

Effects of Orthodontic Tooth Movement on Pulp Vitality

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Abstract

Introduction: Orthodontic tooth movement brings about a biological response to the surrounding tissues. The dental pulp can show various types of reactions such as inflammation, cell damage, or wound healing in response to such a movement. Orthodontic tooth movement can affect the reparative capacity of the pulp, secondary dentin formation, pulp necrosis, and root resorption as well. Therefore, it is important that these changes are recognized when they become clinically or pathologically significant.

Aim of the Work: The study aimed to evaluate the knowledge and practices of orthodontic tooth movement and its effects on pulp vitality.

Methodology: This review is thorough research of PUBMED from the year 1980 to 2020.

Conclusion: The neural responses of the pulp are affected because of the physiological changes seen during the early stages of the orthodontic force application. It is important to use optimum force for a controlled tooth movement with adequate resting periods to achieve the orthodontic goal and avoid unwanted side effects; Pulp sensitivity tests can be helpful during the course of the treatment to assess the status of the pulp. However, practitioners must be careful in the interpretation of the results from electric pulp testing (EPT).

Keywords: Pulpal Reaction; Pulpal Blood Flow; Orthodontic Force; Tooth Movement

Introduction

The dental pulp is in the core of the tooth under a dentinal cover. There are many blood vessels going through the apical foramen, which determines its vitality. The dental pulp consists of many cells, which include: odontoblasts, fibroblasts, and undifferentiated mesenchymal cells. There are a series of changes that are seen in and around the pulp during or after orthodontic tooth movement. The remodeling of the periodontium, i.e. the PDL, Alveolar Bone and Cementum, can also be seen when Orthodontic tooth movement. The pulp-dentine complex may experience an inflammatory response or mechanical damage [1,2].

An acute inflammatory response is seen in the PDL as vasodilation and migration of the leukocytes. These cells initiate biochemical signal molecules and cytokines that reacts with the innate cell group found in the periodontium. After 1 or 2 days, there is a shift from the acute phase to the chronic process that involves a number of cells like endothelial cells, fibroblasts, osteoblasts and alveolar bone marrow cells. During this phase, the continuous leukocyte migration into strained periodontal tissues modulates the remodeling process [3,4].

Even though pulp tissue can turn necrotic occasionally, the health of the dental pulp is usually safe with orthodontic tooth movement.

Pulpal reactions

Molecular changes are seen within the periodontium after the application of orthodontic forces through the release of neuropeptides. Acute and chronic inflammatory processes are a result of the peripheral sensory nervous system. The patient may undergo some uneasiness for a few days due to the acute inflammatory response. The chronic inflammatory process begins after 24 - 48 hours of the force application [1,3]. Even though no substantial indication is seen between orthodontic force and pulp tissue in humans, tooth movement usually does involve cell damage, inflammation, and wound healing, which in turn has a direct correlation to the health of the pulp [5]. It has been mentioned by Profitt that the impact of continuous light force on pulp is almost none; however, some impact can be seen on the PDL [6].

In certain scenarios, there is a block of the blood supply entering the tooth when excessive orthodontic force or dental movement happens outside the trough of the alveolar process occurs. Pulp necrosis usually found due to previous trauma or injury or due to large decay are more susceptible to necrosis. High extrusive or intrusive forces can lead to permanent damage to the pulp as well. Known history of previous pulpal damage must be cautiously monitored during the entire course of the orthodontic treatment [7].

Effect of orthodontic force application to pulp

Application of orthodontic force to the teeth can vary from months to years. The clinical significance of pulpal changes caused by orthodontic forces solely depends on whether the long-term vitality of the teeth will be affected [8].

The dental pulp lacks collateral circulation, which makes it the most sensitive tissue of the body. This tissue is hence susceptible to easy damage by orthodontic forces (controlled trauma).

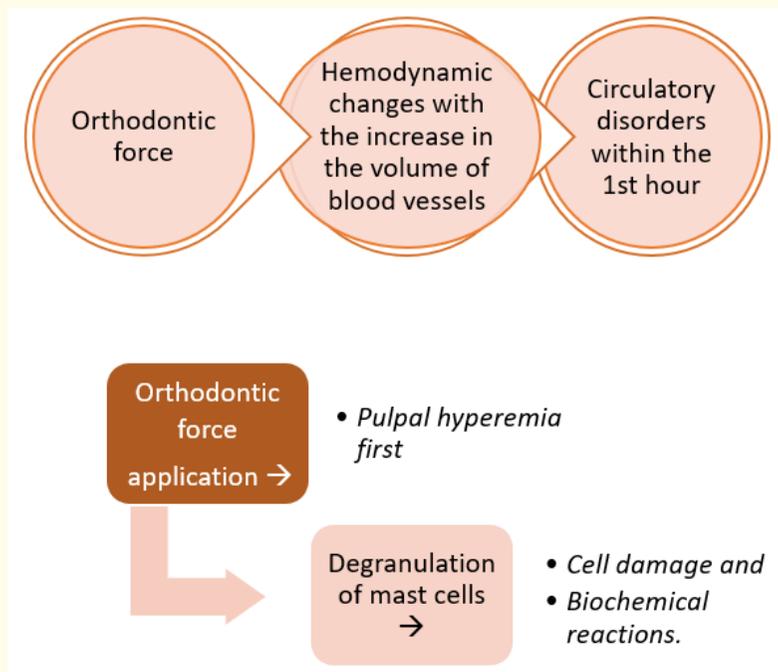


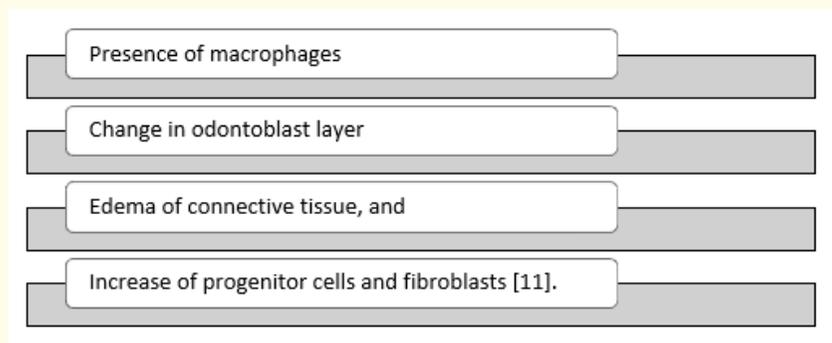
Figure 1: Earlier symptoms are seen in pulp [9].

The above classical features of acute inflammation cause the release of inflammatory mediators such as

- Bradykinin,
- Neuropeptides,
- Prostaglandins,
- Growth factors,
- Histamine.

All of which can cause a rise in blood flow with edema [8]. After a few days, the pulp shows increased neural activity and a heightened response threshold to an electrical stimulus. The metabolism of pulp gets altered, which results in increased enzymatic activity, apoptosis and death of pulp cells. An increase in the aspartate aminotransferase (AST) activity levels that develops during orthodontic treatment due to the changes in the tissue respiration and likely hypoxia affects the dental pulp tissue by altering the pulpal neural response [10].

The adaptive process and inflammation of pulp tissue by orthodontic force is represented by:



Figure

Cellular responses - Neuropeptides and inflammatory cytokines

There is a synthesis of neuropeptides, cytokines, and growth factors seen when there is a change in vascularity and blood flow of peri-odontal tissue after an application of orthodontic force. Neuropeptides include substance P (SP), calcitonin gene-related peptide (CGRP), neurokinin A (NKA) are the key to bone metabolism (growth and remodeling) [1,12].

A sensory neuropeptide seen in both the central and peripheral nervous systems is SP. When inflammation occurs, lymphocytes, eosinophils, macrophages and dendritic cells secrete SP. It influences the production of pro-inflammatory cytokines from pulpal fibroblast (Figure 2) [13].

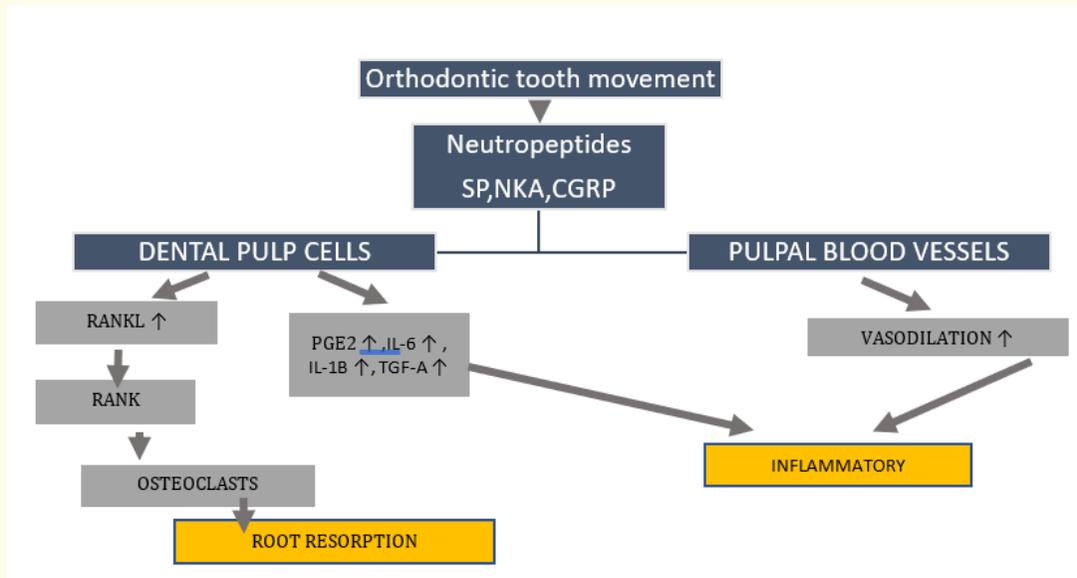


Figure 2: Pulpal inflammatory process to orthodontic force [1,13].

During inflammation, the release of SP causes vasodilation, and a rise in vascular permeability is seen. This response increases the blood flow to the inflammation sites. CGRP is usually restricted to small to medium sensory nerve fibers. It also plays a vital role in the response of pulp to inflammation and wound healing. It is also an effective vasodilator and regulates blood flow in bone and periosteum. Both SP and CGRP stimulates the synthesis of interleukin (IL)-1 β , IL-6 and tumor necrosis factor (TNF)- α from the fibroblasts in the dental pulp [1].

Vasodilatation and angiogenic response to orthodontic forces

There is a substantial impact on the blood flow of pulp due to the application of orthodontic force. A temporary decrease in the pulpal blood flow (PBF) is seen, which usually reverts back in 72 hours. Laser Doppler flowmetry helps to measure PBF. When PBF reduces, oxygen supply also reduces. This, in turn, directly influences the metabolism of the pulp tissue, cellular injury, and apoptosis.

Changes in PBF due to orthodontic force depends on

- Apical foramen size
- Age of the patient
- Dentinogenic activity
- Magnitude and extent of the force applied [14].

Angiogenesis can be described as the formation of new capillary structures, which eventually lead to the organization of bigger structures by neovascularization. During the initial stage of orthodontic movement, angiogenic factors of growth tend to show a marked in-

crease in the number of micro-vessels. The vascular volume density, which is increased, returns to normal within 72 hours of the force application [15].

Effect of intrusive force on pulp

The dental pulp responds to orthodontic forces, which can range from slight hyperemia to full necrosis in the literature. The duration of force, type of force application, age of the patients, and apical foramen size could be the contributory factors. Intrusive orthodontic forces tend to induce more pulpal changes. Teeth with complete root formation tend to show an increased incidence of irreversible pulpal actions [16,17]. In a study done by Abtahi, *et al.* [16] histologic changes of the pulp of human premolars to intrusion were done where changes in the pulp in patients of two different age groups were compared. In the test teeth, a marked difference between adolescents and adults after one month with respect to the intensity and type of inflammation was seen [16].

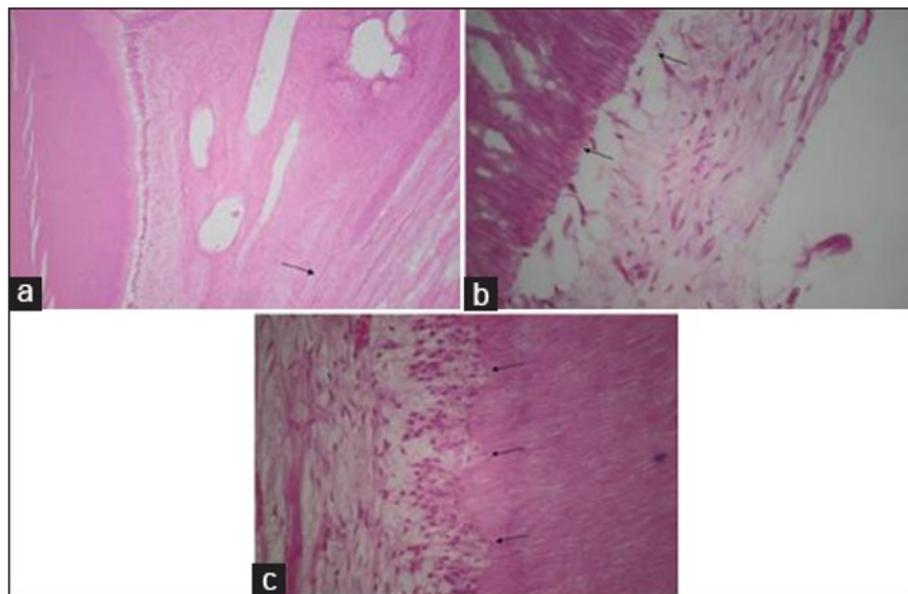


Figure 3: (a) Fibrous tissue formation in the dental pulp. (b) Disruption of the odontoblastic layer. (c) Aspiration of odontoblasts into dentinal tubules [16].

This study concluded that no significant histological changes in adolescents and adults with mild orthodontic intrusive force application in closed apex teeth. However, the inflammatory-related histological pulpal changes are less severe in adolescents one month after the intrusion. Hence it is of utmost importance that mild orthodontic forces are applied during the treatment with required break intervals in older individuals as compared to adolescents [16].

Effect of extrusive force on pulp

Spoto, *et al.* used a sectional extrusive force applied in a study group, which showed no inflammatory response in the pulp or hard tissue. However, there was an observation where pulp stones were formed in many cases. The presence of a light pulp inflammation reaction and formation of a big pulp stone was seen after 40 days in the experimental study group [18].

18 Orthodontic subjects were subjected to an extrusive force on premolar teeth, which were meant to be extracted as a part of the treatment by Mostafa., *et al.* They concluded Orthodontic extrusion could cause few characteristic reactions of the dental pulp, including:

- Odontoblastic degeneration,
- Disturbance in circulation with congested blood vessels,
- Vacuolization and edema of the pulp tissues, and
- Presence of fibrotic changes by the 4th week.

A compromised blood supply can lead to odontoblastic degeneration. Topographic change, or prolapse, of the pulp, through the fairly wide apical foramina, can lead to the vacuolization of the pulp tissues [19].

Effect of orthodontic forces on tooth response to electric pulp test

In order to assess the health and vitality of dental pulp during the orthodontics treatment, pulp sensitivity tests can be done. They are a reliable source of pulp assessment. Various pulp tests have been suggested and observed, aiming to assist the diagnosis and treatment planning for the clinician [20]. A suggested method to evaluate the blood flow in the dental pulp is by Laser Doppler flow cytometry (LDF), which investigates the vascular supply to the pulp. However, drawbacks like equipment expenses, technique sensitivity, lengthy experiment period, and possible wrong readings from the periodontium are a possibility [21].

An alternative methodology of electrical pulp testing (EPT), which is simple and non-invasive, helps provide the clinician with the electrical responsiveness of the pulp. This test instigates a group of fast-acting low-threshold A-delta fibers seen in the pulp. EPT is used as a sensitivity test and provides the clinician with sensory manifestations that are qualitative in nature [22].

EPT does not provide information on the vascularity (vitality) of the pulp but only an insight into the pulp nerves' status. A judgment of whether the pulp is healthy or inflamed can be made by noting the response duration and patient's history. But in general, a pulp vitality is interpreted when there is a positive response to the EPT. A-delta, and A-beta fibers get affected when there is a change in the physiology of the pulp. This, in turn, can alter the EPT results [23].

Modaresi., *et al.* evaluated teeth response to EPT before and during orthodontic treatment; increased EPT values were observed within minutes of the orthodontic load. There was a decrease in the threshold one month after the orthodontic load; however, it was still higher than that recorded before the treatment commenced [22].

Changes in dental pulp tissue histology due to orthodontic force

Effect on the teeth by application of torque and bodily movements on the incisors of the mandible of two groups were studied. Changes were observed for a treatment length of 21 days. An increase in the number of collagen fibers in the whole pulp and a reduction in cellular concentration was seen in the teeth, which were moved bodily. Decreased fibroblast cells and an increase in inflamed cells, particularly in the crown of the pulp area was also observed.

Disruption of the blood flow decrease in the quantity of blood vessels, and narrow blood vessels were seen-the extravasation of red blood cells and odontoblast damage, which varied according to the magnitude of force applied to teeth. Odontoblast damage on the middle third of the root was seen on torque movement. Lingual torque movement showed damage to the odontoblast on the central third of the root and cellular damage on the lingual and labial side of an apical portion of the dental pulp [24].

The damage was mostly seen in the central third of the root with torque movements, the, which correlates with the fulcrum of the teeth. Bodily movements showed odontoblast damage on the pressured- as well as on the stretched-areas. The length of cellular activity directly correlated with the time-span of cellular damage fitted on alveolar bone next to the bodily-moved tooth. Odontoblast damage was spread to the dental root in bodily movement. Histological changes were due to internal dental structure, which couldn't withstand the orthodontic force, which caused an impact on dental internal histomorphology [24].

Conclusion

The effect of orthodontic force on pulp tissue so far is a matter of debate faced by researchers. A severe orthodontic force application for an increased period may cause irreversible pulpitis and pulp necrosis due to the inflammation process. Moderate or intermittent force application permits satisfactory tooth movement, which can limit the damage to the pulp and allow pulp healing. Orthodontic treatment with controlled mechanic forces may cause temporary pulpal changes.

Careful interpretation of the pulp sensitivity test must be made in orthodontically treated patients (thermal tests being more reliable than EPT). Teeth having a trauma history have a higher risk of necrosis in pulp as a result of orthodontic forces. Hence careful clinical and radiographic evaluations must be done before force is applied to these teeth.

Successful endodontic treatment must precede a successful orthodontic movement.

The quality of the root canal treatment, the health of the PDL, and the cautious application of orthodontic forces are the factors that need attention during the treatment.

It is also important to inform the patient about the probable complications and a likely prolongation of the treatment period depending on the preexisting condition of the teeth being subjected to orthodontic tooth movement.

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