Suboxone)**: Buprenorphine, an opioid partial agonist, is used in the treatment of opioid dependence and pain management. It is available in sublingual and buccal formulations, allowing for controlled release and preventing withdrawal symptoms in opioid-dependent patients.
2. **Hormone Replacement Therapy**
   - **Testosterone Buccal Tablets (Striant)**: Striant is a buccal tablet formulated for testosterone replacement therapy in males with hypogonadism. The testosterone is absorbed through the buccal mucosa, providing an alternative to transdermal or injectable treatments. This formulation helps avoid the inconvenience and potential side effects of traditional delivery methods.
3. **Antiemetics**
   - **OndansetronBuccal Tablets (Zofran)**: Ondansetron is a 5-HT3 receptor antagonist used to prevent nausea and vomiting caused by chemotherapy or surgery. The buccal tablet formulation offers rapid absorption, providing quicker relief compared to oral tablets, which may be hindered by vomiting or delayed gastric emptying.
   - **ProchlorperazineBuccal Tablets (Compazine)**: Prochlorperazine is used to manage nausea and vomiting associated with conditions like vertigo or chemotherapy. The buccal formulation improves patient compliance, especially in individuals who cannot tolerate oral administration.
4. **Local Treatments for Oral Conditions**
   - **ChlorhexidineBuccal Tablets**: Chlorhexidine, an antimicrobial agent, is used for the management of oral infections and gingivitis. Buccal tablets release the drug locally, ensuring a prolonged antimicrobial effect directly at the site of infection.[38]

Drugs Under Development

1. **Peptide and Protein Drugs**
   - **Insulin Buccal Tablets**: Insulin, a peptide hormone, has traditionally been administered via subcutaneous injection. Several pharmaceutical companies are investigating buccal formulations of insulin to offer a non-invasive alternative for diabetic patients. Although challenges remain in

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achieving adequate absorption and stability, progress in enhancing the permeability of buccal mucosa holds promise for this route.

- **Calcitonin Buccal Tablets**: For the treatment of osteoporosis, calcitonin has been investigated in buccal tablets to provide an alternative to subcutaneous injections. These formulations aim to enhance drug absorption and patient comfort.

2. **Cardiovascular Medications**
   - **NitroglycerinBuccal Tablets (Nitrostat)**: Nitroglycerin, a vasodilator used for the acute relief of angina pectoris, is available in buccal tablet form. This allows for rapid absorption through the buccal mucosa, providing quick relief from chest pain, as it bypasses first-pass metabolism and avoids delays associated with oral administration.
3. **Anticancer Drugs**
   - **TamoxifenBuccal Formulation**: Tamoxifen, an anticancer agent used primarily in the treatment of breast cancer, is under investigation for buccal administration. Its potential benefits include improved bioavailability and reduced systemic side effects compared to conventional oral tablets.
4. **Antiviral Agents**
   - **Acyclovir Buccal Tablets**: Acyclovir, used to treat herpes simplex virus infections, has been formulated into buccal tablets to treat cold sores or genital herpes. The buccal formulation allows for a direct and sustained antiviral effect at the site of infection, potentially improving patient outcomes.

Emerging Areas of Therapeutic Application

1. **Neurological Disorders**
   - **Alzheimer's Disease**: There is ongoing research into buccal formulations of acetylcholinesterase inhibitors (e.g., donepezil) for the treatment of Alzheimer's disease. The buccal route could provide more consistent plasma levels and enhance patient compliance in this population.
   - **Migraine**: Buprenorphine and other analgesics are being explored for buccal delivery for the management of acute migraine attacks, providing rapid onset and avoiding gastrointestinal side effects associated with oral formulations.
2. **Vaccines**
   - **Buccal Vaccines**: The buccal route for vaccine delivery is a growing area of interest, particularly for mucosal vaccines targeting pathogens like influenza, hepatitis, and COVID-19. Buccal vaccines could offer a needle-free alternative, improving accessibility and compliance, especially in pediatric and non-compliant adult populations.

The clinical application of buccal tablets spans a wide range of therapeutic areas, including pain management, hormone replacement, antiemetic therapy, and oral health, among others. Current formulations on the market, such as fentanyl for pain management and buprenorphine for opioid dependence, have already demonstrated the significant advantages of buccal drug delivery in terms of bioavailability, patient comfort, and adherence. Furthermore, ongoing research and development in areas such as peptide drug delivery, cardiovascular treatments, and vaccines suggest a promising future for buccal tablets in expanding therapeutic options.[39,40]

VIII. ADVANTAGES OF BUCCAL TABLETS

Avoidance of First-Pass Metabolism

A major pharmacokinetic benefit of buccal tablets is their ability to bypass first-pass metabolism. When drugs are taken orally and swallowed, they travel through the gastrointestinal (GI) tract and are absorbed into the portal circulation, which directs them to the liver. In the liver, many drugs undergo metabolic transformation before reaching systemic circulation—a process known as first-pass metabolism. This can significantly reduce the amount of active drug that is ultimately available to exert a therapeutic effect. Buccal tablets, however, are designed to be placed between the cheek and gum, where the drug is absorbed directly through the buccal mucosa into the systemic circulation. This route avoids the GI tract and liver, thereby minimizing metabolic degradation and enhancing the overall effectiveness of the drug.

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Improved Bioavailability

By circumventing the gastrointestinal tract and liver metabolism, buccal tablets provide significantly improved bioavailability compared to conventional oral dosage forms. Bioavailability refers to the proportion of the administered drug that enters the bloodstream in an active form and is available to have a therapeutic effect. In traditional oral delivery, the bioavailability can be reduced due to enzymatic activity in the stomach and intestine, as well as the first-pass effect in the liver. Since buccal tablets allow direct absorption through the mucosal tissues of the mouth, they ensure that more of the active drug reaches the bloodstream intact. This improved efficiency often allows for lower dosages, potentially reducing side effects and improving safety and cost-effectiveness.

Ease of Administration and Patient Compliance

Buccal tablets are particularly advantageous when it comes to ease of administration and improving patient compliance. These tablets are small, discreet, and designed to dissolve slowly in the buccal cavity without the need for water or chewing. This makes them an ideal option for patients who have difficulty swallowing conventional tablets or capsules, including children, elderly individuals, and those with certain medical conditions such as dysphagia. Additionally, the non-invasive nature of buccal administration is less intimidating than injections and more convenient than frequent dosing schedules associated with some medications. The comfort and simplicity of this dosage form often lead to better adherence to prescribed treatments, which is essential for achieving desired therapeutic outcomes.

Controlled Drug Release Potential

Another significant advantage of buccal tablets is their potential for controlled or sustained drug release. These formulations can be engineered to slowly release the drug over a predetermined period, allowing for a steady and prolonged therapeutic effect. This is particularly beneficial for medications that require consistent plasma concentrations over time to be effective. Controlled release reduces the frequency of administration, which can further enhance patient compliance and convenience. It also minimizes fluctuations in drug levels, which helps maintain efficacy while reducing the risk of side effects associated with peak concentrations. In conditions that require long-term management, such as chronic pain or hormone replacement therapy, buccal tablets with controlled-release properties offer a reliable and patient-friendly solution.[40]

IX. CONCLUSION

Buccal tablets offer a compelling alternative to traditional drug delivery methods, particularly for drugs with poor oral bioavailability or susceptibility to degradation in the gastrointestinal tract. Advances in formulation, especially in mucoadhesive technologies and controlled-release mechanisms, have enhanced the potential of buccal tablets to provide consistent and efficient drug delivery. Despite these advancements, further research is needed to overcome existing limitations such as mucosal irritation, interindividual variability, and the relatively small absorption area. Continued innovation in drug formulation and delivery systems will be crucial for optimizing buccal tablets and fully realizing their potential in clinical applications.

REFERENCES

[1] Giunchedi et al. (2002). *Formulation and in vivo evaluation of chlorhexidinebuccal tablets prepared using drug-loaded chitosan microspheres*. European Journal of Pharmaceutics and Biopharmaceutics, 53(2), 233–239.

[2] Madhusudan Rao et al. (2006). *Novel buccoadhesive formulation of chlorpheniramine maleate: in vitro and in vivo characterization*. Asian Journal of Pharmaceutics, 1(1), 33–40.

[3] Vamshi Vishnu et al. (2007). *Development and in vitro evaluation of buccoadhesivecarvedilol tablets*. ActaPharmaceutica, 57(2), 185–197.

[4] Ikinci et al. (2000). *In vitro/in vivo studies on a buccalbioadhesive tablet formulation of carbamazepine*. Pharmazie, 55(10), 762–765.

[5] Ali et al. (2002). *Buccoadhesive erodible disk for treatment of oro-dental infections: design and characterization*. International Journal of Pharmaceutics, 238(1–2), 93–103.

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[6] Krishnarajan et al. (2016). *Recent trend and approaches of buccal drug delivery system: A review*. Pharmacophore, 7(5), 1–8.

[7] Sarkar et al. (2017). *A comprehensive review on buccal drug delivery system*. Research and Reviews: A Journal of Pharmaceutical Science, 8(2), 20–32.

[8] Rathod et al. (2020). *Prospective designing and types of buccal drug delivery system: The Review*. GSC Biological and Pharmaceutical Sciences, 12(3), 174–179.

[9] Gandhi & Robinson (1994). *Oral cavity as a site for bioadhesive drug delivery*. Advanced Drug Delivery Reviews, 13(1), 43–74.

[10] Shojaei et al. (2001). *Systemic drug delivery via the buccal mucosal route*. Journal of Pharmaceutical Technology, 25(6), 70–81.

[11] Gandhi & Robinson (1992). *Drug delivery via the mucous membranes of the oral cavity*. Journal of Pharmaceutical Sciences, 81(1), 1–10.

[12] Rojanasakul et al. (1992). *The transport barrier of epithelia: a comparative study on membrane permeability and charge selectivity in the rabbit*. Pharmaceutical Research, 9(8), 1029–1034.

[13] Hassan et al. (2010). *Chemical permeation enhancers for transbuccal drug delivery*. Expert Opinion on Drug Delivery, 7(1), 97–112.

[14] Shinkar et al. (2012). *Drug delivery from the oral cavity: a focus on mucoadhesivebuccal drug delivery systems*. PDA Journal of Pharmaceutical Science and Technology, 66(5), 466–500.

[15] Fonseca-Santos &Chorilli (2018). *An overview of polymeric dosage forms in buccal drug delivery: State of art, design of formulations and their in vivo performance evaluation*. Materials Science and Engineering: C, 86, 129–143.

[16] Rojanasakul et al. (1992). *The transport barrier of epithelia: a comparative study on membrane permeability and charge selectivity in the rabbit*. Pharmaceutical Research, 9(8), 1029–1034.

[17] Gandhi & Robinson (1992). *Drug delivery via the mucous membranes of the oral cavity*. Journal of Pharmaceutical Sciences, 81(1), 1–10.

[18] Hassan et al. (2010). *Chemical permeation enhancers for transbuccal drug delivery*. Expert Opinion on Drug Delivery, 7(1), 97–112.

[19] Shinkar et al. (2012). *Drug delivery from the oral cavity: a focus on mucoadhesivebuccal drug delivery systems*. PDA Journal of Pharmaceutical Science and Technology, 66(5), 466–500.

[20] Fonseca-Santos &Chorilli (2018). *An overview of polymeric dosage forms in buccal drug delivery: State of art, design of formulations and their in vivo performance evaluation*. Materials Science and Engineering: C, 86, 129–143.

[21] Desai, D. D., et al. (2023).*Nanotechnology-Based Mucoadhesive and Mucus-Penetrating Drug-Delivery Systems for Transbuccal Drug Delivery*. Nanomedicine, 18(21), 1495–1514.

[22] Gandhi, R. S., & Robinson, J. R. (2023).*Buccal Delivery of Small Molecules and Biologics: Of Mucoadhesive Polymers, Films, and Nanoparticles – An Update*. International Journal of Pharmaceutics, 636, 122789.

[23] Xia, Y., et al. (2023).*Formulation and Characterization of Buccal Films Containing Valsartan with Additional Support from Image Analysis*. AAPS PharmSciTech.

[24] Anwar, S., et al. (2020).*Rosuvastatin, Perindopril, and Ezetimibe Loaded Instant Release Buccal Films: Development and In Vitro Characterization*. Journal of Applied Biomedicine, 18(2), 115–125.

[25] He, S., et al. (2021).*Exploration of In Vitro Drug Release Testing Methods for SaquinavirMicroenvironmental pH Modifying Buccal Films*. European Journal of Pharmaceutical Sciences, 163, 105867.

[26] Kumria, R., et al. (2016).*Buccal Films of Prednisolone with Enhanced Bioavailability*. Drug Delivery, 23(4), 471–478.

[27] Lodagekar, A., et al. (2019).*Co-Amorphous Valsartan-Nifedipine System: Preparation, Characterization, In Vitro and In Vivo Evaluation*. European Journal of Pharmaceutical Sciences, 139, 105048.

[28] Abdella, S., et al. (2022).*MucoadhesiveBuccal Film of Estradiol for Hormonal Replacement Therapy: Development and In-Vivo Performance Prediction*. Pharmaceutics, 14(4), 542.

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[29] Tam, C. H., et al. (2021).*Drop-on-Demand Printing of Personalized Orodispersible Films Fabricated by Precision Micro-Dispensing*. International Journal of Pharmaceutics, 610, 121279.

[30] Godec, P., et al. (2019).*Democratized Image Analytics by Visual Programming Through Integration of Deep Models and Small-Scale Machine Learning*. Nature Communications, 10, 4551.

[31] Hassan, M. A., et al. (2010).*Chemical Permeation Enhancers for Transbuccal Drug Delivery*. Expert Opinion on Drug Delivery, 7(1), 97–112.

[32] Shinkar, D. M., et al. (2012).*Drug Delivery from the Oral Cavity: A Focus on MucoadhesiveBuccal Drug Delivery Systems*. PDA Journal of Pharmaceutical Science and Technology, 66(5), 466–500.

[33] Fonseca-Santos, B., &Chorilli, M. (2018).*An Overview of Polymeric Dosage Forms in Buccal Drug Delivery: State of Art, Design of Formulations and Their In Vivo Performance Evaluation*. Materials Science and Engineering: C, 86, 129–143.

[34] Gandhi, R. S., & Robinson, J. R. (1994).*Oral Cavity as a Site for Bioadhesive Drug Delivery*. Advanced Drug Delivery Reviews, 13(1), 43–74.

[35] Shojaei, A. H., et al. (2001).*Systemic Drug Delivery via the Buccal Mucosal Route*. Journal of Pharmaceutical Technology, 25(6), 70–81.

[36] Batchelor, H. K. (2004).*Commercial Buccal Adhesive Drug Delivery Systems*. Pharmaceutical Technology, 28(7), 1–10.

[37] Gandhi, R. S., & Robinson, J. R. (1992).*Drug Delivery via the Mucous Membranes of the Oral Cavity*. Journal of Pharmaceutical Sciences, 81(1), 1–10.

[38] Rojanasakul, Y., et al. (1992).*The Transport Barrier of Epithelia: A Comparative Study on Membrane Permeability and Charge Selectivity in the Rabbit*. Pharmaceutical Research, 9(8), 1029–1034.

[39] Hassan, M. A., et al. (2010).*Chemical Permeation Enhancers for Transbuccal Drug Delivery*. Expert Opinion on Drug Delivery, 7(1), 97–112.

[40] Shinkar, D. M., et al. (2012).*Drug Delivery from the Oral Cavity: A Focus on MucoadhesiveBuccal Drug Delivery Systems*. PDA Journal of Pharmaceutical Science and Technology, 66(5), 466–500.