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Pathways of pain to pleasure in orthodontics: A review

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Abstract
In this era esthetic being prim concern for all the patients, orthodontics provides correction and enhancement of esthetics of patient with long term stable results. Orthodontic therapy involves pain and it is a major concern for parents, patients and clinicians. The most cited negative effect arising from orthodontic force application is orthodontic pain. It is major deterrent to orthodontic treatment and an important reason for discontinuing treatment. This area requires attention in clinical practice as well as in research and is ignored as evidenced by the scarcity of publications on the topic in comparison with other areas of orthodontic research. The purpose of this review is to enlighten us with the physiological aspects of pain perception and to assess various therapeutic procedures for pain management along with discuss the changes in the materials and procedures of fixed mechanotherapy to give patients ease of treatment and make their painful procedure to a pleasant experience.

Introduction
Pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage"(1) by International Association of the Study of Pain.

Pain includes sensations evoked by noxious stimuli due to inflammatory responses. It is affected by age, gender, emotional status and stress level of patients but altogether it is a complex experience. Pain often accompanies orthodontic appointments. During orthodontic tooth movement, pain is described by its physiology and various assessment methods which are generally and specifically related to duration and amount of orthodontic force application. Force application causes compression of periodontal ligament, ischemia, inflammation and edema. The intensity of the pain symptoms has been studied but there is little knowledge on the quality and duration of such symptoms and their significance regarding the treatment.

In orthodontic therapy control of pain includes adjusting the forces to a level below the pain threshold but such low forces which are below the optimum force threshold would have direct effect on the tooth movement. Hence the force level cannot be changed.

To alleviate the pain and discomfort clinicians have tried different approaches like pharmacological analgesia, physiologically by having patients to chew on something fairly hard for example a plastic wafer, analgesic chewing gum, transcutaneous electrical nerve stimulation (TENS), low level laser therapy and magnetic force fields. Along with this nowadays there are changes in the materials available for fixed orthodontic treatment that causes less yet optimum force, so are less painful.(2,3)

This review attempts to provide an overview of the physiologic aspect of orthodontic pain and current management strategies employed for alleviating orthodontic pain.

Physiology of pain related to orthodontic force application
Peripheral pain mechanisms associated with orthodontic treatment are similar to the mechanisms observed in all other body parts including the type of sensory neurons involved and the different molecules playing role in these processes (e.g., receptors, channels, transmitters, and intracellular signalling effectors responsible for the transduction, modulation, and propagation of peripheral stimuli).

Fibers involved in nerve conduction are A-type and C- type. Unmyelinated C-fibers and myelinated A-δ fibers of primary sensory neurons conduct the pain signals to secondary order neurons in the spinal cord and finally to the cortex via a relay in the thalamus. In tooth both myelinated (A- δ type) and unmyelinated (C-type) nerve fibers enter pulp tissue and periodontium. A- δ fibers with diameters between 2-4 and 20 microns and the conduction velocity of up to 30 meters per second carry mechnoreceptive signals, pressure and proprioceptive impulses at the speed that may exceed 100 meter per second. The unmyelinated C-fibers having smaller diameter up to 2 microns carry nociceptive signals but at a lower speed, approximately 0.5-2.5 meters per second.

Due to functional differences they react differently to the character of the tooth pain. Hydrodynamic mechanism activates A- δ fibers and is responsible for dentin sensitivity for example Heat stimulation induces an immediate sharp pain, thus A - δ fibers are thought to be involved in the mediation of pain in the initial phases of pulpal inflammation that is sharp pain.

C-fibers are activated by a direct effect of mechanical and chemical irritants, like, bradykinin and histamine and a delayed dull pain is felt. The dull pain induced during the later phases is due to C-fiber activation. Release of neuropeptides has been suggested to be related to the activation of C-fibers and some small diameter A δ-fibers.

Prostaglandins have been shown to increase intradental nociceptor sensitivity to thermal stimulation and cause hyperalgesia. The inflammatory reactions and nerve sensitization take place in the periodontal tissues thus, tissue injury and consequent inflammation of gingival and periodontal tissues during orthodontic treatment could lower pain threshold by inducing nociceptor sensitization. These tissues then become responsive to stimuli that would not ordinarily evoke any pain reaction. The periodontal ligament nociceptive nerve fibers perform two main functions: centrally transmission of pain impulses and release of neuropeptides peripherally and they respond to strong forces applied to the tooth. The increase in the expression of Calcitonin Gene-Related Peptide (CGRP) and Substance P (SP) during the first two days after application of an orthodontic force shows pain symptoms reaches to the peak in approximately one to two days after force application.[4,5,6,7,8]

Pathophysiology of Pain associated to orthodontics

Various procedures in fixed orthodontics that are painful to the patients are listed below:

Separator placement, Band placement, Initial wire placement for alignment and leveling, Decrowding wire, Retraction of proclined teeth, Extraoral appliances like head gears and face masks, Rapid maxillary expansions and distractions, Space Closure Finishing, Detailing , and finally Debonding.

All orthodontic procedures produce pain, fixed appliances produce more pain than removable or functional appliances with little correlation between applied force magnitude and pain experienced. These discomforts experienced by patients are often described as feelings of pressure, tension, soreness of the teeth, and pain.

Pain connected to orthodontic tooth movement originates from the periodontal tissues due to mechanical injury causing pressure, ischaemia, inflammation, and oedema in the PDL space producing inflammatory reaction.Reduction of the proprioceptive and discriminating abilities occurs after orthodontic force application for few days, which result in lowering of the pain threshold and disruption of normal mechanisms associated with proprioception input from nerve endings in the periodontal ligament.[5,6]

Due to diffusion of various inflammatory mediators intradental nociceptive nerves get involved, as already mentioned due to the neurogenic effects transmitted by branching axons innervating both the pulp and PDL, the effects of periodontal tissue injury may also be reflected in the pulp. All these effects are perceived as pain by the patient.[4]

Burstone (1962) reported an immediate and delayed painful response after orthodontic force application. He attributed the initial response to compression and the delayed response to hyperalgaesia of the PDL. Reversible pulpal injury is a common response to orthodontic treatment.[9]

Diagnosis of pain/ grading of pain

To study or evaluate pain many methods are used such as patient interview/questionnaire and ratings with VAS, McGill pain questionnaire (MPQ), Verbal Rating Scales (VRS) and algometers.

The VAS is considered as the most reliable and accurate tool in the evaluation of subjective experiences such as pain (Jones and Richmond, 1985; Jones and Chan, 1992a, b). This consists of a list of adjectives to describe different intensities of pain. The method requires patients to read a list of adjectives and select the word or phrase that best describes their level of pain. An adequate VRS scale includes adjectives showing two extremes such as 'no pain' and 'excruciating/extremely intense pain'.

The McGill pain questionnaire (MPQ) is not the gold standard and the validity of this method has yet to be confirmed. This consists of three major classes of word descriptors — sensory, affective, and evaluative — that is used by patients to specify subjective pain experience. It also contains an intensity scale and other items to determine the properties of pain experience. The main advantage of the MPQ is the provision to identify quantitative measures of clinical pain.[10]

Algometer is electronic system of pain assessment of patient sitting on the dental chair. This method requires more research before clinical application.

For orthodontic purpose Burstone has given methods for pain assessment according to the relationship of force application with pain and according to the time of onset of pain.

According to Burstone, the degree of pain perceived in response to the amount of force application can be divided into three:[9,10]

1. First degree: the patient is not aware of pain unless the orthodontist manipulates the teeth to be moved by the appliance, e.g. using instruments such as a band pusher or force gauge.
2. Second degree: pain or discomfort caused during clenching or heavy biting — usually occurs within the first week of appliance placement. The patient will be able to masticate a normal diet with this type of pain.
3. Third degree: if this type of pain appears, the patient might be unable to masticate food of normal consistency.

Based on time of onset, Burstone further classified pain as follows:

1. Immediate: which is associated with sudden placement of heavy forces on the tooth, e.g. hard figure of eight tie between the central incisors to close a midline diastema.
2. Delayed: produced by variety of force values from light to heavy and representing hyperalgaesia of the periodontal membrane. This type of pain response decreases with time i.e. the pain reaction might start as third degree but become second or a first degree with the passage of time.

Optimal forces for tooth movement

The term optimum orthodontic force is usually regarded as meaning the force that moves teeth most rapidly, with the least discomfort to the patient and least damage to the teeth and their investing tissues. In 1932 Schwarz stated that biologically the most favorable treatment is that which works with forces not greater than the pressure in the blood capillaries. Oppenheim (1944) and Reitan (1959) have also reported the optimal force levels based on capillary blood pressure in the periodontal membrane.[51,52] Schwartz (1932) in his experience, recommended light, continuous forces because he was of the opinion that this prevents the formation of resorption-resistant osteoid bone and certain reparative processes on the side toward which tooth moves.[50] Burstone (1985) characterized optimal force by maximal cellular response from the tooth supporting tissues, including apposition and resorption of alveolar bone, at the same time as the maintenance of the vitality of these tissues is secured. Thus, the amount of tooth movement is not the only indicator of optimal force.[11,12,13,14,15]

Light differential forces for tooth movement has been recommended and are more efficient and more biologic thus produces less pain and discomfort to the patient. Reitan has always advocated light forces, especially at the initial stages of tooth movement, to minimize adverse tissue reaction. The use of light continuous force is thought to be the key factor for orthodontic tooth movement.[17]

Management of orthodontic pain

Pain caused by orthodontic treatment can be a major negative component of the entire therapy. Pain control during orthodontic treatment is considered an important aspect of orthodontic mechanotherapy.

Conventional analgesics like acetaminophens, ibuprofen have been used to alleviate orthodontic pain. The drug taken prior to the installation of an active orthodontic appliance reduces pain of the procedure and continued for a minimum of 24 hours following the procedure allivates the major discomfort of the patients. Numerous studies investigated various drugs such as ibuprofen, aspirin, acetaminophen, misoprotol, indomethacin, naproxan sodium. These drugs effectively reduce the discomfort and pain caused by appliances by inhibiting or at least reducing the inflammatory response caused by the applied force. The major concern with using NSAIDs to manage orthodontic pain is that it may interfere with tooth movement by inhibiting cylcooxygenase activity and thus prostaglandin production. A recent development in this area of pain management is the introduction of rofecoxib, the cox-2 inhibitor. It has been reported that this drug has no effect on PGE 1 levels and can be safely used for pain control during orthodontic mechanotherapy.[18,19,20]

In addition to the conventional analgesics, more physiological approaches for the treatment or prevention of pain have been applied. Chewing something fairly hard -a plastic wafer, for example within the first two hours after arch wire adjustment may act to reduce the ischemia and inflammation in the periodontal ligament.[13] Patients reported less discomfort after chewing Aspergum — a weak analgesic chewing gum with aspirin, after orthodontic mechanotherapy. The mechanism of pain suppression is due to rhythmic behaviour of chewing which suppresses nociceptive responses via the serotonergic (5-HT)-descending inhibitory pathway.[21,22,23]

Low level laser has been shown to produce analgesic effects in various therapeutic and clinical application. The mechanism of laser analgesia has been attributed to its anti-inflammatory effects. Low level laser therapy has been applied for the treatment of pain related to orthodontic activations but without success.[24,25]

Theoretically, the ideal way to control pain during orthodontic treatment would simply be to keep the applied force levels to a minimum, below the pain threshold. This approach, however, is contradictory for the purpose if the force levels should be kept too low to result in any tooth movement.[15] Introduction of superelastic, heat-activated archwires to orthodontics, claims to enable the practitioner to reduce the treatment time by combining different stages of orthodontic treatment done separately earlier, namely alignment, leveling and tooth movement.[26,27]

Modification in Orthodontic procedures for less pain perception by patient

With the newer advances in the field of orthodontics pain felt by patient is reduced to minimal.

a. **Pain due to separator placement and banding of tooth:** Nowadays bonding of buccal tubes are preferred than banding of molars so separation of teeth, being most painful step is not required.
b. **Pain due to initial wire placement:** Initial wires used for alignment and leveling are thermal NiTi and copper NiTi which have low load deflection and produces very low level forces and thus result in less pain to the patient. These wires become inactive on low temperatures so after insertion if there is more discomfort, the patient is asked to do mouth rinses with cold or icy water which soothes the patient.[28,29]

c. **Pain due to retraction mechanics:** Previously retractions were done with sliding mechanics and force was applied via head gears and J-hooks. As the advancement happened these were replaced by NiTi coil springs which give low continuous forces. After introduction of loops made by TMA wires like T-Loop and KSIR arch wire optimum tooth movements were done with less force and less pain to the patient.

d. **Pain due to extra oral appliances:** All extra oral appliances were used for anchorage preservation, require patient compliance and exert orthopedic forces. Now a day's these are mostly substituted by absolute anchorage devices like orthodontic implants. Placements of implants are done under local anesthesia so is less painful to patient and it gives ease of retraction without taxing anchorage.[30,31]

e. **Pain due to expansion of maxilla:** Rapid maxillary expanders are orthopedic devices and produces separation between the two halves of the maxilla. Since the process is very rapid, over the period of 15-20 days, and is a painful procedure. NiTi palatal expanders are the newer advances, exerting low level forces over the period of 3-6 months and less painful.[31,32,33]

Conclusion

In Orthodontics force is applied that causes inflammation which is used for effective tooth movement. This inflammation is perceived as pain by the patient. Both phenomenon are interrelated to each other and nether can be eliminated. But the changes in the mechanotherapy and drug therapy along with newer advancements the perception of pain by the patient is reduced along with effective orthodontic treatment results can be obtained. Hence, the painful experience is converted to pleasure.

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