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Pulpal Response to Orthodontic Treatment: A Review

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I. Introduction

The effect of orthodontic treatment on the dental pulp are of particular concern to the orthodontist. Alteration to pulpal physiology are may result in altered responses to external stimuli. Several studies have evaluated the impact of orthodontic force on dental pulp, however they reported results in the literature are inconsistent and inconclusive, mostly due to methodological limitations. One of few studies of human pulpal tissue obtain from teeth subjected to orthodontic force suggests that pulpal respiration rates are on average reduced in early stage of the application of orthodontic force.(1-3) Although the state of maturity of the apex may be a modifying factor and teeth with incomplete apical foramina may demonstrate an increased respiration rate. some studies have reported short term effect such as changes in tissue respiration(4,5) and others have reported lasting consequences such as necrosis(6,7)

Histological examination, is neither practical nor feasible in clinical situation, therefore application of pulp testing methods are suggested to provide additional diagnostic information(8) .Different pulp test have been proposed and examined aiming at assisting the diagnosis and treatment planning for clinician(9) Laser doppler flow cytometry (LDF) is proposed method for evaluating the blood flow in the dental pulp by investigating the vascular supply to that pulp.(2,10)This method contains some limitation, such as highly expensive equipment, high technique sensitive, long experiment period and possibility of false reading from periodontium. Another alternative method is electrical pulp testing (EPT) a simple non-invasive test that provides the clinician with electrical responsiveness of the pulp

II. Early Changes In Pulpal Microvasculature During Orthodontic Tooth Movement

In most of the investigations, the parameters used most commonly are the measurement of pulpal vasculature and blood flow changes. Guevara et al. (1977) showed an initial decrease in blood flow using in vivo microscopy in rats. Kvinnsland et al.(1989) demonstrated substantial increase in blood flow following orthodontic force application, using fluorescent microspheres in mesially tipped molars in rats. Mostafa et al. (1991) reported presence of congested and dilated blood vessels and oedema of pulpal tissue in their study carried out by histological technique. McDonald and Pitt (1994) using laser Doppler Flow metric study found human pulpal blood flow decreased when continuous light tipping force was applied to a maxillary canine. This decrease was followed by a longer period of increased blood flow, which lasted approximately 48 hours. Nixon et al (1993) contradicted previous results, reporting a significant vascular change with an increase in number of functional pulpal vessels. This result was supported by the study of Derringer et al. (1996) which showed all increased angiogenic growth factors in pulp of orthodontically treated teeth.[5]

A study was carried out by Milton SantamariaJr et al. in order to quantify the vascular volume density (*V*v) in the initial periods of induced tooth movement in rats to verify the vascular reaction and the capacity of adaptation of the pulp tissue during initial force application. This study was conducted on rat molar teeth as their physiology was similar to that of human teeth. This study confirmed the result of previous study that the magnitude of force does not need to be excessive; even small forces of short duration of around 4 hours may be adequate to evoke cellular responses. At the same time, the pulp tissue demonstrated an excellent capacity of adaptation with a reduction of vascular volume density after 24 and 72 hours of force application and a return to similar values in the control group.[5]

III. Discussion

With the increase in knowledge of biology of tooth movement and the effects of orthodontic tooth movement on the surrounding tissues, the interest in the pulpal responses to the orthodontic tooth movement has been increased. The significance of pulpal reactions during orthodontic tooth movement has been recognized and various studies have been and are being carried out in regard to the same [(4)] Laser Doppler flowmetry has been applied to the study of blood flow in the pulp of human teeth with the application of force. Results suggest an immediate reduction in blood flow upon the application of the force. This gives way to a reactive hyperaemia after approximately half an hour. Within seventy two hours the flow rate returns to normal. It is important to recognize that the results tell only of the responsiveness of the particular tooth to the test, there being no reliably predictable relationship between the test response and micro structural or cellular changes within the pulp. The neural elements of the pulp include both mylinated and unmyelinated fibres. The main sensory fibres pass out to the pulp-dentine border to form the plexus of Raschkow [(6 -9)] The highest concentration of neural elements is found in the pulpal horns. Intra-dental sensory nerve fibres respond to stimuli and conduct impulses, yet if their integrity is disrupted or their physiological status altered their response thresholds may be changed. Electrical tests stimulate the fast acting, low threshold, myelinated A fibres. Both heat and cold also produce an A fibre response. As the pulp undergoes thermal change, the slower acting, high threshold, unmyelinated C fibres become stimulated .Thermal stimulation of C fibres, in an otherwise

Healthy pulp, does not occur where prior thermal activation of the A fibres produces an intense pain before the C fibres reach a stimulus threshold. If thermal stimulation persists such that pulpal temperature is affected, a dull radiating pain occurs indicating C fibre response. This is described as a two-phase response.8 In the case of the orthodontic patient where force application has altered the physiological status of the pulpal elements, reports suggest that the responsiveness of the pulp to electrical stimulation becomes inconsistent.[(10-12)] Vascular changes causing hypoxia may suppress A fibre response. However, C fibre response would seem to be more persistent in the presence of hypoxia.6,9Electrical pulp testing may also be less reliable in teeth where the apex is immature and the plexus of Raschkow is not fully developed. [(4,6,10,11)]

Spector reported on a few cases where teeth were devitalized during orthodontic therapy. There are also several reports which demonstrate the obliteration of pulp chambers after orthodontic therapy. This could possibly due to a compromised pulpal circulation during therapy leading to a localized necrosis with subsequent mineralization of the pulp. Seltzer and Bender felt that orthodontic forces may induce more rapid aging processes within the pulp due to circulatory interferences thereby reducing the ability of the pulp to withstand the future forces. They also reported that orthodontically treated teeth show histologic findings similar to periodontally involved teeth. Derringer and Linden (2003) stated that tooth movement can cause stimulation of blood vessels and activation of the vascular system is the key factor as stated by Rygh et al (1986). However, Hamersky et al. (1980) stated that age is a limiting factor in humans, with delayed cellular response and different cell populations and vascularization in adults.[4]

Few studies have suggested that pulpal respiration rates are reduced in the early stages of the application of orthodontic forces although the state of maturity of the apex may be a modifying factor. Stenvik and Mjor felt that the effects on the pulp were dependent on the stage of root development and that teeth with open apices had a better prognosis. In contrast to this, Butcher and Taylor stated that open apices are more susceptible to trauma from the orthodontic force application especially intrusive forces. In this context, Oppenheim recommended the use of light forces with frequent rest periods to decrease iatrogenic effects on the pulp. According to Schwartz, orthodontic forces should not exceed the capillary pressure of 20 mm/Hg or else strangulation of the vessels could ensue with subsequent necrosis. Many researchers including Oppenheim et al observed and described the histologic changes in the pulp due to orthodontic forces which include hyperemia, diapedesis, margination of white blood cells, stasis, vacuole formation in the odontoblastic layer, cyst formation and haemorrhage. Butcher and Taylor reported that vacuole formation, dilation of vessels, thrombosis etc. could occur as a result of intrusive forces however they questioned their results because the controls also exhibited vacuole formation and congestion of blood vessels. Pohto and Scheinin questioned the validity of using vacuole formation and dilation of vessels as an index of trauma stating that fixation techniques could produce such artifacts.[9]Derringer et al. in 1996 reported an increase in micro-vessel outgrowth of the pulp explants from orthodontically treated teeth indicating an increase of pulpal angiogenic growth factors in response to orthodontic force. The application of orthodontic force used with fixed appliances involves cellular strain, direct tissue damage, inflammatory changes and wound healing which in turn lead to the release of angiogenic growth factors in the pulp. Various researchers have reported presence of platelet-derived growth factor (PDGF), insulin-derived growth factor (IGF-1), epidermal growth factor(EGF) in the dental pulp during orthodontic force application. It is possible that some of these factors may therefore participate in an angiogenic response of the pulp to orthodontic force application .[8]

IV. Conclusion

The physiological changes of the pulp affect the neural response in the early stages after application of orthodontic forces. Response thresholds to electrical stimulation are also
increased and consequently the EPT may not initiate a response.
The pulpal response during orthodontic treatment is due to many factors such as Pulpal anatomy, microvasculature & epidedrmal growth factors .Further studies to be carried out to know the proper reason behind this.

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