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Mathematical modeling for controlled drug release of Erythromycin dental implants

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ABSTRACT: If we doing a controlled drug therapy in dental treat ment reduced the risk of damage too ther tissues and adverse drug treatment be comes less and cost sare minimized. In this study, the method of making dental implants by Solvent casting method sare described and release time of erythromycin was determined also mathematical models are formulated and analytical solution sare present edin the controlled release drug erythromycin. this modeling is effective in the prediction of suitable dosages for drugs without additional experimental of testing.

***Keywords*:** Controlled drug delivery, Dental implants, Erythromycin, Mathematical Modeling.
Abbreviations: C = Concentration, D = Diffusion coefficient drug

INTRODUCTION

The aim of controlled release is Delivery of bioactive molecules Nan optimal concentration.in controlled Drug delivery systems, drug is inscribed in a biodegradable polymer membrane or compatible. The first way release is through the hydrogel matrices with large porosity that they do not provide much resistance against if fusion. The second way is the hydrogel matrices with smaller porosity. In such cases, the drug cannot bet escape from it until the matrix begins to destroyed. As the material begins to be hydrolyzed Polymer network structure is broken and this leads to an increase in the size of pores. So, the monopoly of the drug within the matrix is reduced and the diffusion process is added and the drug concentration is reduced and finally these two properties are balanced.

Preparation of Implants Containing Erythromycin

Dental implants were prepared by solvent casting technique using glass moulds. Ethyl cellulose was taken as the main non-biodegradable polymer in combination with different co-polymers for each cast films. Films were prepared by dissolving Ethyl cellulose alone and with copolymers (HPMC K4M, Sodium Alginate) in chloroform and dichloromethane (1:1) solution. Erythromycin was added in to the polymeric solution and mixed homogenously using magnetic stirrer in a closed beaker. After complete mixing the solution was taken and poured into the clean leveled glass moulds (Kothari et al., 2012) and (Dehghan and Wasankar, 2011).

The *mathematical model of controlled release drug erythromycin*

Because of biodegradable polymers used in the manufacture of dental implants, So, to provide a model for drug release from a biodegradable matrix is resulted a Stefan problem with moving boundary. Because the polymer at a time does not lose all its strength. The modelthat reviewed here is provided by (Collins et al.,1998),[3]. That focuses on the diffusion of the drug and erode of the matrix.

Model development

For simplicity and without loss of generality, a constant erosion velocity is chosen, inthe form ds/dt = - B, such that the position of the erosion front is given by the linear relations = s0 - Bt. in this equation s0 is the thickness of the matrix.

The distribution of drug concentration within the matrix at any time t and position x is governed by Fick's second law.

$$\frac{\partial C}{\partial t} = D[\frac{\partial^2 C}{\partial X^2} + \frac{\partial^2 C}{\partial y^2} + \frac{\partial^2 C}{\partial z^2}] \quad (1\text{-}1)$$

We assume the diffusion of drug takes place only in one dimension. Then Fick's second law in one dimension is as follows:

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial X^2} \quad (1\text{-}2)$$

In this relation C is concentration and Dis the diffusion coefficient drug in the matrix.

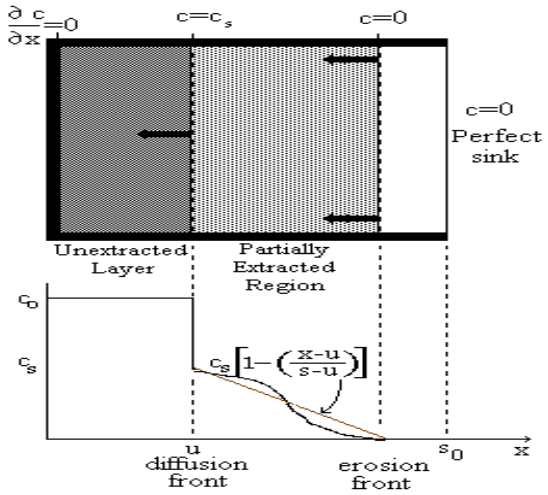

Figure 1. Schematic of matrix

Initial and Boundary conditions

It is assumed that the injected drug initially has a homogenous distribution

At t = 0 c(x, 0) = c_0 set at the initial drug loading concentration

At x = u (t)c (u, t) = c_s set at the solubility limit behind the diffusion front

At x = s (t) c(s, t) = 0 representing a perfect sink at the exposed erosion front surface

Were the matrix non-erodible, this initial and boundary value problem could be solved analytically in terms of transcendental functions (error functions) for the simple one-dimensional geometry of the idealized slab to yield the drug concentration distribution c(x,t) in the region u < x < s between the diffusion front and the eroding outer surface of the slab. However, the resulting expressions for the eroding matrix will be difficult to integrate analytically for the subsequent determination of the position of the moving diffusion front. Therefore, we are applying a straightforward mass balance across the diffusion front (Collins et al.,1998), [3]. The mass flux across the diffusion front is given as

$$D\frac{\partial C}{\partial x}|x = u = (c_0 - c_s)\frac{du}{dt} \quad (1\text{-}3)$$

$$C(x) = C_0\left[1 - \frac{x-u}{s-u}\right] \quad (1\text{-}4)$$

We can determine the time T1 at which the diffusion front reaches the left boundary of the slab at X = 0 as

$$T_1 = T|_{U=0} = \frac{1}{\beta}\left[1 + \frac{W(T_1)}{\beta}\right] \quad (1\text{-}5)$$

$$\alpha = \frac{1}{(C_0 - 1)} and\ \beta = \frac{BS_0}{D} \quad (1\text{-}6)$$

Higuchi and power low model are two type of Model that often used to describe the drug release rate.Collinsfor accommodated data, he use from 31 the calculated Valuecomputations corresponding to the parameter values: α = 0.5 and β = 0.1. In this range of practical interest, the agreement of the linear approximation with the exact numerical solution of the Higuchi model for the position of the diffusion front as a function of time is seen to be very adequate.

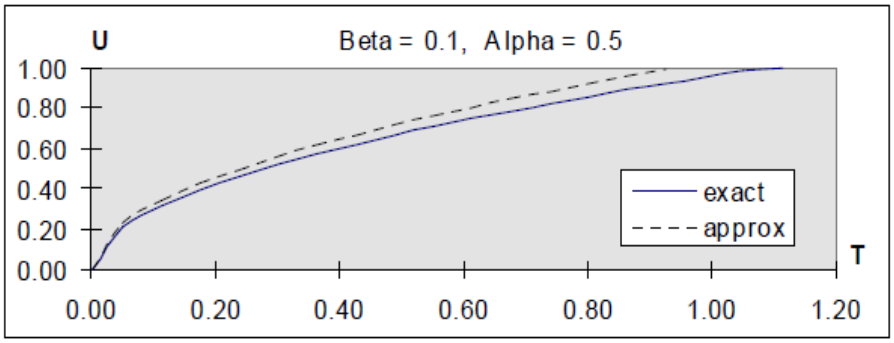

Figure 2. Position U of the moving diffusion front

RESULTS AND DISCUSSION

Figure 3 and Tabel 1 shows the release profile of the formulations of Erythromycin implants.According to the results shown in the following drug release in 6 to 7 days to complete. So erythromycin plants can be used as a slow release of the drug to treat periodontitis.

Table 1. In vitro release profile of Erythromycin implants

Time(days)	% drug release			
0	F1	F2	F3	F4
1	0	0	0	0
2	32.16	30.38	37.8	33.22
3	64.42	61.52	68.46	66.96
4	71.59	74.18	77.19	80.32
5	78.94	81.91	85.41	89.27
6	86.2	89.62	93.51	94.36
7	94.91	93.31	99.75	98.3

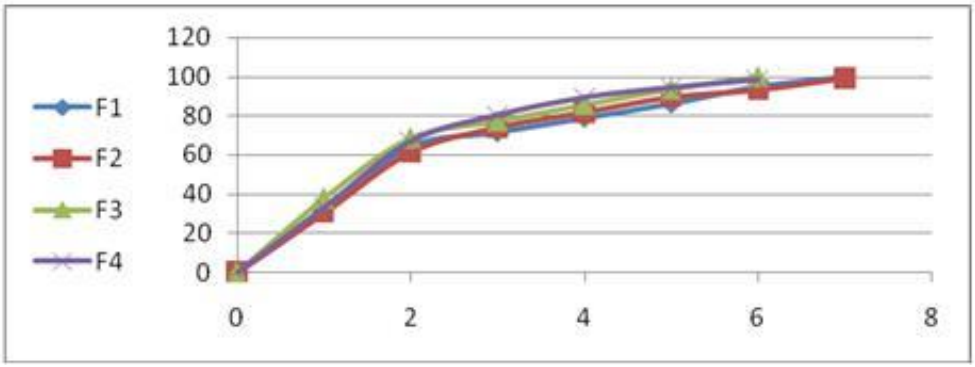

Figure 3. In vitro release profile of Erythromycin implants

C	Concentration
D	Diffusion coefficient drug

CONCULSION

Matrix coated with an impermeable film or membrane,can reduce the drug release rate until happen environmental degradation, And slow release of the drug would be able to offer benefits such as increasing residence time, prolonging drug release, reducing frequency of administration, and there by may help to improve patient compliance.

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