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Review Article

RECENT TRENDS IN DENTAL DRUG DELIVERY SYSTEMS

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ABSTRACT
Controlled release local drug delivery systems offer advantages compared to systemic dosage forms for many dental diseases like gingivitis, periodontitis. The objective of this literature survey was to gain knowledge about various dental drug delivery systems for targeted delivery of the drug. The polymer ethyl cellulose was used in the formulation of dental films. The dental film was then evaluated for various parameters like thickness, folding endurance and weight variation and content uniformity, *in vitro* and *in vivo* study. There has been a great attention in using iontophoretic technique for the transdermal drug delivery of medications, both ionic and non ionic. This technique of facilitated movement of ions across a membrane under the influence of an externally applied electric potential difference is one of the most promising physical skin penetrations enhancing method. Another novel approach is the use of lasers in dentistry. Lasers can be used in both hard and soft tissue applications including laser bleaching, frenectomy, gingivectomy, caries removal etc. Drugs delivery via the buccal routs using bio adhesive dosage forms offers such a novel route of drugs administration. This route has been used successfully for the systematic delivery of number of drugs candidates. Problems such as high first pass metabolisms and drugs degradation in the gastrointestinal tract can be circumvented by administrating the drug buccal routes.
Keywords: Dental inserts, laser, iontophoretic drug delivery, mucoadhesive, transdermal.

INTRODUCTION

Dental Inserts

Dental inserts are described by positioning between interproximal surfaces of teeth during a dental procedure. The tooth inserts have thin regions positioned in the interproximal contact of the teeth. In one form, a tooth inserts comprises an elongated band having spaced apart from the thin central regions positioned so that, when the band is wrapped around a teeth, a first of the central regions is positioned between a first tooth and adjacent tooth and the second of the central regions is positioned between the first and third tooth, which is adjacent to the first tooth and at the opposite side of the first tooth from the second tooth.[1] Dental inserts used for stopping or filling a cavity of carious tooth treated by a preparation. Nowadays dental inserts used for the treatment of local disease like periodontitis in a form chip, strip, gels and bio-dental inserts as a local drug delivery for the sustained and controlled effect.[2]

Advantages

1. Periodontal pockets are easily accessible and are therefore a convenient site for localized drug delivery system, which could be inserted into the pocket.
2. It is useful in controlling and monitoring the desired drug levels in the site.
3. It allows local modification of tissue permeability, inhibit protease activity or decrease immunogenic response.
4. It is a useful means of delivering a drug to oral cavity that is not absorbed into the gastrointestinal system.
5. It passes by hepatic first pass metabolism, thereby offering a greater bioavailability and reduction in dosage.
6. The drugs escape from the destructive acidic environment of the stomach.
7. Therapeutic serum concentration of the drug can be achieved more rapidly.
8. Sustained release drugs offer a onetime application and have an advantage over repeated application.[3]

Disadvantages

1. There is difficulty in placing therapeutic concentration of antimicrobial agent into deeper parts of periodontal pockets.
2. Personal application of antimicrobial agents by patients, lack of adequate manual dexterity, limited understanding of periodontal anatomy and poor compliance and performance with recommended procedure.
3. The task of professionally applying local antimicrobial agents in periodontitis patients with numerous advanced lesions distributed throughout their mouth is time consuming and labour intensive.
4. Antimicrobial agents locally applied into periodontal pockets do not affect pathogens residing within adjacent gingival connective tissues and on extra- pocket oral surfaces which increases the risk of re-infection.[4]

Formulation of Standard Dental Inserts

The standard dental inserts were formulated using drug, synthetic polymer polycaprolactone and ethylcellulose in a ratio of 1:1:1, 1:2:1, 1:4:1, 1:5:1, 1:6:1, 1:8:1 and 1:10:1 and using drug (moxifloxacin) with polycaprolactones and ethylcellulose in a ratio of 1:14.4 separately by employing solvent casting technique.[5]

Procedure (Polycaprolactone and Ethyl Cellulose Dental Inserts)

The standard polymer polycaprolactone 10 mg and ethyl cellulose 10 mg were weighed for the formuation FS1 (1:1:1) and was taken in a beaker. Then it was dispersed uniformly using a solvent dichloromethane 3.0 ml by sonication, after that drug (moxifloxacin) 10 mg was mixed by continuous stirring in a sonicator until a unifom solution was formed. After that it was poured in the petridish and dried in the room temperature. In last, bio-dental inserts were scraped out and well stored in aluminium foil and the same experimental procedures were repeated for formulation FS2 (1:2:1), FS3 (1:4:1), FS4 (1:5:1), FS5 (1:6:1), FS6 (1:8:1) and FS7 (1:10:1).[5] The standard dental inserts were also prepared

using polycaprolactone and ethyl cellulose separately. The standard polymer polycaprolactone 6 beads were weighed and taken in a 100 ml beaker and then it was dispersed uniformly using a solvent dichloromethane 3.0 ml by sonication after that drug (moxifloxacin) 10 mg was mixed by continuous stirring in a sonicator until a uniform solution was formed. After that it was poured in the petridish and dried in the room temperature. In last, bio-dental inserts were scraped out and well stored in aluminium foil and the same experimental procedures were repeated by taking ethyl cellulose 144 mg weight equivalent to six beads of polycaprolactone.[5]

Evaluations of Formulations

Periodontal bio-dental inserts were evaluated for physical characteristics as follows[6]:

Thickness Uniformity of the Bio-Dental Inserts

Thickness of the bio-dental inserts was measured using digital screw gauge (Mitutoyo) at different areas of the films and the average was calculated and reported[6].

Uniformity of Weight of the Bio-Dental Inserts

Bio-dental inserts (size of 7 x 2 mm^2) was taken from different areas of film. The weight of each bio-dental insert was taken and the weight variation of 5 bio-dental inserts were calculated and reported[6].

Surface pH

Periodontal bio-dental inserts were left to swell for 1 h on the surface of the agar plate, prepared by dissolving 2 % (w/v) agar in warmed double distilled water with constant stirring and poured into the petridish to solidify at room temperature. The surface pH was measured by means of pH paper placed on the surface of the swollen film. The mean of three readings was recorded[6]

Swelling Index (% S)

Swelling index of the drug loaded bio-dental inserts was determined by placing the film (area 7×2 mm^2) in the petridish containing about 10.0 ml of phosphate buffer 7.6, before placing the film in the petridish its initial weight was calculated and increase in weight due to swelling was determined by weighing the bio-dental inserts at the time interval of 1,2,3,4,5,6,7,8,9,10,11 and 12 h.

The Percentage of swelling was determined by using the following formula

$$\% S = Xt - X_0 / X_0 \times 100$$

Where, % S - swelling percentage,
Xt - the weight of swollen dental inserts after time t,
X0 -weight of film at zero time zero.

Folding Endurance

The folding endurance of the dental inserts was determined by repeatedly folding the inserts at the same place until it broken, which is considered satisfactory to reveal good insert properties. The number of times dental inserts could be folded at the same place without breaking gave the value of folding indurance. This test was done on all the bio-dental inserts for three times and the results were compiled and reported.

Drug Content Uniformity

Dental inserts (size of 7 x 2 mm^2) were taken from different areas of the film and placed into a 10 ml volumetric flask, in to which 5.0 ml of methanol was added and kept aside till the film is completely dissolved. Withdraw 1 ml of solution and diluted to 10 ml with pH 7.6 phosphate buffers. The absorbance of the solution was measured at 290.5 nm. The polymeric solution without drug served as blank.[7]

Tensile Strength of the Dental Inserts

Tensile strength of the dental inserts was determined by universal strength testing apparatus. It consists of the glass plate which is fixed on lower base of apparatus, a pull through which a strings is attached and a weight holder box which is connected with the strings. The test film of specific size (7 × 2 mm^2) was fixed between glass plates and strings and weights are applied until the bio-dental inserts breaks. The tensile strength of bio-dental inserts was directly measured from weight in the weight box and reported[8].

***In-vitro* Drug Release**

Dental inserts were subjected to *in-vitro* release by using fabricated static dissolution method reported in the literature was adopted. Dental inserts of known weight and dimensions (size of 7 × 2 mm^2) were placed separately into small vials containing 5.0 ml of pH 7.6 phosphate buffer. The vials were closed with closer and kept at 37°C for 5 days. The buffer was drained off and replaced with fresh 1 ml of pH 7.6 in a time intervals of 1,2,3,4,6,8,10,12,24,48,72,96 and 120 h. After that the absorbance of samples were determined by U.V. Spectroscopy at λ_{max}[9].

Iontophoresis

The highly lipophilic nature of the skin restricts the permeation of hydrophilic[10], high molecular weight and charged compounds through the stratum corneum into the systemic circulation. However, many therapeutically active drug molecules are hydrophilic and possess high molecular weights for example, peptides (Sloan *et al*., 1986 and Williams *et al*., 1992). Iontophoresis simply defined is the application of an electrical potential that maintains a constant electric current across the skin and enhances the delivery of ionized as well as unionized moieties (Williams *et al*., 1992). This technique is capable of expanding the range of compounds that can be delivered transdermally. Along with the benefits of bypassing hepatic first pass effect and higher patient compliance, the additional advantages that the iontophoretic technique offers can be summarized as follows (Williams *et al*., 1992, Williams *et al*., 1991 and Glikfeld *et al*., 1988).[11]

- Delivery of both ionized and unionized drugs.
- Depending on the current applied it is enabling continuous or pulsatile delivery of drug.
- Permitting easier termination of drug delivery.
- Offering better control over the amount of drug delivered since the amount of compound delivered depends on applied current, duration of applied current and area of skin exposed to the current.
- Restoration of the skin barrier functions without producing severe skin irritation.
- Improving the delivery of polar molecules as well as high molecular weight compounds.
- Ability to be used for systemic delivery or local (topical) delivery of drugs.
- Reducing considerably inter and / or intra subject variability in view of the fact that the rate of drug delivery

is more dependent on applied current than on stratum corneum characteristics.[12]

Merits

1. It is a non-invasive technique could serve as a substitute for chemical enhancers.
2. It eliminates problems like toxicity problem, adverse reaction formulation problems associated with presence of chemical enhancers in pharmaceuticals.
3. It may permit lower quantities of drug compared to use in TDDS, this may lead to fewer side effects.
4. TDDS of many ionized drug at therapeutic levels was precluded by their slow rate of diffusion under a concentration graduation, but iontophoresis enhanced flux of ionic drugs across skin under electrical potential gradient.
5. Iontophoresis prevent variation in the absorption of TDDS.
6. Eliminate the chance of over or under dosing by continuous delivery of drug programmed at the required therapeutic rate.
7. Provide simplified therapeutic regimen, leading to better compliance.
8. Permit a rapid termination of the modification, if needed, by simply by stopping drug input from the iontophoretic delivery system.
9. It is important in systemic delivery of peptide / protein based pharmaceuticals, which are very potent, extremely short acting and often require delivery in a circadian pattern to simulate physiological rhythm, e.g. Thyrotropin releasing hormone, somatotropine, tissue plasminogen activates, interferons, enkaphaline etc.
10. Provide predictable and extended duration of action.
11. Reduce frequency of dosage.
12. Self-administration is possible.
13. A constant current iontophoretic system automatically adjust the magnitude of the electric potential across skin which is directly proportional to rate of drug delivery and therefore, intra and inter-subject variability in drug delivery rate is substantially reduced. Thus, minimize inter and intra-patient variation.
14. An iontophoretic system also consists of an electronic control module which would allow for time varying of free-back controlled drug delivery.
15. Iontophoresis turned over control of local anaesthesia delivery in reducing the pain of needle insertion for local anaesthesia.
16. By minimizing the side effects, lowering the complexity of treatment and removing the need for a care to action, iontophoretic delivery improve adherence to therapy for the control of hypertension.
17. Iontophoretic delivery prevents contamination of drugs reservoir for extended period of time.

Demerits

1. Iontophoretic delivery is limited clinically to those applications for which a brief drug delivery period is adequate.
2. An excessive current density usually results in pain.
3. Burns are caused by electrolyte changes within the tissues.
4. The safe current density varies with the size of electrodes.
5. The high current density and time of application would generate extreme pH, resulting in a chemical burn.
6. This change in pH may cause the sweat duct plugging perhaps precipitate protein in the ducts, themselves or cosmetically hyper hydrate the tissue surrounding the ducts.
7. Electric shocks may cause by high current density at the skin surface.
8. Possibility of cardiac arrest due to excessive current passing through heart.
9. Ionic form of drug in sufficient concentration is necessary for iontophoretic delivery.
10. High molecular weight 8000-12000 results in a very uncertain rate of delivery.[13]

Lasers in Dentistry

Lasers have been used in the dental arena for over more than 20 years. The wavelength of the light is an important criterion in laser induced treatment of various dental diseases. The wavelength of the light is the primary determinant of the degree to which the light material in induced in the target material. Lasers produce light energy in narrow frequency range. For most practical purposes the light produced by lasers is mostly considered to be monochromatic light. Typically lasers are named according to the active element present within them that goes to the stimulated quantum transitions which produce light. The wavelength or inversely the frequency produced by the laser is characteristic if the element present within it. For example, carbon dioxide lasers produce light of wavelength 10.6 micrometer[14].

CO_2 Lasers

Several laser wavelengths are used in dentistry. Carbon dioxide lasers operate at a frequency of 10.6 micrometers. They can be operated in a gated wave form or continuous wave form.[15]

- These can be used in a number of soft tissue applications including the following.
- Soft tissue incision and tissue ablation.
- Gingival troughing.
- Esthetic countering of gingival.
- Treatment of oral ulcers.
- Frenectomy and gingivecttomy.
- De epithelisation of the gingival tissue during periodontal regenerative process.

Argon Lasers

Argon lasers are used in treatment of various dental diseases like periodontits, gingitivits etc. They operate at a wavelength of 457 to 502 nanometers. They can be used of resin curing and laser bleaching. In addition they are used in various soft tissue applications including esthetic contouring of gingival, treatment of oral ulcers, frenectomy, gingivectomy etc. The primary advantage of argon lasers is that it operates at wavelength that is absorbed by haemoglobin that in produces excellent haemostatis.[16]

Laser Bleaching

The argon lasers proved out to be an excellent replacement for the conventional curing light if the manufacturer's suggested procedures are strictly followed. Lasers are also used for activating bleaching solutions for tooth whitening procedures.[17]

Laser Caries Detection

Lasers fluorescence appears to compare favourably with standard methods of caries detection in occlusal fissures. Lasers fluorescence has also played excellent activity in detection of residual caries. Lasers are also used in curettage techniques that are used in periodontitis.[18,19]

Mucoadhesive Dental Drug Delivery

The interest in novel rout of drugs administration occurs from their ability to enhance the bioavailability of the drugs impaired by narrow absorption windows in the gastrointestinal tracts. Drugs delivery via the buccal routs using bio adhesive dosage forms offers such a novel routs of drugs administration. This route has been used successfully for the systematic delivery of number of drugs candidates[20-24]. Problems such as high first pass metabolisms and drugs degradation in the gastrointestinal tract can be circumvented by administrating the drug buccal routes[23,24]. Moreover, buccal drug delivery offers safe and easy method of drugs utilization, because drug absorption can be promptly terminated in case of toxicity by removing buccal dosage form from buccal cavity. Aceclofenac, a new NSAID posses good anti inflammatory, analgesics and anti-pyretic, used for treatment of treating condition like osteoarthriritis, rheumatoid arthritis, dental pain and other rheumatoid disorder. It is highly protein bound and posses' short biological half life of 4-5 h, which makes it's an ideal candidate for administration by buccal routs the effectiveness of mucoadhesive formulation is greatly determined by the nature the polymer composition used[8]. In the presented study, an attempted was to formulate mucoadhesive patch of Aceclofenac using PEG, PVA and gelatin by solvent casting method.

Methods

Preparation of Mucoadhesive Patches

Mucoadhesive patch were prepared by solvent casting method. All ingredients were accurately weighed and mixed by trituration in glass pestle and mortal. The mixture was then added gradually to magnetically stir solvent system containing the plasticizer. Stirring was continued until a clear solution was obtained. The solution was then transferred quantitatively to petri-dish (glass) diameter 6 cm .The petri-dishs were covered with inverted funnels to allow controlled evaporation of the solvents. These were lefts undisturbed upon temperature (20-25^{0}C) for one to two days depending upon the solvent system used. Small patches of size 15 mm and 20 mm diameter, 0.2 to 0.3 mm thick were carefully pull out from the petri-dishes.

Evaluation of Mucoadhesive Patches

Weigh Variation

Weigh variation was tested by comparing the averages weighed of 10 different randomly selected patches from each batch with individual patch.

Patch Thickness

Patch thickness was measured at 5 different randomly selected spots using a screw gauge.

Volume Entrapment Efficiency %

Volume entrapment efficiency % is volume uptake by capacity by buccal capacity of fluid (saliva) by buccal patches after adhesion into the buccal cavity. Mucoadhesive patch were weighed individually (X0) and placed separately in 2 % agar gel plates and incubated at 370C ± 10C. After 90 minutes the final weight of the patch (XT) were noted and the volume entrapment efficiency was using the following formula (Nafee N A.; *et al* 2003).

Volume entrapment efficiency % = (XT – X0) 100/X0
Where X0 = initial weight of patch, XT = final weight of patch (after 90minutes)

Measurement of the % Elongation at Break

The initial length of the patch was measured on scale and applying the force the patch unit the patch was broken and calculated the % elongation of patch by using the following formula.

% Elongation at break = Increase in length x 100/ Initial length

Surface pH

The patches was allowed to swell then in contact with 0.5 ml of distilled water (pH 6.5 ± 0.5) for one hour at room temperature and pH was noted down by bringing electron in contact the surface the pH , allowing it equilibrate for 1 minute[26].

Folding Endurance

Folding endurance of the patches was determined by repeatedly folding one patch at 1800 angle of plane at same plane till it broke or folded to 200 time without breaking[27] .

***In vitro* Mucoadhesive Time**

In vitro mucoadhesive time was measured (n = 3) after application of the patches onto freshly cut sheep buccal mucosa. The fresh buccal mucosa was fixed in the inner side the beaker, above 2.5 cm from the bottle, with cynoacrylate glue. One side of the each patch was wetted with one drop of isotonic phosphate buffer pH 6.8 and pasted to the sheep buccal mucosa by applying the small force with a fingertip for 30 seconds. The beaker was filled with 500 ml of isotonic phosphate buffer 6.8 and was kept at 37 ±10C. After 2 minutes a 50 rpm string rate was applied to simulate the buccal cavity environment. The time required for the patch to detach from the sheep buccal mucosa was recorded as mucoadhesive time.

***In vitro* Release**

In vitro permeation studies were carried out in an all glass modified two-chambered diffusion cells. The lower side of upper compartment was completely closed tied membrane of goat was kept at 340C[20]. The buccal mucosa was kept in saline solution for the prevention of damage the cells. The appropriate size 2 cm^2 was cut down and fixed in between the lower surface the diffusion cell i.e. on the mouth of receptor compartment and was kept fixed with in donor compartment, thus by incorporating the PBS solution in the donor compartment which is having 1 ml capacity the drug release phenomenon was yet started. The lower chamber of the apparatus had small volume compartment (60 ml) and liquid in it was string using a steel coated needle at 100 rpm, the two chamber were tightly and cell connected by flow maintaining the temperature at 37 ± 10C.

Stability Study

The stability study of optimized mucoadhesive patch formulation was performed at 40^{0}C 37 ± 50C and 75 ± 5 % RH for three months. The value of all parameter after three months remain same as their values and minor changes occur

in value of volume entrapment efficiency, % elongation and % drug release after 8 h which was considerable.

RESULT AND DISCUSSIONS

The various dental drug delivery systems were studied for their formulation and evaluation parameters. On the basis of thorough and regular study of literature survey, solvent casting method was employed to formulate dental and mucoadhesive patches. They were evaluated for weight uniformity, drug content, folding endurance, thickness, percentage moisture loss, swelling index, tensile strength and *in vitro* drug release study. Lasers like carbon dioxide and argon lasers were used at specific wavelengths that have improved the use of lasers in dentistry. Another recent trend is iontophoretic drug delivery in dental orifice. The two primary principal mechanisms by which the molecular transport of ions across the skin is enhanced is repulsion of a charged ion from electrode of same charge and electrosmosis. Hence it can be concluded that these dental drug delivery systems can be employed in order to achieve controlled drug release in a prolonged manner in various dental diseases like periodontits, gingivitis etc.

REFERENCES

1. Pragati S, Ashok S, Kuldeep S. International Journal of Drug Delivery. Recent advances in periodontal drug delivery systems 2011; 3(1): 114.
2. Ahmed MG, Harish NM, Charyulu RN, Prabhu P. Formulation of chitosan-based ciprofloxacin and diclofenac film for periodontitis therapy. Tropical Journal of Pharmaceutical Research 2009; 8(1): 33-41. http://dx.doi.org/10.4314/tjpr.v8i1.14710
3. Sunil A, Venkatesh M, Udupa N. Controlled-drug delivery systems for periodontitis. The Pharm Review 2004; 61-82.
4. Slots Rams TE. Antibiotics in periodontal therapy: advantages and disadvantages. J Clin periodontal 1990; 17: 479-93.
5. Kornman K. Controlled-release local delivery antimicrobials in periodontics prospects for the future. J periodontal 1993; 64: 782-91.
6. Goodson JM, Haffajee A and Socransky SS. Periodontol therapy by local delivery of tetracycline. J. Clin. Periodontal 1979; 6: 83-92. http://dx.doi.org/10.1111/j.1600-051X.1979.tb02186.x PMid:379050
7. David S Jones, A David Woolfson, Andrew F Brown. Mucoadhesive, syringe able drug delivery systems for controlled application of metronidazole to the periodontal pocket: *In vitro* release kinetics, syringe ability, mechanical and mucoadhesive properties. Journal of Controlled Release 1997; 49: 71–79. http://dx.doi.org/10.1016/S0168-3659(97)00060-6
8. Hugoson A, Norderyd O, Slotte C, Thorstensson H. Distribution of periodontal disease in a Swedish adult population 1973, 1983 and 1993. J Clin Periodontol 1998; 25: 542-548. http://dx.doi.org/10.1111/j.1600-051X.1998.tb02485.x PMid:9696253
9. Page RC. The pathobiology of periodontal diseases may affect systemic diseases: inversion of a paradigm. Ann Periodontol 1998; 3: 108-120. http://dx.doi.org/10.1902/annals.1998.3.1.108 PMid:9722695
10. Hill AC, Baker GF, Jansen GT. Mechanism of action of iontophoresis in the treatment of palmar hyperhidrosis. Cutis 1981; 28: 69–70. PMid:7261675
11. Williams AC, Barry. Skin absorption enhancers, Crit. Rev. Ther. Drug. Carrier Syst 1992; 9: 305–353. PMid:1458546
12. AC Williams, Barry BW. Terpenes and the lipid-protein partitioning theory of skin penetration enhancement. Pharm 1991; 8(1): 17-24.
13. Moliton H, Fernandez LI. Experimental studies on the causes and prevention of iontophoretic burns. Am. J. Med. Sci 1939; 198(6): 778-784. http://dx.doi.org/10.1097/00000441-193912000-00005
14. Research, science and therapy committee of the American Academy of Periodontology. Lasers in periodontics. J periodontal; 2002.
15. Fischer SE, Frame JW, Browne RM, Tranter RM. A comparative histological study of wound healing following carbondioxide laser 1983; 28(4): 287-91.
16. Brunetaud JM, Jensen DM. current status of argon laser haemostatics of bleeding ulcers 1986; 18(Suppl 2): 40-5.
17. Puppula R, Hegde A, Munshi AK. Laser and light cured composite resin restoration.
18. Tam LE, Mc Comb D. Diagnosis of occulasal caries 2001; 67(8): 459-63.
19. Lussi A, Megert B. Clinical performance of a laser fluorescence device for detection of occlusal caries 2001; 109(1): 14-19.
20. Anders R, Merkle HP. Evaluation of laminated mucoadhesive patches for buccal drug delivery. Int J Pharm 1989; 49: 240. http://dx.doi.org/10.1016/0378-5173(89)90347-5
21. Chem WG, Hwang G. Adhesive and *in vitro* release characteristics of proponolol Bioadhesive disc system. Int J Pharm 1992; 82: 61-66. http://dx.doi.org/10.1016/0378-5173(92)90072-A
22. Alur HH, Pather SI, Mitra AK. Transdermal sustained delivery of chlopheniramine maleate in rabbits using a novel natural mucoadhesive gum as an excipients in buccal tablets. Int J Pharm 1999; 188: 1-10. http://dx.doi.org/10.1016/S0378-5173(99)00211-2
23. Guo JH. Bioadhesive polymer buccal patches for buprenorphine controlled delivery formulation *in vitro* adhesion and release properties. Drug Dev Ind. Pharm 1994; 20: 2809-2821. http://dx.doi.org/10.3109/03639049409042682
24. Ahija A, Dorga M, Agrawal SP. development of buccal tablets of dilitazem HCL Indian J Pharm Sci 1995; 57: 26-30.
25. Nagai T, Koshini R. Buccal / gingival drug delivery systems. J Control release 1987; 6: 353-360. http://dx.doi.org/10.1016/0168-3659(87)90088-5
26. Harris D, Robinson JR. Drug delivery via the mucous membrane of the oral cavity. J .Phram Sci 1992; 81(1).
27. Panigrahi L, Pattanaik S, Ghosal SK. Design and characterization of Mucoadhesive Buccal Patches of Diclofenac Sodium, Indian J . Pharm Sci 2005; 67(3): 319-326.
28. Khurana R, Ahuja A, Khar RK. Development and evaluation of mucoadhesive film miconazole nitrate, Indian J Pharm. Sci 2000; 60: 449-453.

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