CURRENT CONCEPTS IN THE BIOLOGY OF ORTHODONTIC TOOTH MOVEMENT: A BRIEF OVERVIEW

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ABSTRACT- Mysteries of OTM have haunted clinicians and orthodontists since the interception of the speciality.

The understanding of OTM is now no longer restricted to bone-PDL-level and an indepth molecular- genetic- cellular intervention have been evolved. This underlying mechanism between genes and transcription factors have given a new insight to OTM helping us better understand the unseen areas of OTM, utilizing the knowledge for better tooth movement and furtherance of speciality.

Keywords- Bone modelling, neurotransmitters, chemical mediators

INTRODUCTION-

Biology of orthodontic tooth movement has always been an interesting field of orthodontist.¹

Orthodontic treatment is based on the principle that if prolonged pressure is applied to a tooth, tooth movement will occur as the bone around the tooth remodels. Bone is selectively removed in some areas (pressure side) and added in others (tension side) leading to tooth movement through the bone.¹

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ORTHODONTIC FORCE APPLICATION

Mineralized tissue response (Bone remodelling)

Associated tissue response (blood vessel and neural elements)

Non mineralized tissue response (pdl and gingiva)

Orthodontic force induced strains

Alter PDL's Vascularity and blood flow

Synthesis and release of neurotransmitters, cytokines, growth factors, Colony stimulating factors, Arachidonic acid metabolites

Cellular response

including dental pulp, periodontal ligament (PDL), alveolar bone, and gingiva.²
This article aims to understand the relationship between these cellular responses generated and their outcome on orthodontic tooth movement.

PHASES OF TOOTH MOVEMENT

There are three phases of tooth movement are\(^1\):

**Initial phase** - The initial phase is characterized by rapid movement immediately after the application of force to the tooth. This rate can be largely attributed to the displacement of the tooth in the PDL space.\(^1\)

**Lag phase** - Immediately after the initial phase, there is a lag period, with relatively low rates of tooth displacement or no displacement. It has been suggested that the lag is produced by hyalinization of the PDL in areas of compression. No further tooth movement occurs until cells complete the removal of all necrotic tissues.\(^1\)

**Post lag phase** - The third phase of tooth movement follows the lag period, during which the rate of movement gradually or suddenly increases\(^1\).

THEORIES OF ORTHODONTIC MECHANISMS

There are two main proposed mechanisms for tooth movement as follows:
1. The application of pressure and tension to the PDL.
2. Bending of the alveolar bone.

**The Pressure-Tension Theory\(^2\)**

When force is applied orthodontically on a tooth a pressure side and a tension side is created.

On the pressure side the PDL displays disorganization and diminution of fiber production. Cell replication decreases seemingly due to vascular constriction causing bone resorption\(^1\).

On the ‘tension side’, cell replication is said to increase because of the stimulation afforded by the stretching of the fiber bundles of the PDL, thus causing bone deposition.

**The Bone-Bending Theory\(^2\)**
(Farrar; 1888)

When an orthodontic force is applied to the tooth it is transmitted to all tissues near force application. These forces bend the bone, tooth and the solid structures of the PDL.\(^2\)

CASCADE OF EVENTS THAT FOLLOW AFTER APPLICATION OF ORTHODONTIC FORCE

The primary stimulus such as that of the orthodontic force may elicit its response to cells of PDL and bone in the form of release of-

a.) Bioelectric signals produced on account of bone bending.
b.) Chemical mediators such as prostaglandins, cytokines, Nitric oxide (NO) etc
c.) Release of neurotransmitters.
When Orthodontic force is applied—Primarily, alteration in the blood flow results in reduced oxygen level at compressed area (pressure area), and there might be an increased oxygen level at tension side. Secondly, generation of Piezo electric signal, which is now stated more appropriately as bioelectric potential in the form of small voltage of current, is released due to bending of bone and deformation of crystal structure.

Thirdly, neurotransmitters (examples Substance P, Vasointestinal polypeptide VIP, calcitonin gene related peptide CGRP) are possibly released on account of physical distortion imposed by peripheral forces on paradental tissues such as nerve fibers and terminals. Thus, the primary stimulus such as that of the orthodontic force may elicit its response to cells of PDL and bone in the form of release of Bioelectric signals produced on account of bone bending.

Chemical mediators such as prostaglandins, cytokines, Nitric oxide (NO) etc., Release of neurotransmitters has been proved that cells in PDL such as fibroblasts and bone cells such as osteoblasts possess receptors for these substances, and all these are highly interacting and interconnected, presenting number of possibilities of transducing mechanical force acting on cells and their adjacent matrices. These interactions lead to transient increase in the intracellular levels of second messengers such as CAMP (Cyclic Adenosine Monophosphate), CGMP (Cyclic Guanosine Monophosphate), IP3 (Inositol phosphatase), Ca++, etc. These second messengers advance signals to the nucleus through series of kinases. In the nucleus of each cell, different second messengers account for the differential patterning, protein synthesis and Gene expression. Such recently identified Immediate Early Gene expression [IEG] transcription factors include Cfos, Cjon mRNA, egr-1, SPI growth differentiation factor 9B and extracellular GLA protein.

The transcription factors seems to increase when cells are exposed to mechanical...
stimulation, cytokines and growth factors. These transcription factors can produce either cellular proliferation or cellular differentiation leading to osteoblastic bone formation or osteoclastic bone resorption.¹

CONCLUSION-The elucidation of the molecular basis that attempt to explain the cell-cell communication during mechanically induced remodelling is an extremely complicated process.

Many questions still remain regarding the relationship between mechanical stimuli and cellular mediators hormones, neurotransmitters, prostaglandins and cytokines.

REFERENCES-


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