Nano-Enhanced Rivaroxaban Tablets: Formulation and Bioavailability - A Review

ANITHA W.[1], SREE JANARDHANAN V.[2]
[1] *Department of Pharmaceutics, School of Pharmacy, Sri Balaji Vidyapeeth, Deemed to be university, Puducherry.*
[2] *Department of Pharmaceutical Chemistry, School of Pharmacy, Sri Balaji Vidyapeeth, Deemed to be university, Puducherry.*

Abstract- ***The development of novel drug delivery systems has gained considerable attention in recent years due to their potential to enhance the bioavailability and therapeutic efficacy of drugs. One such approach is the formulation of nanoparticle-loaded fast dissolving tablets, which have shown promising results in improving drug release and absorption. In this review article, we will focus on the optimization, formulation, design, and evaluation of nano particle-loaded fast dissolving tablets of Rivaroxaban, ananticoagulant, for bioavailability enhancement. We will discuss the various techniques used for nanoparticle preparation, optimization of formulation parameters, and the evaluation methods employed to assess the performance of these tablets.***

Indexed Terms- ***Rivaroxaban Tablets, Bioavailability, nanoparticle-loaded, anticoagulant***

I. INTRODUCTION

Rivaroxaban is a relatively new oral anticoagulant that was introduced in 2008 as a promising alternative to traditional anticoagulants, such as warfarin. It belongs to a class of drugs known as direct oral anticoagulants (DOACs).

Rivaroxaban acts by selectively inhibiting factor Xa, a key enzyme involved in the blood coagulation cascade. Unlike warfarin, which requires regular monitoring and dose adjustments, rivaroxaban has a predictable pharmacokinetic profile and does not necessitate routine coagulation monitoring.

Additionally, it has a rapid onset of action and a relatively short half-life, further contributing to its ease of use. These characteristics make rivaroxaban an attractive option for the prevention and treatment of various thromboembolic diseases, including deep vein thrombosis and atrial fibrillation.

A. Background information on Rivaroxaban as an anti-coagulant

Bioavailability enhancement in drug delivery is of utmost importance in the pharmaceutical industry. It refers to the amount of the drug that enters the systemic circulation and is available to produce a therapeutic effect. Various factors affect bioavailability, including solubility and permeability of the drug. Nanoparticle-loaded fast-dissolving tablets have emerged as a promising approach to enhance bioavailability.

These tablets combine the advantages of nanoparticles, such as improved solubility and stability, with the convenience and patient compliance of fast-dissolving tablets. Optimization, formulation, design, and evaluation of such tablets play a crucial role in ensuring the successful delivery and therapeutic efficacy of the drug.

B. Importance of bioavailability enhancement in drug delivery

Moreover, the small size and uniform distribution of nanoparticles ensure uniform drug delivery and reduce inter- and intra-subject variability. This significance of nanoparticle-loaded fast-dissolving tablets in bioavailability enhancement makes them a promising approach in improving drug therapies.

C. Significance of nanoparticle loaded fast dissolving tablets in bio availability enhancement

In recent years, nanotechnology has emerged as a promising field for drug delivery systems, offering potential improvements in bioavailability and therapeutic efficacy. The optimization, formulation, design, and evaluation of nanoparticle-loaded fast-dissolving tablets of rivaroxaban, an anticoagulant, have been the focus of extensive research. These tablets aim to enhance the dissolution rate and provide quick onset of action, thus improving the therapeutic outcomes for patients.

Various approaches have been explored to achieve this goal, including the use of different excipients, particle size reduction techniques, and formulation optimization. Additionally, several evaluation techniques have been employed to assess the performance of these novel drug delivery systems, including in vitro dissolution studies, in vivo pharmacokinetic studies, and stability testing. Overall, the development of nanoparticle-loaded fast-dissolving tablets of rivaroxaban shows great potential for bioavailability enhancement, offering a promising option for patients in need of anticoagulant therapy.

In recent years, there has been a growing interest in the development of nanoparticle-loaded fast-dissolving tablets for the enhancement of bioavailability of various drugs. These tablets offer several advantages over traditional drug delivery systems, including rapid disintegration and dissolution, improved drug release profile, and increased drug uptake. The optimization of such tablets involves the selection of appropriate excipients, determination of the optimal concentration of nanoparticles, and optimization of the manufacturing process. Additionally, various design and evaluation techniques have been employed to assess the physicochemical properties, dissolution behavior, and in vitro/in vivo performance of these tablets. Overall, the optimization of nanoparticle-loaded fast-dissolving tablets holds great potential for improving the bioavailability and therapeutic efficacy of drugs, including rivaroxaban, an anticoagulant.

II. OPTIMIZATION OF NANOPARTICLE LOADED FAST DISSOLVING TABLETS

A. Explanation of Optimization Techniques Used in Formulation:

In formulating nanoparticle-loaded fast-dissolving tablets of Rivaroxaban, various optimization techniques were employed to enhance its bioavailability. One such technique is the use of Design of Experiment (DoE), allowing for the systematic and efficient evaluation of multiple variables simultaneously. By employing DoE, formulation parameters such as drug-to-polymer ratio, nanoparticle concentration, and disintegration time were optimized to maximize drug release and dissolution rate. Additionally, the technique of particle size reduction was utilized, where the drug particles were reduced in size to enhance their bioavailability. These optimization techniques play a crucial role in achieving the desired therapeutic effectiveness and bioavailability of Rivaroxaban-loaded fast-dissolving tablets.

B. Factors Considered in Optimizing the Formulation:

In addition to the factors discussed above, several other aspects need consideration in optimizing the formulation of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban for bioavailability enhancement. The selection of suitable excipients is crucial, as they play a significant role in drug release and dissolution characteristics. Compatibility between the drug and excipients should be evaluated to ensure stability and efficacy. Furthermore, the manufacturing process and techniques utilized should be chosen carefully to ensure uniformity in particle size and distribution. Selection of appropriate evaluation parameters, such as dissolution rate, drug content, and physical properties, is crucial to accurately assess the performance and bioavailability enhancement of the optimized formulation.

C. Benefits of Optimization in Enhancing Drug Delivery:

In conclusion, optimization plays a significant role in enhancing drug delivery, particularly in the case of

nanoparticle-loaded fast-dissolving tablets of Rivaroxaban. The formulation and design of such tablets require meticulous optimization to achieve the desired bioavailability enhancement. Through optimization techniques, properties of the drug delivery system, such as particle size, surface charge, and drug release profile, can be tailored to maximize drug absorption and therapeutic efficacy. Moreover, optimization facilitates the selection of suitable excipients and manufacturing processes, ensuring the reproducibility and stability of the drug product. Therefore, optimization is crucial in the development of nanoparticle-loaded fast-dissolving tablets for enhanced drug delivery.

D. The Formulation of Nanoparticle-Loaded Fast Dissolving Tablets:

The formulation of nanoparticle-loaded fast-dissolving tablets plays a crucial role in enhancing the bioavailability of Rivaroxaban. Various techniques have been explored to achieve optimum formulation, design, and evaluation of these tablets. One such technique involves the use of supercritical fluid technology, which utilizes carbon dioxide as a solvent to produce nanoparticles. Another approach involves the use of chitosan nanoparticles, shown to enhance drug solubility and dissolution rate. Additionally, the incorporation of polymers such as hydroxypropyl methylcellulose (HPMC) and polyvinylpyrrolidone (PVP) helps improve tablet disintegration and drug release. Overall, the successful formulation of nanoparticle-loaded fast-dissolving tablets holds great potential for increasing the therapeutic efficacy of Rivaroxaban.

III. FORMULATION OF NANOPARTICLE-LOADED FAST-DISSOLVING TABLETS

The formulation process of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban is a multi-step procedure that begins with a thorough literature review to gather information on suitable techniques and excipients for enhancing drug bioavailability. The subsequent step involves the selection of appropriate polymers based on their compatibility and solubility. Nanoparticles are then prepared using methods such as nanoprecipitation, solvent evaporation, and emulsion-diffusion. These nanoparticles are incorporated into the tablet formulation through techniques like direct compression or wet granulation. Finally, the formulated tablets undergo evaluation for drug content, dissolution rate, hardness, friability, and stability to ensure their efficacy and quality.

A. Overview of the Formulation Process

The selection of excipients plays a crucial role in formulating nanoparticle-loaded fast-dissolving tablets of Rivaroxaban. Excipients, which are inactive ingredients added to aid in the stability, bioavailability, and performance of the drug, are chosen carefully based on their specific roles. Superdisintegrants such as crospovidone and croscarmellose sodium are included to promote rapid tablet disintegration in the oral cavity, ensuring fast drug release and dissolution. Binders like polyvinylpyrrolidone (PVP) improve the tablet's mechanical strength and prevent drug loss during manufacturing and handling processes. Additional excipients such as diluents, lubricants, and glidants are incorporated to further optimize the drug delivery system.

B. Selection of excipients and the irroles in the formulation

The formulation of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban involves the utilization of various techniques to enhance bioavailability. Wet granulation, a commonly employed technique, involves mixing powders with a binder and a liquid solvent, followed by the formation of granules through granulation and drying processes. Direct compression is another technique where the active pharmaceutical ingredient and other excipients are blended and compressed directly into tablets. Spray drying is also utilized to produce nanoparticles that can be incorporated into the tablet formulation. These techniques collectively contribute to the optimization, design, and evaluation of the final product, ultimately enhancing its bioavailability.

C. Techniques used in formulating the tablets

In conclusion, the optimization, formulation, design, and evaluation of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban have proven effective in

enhancing the bioavailability of this widely used anticoagulant. Incorporating nanoparticles improves the solubility and dissolution rate of the drug, providing sustained release and controlled drug delivery. The fast-dissolving property of the tablets ensures rapid onset of action, making them a promising alternative to conventional oral dosage forms. Overall, this novel drug delivery approach shows great potential in improving the therapeutic efficacy and patient compliance of Rivaroxaban. In the design of these tablets, factors such as excipient selection, particle size control, and manufacturing techniques play crucial roles in achieving optimal performance and bioavailability enhancement.

IV. DESIGN OF NANOPARTICLE-LOADED FAST-DISSOLVING TABLETS

Considerations in designing tablets for optimal drug delivery are crucial in ensuring effective bioavailability enhancement. The size and shape of the tablets play a significant role in drug dissolution and absorption. The use of nanoparticles in the formulation is essential for enhancing the drug's solubility and dissolution rate. Moreover, the choice of excipients should be carefully selected to ensure compatibility with the drug and to promote fast dissolution. Additionally, the design should incorporate technologies such as superdisintegrants and polymers that aid in rapid dissolution of the tablet upon contact with saliva. These considerations collectively contribute to the optimal delivery of Rivaroxaban, thereby enhancing its therapeutic efficacy.

A. Considerations in Designing the Tablets for Optimal Drug Delivery

The role of nanoparticle loading in the design process is crucial to enhance the bioavailability of the drug Rivaroxaban in fast-dissolving tablets. The nanoparticles act as carriers for the drug, providing a larger surface area for drug dissolution and absorption. This loading process enables improved drug release and dissolution rates, leading to enhanced drug absorption and efficacy. Additionally, the size and composition of the nanoparticles can be tailored to optimize drug delivery and control the release rate. Thus, nanoparticle loading plays a significant role in the formulation and design of fast-dissolving tablets of Rivaroxaban to improve bioavailability and therapeutic outcomes.

B. Role of Nanoparticle Loading in the Design Process

Techniques used in designing the tablets involved several critical considerations. First and foremost, the optimization process was essential to determine the most effective formulation and design. This involved evaluating various parameters such as particle size, drug loading capacity, and surface charge. Additionally, the formulation process required careful selection of excipients to enhance the bioavailability of rivaroxaban. Techniques such as direct compression, wet granulation, and freeze-drying were employed to achieve the desired tablet characteristics. Furthermore, the design of nanoparticle-loaded fast-dissolving tablets required expertise in nanotechnology, specifically the preparation of nanoparticles and their incorporation into the tablet matrix. Overall, a combination of these techniques was employed to successfully design the efficient delivery system for rivaroxaban.

C. Techniques used in Designing the Tablets

The formulation design and optimization of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban, an anti-coagulant for bioavailability enhancement, has gained significant attention in recent years. In order to improve the therapeutic efficacy and patient compliance, fast-dissolving tablets have emerged as a suitable dosage form. Nanoparticles have been employed as carriers for enhancing the solubility and dissolution rate of poorly water-soluble drugs like Rivaroxaban. The design and optimization of these nanoparticles facilitate enhanced drug release, improved absorption, and ultimately, increased bioavailability. This article reviews the various formulation strategies, optimization techniques, and evaluation parameters employed in the development of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban for bioavailability enhancement.

In vitro dissolution studies represent a key aspect of evaluating nanoparticle-loaded fast-dissolving tablets. Several methods have been employed to assess the drug release profile from these tablets,

including paddle over disc apparatus, rotating basket apparatus, and flow through cell apparatus. The selection of the method depends on the characteristics of the drug, the tablet composition, and the desired testing conditions. Furthermore, dissolution medium selection plays a critical role in mimicking the physiological conditions of the gastrointestinal tract and ensuring accurate predictions of in vivo drug release patterns. Additionally, the use of biorelevant media can provide valuable insights into the behavior of orally administered nanoparticle-loaded fast-dissolving tablets and their potential for bioavailability enhancement.

V. EVALUATION OF NANO PARTICLE LOADED FAST DISSOLVING TABLETS

In evaluating the performance of tablets, various methods are commonly used. One such method is the dissolution test, which assesses the release rate of the drug from the tablet. This test helps determine the drug's bioavailability and its ability to reach therapeutic levels in the bloodstream. Another method is the physical characterization of tablets, which includes evaluating their appearance, size, weight, and hardness. These characteristics provide valuable information regarding the tablet's quality and stability. Furthermore, in vitro drug release studies and pharmacokinetic assessment can also be conducted to evaluate the tablets' performance, providing insight into their drug release behavior and systemic absorption. Overall, the combination of these methods helps in assessing the efficacy and quality of the nanoparticle-loaded fast-dissolving tablets of Rivaroxaban.

A. Methods used in evaluating the tablets' performance

During the evaluation process of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban, several parameters are considered to ensure the efficacy and bioavailability enhancement of the anticoagulant drug. These parameters include particle size analysis, zeta potential, drug content uniformity, in-vitro drug release, dissolution studies, and stability testing. Particle size analysis allows for the determination of the average particle size and size distribution of the nanoparticles, which directly impacts the drug's dissolution and absorption rate. Zeta potential measures the surface charge of the nanoparticles, influencing their stability and interactions within the formulation. Drug content uniformity ensures consistent drug concentration in each tablet, promoting accurate dosing. In-vitro drug release studies assess the release kinetics of Rivaroxaban from the tablets, providing insights into its dissolution behavior. Finally, stability testing examines the physical and chemical stability of the nanoparticle-loaded fast-dissolving tablets over time, evaluating their quality, efficacy, and shelf-life.

B. Parameters assessed in the evaluation process

Results and findings from the evaluation studies of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban, an anticoagulant for bioavailability enhancement, have provided valuable insights. The studies showed that the incorporation of nanoparticles improved the dissolution rate and dissolution efficiency of Rivaroxaban. Additionally, the nanoparticle-loaded tablets exhibited enhanced bioavailability compared to conventional tablets. Moreover, the optimized formulation demonstrated excellent physicochemical properties, including acceptable drug content, uniform particle size, and good flowability. Furthermore, the nanoparticle-loaded fast-dissolving tablets showed improved stability, with minimal changes observed in drug content and dissolution rate over an extended period. These positive results indicate the potential of nanoparticle-loaded tablets for effective delivery and enhanced therapeutic outcomes.

C. Results and findings from the evaluation studies

In recent years, there has been a growing interest in the development of fast-dissolving tablets loaded with nanoparticles for bioavailability enhancement of drugs. One promising drug that has gained attention in this area is Rivaroxaban, which is an anticoagulant used for the prevention of thromboembolic events in patients. This review article aims to highlight the various optimization, formulation, design, and evaluation strategies employed in the development of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban. By enhancing the bioavailability of Rivaroxaban, these innovative drug delivery systems have the potential to improve patient compliance and therapeutic outcomes.

To enhance the bioavailability of Rivaroxaban, researchers have explored the use of nanoparticle-loaded fast-dissolving tablets. Nanoparticles have gained attention in drug delivery due to their small size and high surface area, allowing for improved drug solubility and absorption. By incorporating Rivaroxaban into nanoparticles and formulating them into fast-dissolving tablets, researchers aim to overcome the limitations associated with the conventional oral delivery of the drug. These nanoparticles can provide targeted delivery, protection against enzymatic degradation, and enhanced absorption, ultimately resulting in improved therapeutic outcomes and patient compliance. Several studies have demonstrated the effectiveness of nanoparticle-loaded fast-dissolving tablets in enhancing the bioavailability of Rivaroxaban.

VI. BIOAVAILABILITY ENHANCEMENT OF RIVAROXABAN THROUGH NANOPARTICLE LOADED FAST DISSOLVING TABLETS

Tablets have been widely used as a dosage form for drug delivery due to their convenience and ease of administration. However, their bioavailability is often limited by factors such as poor solubility and low dissolution rate. In order to overcome these challenges, nanoparticle-loaded fast-dissolving tablets have been developed. The incorporation of nanoparticles increases the surface area of the drug, leading to enhanced dissolution and higher bioavailability. Additionally, nanoparticles can improve drug stability and protect the drug from degradation. By optimizing the formulation and design, these tablets have the potential to significantly enhance the bioavailability of rivaroxaban, an anticoagulant, providing better therapeutic outcomes for patients.

A. Explanation of how the tablets enhance bioavailability

Bioavailability is a crucial aspect to consider when comparing nanoparticle-loaded fast-dissolving tablets with conventional formulations of drugs. Nanoparticle-loaded fast-dissolving tablets have been shown to have significantly higher bioavailability compared to conventional formulations. This is due to the enhanced dissolution and absorption properties of nanoparticles, which can result in increased drug permeability and systemic availability. Additionally, the smaller particle size of the nanoparticles allows for improved drug release and dissolution rates. Therefore, nanoparticle-loaded fast-dissolving tablets can effectively enhance the bioavailability of drugs such as Rivaroxaban, offering potential benefits in terms of therapeutic effectiveness and patient compliance.

B. Comparison of bioavailability with conventional formulations

Potential benefits of enhanced bioavailability include improved therapeutic outcomes and reduced drug dosage requirements. When a drug has higher bioavailability, it is more likely to reach its target site in an active form, leading to a greater pharmacological effect. This can be particularly important for drugs with a narrow therapeutic window or those that require precise dosing. Furthermore, enhanced bioavailability can also improve patient compliance as it may allow for less frequent dosing or lower daily pill burdens. However, there are also implications to consider, such as the potential for increased adverse effects due to higher drug concentrations and the need for careful monitoring of drug levels in the body.

C. Potential benefits and implications of enhanced bioavailability

The formulation and design of nanoparticle-loaded fast-dissolving tablets of rivaroxaban have gained significant attention in recent years due to their potential in enhancing the bioavailability of the drug. Nanoparticles offer unique properties such as increased surface area and improved solubility, which can overcome the limitations associated with poor water solubility of rivaroxaban. Various optimization techniques have been employed to achieve the desired characteristics of the nanoparticles, such as particle size, drug loading capacity, and drug release kinetics. The evaluation of these nanoparticle-loaded tablets involves studying their physicochemical properties, dissolution behavior, and pharmacokinetics to ensure their efficacy and safety for therapeutic use.

In conclusion, the development and evaluation of nanoparticle-loaded fast-dissolving tablets of rivaroxaban have shown promising results in terms of bioavailability enhancement of this anticoagulant drug. The optimization, formulation, design, and evaluation processes have been successfully executed, utilizing various techniques such as experimental design approaches and statistical analysis. The use of nanoparticle technology has proven to be an effective strategy for improving drug solubility and dissolution rate, thus enhancing the overall therapeutic efficacy of rivaroxaban. Additionally, the fast-dissolving tablet formulation offers convenience and ease of administration for patients. Further research and clinical trials are warranted to validate the effectiveness and safety of this formulation for broader applications in the field of anticoagulant therapy.

CONCLUSION

In summary, the review article highlights various key points regarding the optimization, formulation, design, and evaluation of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban, an anti-coagulant for bioavailability enhancement. These points include the importance of enhancing bioavailability to improve therapeutic efficacy, the utilization of nanoparticles to overcome various challenges such as low solubility and poor dissolution rate, the significance of fast-dissolving tablets in offering rapid drug release and increased patient compliance, and the crucial role of optimization and formulation techniques in ensuring the desired drug release profile. Furthermore, the article emphasizes the importance of evaluating the performance and efficacy of these nanoparticle-loaded tablets through various in vitro and in vivo studies.

A. Summary of key points discussed in the review article

The findings of this study have significant implications for future research and development in the field of nanoparticle-loaded fast dissolving tablets of Rivaroxaban. Firstly, the successful optimization, formulation, design, and evaluation of these tablets demonstrate the potential for bioavailability enhancement of the anti-coagulant drug. This opens doors for further investigation into the use of nanoparticles in improving the therapeutic efficacy of other drugs. Additionally, the study highlights the importance of understanding the physicochemical properties and release characteristics of the nanoparticles, which can guide the development of more effective drug delivery systems. Future research should focus on exploring different nanoparticle formulations and evaluating their performance in vivo to establish their clinical relevance and safety profiles.

B. Implications of the findings for future research and development:

Overall, the effectiveness of nanoparticle-loaded fast dissolving tablets in enhancing the bioavailability of Rivaroxaban appears to be promising. The use of nanoparticles as carriers for the drug allows for improved drug solubility and dissolution rates, leading to increased drug absorption and bioavailability. Additionally, the fast dissolving tablets provide quick disintegration and dissolution in the oral cavity, ensuring rapid drug release and absorption. However, further studies are warranted to fully understand the potential benefits and drawbacks of this delivery system, such as long-term stability, drug compatibility, and potential drug interactions. Overall, the nanoparticle-loaded fast dissolving tablets of Rivaroxaban show potential as a viable option for bioavailability enhancement.

In conclusion, the exploration of nanoparticle-loaded fast-dissolving tablets of Rivaroxaban presents a promising avenue for advancing the bioavailability and therapeutic efficacy of this vital anticoagulant. The optimization, formulation, design, and thorough evaluation discussed in this review underscore the multifaceted approach to enhancing drug delivery. The amalgamation of innovative nanoparticle technologies with the formulation of fast-dissolving tablets offers a synergistic solution to the challenges associated with Rivaroxaban's bioavailability. Through systematic optimization, researchers can fine-tune various parameters to achieve an optimal drug release profile and bioavailability, ensuring improved patient outcomes. The comprehensive evaluation of these nano-enhanced tablets, encompassing in vitro and in vivo studies, provides valuable insights into their performance, stability, and pharmacokinetic attributes. Such thorough

assessments are crucial for establishing the reliability and effectiveness of these formulations in clinical settings. As the field of pharmaceutical research continues to evolve, the findings presented in this review pave the way for future innovations in anticoagulant therapy. The successful integration of nanoparticle technologies into the formulation of fast-dissolving tablets holds great promise for enhancing patient compliance, reducing dosing frequency, and ultimately improving the overall therapeutic impact of Rivaroxaban. In summary, the pursuit of optimized formulations for Rivaroxaban through the incorporation of nanoparticles into fast-dissolving tablets is a dynamic and evolving field that merits continued exploration. The advancements discussed herein contribute to the collective knowledge base, fostering a foundation for further research and development in the quest for enhanced bioavailability and therapeutic efficacy in anticoagulant therapy.

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