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MINIREVIEWS

Insight into orthodontic appliance induced pain: Mechanism, duration and management

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Abstract

Most of the orthodontic patients experience pain during treatment and this significantly influences their attitudes and the approach towards treatment. A number of factors that influence pain response include age, gender, personal pain threshold, mood and stress level of the person, cultural differences and types of orthodontic treatment. Pain is a often overlooked subject by orthodontists, it is nevertheless important to understand the source and mechanism of the pain that occurs during treatment, as well as the methods for managing and controlling this pain. This review attempts to overview the mechanism, duration and current management strategies of orthodontic treatment.

Key words: Orthodontic appliance; Pain mechanism; Orthodontic treatment; Pain; Pain management

Core tip: Pain during orthodontic treatment is an important concern for both clinicians and patients. Although it is not possible to completely eliminate pain during orthodontic treatment, it is still necessary to understand its causes and to minimize it to the greatest extent possible.

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INTRODUCTION

Pain is a commonly encountered sensation in daily human life that is usually difficult to describe or diagnose, and which often represents an important problem that must be addressed through a multidisciplinary approach encompassing all branches of medicine.

Pain during orthodontic treatment is an important concern for both clinicians and patients[1,2]. Patient motivation and cooperation is an important factor in orthodontic treatment, while pain significantly influences patient attitudes and the approach towards treatment. Studies indicate that 90% of orthodontic patients experience pain during treatment, and that 30% consider discontinuing or interrupting their treatment due to pain[3,4].

The study of Abu Alhaijaa *et al*[5] evaluated the relationship between personal characteristics, expectation of pain, and treatment compliance, reporting that individuals who experienced less pain during treatment generally displayed a more positive attitude, and that those sufficiently informed about treatment procedures had less expectations of pain.

In another study, 95% of the patients reported that they experienced pain in different stages of their treatment, and that this inevitably affected their diet[6].

For these reasons, although pain is a subject that is often overlooked by orthodontists, it is nevertheless important to understand the source and mechanism of the pain that occurs during treatment, as well as the methods for managing and controlling this pain.

Mechanism of pain

The International Association for the Study of Pain defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage". Pain also has a strong motivational component, in that it not only triggers a withdrawal reflex, but also induces a highly organized avoidance and evasive behavior[7]. The motivational aspect of pain is an essential function, without which it would be difficult - if not impossible - for the human body to protect and sustain itself[7].

In orthodontic treatments, the force transmitted by appliances allows the movement of the teeth within the alveolar bone[8]. However, this movement also has the effect of causing the compression and inflammation of the blood vessels and nerves within the periodontium. The perception of orthodontic pain is associated with changes in blood flow that occur due to inflammatory reactions following the application of force[9]. Studies indicate that periodontal pain consists of a combination of pressures, ischemia, inflammation, and oedema[10]. Davidovich and Shanfeld have reported that the application of force leads to acute inflammation, which, in turn, results in periodontal vasodilation and the sensation of pain[11]. It is known that the development of hyperalgesic resistance is associated with the release of various chemical mediators[12,13]. Studies have shown that the chemical mediators involved in the development of the hyperalgesic response include histamine, substance P, encephalin, dopamine, serotonin, glycine, glutamate gamma-amino butyric acid, prostaglandins (PGs), leukotriene, and cytokines[9,12,13]. The studies in the literature concerning the increase in the level of these mediators have also demonstrated that the hyperalgesic response occurs following the application of force[9,14,15]. Recent studies have investigated the molecular basis of orthodontic pain by evaluating subjects such as the elevation in the level of various neuropeptides[9].

Kato *et al*[16] previously investigated in rats the distribution of the neurofibrils within the PDL [such as the neurofilament protein (NFP), calcitonin gene-related peptide (CGRP), vasoactive intestinal polypeptide and neuropeptides Y] following the application of force on the first molar. Three days after the application of force, they observed that the level of neurofibrils consisting of NFP and CGRP increased in both the compressed and strained sides, and that these levels returned to normal on the 14th day[9,16].

Studies indicate that substance P - a sensory neuropeptide released from the peripheral nerve ends - and CGRP both regulate the secretion of proinflammatory cytokines released by monocytes, such as IL-1β, IL-6, and TNF-α[15,17,18]. Yamaguchi *et al*[19] determined that the level of three major cytokines (IL-6, IL-8, and TNF-α) released from the human dental pulp cells increased significantly in the 12 h following the application of mechanical force. They also reported that major neuropeptides, such as proinflammatory cytokines, might be involved in pulpal inflammation during orthodontic teeth movement.

Duration of pain

The time of onset and duration of orthodontic pain was similar in most studies, with patients generally beginning to experience discomfort four hours after the application of orthodontic force[20]. In a study using the Visual analogue scale (VAS) to evaluate the level of pain that developed following the placement of separators, the highest intensity of pain was observed on the second day, while the pain fully subsided by the fifth day[21]. Nearly half of the patients evaluated during this study were compelled to change their diet habits and to use analgesics.

In a study using the VAS to evaluate pain in patients with arch wire and separators placed between their molars, Wilson *et al*[20] reported that pain generally began four hours after the application of force, reaching its highest level 24 h later, and almost fully disappearing by the seventh day. On the other hand, Tuncer *et al*[22] described that pain began two hours following the application of orthodontic elastics, reaching its highest level six hours later, and almost fully disappearing by the second day.

A previous study reported that although pain ended in most patients on the seventh day following the application of orthodontic force, 25% of the patients still continued to experience a certain level of pain[23]. The results of the said study indicated that orthodontic pain began two to six hours following the application of orthodontic pain, reaching its maximum level within the first two days, and then gradually decreasing until it completely disappeared by the seventh day.

FACTORS AFFECTING ORTHODONTIC PAIN

Pain is a subjective finding, and different individuals may display different pain responses to the same stimulus. There are a number of factors that are responsible for these differences in response. The main factors that influence pain response include age, gender, personal pain threshold, mood and stress level of the person, as well as cultural differences and the person's previous pain experiences[1,4,9,24,25].

Age

As orthodontic treatments generally involve different therapeutic procedures for different age groups, making comparisons regarding the effect of age is difficult, with studies on this subject generally providing somewhat contradictory results. However, Ngan *et al*[26] previously reported that there were no statistically significant differences between adolescents and adults regards to pain. On the other hand, in their comprehensive and large-scale study on pre-adolescents, adolescents, and adults, Moerenhout and Brown[27] reported that adolescents exhibited higher levels of pain.

In recent years, there is a growing consensus that the relationship between pain and age should be evaluated by also taking into account the effect of age, since this relationship appears to be particularly affected by adolescence. Sandhu and Sandhu[28] determined in their study that girls between the ages of 14 and 17 experienced the highest levels of pain during orthodontic treatments. These authors emphasized that due to their synergistic interaction, the effects of age and gender on the level of pain during orthodontic treatment should be evaluated together rather than separately[28].

These contradictory and conflicting results appear to stem not only from the fact that different orthodontic treatment methods are generally used for different age groups, but also from the fact pain is a multifactorial element that can be affected by gender differences, as well as the psychological and emotional state of the patients.

Gender

Similar to age, gender is another factor that is unlikely to provide accurate assessments when used independently to evaluate pain. This is because even within the same gender, factors such as age group and cultural differences can significantly affect the level of pain that is experienced. Certain studies report that while there are no statistical differences between males and females within the 11-14 age group, a significant difference begins to be observed within the 14-17 age group. This change is reported to be associated with the hormonal changes experienced by females during adolescence[28,29]. Cultural differences similarly appear to cause significant variations in study results regarding the relationship between pain and gender. In a study evaluating the pain response of both male and female individuals, it was observed females generally found it easier to express and describe the pain they experienced compared to males[30]. These contradictory results indicate that the perception of pain is affected not only by physiological differences, but also by cultural factors[31].

Although certain studies evaluating the effect of gender on orthodontic pain describe that females exhibit higher levels of pain than males[6,32,33], most studies from the orthodontics literature have not identified a gender-related difference in the perception of pain[34-37].

Emotional state

Dental anxiety ranks fifth among the objects and situations that are the most common sources of anxiety[38]. A study conducted by Hamurcu[39] compared the intensity of pain experienced with their level of anxiety, and determined that patients exhibiting higher anxiety scores also experienced more pain.

In a study comparing the level of pain experienced by patients at the beginning of orthodontic treatment with their personal characteristics, Bergius *et al*[40] determined that individuals with dental anxiety experienced higher intensities of pain. A similar study observed that anxiety reduced the pain threshold, causing patients to perceive even the simplest procedures as painful[41].

THE EFFECT OF THE TYPE OF ORTHODONTIC TREATMENT ON PAIN

Orthodontic separation

Orthodontic separation is a method applied prior to the placement of an orthodontic band, and is usually associated with significant pain for the patients[9,21,26,42]. In another study performed on 55 patients, 87% of the patients described pain following the placement of an orthodontic separator, while 72% required analgesics[37]. In a study evaluating motor and sensory changes following the placement of a separator by using an electromyograph (EMG), Michelotti *et al*[43] observed a decrease in the pain threshold and motor output of the chewing muscles, and suggested that this was a protective mechanism to prevent further damage to the injured area.

Dental archwire placement and activation

The pain that develops following the initial placement of an archwire has been the subject of numerous studies. These studies generally report that most patients begin to experience pain four hours after the application of the arch, with the level of pain reaching its peak within the first 24 h, and then gradually decreasing[6,26,32,34,42,44,45].

No statistically significant differences have been identified between the perception of pain and the intensity, prevalence, and duration of the archwire usage[34,46,47]. In a study comparing the super-elastic nickel titanium wires with helical stainless steel wires, Sandhu *et al*[48] reported no statistically significant differences in the level of pain experienced with these two wires. However, they suggested that the super-elastic wire caused more pain during the hours when the level of pain reached its peak (between the 12th and 24th h), and that was probably due to the greater force applied by this type of wire. Although the current literature indicates that the application of either strong or weak forces by the wires does not lead to a significant difference in terms of the resulting level of pain, Sandhu's study nevertheless suggests that higher forces result in higher IL-1 beta concentrations, and that this engenders a difference in the level of pain observed during the peak period[48]. Ogura *et al*[49] similarly performed comparisons between weak and strong forces, and determined that during the period of maximum pain levels, biting while the teeth were exposed to stronger forces lead to higher levels of pain.

Previous studies evaluating the activity of chewing muscles following arch activation by using EMG identified a decrease in the masseter muscle activity, which is believed to be responsible for the reflex mechanism for avoiding harmful stimuli[50-52]. Murdock *et al*[44] and Erdinç *et al*[34] have reported that patients report greater pain in the posterior teeth than their anterior teeth during the leveling stage and chewing. In sum, most studies indicate that arch placement and activation can lead to pain, and adversely affect the daily activity and diet habits of patients[9].

Type of appliance

The level of pain caused by different types of appliances during orthodontic treatments has been evaluated in many studies. In studies comparing fixed and removable appliances, Oliver and Knapman[1] identified no significant differences between these two types of treatments, while Sergl *et al*[25] and Gianelly *et al*[53] reported that treatment with fixed appliances resulted in greater pain.

Various comparisons have been performed between fixed orthodontic treatments applied using different methods. Wu *et al*[54] and Caniklioglu *et al*[55] have performed comparisons between labial and lingual appliances, and reported no statistically significant difference with regards to the total level of perceived pain associated with these appliances. However, they also described greater pain on the tongue among patients who received lingual appliances, as well as greater pain on the lips and cheeks among patients who received labial appliances[54,55]. A recent study compared the application of a fixed labial appliances with the Invisalign® and determined that Invisalign® caused less pain[56].

Shalish *et al*[57] have evaluated and compared the fixed lingual treatment, fixed labial treatment and Invisalign® treatment in adult patients, and determined that the most pain and general oral dysfunction occurred in the lingual apparatus group; that Invisalign® caused significant pain in the first day of treatment; and that Invisalign® was similar to conventional labial techniques in terms of general oral dysfunction[57].

Bertl *et al*[58] have examined self-ligating brackets and conventional brackets with respect to pain, and determined that self-ligating brackets caused significantly more pain. In contrast to Bertl *et al*[58], Tecco *et al*[59] suggested that conventional brackets lead to stronger and more persistent pain, while self-ligating brackets tended to cause pain mainly during chewing and biting.

Orthopedic forces

The main purpose of craniofacial orthopedics is to bring skeletal changes by applying significant forces to the craniofacial complex. Various publications report the occurrence of pain during rapid palatal expansion applied for the transversal skeletal development of the maxilla[60-62]. In such cases, patients generally describe a sensation of pain spreading across the craniofacial area[9].

Headgear applications represent another treatment method used during the development stages of children to bring about skeletal and dental modification. Studies have demonstrated that patients with such appliances generally begin to experience pain approximately 24 h after initial application, with the sensation of pain and discomfort gradually decreasing after the 3rd day[63,64].

Egolf *et al*[65] have reported that nearly 28% of patients using orthodontic elastics and headgear discontinue to wear them due to pain. Ngan *et al*[64] previously examined the chewing muscles of protraction headgear patients by using EMG, and determined that the pain associated with the orthopedic devices originated not from the muscle tissues, but instead from the acute inflammation caused by the accumulation of forces in the sutural areas.

Skeletal anchorage systems

Recently, skeletal anchorage systems are being used for absolute anchorage. These devices can be grouped/classified as "mini-plate" and "mini-screws". Zawawi[66] reported that patients with mini-screw implants reported significantly less pain; that 32.5% of patients receiving mini-screw implants did not require any medication; that 59.1% of these patients only required a single-dose analgesic; and that patients generally preferred mini-screws instead of extraction.

Kuroda *et al*[67] previously compared the level of pain experienced with mini-plate and mini-screws. No significant differences were observed in terms of perceived pain levels between mini-plates and mini-screws inserted through incisions, while a significant difference was observed when mini-plates and mini-screws were implanted without using incisions, with the mini-plates resulting in noticeably more pain[67]. In agreement with Kuroda *et al*[67]'s findings, Kawaguchi *et al*[68] demonstrated that implanting mini-plates without using incisions resulted in three times greater pain than placing mini-screws without incisions. The abovementioned studies have generally suggested that the main causes of pain during the application of skeletal anchorage systems could mainly be associated with sutures, periosteal separation, and incisions.

Debonding

Many patients also describe pain when removing their fixed appliances. Various studies have shown that applying intrusive forces during the debonding of fixed appliances reduced the level of pain experienced. These studies have therefore recommended applying finger pressure, biting a cotton roll, or using an occlusal wax layer during the removal process in order to reduce pain[69,70].

PAIN MEASUREMENT

It is important that pain is measured by the use of standardized pain scales and by using common language due to its complex and subjective nature. Unfortunately, objective assessment methods are still developing and subjective assessment is still the commonly used method. As the pain perception varies among individuals, it is important to take the patients' own report into consideration. Ideally, a pain intensity scale must have a low rate of incorrect responses, should be easy to administer, and be sensitive with an adequate number of response categories and be statistically powerful to detect treatment effects.

VAS is considered to be superior to other pain scales in terms of reproducibility and ease of measurement. VAS is a numeric scale and consists of a horizontal or vertical 100 mm line that has "no pain" and "worst pain" labels on two endpoints; the patient is asked to mark on the line to show the degree of pain experienced. The distance between the low end of the scale and the patient's mark is used as the index of pain intensity[8].

MANAGEMENT AND CONTROL OF ORTHODONTIC PAIN

Although it is not possible to completely eliminate pain during orthodontic treatment, it is still necessary to understand its causes and to minimize it to the greatest extent possible. It is therefore important to take into consideration and avoid overlooking the patient's complaints during the treatment process, and to inform them beforehand about the pain the treatment may cause. A study performed by Krukemeyer *et al*[4] determined that orthodontists tend to ignore or dismiss the pain caused by the treatment, and that they generally expect a lower level of pain and medication use than the level reported by patients. Krukemeyer *et al*[4] also reported a general lower-than-necessary amount of medication use. Abu Alhaijaa *et al*[5], on the other hand, reported that patients sufficiently informed about the treatment process had a lower medication requirements.

Nonsteroidal anti-inflammatory drugs (NSAIDs) are usually the medication of choice in orthodontics to alleviate mild and moderate pain and inflammation, although there is no standard protocol concerning the application of NSAIDs. Many drugs such as acetaminophen, ibuprofen, aspirin, and flurbiprofen have been used and determined to be effective in the management of orthodontic pain[71-76]. However, a number of previous studies have suggested that PGs, and especially prostaglandin E2 and prostaglandin E1, can affect bone remodeling and teeth movement[14,77-80]. Nevertheless, the general consensus in orthodontic pain management is that the application of a low-dose analgesic during the first days of treatment will not have a clinically significant effect on the movement of the teeth. Another point that needs to be taken into consideration during orthodontic treatment is the possibility that teeth movement might be affected in patients who have been regularly receiving NSAIDs for a long period of time due to a systemic condition. In such cases, acetaminophen should be preferred because it provides sufficient analgesia without affecting teeth movement[8].

In recent times, there has been an increasing focus on preventing the development of a pain memory through preemptive drug administration. Steen Law *et al*[76] previously assessed the effect of ibuprofen and placebo administered one hour prior to separator application, and determined that the ibuprofen administration significantly reduced the pain experienced by the patients. Polat and Karaman[72] similarly conducted a comprehensive study evaluating the administration of five different medication (placebo, ibuprofen, flurbiprofen, acetaminophen, naproxen sodium, and aspirin) one hour before and six hours after bracketing procedures. The lowest pain scores were observed in the naproxen sodium and aspirin groups, while the highest pain scores were observed in the acetaminophen group[72]. In another study of the same authors, a single preoperative dose of placebo, ibuprofen and naproxen sodium was applied, and - in agreement with the findings of their previous study - lower levels of pain were reported during the first day in the naproxen sodium group. However, the authors also described that a single-dose application was not sufficient, and that additional postoperative doses were also necessary[42].

Non-pharmacological methods used for pain management include transcutaneous electrical nerve stimulation (TENS), laser applications, vibration, and chewing apparatuses. Profitt described that the use of chewing gum or biting blocks during application would help reduce pain[81]. This theory was investigated by Mohri *et al*[82] by evaluating the relationship between chewing and the serotonergic (5-HT) neurons responsible for nociceptive transmissions. Mohri *et al*[82] determined that the rhythmic behavior of chewing indeed suppressed the nociceptive response. Hwang *et al*[83] similarly determined that biting blocks reduced pain in 56% of their patients; however, they also observed that in other patients, biting blocks had the effect of increasing the experienced pain. Murdock *et al*[44], on the other hand, compared the effect of analgesics and biting blocks, and determined that these apparatuses were as effective as analgesics, and that they represent a good option for adolescents.

Laser - a highly popular technological application in recent times - is also being used in the management of orthodontic pain. Fujiyama *et al*[84] reported that CO_2 laser applications are able to reduce orthodontic pain without affecting teeth movement. In another study, comparisons were performed between a low-energy gallium-arsenic-aluminum laser (LLLT) group, a placebo group, and a control group following the implantation of an arch wire. The study determined that the LLLT and placebo groups both experienced significantly less pain, although the difference between these two groups was not significant[85]. Although numerous alternative, non-pharmacological methods are being used for the management of orthodontic pain, it is known that pharmacological methods still represent the most effective approach.

CONCLUSION

Although it is not possible to completely eliminate pain during orthodontic treatment, it is still necessary to understand its causes and to minimize it to the greatest extent possible. It is therefore important to take into consideration and avoid overlooking the patient's complaints during the treatment process, and to inform them beforehand about the pain the treatment may cause. During pain management, medication that ensures the maximum reduction of pain with the minimum side effects should be administered by employing the most effective methods. In particular, the decision regarding the choice of medication or approach for reducing pain should not be left to the patient's relatives. Although there are no controlled studies supporting low-energy laser and TENS applications, further studies and growing interest on these techniques might eventually bring a new dimension to orthodontic pain management.

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