A REVIEW ON NAIL DRUG DELIVERY SYSTEM

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ABSTRACT
The nails disorders are mainly due to fungal infection when the drug is given through oral/systemic route the potency of drug gets decreased at the site of action. To avoid this lose of drug potency topical route of administration is used. The absorption of drugs into the nail unit to the nail plate is essential to produce therapeutic effects. By the means of nail drug delivery system oral toxicity of different drugs like anti-fungal can be avoided & also drug get longer contact time at the site of application. The topical therapy is highly desirable in treating the nail disorders due to its localized effects which results in minimal adverse systemic events & possibly improved adherence. However, the effectiveness of the topical therapies is limited by the minimal drug permeability through the nail plate. The use of chemical permeation enhancers has been a common approach for enhancing trans-nail delivery of drugs. The potential of physical permeation enhancement techniques has been found to be higher than the potential of chemical permeation enhancers in transdermal delivery of macromolecular therapeutic agents & hydrophilic drugs. However the application of physical permeation enhancement techniques has not been explored for trans-nail drug delivery. In the current work, iontophoresis was applied across human nail in vitro to assess its efficiency in enhancing the drug delivery. This new therapy may reduce the need for hazardous systemic administration of oral antifungal drugs for nail infections.

Key words: Anti-fungal drugs, Iontophoresis, Human nail, Nail disorders

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INTRODUCTION
A nail is a horny structure. The Nail plate is responsible for the penetration of the drug across it. As the nail plate is hard enough the penetration becomes difficult, only the fraction of the topical drug penetrates across it. Therefore the effective therapeutic concentration is not achieved. As the result of the decreased glow the nail plate may appear abnormal. It’s involvement of the nail bed, reduction of the blood supply, chemical or physical features of the nail bed.

As the result the variety of the diseases occurs. By achieving the desired therapeutic concentration of the drug by nail drug delivery system these diseases can be cured. The Human nails do not have an decorative role, but it can also be considered as an alternative pathway for the drug. The delivery, specially in the nail diseases such as psoriasis or Onychomycosis. These nail diseases are spread widely in the population, particularly among the elderly & patients that are immune compromised. The topical
therapies are limited by the low permeation rate through the nail plate while the oral therapies are accompanied by the drug interactions & systemic side effects. The applied active drug must permeate through the dense keratinized nail plate and reach deeper layers, the nail bed and the nail matrix for the successful treatment of the nail disease. The studies conducted on the human skin elucidated its functions, structure, & its permeability for some of the substances, but very little is known about the nail, the skin derivate & the properties of the nail keratin. The main purpose of this work is to improve the understanding of the physicochemical parameters that influence the drug permeation through a nail plate in order to treat not only the topical nail diseases but also to consider a possibility to reach the systemic circulation & the neighboring target sites. To explore the difficulties in penetration of drug across nail plate & enhancement of bioavailability of antifungal drug is the main purpose of this review. The evidence suggests that the key to the successful treatment of the fungal diseases through the topical antifungal product lies in ineffectively overcoming the nail barrier. The current topical treatments have limited therapeutic effectiveness possibly because they cannot sufficiently penetrate in to the nail plate to transport the therapeutically sufficient quantity of the antifungal drug to the target sites to eradicate the protection. The analysis of the drug's penetration is also the difficult task. The topical therapy of the nail diseases especially of the onychomycosis & to the smaller extent of the nail psoriasis is desirable to avoid the side effects associated with their systemic therapy, reduce the cost of treatment & to increase compliance of the patient. Due to the poor permeability of the nail plate to the topically applied drugs the systemic therapy is however the mainstay of treatment. For the effective topical therapy, this can be achieved by disrupting the nail plate using physical techniques or chemical agents. The drug permeation into the intact nail plate may be encouraged alternatively. For eg, By iontophoresis or by formulating a drug within a vehicle which enables the high drug partition out of the vehicle & into the nail plate. The chemicals techniques[sulphites, thiols, hydrogen peroxide, water, enzymes, urea] & the physical techniques [manual & electrical nail abrasion, acid etching, ablation by lasers, microporation, the application of low-frequency ultrasound & electric currents] that have shown fungal enhancer activity. The human nail can be afflicted by the several disease states which include paronychia, psoriasis & the infections due to bacteria, viruses or fungi. While rarely life threatening, these generate self-consciousness & psychological stress. Approx 50% of all the problems result from the fungal infections, onychomycoses & the prevalence of these may be as high as the 27% in Europe & in the United States it is 10%. There are so many treatment regimens, but the most common involves the oral dosing with the antifungal agents such as the Itraconazole or terbinafine. The experimental techniques for the investigation of the penetration & distribution of the chemicals into & through the nail plate demonstrated that it is possible to deliver the drugs to the nail following the
topical application which led to the development of the newer more effective topical products & regimens for treatment of the onychomycoses & other nail diseases. The novel ultrasound-mediated drug delivery system has been developed for the treatment of the nail fungal disorder [onychomycosis] to increase the permeability of the nail, by improving delivery to the nail bed by using ultrasound.

**NAIL DISEASES & DISORDERS** [1, 3, 6-8]

**The Onychorrhexis**- are brittle nails which often split vertically, peel or have vertical ridges. This irregularity can be the result of the heredity the use of the strong solvents in the workplace or the home including the household cleaning solutions. Although the oil or the paraffin treatments will re-hydrate the nail plate.

**The Onychatrophia**- is an atrophy or wasting away of a nail plate which causes it to lose its luster become smaller & sometimes entirely sheds. The injury or the disease may account for this irregularity.

**The Onychogryposis**- In this the claw-type nails that are characterized by the thickened nail plate & are often the result of the trauma. This types of nail plates will curve inward, pinching the nail bed & sometimes requires the surgical intervention to relieve the pain.

**The Nail Patella Syndrome**- It is the rare genetic disorder which involves skeletal & nail deformities [among the host of the other related anomalies] that occurs in the approximately 2.2 out of every 100,000 people. It is transmitted as the simple autosomal dominant characteristic in a ABO blood group [The autosomal dominant means that you only have to inherit one copy of the gene to get it]. It also means that there is no such thing as an unaffected carrier & Nail Patella Syndrome cannot skip the generation. In some cases where there seems to be no previous family history of the Nail Patella Syndrome it is thought to be caused by the sporadic gene mutation [which is probably how it began in all families at one time or another]. The risk of transmitting the disorder from the parent to offspring is 50% for each pregnancy, regardless of the sex of the child with females being affected approximately 10% more often, once the Nail Patella Syndrome is in the family.

**The Vertical Ridges**- are also characteristic of aging, although are not limited to the elderly or aged. The nail plate grows forward on the nail bed in the “rail & groove” effect much like the train rides on its' tracks. As we age the natural oil & moisture levels decline in the nail plate & this rail & groove effect becomes apparent. The ridged nails will improve through the re-hydration of the nail plate with twice daily applications of the good quality nail & cuticle oil containing Vitamin E & Jojoba.

**The Melanonychia**- these are vertical pigmented bands often described as the nail “moles” which usually form in the nail matrix. Seek the physicians care should you suddenly see this change in the nail plate. It could signify the malignant melanoma or the lesion. The dark streaks may be the normal occurrence in the dark-skinned individuals, & are fairly common.
Paronychia- The infections of the nail fold can be caused by the fungi, bacteria & some viruses. The proximal & lateral nail folds act as the seal or barrier between the nail plate & the surrounding tissue. If the tear or the break occurs in this seal the bacterium can enter easily. This type of infection is characterized by the redness, pain & swelling of the nail folds. The people who have their hands in the water for the extended periods may develop this condition & it is contagious highly.

The Pterygium- is the inward advance of the skin over the nail plate usually the result of the trauma to the matrix due to the surgical procedure or by the deep cut to the nail plate. The Pterygium results in the loss of a nail plate due to the development of the scar tissue. The cortisone is used to prevent the advancement of the scar tissue. Never attempt to remove the pterygium –instead.

The Psoriasis- of the nails is characterized by the raw, scaly skin & is sometimes confused with the eczema. When it attacks a nail plate it will leave it dry, pitted & it will crumble often. The plate may separate from a nail bed & may also appear orange, red or brown, with the red spots in the lunula. Do not attempt salon treatments on the client with the Nail Psoriasis.

Pseudomonas bacterial infection- It can occur between the natural nail plate & the nail bed &/or between an artificial nail coating & the natural nail plate. Many of the people have been led to believe that a classic “green” discoloration of this type of the infection is some type of the mold. In actuality the mold is not the human pathogen. A discoloration is simply the by-product of the infection & is caused primarily by the iron compounds. The Pseudomonas thrive in the moist places, it feeds off the dead tissue & bacteria in to the nail plate while the moisture levels allows it to grow. The after effects of this infection will cause the nail plate to soften underneath & darken an artificial coating. A darker the discoloration the deeper into the nail plate layers the bacteria has traveled. If the bacteria has entered between the nail plate & the nail bed it will cause the same discolorations & may also cause the nail plate to lift from the nail bed.

The Beau's Lines- are the nails that are characterized by the horizontal lines of the darkened cells & linear depressions. This disorder may be caused by the illness, trauma, malnutrition or any major metabolic condition, the chemotherapy or other damaging event & is the result of any interruption in the protein formation of the nail plate.

The Koilonychia- is usually caused through the iron deficiency anaemia. These nails show raised ridges & are concave & thin.

The yeast or fungal infection- which results in the Onychomycosis can invade through the tear in the proximal & lateral nail folds as well as the eponychium. These types of infections are characterized by nail plate separation [onycholysis] with evident debris under a nail plate. Normally it appears yellowish or white in color & may also change the shape & texture of the nail. The fungus digests a keratin protein of which the nail plate is comprised. The
organic debris accumulates under the nail plate often discoloring it, as the infection progresses. The other infectious organisms may be involved & if it is left untreated the nail plate may separate from the nail bed & crumble off.

**The Hematoma**- is a result of the trauma to the nail plate. It can be happened from simply trapping your finger or the toe in the car door to friction from improperly fitting or “too-tight” shoes to the sports related injury. The hammer does the pretty good job at causing the hematoma as well. The nail bed will bleed due to this trauma & the blood is trapped between the nail bed & a nail plate. The hematoma may also indicate the fractured bone. Many of the people who participate in the sports activities experience hematoma because of the constant friction from the shoes against the toe nails. The hematoma may result in the nail plate separation & infection because the blood can attract bacteria & fungi. If several days have passed & the blood clot becomes painful the removal of nail plate may be required so that the nail bed can be cleansed.

**Ringworm of the nails or Tinea Unguis**- is characterized by deformity, nail thickening & eventually results in nail plate loss.

**The Leuconychia**- it is evident as white lines or spots in a nail plate & may be caused by the tiny bubbles of air that are trapped into the nail plate layers due to the trauma. This condition may be hereditary & no treatment is required as the spots will grow out with the nail plate.

**The Pterygium Inversum Unguis**- it is an acquired condition characterized by the forward growth of the hyponychium characterized by the live tissue firmly attached to a underside of the nail plate which contains the blood supply & the nerves. The possible causes are hereditary, systemic or from an allergic reaction to solvents or the acrylics. Never use the force to “push back” the advancing hyponychium- it is an extremely painful approach & will result in the blood flow.

**ANATOMY OF NAIL** [5-10]

**Parts of the nail**

A matrix [sometimes it is called the matrix unguis, keratogenous membrane, onychostroma or nail matrix] is the tissue [or the germinal matrix] which the nail protects the part of the nail bed that rests beneath the nail & contains the blood vessels, lymph & nerves. For the producing cells the matrix is responsible that becomes a nail plate. The width & thickness of a nail plate is determined by the length, size & thickness of the matrix while the fingertip shape itself shows if the nail plate is hooked, flat or arched. As long as it receives nutrition & remains in the healthy condition the matrix will continue to grow. As the new nail plate cells are made they push the older nail plate cells forward & in this way the older cells become translucent, compressed & flat. This makes the capillaries in the nail bed below visible, resulting in the pink color. The lunula [the moon] is a visible part of the matrix, the whitish crescent shaped base of the visible nail. A lunula can be seen as the largest in the thumb & often is not present in the little finger. A nail bed is the skin beneath the nail plate. Like all the skin, it is made of 2 types of tissues, the deeper dermis, the living tissue fixed to a bone
which includes the capillaries & glands & the superficial epidermis, the layer just beneath the nail plate which moves forward with the plate. By tiny longitudinal grooves known as matrix crests [cristae matricis unguis] the epidermis is attached to the dermis. During the old age, the plate thins & these grooves are more visible. The nail sinus [sinus unguis] is where the nail root is inserted. The nail root [radix unguis] is the part of the nail situated in the nail sinus that is the base of the nail under beneath the skin. It originates from a actively growing tissue below the matrix. The nail plate [corpus unguis] is the actual nail, made of the translucent keratin protein. The several layers of the dead compacted cells cause the nail to be strong but flexible. By the form of the underlying bone its [transversal] shape is determined. In the common usage the word nail often refers to this part only. The free margin [margo liber] or the distal edge is the anterior margin of the nail plate corresponding to an abrasive or cutting edge of the nail. A hyponychium [informally known as the quick] is the epithelium located beneath the nail plate at the junction between the free edge & the skin of the fingertip. It forms the seal that protects the nail bed. The onychodermal band is a seal between the nail plate & the hyponychium. It is found just under the free edge, in that portion of a nail where the nail bed ends & can be recognized by its glassy grayish colour [in fair-skinned people]. It is not perceptible in some of the individuals while it is highly prominent on others. A eponychium is a small band of the epithelium that extends from the posterior nail wall onto the base of the nail. Often & erroneously called the proximal fold or cuticle the eponychium is the end of the proximal fold that folds back upon itself to shed an epidermal layer of the skin onto the nail plate which is newly formed. This layer of non-living almost invisible skin is the cuticle that rides out on the surface of the nail plate. The eponychium and the cuticle together form the protective seal. The cuticle on a nail plate is dead cells & is often removed during the manicure, but the eponychium is living cells & should not be touched. A perionyx is the projecting edge of the eponychium covering the proximal strip of the lunula. The nail wall [vallum unguis] is the cutaneous fold overlapping the proximal end of the nail & the sides. The lateral margin [margo lateralis] is lying beneath the nail wall on the sides of the nail & the nail groove or fold [sulcus matricis unguis] are the cutaneous slits into which the lateral margins are embedded. The paronychium is a border tissue around the nail & in this area paronychia is an infection.

FACTORS AFFECTING DRUGS TRANSPORT INTO/ACROSS THE NAIL [11-15]

The drug has to enter the nail plate & diffuse into the deeper nail layers & possibly into the nail bed in topical application of the drug formulation onto the nail plate. The Walters et al. found that the nail plate behaves like the concentrated hydrogel rather than the lipophilic membrane. The drug delivery into & through the nail plate is influenced by the,

- Interactions between the permeant & the keratin network of the nail plate
- The physicochemical properties of the drug molecule to be applied
The presence of permeability enhancers in the formulations

- The properties of nail
- The type & nature of formulations

The Nature of Vehicle used in the formulation

Permeability coefficients of the alcohols diluted in saline through the nail plates was 5 times greater than the permeability coefficients of the neat alcohols. The water hydrates the nail plate which swells consequently. By considering the nail plate to be a hydrogel the swelling results in increased distance between the keratin fibres larger pores through which permeating molecules can diffuse & hence increased permeation of the molecules. By replacing water with the non-polar solvent which does not hydrate the nail is therefore expected to reduce the drug permeation into the nail plate.

The Molecular size of drug

Larger the molecular size, it is harder for the drug to diffuse through the keratin network & lower the drug permeation. The Mertin & Lippold demonstrated the decreasing permeability coefficients through the human nail plate & through the bovine hoof membrane with the increasing molecular size of the series of alkyl nicotinates.

The PH of vehicle & solute charge

pH of the aqueous formulations affect the ionization of the weakly acidic/basic drugs which in turn influences the drug’s Hydrophobicity / Hydrophilicity solubility in the drug, the formulation, solubility in the nail plate & its interactions with the keratin matrix. It seems that the pH of the formulation has the distinct effect on the drug permeation through the nail plate.

The Hydrophilicity / Lipophilicity of drug

The Walters et al. studied the permeation of the series of the homologous alcohols [C1–C12] diluted in the saline through the avulsed human nail plates. If the chain length is increased from 1 carbon to 8 carbon atoms it results in the decrease in the permeability coefficient, after which increasing chain length [>C12] resulted in the increased permeability coefficient. The study by the Walters et al. concluded that the nail plate is characterized as the hydrophilic gel membrane.

METHODS FOR ENHANCING THE NAIL PENETRATION

The effective penetration across the nail is not easy, as the nail consists of the approximately 25 layers of the tightly bound keratinized cells & is 100-fold thicker than the stratum corneum. It increases in the toe nail thickness along the nail. The Physical, chemical & mechanical methods have been used to decrease the strength of the nail barrier.
A] THE PHYSICAL METHODS TO ENHANCE THE NAIL PENETRATION

The physical permeation enhancement may be superior as compared to chemical methods in delivering the hydrophilic & macromolecular agents. There are several physical enhancement methods both experimental & established.

1] The Etching

It includes the exposure with the surface-modifying chemical [For e.g. phosphoric acid] resulting in the formation of the profuse microporocytes. These micro porosities increase the wettability & surface area & decrease the contact angle. Furthermore the presences of the micro porosities promotes the interpenetration & bonding of the polymeric delivery system & thus facilitate of the inter diffusion of the therapeutic agent. After etching of the nail plate the hydrophilic, sustained-release, the polymer film drug delivery system may be applied.

2] The hydration and occlusion

The diffusivity of the water & drugs increases as the human skin becomes more hydrated & nails became permeable & more elastic. It may lead to increase the pore size of the nail matrix enhancing transungual penetration. The ionic strength & Solution pH have demonstrated no significant effect on the nail hydration.

3] The carbon dioxide laser

It shows the unpredictable response it may be positive. There are 2 methods one is the avulsion of a affected nail portion followed by the laser treatment at the 5000W/cm² [power density]. In this way the underlying tissue is exposed to the direct laser therapy. The another method involves, penetrating the nail plate with the CO₂ laser beam followed with the daily topical antifungal treatment penetrating laser-induced puncture holes.

4] The Iontophoresis

The iontophoresis involves the use of the electric field for a delivery of the compound across the membrane. The drug diffusion through the hydrated keratin of a nail is enhanced by iontophoresis, as compared to passive transport. The Iontophoresis significantly enhances drug penetration through the nail. This is due to the electrophoresis/ electro repulsion - interaction between the electric field & the charge of the ionic permeant electro osmosis convective solvent flow in the pre-existing & newly created charged pathways & permeabilization / electroporation electric field-induced pore induction.

5] Micro needle

This method involves the use of arrays of the microscopic needles to open pores in the stratum corneum directly to the skin capillaries. Being too short to stimulate the pain fibres, and facilitate drug permeation, is its advantage.

B] THE CHEMICAL METHODS TO ENHANCE THE NAIL PENETRATION

Chemically the drug permeation into the nail plate can be assisted by breaking the physical & chemical bonds responsible for
the stability of the nail keratin. This destabilizes the keratin, interferes the integrity of the nail barrier & allows the penetration of drug molecules.

1] The compounds containing sulfhydryl groups

The compounds which contain sulfhydryl [SH] groups such as the cysteine, acetylcysteine, mercaptoethanol can reduce & thus cleave the disulphide bonds in the nail proteins.

2] The keratinolytic enzymes

The nail keratinic tissues hydrolyzed by the keratinolytic enzymes thus leads to the weakening of the nail barrier & enhanced permeation.

3] The keratolytic enhancers

The keratolytic agents [salicylic acid, papain & urea] may be used to improve the penetration of the antifungal drugs. These are supposed to act by the disruption of the keratin disulphide bonds & the associated formation of the pores that provide more “open” drug transport channels.

C] THE MECHANICAL METHODS TO ENHANCE NAIL PENETRATION

1] The nail avulsion

It involves the removal of the entire nail plate or the partial removal of the affected nail plate is done surgically by the partial nail avulsion & total nail avulsion & under local anaesthesia prior to the topical treatment.

2] The nail abrasion

This method uses the sandpaper nail files prior to the nail treatment by the drug that is anti-fungal to decrease the fungal mass. It involves the sanding of the nail plate to reduce the thickness or to destroy it completely. The sandpaper number 150 or 180 can be utilized. The nail abrasion thins the nail plate, decreasing the fungal mass of the onychomycosis & exposing the infected nail bed.

RECENT ADVANCES IN THE NAIL DELIVERY [21]

Recent technologies are introduced in the development of the more efficient drug delivery, apart from the traditional formulations like nail patches, nail lacquers, nail varnish. Some of the recent technologies are listed below which open the new horizons for the drug delivery to the human nail.

i) The Mesoscissioning technology

The mesoscissioning technology creates the micro-conduit through the skin or the nail within the specified depth range. The fully open pathways can be painlessly cut through the stratum corneum of the skin or through the nail. The Microconduits 300-500 microns in diameter are produced without sensation & within the seconds. These pathways can be used to deliver the drugs across the skin [the proof-of-concept in the in vivo human experiments have shown that full anaesthesia occurs within 3 minutes through the microconduits as compared with 1+hour through the intact stratum corneum]. Such microconduits also permit the access
for the subdermal analyte extraction [including the blood for glucose testing]. In addition, for the biopotential measurements they reduce the skin electrical impedance to less than 1000 ohms. In the nails, microconduits quickly reduce the painful pressure of the subungual hematoma [black toe] & could serve as the prophylactic to prevent such pressure build-up in the runner's nails.

ii) The NanoPatch Nail Fungus

The NanoPatch Fungus uses the AC/DC electrochemistry & the targeted drug delivery to the actively push antifungal drugs right through the nail cuticle to the actual location of the fungus growth. To directly target the nail fungus at its source of growth, it would be the first treatment option.

Table 1: DEVELOPED FORMULATIONS FOR NAIL DISORDERS

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Name of product</th>
<th>Name of company</th>
<th>Name of drug</th>
<th>Uses/Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Penlac nail lacquer</td>
<td>Dermik Laboratories Inc.</td>
<td>Ciclopirox topical solution</td>
<td>a broad-spectrum antifungal medication that also has anti-inflammatory &amp; antibacterial properties</td>
</tr>
<tr>
<td>2</td>
<td>Eco-Nail nail lacquer</td>
<td>MacroChem Corporation</td>
<td>5% econazole + 18% SEPA nail lacquer</td>
<td>Promotes the release of the econazole from the dried lacquer film creating a large chemical gradient at the lacquer nail interface to drive econazole into the deep nail plate. SEPA acts as the percutaneous penetration enhancer which itself has no effect on nail &amp; do not penetrate nail.</td>
</tr>
<tr>
<td>3</td>
<td>Zalain nail patch</td>
<td>Labtec</td>
<td>Sertaconazol nitrate</td>
<td>Once-a-week nail patch for the treatment of the onychomycosis &amp; onychodystrophy</td>
</tr>
<tr>
<td>4</td>
<td>Loceryl nail film</td>
<td>Galderma Australia Pty Ltd</td>
<td>antifungal drug, amorolfine</td>
<td>The non-water-soluble film of the amorolfine formed on the nail plate &amp; this film remains in place for 1 week. The film contains the high concentration of amorolfine &amp; forms a depot from which the drug is delivered &amp; which allows the drug to permeate the nail plate.</td>
</tr>
<tr>
<td>5</td>
<td>Tazorac 0.1% Gel</td>
<td>Allergen Inc</td>
<td>Tazarotene</td>
<td>Used in the Treatment of the Fingernail Psoriasis</td>
</tr>
<tr>
<td>6</td>
<td>Umecta nail film</td>
<td>JSJ Pharmaceuticals</td>
<td>Urea 40%</td>
<td>Psoriatic nails, brittle and thick nails, &amp; calluses</td>
</tr>
</tbody>
</table>
iii) The Electrochemotherapy for the nail disorders

Goal of this therapy is to develop an active method of the drug delivery across the nail plate which in turn is believed to decrease the duration of the treatment of the nail disorders & increase the success rate of the topical monotherapy. Currently the electrically mediated techniques for the drug delivery across the nail plate are investigated. Recently the iontophoretic trans-nail delivery method studied, the Iontophoresis was found to enhance significantly the transport of the drugs across the nail plate. Similar to the transdermal iontophoresis the predominant mechanisms contributing to the enhanced transport of the drugs in case of transnail iontophoresis are Electroosmosis & electrophoresis. The iontophoretic permselectivity of the human nail plate & its applicability on the trans-nail delivery of the drugs are also under investigation.

CONCLUSION

By the topical delivery of drug to the nail there are some benefits. Some of the benefits like sustained release, first pass avoidance & convenience are cited most often. Nail diseases like paronychia, nail psoriasis, onycomycosis, yellow nail syndrome & many more are being cured successfully by using the medicated lacquers. This will avoid the oral toxicity of the anti-fungal drugs & provides the longer contact time at the site of action. With the lack of understanding of both the barrier properties of the nail & the formulations, the delivery of the drug to the nail [ungual drug delivery] constitutes the major challenge, to achieve enhanced ungula delivery restricting the efficiency of the topical treatments for nail disorders. This review covers the diseases related to nail plate, the anatomy of a human nail, some techniques used to enhance the topical bioavailability of the drugs across the nail, formulations designed for nail application & recent advances in nail delivery.

REFERENCES

8. Kobayashi Y, Miyamoto M, Sugibayashi K, Morimoto Y; Drug permeation through the


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