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Review Article

Recent progress in alleviating orthodontic discomfort: Mechanism and management-the state of evidence

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ABSTRACT

Orthodontic treatment has demonstrated efficacy in enhancing dental health and rectifying tooth misalignments. Nevertheless, patients experience substantial discomfort and distress. Advancements in orthodontic technology and treatment procedures have led to a decrease in orthodontic discomfort. Orthodontic discomfort refers to the inflammation that occurs due to the obstruction of blood vessels by orthodontic force. This leads to inflammatory responses, which encompass alterations in blood vessels, recruitment of inflammatory and immune cells, and heightened sensitivity of nerves along with the release of chemicals that promote inflammation. The body's inherent analgesic systems ultimately regulate the inflammatory response, thereby diminishing pain. Orthodontic pain signals are transmitted by three-order neurons, beginning with the trigeminal neuron located in the trigeminal ganglia. The signals subsequently arrive at the trigeminal nucleus caudalis located in the medulla oblongata, as well as the ventroposterior nucleus in the thalamus, where the sensation of pain is perceived. The processing of orthodontic pain involves the interplay of emotion, cognition, and memory in many parts of the brain. The structures encompassed in this list are the insular cortex, amygdala, hippocampus, locus coeruleus, and hypothalamus. The inherent analgesic neuronal pathway of the periaqueductal gray and dorsal raphe regions alleviates orthodontic discomfort. Various techniques are employed to manage orthodontic discomfort. These therapies encompass pharmacological, mechanical, behavioral, and low-level laser treatments. Nonsteroidal anti-inflammatory medicines (NSAIDs) alleviate pain, but their impact on tooth movement remains uncertain. Additional research is required to establish the effectiveness of alternative modalities. Gene therapy provides a new, practical, and hopeful approach to treating orthodontic pain. This article explores new advancements and techniques that have enhanced the level of comfort experienced by orthodontic patients.

1. Introduction

Pain is a disagreeable perception and emotional response that arises from actual or perceived harm to bodily tissues. Orthodontic discomfort is consistently characterized by a dull, unpleasant, and hypersensitive sensation. Typically, individuals are motivated to steer clear of dangerous circumstances due to pain.[1] Many orthodontic patients tolerate orthodontic pain as they are aware that it is a common consequence of tooth repositioning. Orthodontic

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pain refers to tooth discomfort resulting from tooth movement, as well as other painful sensations such as mucosal ulcers, tongue soreness, and gingival lesions caused by orthodontic appliances.[2] This review will focus on the specific definition of orthodontic discomfort, unless otherwise specified. This review provides a comprehensive analysis of the characteristics, processes, brain circuits, and therapeutic therapy associated with orthodontic discomfort.[3] Orofacial pain resulting from orthodontic tooth movement is a common phenomenon in orthodontic treatment. Between 72% and 100% of individuals encounter discomfort, compression, and strain in their teeth when undergoing orthodontic treatment.[4] The application of orthodontic force stimulates sensory receptors in the tissues surrounding the teeth, leading to a series of pain processing and transmission in the peripheral and central nervous systems that orthodontic patients perceive. Various orthodontic procedures, such as the placement of separators, initial wire engagement, banding, elastics, rapid maxillary expansion, and debonding, typically induce pain.[5] Orthodontic pain typically begins 12 hours after the application of force, reaches its most intensity after 1 day, and gradually diminishes over a period of three day - one week later, patients typically return to their initial condition, and after one month, they fully recover. However, 40% of adolescent patients continue to experience orthodontic discomfort beyond one week, indicating that it may persist for a longer duration. Furthermore, orthodontic pain has negative effects on patients' overall well-being, ability to chew, and speech.[6] Research conducted on animals indicates that orthodontic pain leads to mental distress and temporary impairments in learning and memory. This article will examine new advancements and techniques that have enhanced the comfort of orthodontic therapy for patients.

2. Recent Advancements and Techniques have Improved Orthodontic Therapy

2.1. Low-friction brackets and arch wires

Conventional braces frequently generate significant friction between the brackets and arch wires, resulting in discomfort and agony when the teeth move. Recent breakthroughs in orthodontic materials, such as Self-ligating brackets and heat-activated arch wires minimize friction. This leads to a more seamless and effective shifting of teeth, resulting in a notable decrease in discomfort throughout the treatment process.[7]

2.2. Temporary anchorage devices (TADs)

Are devices used to provide temporary stability and support in orthodontic treatment. TADs, also known as titanium screws or mini-implants, provide as supplementary anchorage for orthodontic stresses. They enable more precision in controlling tooth movement, hence minimizing the requirement for cumbersome headgear or other painful devices. TADs have become an essential component of contemporary orthodontics, enhancing treatment results while reducing patient discomfort.[8]

2.3. Accelerated orthodontics

Methods like as rapid orthodontics utilize regulated micro-osteoperforations or vibration devices to expedite the process of tooth movement. Patients can minimize discomfort and inconvenience by shortening the time of orthodontic therapy.[9]

2.4. 3D Printing and customization

Recent developments in 3D printing technology have facilitated the production of personalized orthodontic devices, including as braces and aligners. Personalized orthodontic appliances provide a superior fit, resulting in decreased irritation and discomfort. Furthermore, the utilization of digital treatment planning enables more accurate tooth repositioning, hence reducing the necessity for modifications and discomfort.[10]

2.5. Invisalign and clear aligners

The comfort and aesthetics of clear aligner therapy, such as Invisalign, have contributed to its increasing popularity. These detachable aligners are nearly imperceptible and provide less irritation to the oral soft tissues in comparison to conventional braces. Advancements in aligner materials and design have recently improved patient comfort even more.[11]

2.6. Strategies for managing pain

Orthodontists are employing pain management techniques more frequently to alleviate the discomfort that is commonly associated with orthodontic treatment. This include the utilization of non-prescription pain medications, orally administered painkillers, and locally applied numbing agents. Orthodontists also give patients clear guidelines on how to manage discomfort at home.[12]

2.7. Progress in retainers

Retainers are crucial for preserving the restored alignment of teeth following orthodontic treatment. Recent developments in retainer design and materials have resulted in improved patient comfort and reduced visibility. This minimizes the discomfort typically experienced when wearing retainers.[13,14]

3. The Mechanisms Responsible for Orthodontic Pain

Orthodontics commonly involves the practice of using pressure to align teeth. Patients may suffer pain and

discomfort as a result of these forces, which play a crucial role in achieving a more aligned smile.[15] Gaining insight into the mechanics of orthodontic discomfort enhances the comfort of patients undergoing treatment. When orthodontic forces are exerted on teeth, the periodontal tissues and tooth pulp react. Orthodontic discomfort and tooth movement are the result of a series of controlled inflammatory reactions involving cells, blood vessels, nerves, and the immune system.[16] These biological processes are connected, with local inflammation being the underlying reason. Pain is induced by the activation of sensory endings by the action of local inflammatory products, such as prostaglandin and bradykinin. Orthodontic discomfort is mostly caused by periodontal inflammation resulting from the application of orthodontic forces.[17] The periodontal inflammation response include vascular, cellular, and chemical processes. These three components combine to form a network. This evaluation will address each of these three components separately to provide clarity, although they are closely interconnected. In this discussion, we will explore the primary causes underlying orthodontic pain.[18]

3.1. Vascular events, inflammation and tissue response

The application of orthodontic stresses on teeth might result in a specific inflammatory reaction in the neighboring tissues. Inflammation is a normal part of the process of moving teeth. It causes certain cells, called osteoclasts and osteoblasts, to break down and form bone in order to make room for the tooth movement.[19] This process can cause pain receptors in the surrounding tissues to be activated, leading to discomfort. The release of substances like prostaglandins and cytokines during inflammation can trigger this pain response. In 1932, Schwarz established the ideal orthodontic force to be within the range of 20-25 ġcm−2. This force produces a tissue pressure that closely matches the capillary blood pressure in compressed periodontal tissues.The optimal pressures on teeth narrow the vascular arteries in compressed regions, resulting in local ischemia. Local ischemia induces heightened anaerobic respiration in periodontal cells, namely fibroblasts, resulting in acidosis. The Cardinal molecular acid-sensing ion channel 3 transforms nearby acidic stimuli into signals that cause pain. Periodontal sensory endings are known to express the H+ ion channel receptor ASIC3. This method may elucidate the reason why orthodontic patients experience minimal or insignificant discomfort within the initial hours following the application of force, as the onset of local inflammation occurs approximately 12 hours later (12-14). When there is an increase in vascular permeability, periodontal tissues attract a significant number of neutrophils, monocytes, and lymphocytes. When these cells are activated in periodontal tissues, they release chemokines, cytokines, and inflammatory mediators, which leads to local inflammation and discomfort.

3.2. Cellular microdamage

Orthodontic forces exert strain on the periodontal ligaments responsible for anchoring teeth in their sockets, leading to cellular microdamage. The application of this force causes microscopic injuries in the bone and the tissues that surround it. Sensory receptors in these regions perceive this physical pressure and convey messages of discomfort and pain to the brain. During local inflammation, there is an increase in vascular permeability, which causes the attraction of many types of white blood cells, including neutrophils, mast cells, macrophages, T cells, and monocytes, to the tissues of the periodontium. In response to local inflammation, mast cells and macrophages produce mediators that attract leukocytes to the periodontal tissues. Mast cell mediators, such as histamine and TNF-α, enhance the expression of adhesion proteins in vascular endothelial cells.[20] A recent study discovered that M1 macrophages contribute to the breakdown of alveolar bone under orthodontic stress, highlighting their involvement in the inflammatory mechanisms that cause orthodontic discomfort. Further investigation is required to examine the involvement of M2 macrophages or the balance between M1 and M2 macrophages in orthodontic discomfort.

3.3. Neurotransmitters and nociceptors

Nociceptors are specialized nerve endings that specifically sense harmful stimuli, such as mechanical pressure and inflammation. Neurotransmitters play a crucial role in transmitting signals between nerve cells. Orthodontic therapy can sensitize nociceptors by releasing neurotransmitters, including substance P and calcitonin gene-related peptide (CGRP), which increases their sensitivity to pain signals. This process of sensitization intensifies the experience of pain.

3.4. Chemical reactions

Leukocytes and inflammatory cells are attracted and stimulated in the periodontal tissues. These cells release substances that cause inflammation in the tissues surrounding the teeth, such as IL-1, IL-6, prostaglandin, TNF-α, IFN-γ, M-CSF, and VEGF. These substances work together to intensify local inflammation during the first discomfort experienced during orthodontic treatment. Interleukin-1 (IL-1), interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), interferon-gamma (IFN-γ), and macrophage colony-stimulating factor (M-CSF) activate osteoblasts and osteoclasts, resulting in periodontal bone remodeling and tooth movement, which in turn causes heightened local inflammation. VEGF promotes the growth of new blood vessels and the restructuring of bone in the affected area once the pain diminishes. This process recurs during the subsequent orthodontic appointment when pressure is exerted.

3.5. Individual pain threshold

Each individual possesses a distinct pain threshold, whereby an experience that is only slightly uncomfortable for one person may be considerably more agonizing for another. Genetics, pain perception, and overall health are factors that can affect how much pain an individual experiences throughout orthodontic treatment. Orthodontic changes, such as the tightening of braces or the changing of aligners, often result in heightened levels of pain and discomfort. These modifications enhance the amount of pressure exerted on the teeth, resulting in a brief surge in discomfort that often diminishes within a few days.[21] Orthodontists frequently utilize diverse pain management treatments to assist patients in managing discomfort. Common treatments for pain relief may encompass non-prescription pain medications, oral analgesics, topical anesthetics, and suggestions for consuming soft diets.[22]

4. The Application of Pharmacological Methods or Procedures

Nonsteroidal anti-inflammatory drugs (NSAIDs) have been used for many years to relieve orthodontic pain. The effectiveness of nonsteroidal anti-inflammatory medicines (NSAIDs) in reducing orthodontic pain has been confirmed. However, there is ongoing debate about their influence on the rate of tooth movement. As a result, the regular use of NSAIDs for pain control in orthodontic treatment is not yet widely practiced.[22] Prostaglandin, as mentioned before, is a mediator that has pro-inflammatory qualities. It causes unpleasant sensations by interacting with sensory endings. Furthermore, it promotes tooth movement by stimulating bone remodeling.[23] There is a lot of information available about how COX enzymes are involved in the production of prostaglandin, and how NSAIDs can block the activity of COX enzymes. Therefore, nonsteroidal anti-inflammatory drugs (NSAIDs) have the potential to reduce orthodontic pain by preventing the release of prostaglandin. The intake of nonsteroidal anti-inflammatory medicines (NSAIDs) may lead to a decrease in prostaglandin levels, which can potentially inhibit osteoclasts and reduce the rate of tooth movement. This can be ascribed to the function of prostaglandin in stimulating localized inflammation and restructuring of bone tissue.[23] Moreover, it has been proposed that nonsteroidal anti-inflammatory medicines (NSAIDs) also impede the process of orthodontic tooth movement through an additional mechanism. NSAIDs interfere with the action of collagenase and the formation of procollagen, which disrupts the remodeling of the periodontal tissues.[24]

4.1. The methodical approach

Several mechanical techniques have been proposed as possible therapies to relieve orthodontic discomfort. These methods encompass the use of vibration, chewing gums, biting wafers, and acupuncture.[25] An intraoral vibrating device is used to put patients' teeth to vibration. Patients are given instructions to alleviate orthodontic discomfort by participating in activities such as chewing gum and biting on wafers. Furthermore, acupuncture involves the use of systemic needles at a precise acupoint called Hegu (LI4), which is located on the back of the hand between the first and second metacarpal bones.[26] The fundamental mechanism behind the effects of vibration, chewing gum, and biting wafers is based on the activation of mechanoreceptors by mechanical stimuli. These mechanoreceptors send tactile impulses and simultaneously block the conveyance of distressing signals. These events can be explained by the act of applying pressure to the skin at a painful area, which has the ability to relieve pain. Moreover, as mentioned before, orthodontic forces apply strain on periodontal vascular vessels, leading to restricted blood flow and consequent inflammation. Vibrations possess the capacity to restore normal blood circulation, hence reducing discomfort.[27] However, there is a controversial discussion over the effectiveness of vibration in reducing orthodontic pain. Additional research is required to examine the effectiveness of chewing gum and biting wafers, as there is currently less empirical evidence available. Although acupuncture has been demonstrated to be beneficial in reducing orthodontic pain, the specific mechanisms responsible for its pain-relieving effects have not been extensively investigated. Therefore, more validation is necessary to determine the effectiveness of the mechanical approach in reducing orthodontic pain.[28]

4.2. Orthodontic wax

A substance used in orthodontics to provide relief from discomfort caused by braces or other orthodontic appliances. Orthodontic wax is a little but crucial tool used by those undergoing orthodontic treatment. Orthodontic items including as braces and aligners can cause irritation and pain, especially during the early phases of treatment. Orthodontic wax is used as a remedy in such situations. This pliable and adaptable substance offers relief and comfort by creating a protective barrier between the device and the sensitive oral tissues.[29] Orthodontic wax is a biocompatible material frequently used in dentistry. Typically, it consists of a blend of natural waxes, such as beeswax, combined with different chemical components. This product is renowned for its non-toxic properties and is specifically tailored for use in medical applications. The substance is obtainable in compact, conveniently sized strips or squares and possesses a translucent or white look.[30] Orthodontic wax is specially designed to be safe for use in the mouth, making it suitable for people of all ages, including children and adults undergoing orthodontic treatment. Its main function is to

reduce irritation and pain caused by orthodontic tools like braces or aligners. Orthodontic wax provides immediate relief from discomfort and soreness caused by orthodontic appliances.[31]

4.3. Low-level laser treatment (LLLT)

The application of low-level laser treatment has been extensively adopted in the medical and dental domains to alleviate pain. Low-level laser therapy has recently been extended to cover the relief of orthodontic discomfort. Entails the application of laser radiation to the complete dental arch.[32] Multiple empirical research have confirmed the effectiveness of low-level laser therapy in reducing orthodontic pain. However, some research investigations have shown that the effectiveness of the indicated strategy is not supported. Additionally, several systematic reviews and meta-analyses have produced conflicting results. The observed inconsistencies may be attributed to variances in the duration and dosage of irradiation. Thus, it is crucial to elucidate irradiation procedures and conduct additional verification of their effectiveness.[33]

4.4. Behavioral approach

Refers to a psychological perspective that focuses on observable behaviors and their relationship to the environment.[34] Different behavioral interventions are employed to relieve orthodontic pain, including cognitive-behavioral therapy (CBT), participation in physical exercise, and the application of music therapy.[35] These behavioral techniques have the property of using reassurance and attention distraction. Numerous documents indicate that orthodontic patients often feel anxious and stressed after experiencing orthodontic discomfort.[36] Research has shown that promptly providing follow-up care can effectively reduce orthodontic pain. This supports the idea that offering reassurance to orthodontic patients could be a practical strategy for managing orthodontic pain.[37] Cognitive Behavioral Therapy (CBT), a psychotherapeutic approach, utilizes a series of techniques. The treatment sessions are designed to correct patients' negative attitudes and decrease their levels of anxiety.[38,39]

4.5. Gene therapy

Gene therapy is a method that includes introducing genes or DNA sequences into certain cells, allowing them to express these genetic materials either temporarily or permanently. This expression then causes changes in the biological functioning of the targeted cells. Pain relief can be achieved by inserting naturally occurring opioid genes into nerve cells.[40] A clinical experiment including human participants has been done to investigate the use of gene therapy for reducing pain associated with cancer, and the findings have been positive. Several viral vectors have been developed to aid in the transfer of desired genes into particular cells.[41] These vectors include adenovirus, lentivirus, herpes simplex virus, and adeno-associated virus. The herpes simplex virus is beneficial in gene therapy for neurological disorders, including pain, because of its affinity for the nervous system.[42] Reports indicate that gene therapy has demonstrated potential effectiveness in reducing trigeminal pain in rats. This includes introducing an opioid gene into the trigeminal ganglia using the herpes simplex virus. Similarly, researchers have investigated the use of the herpes simplex virus to deliver natural opioid genes or RNA interference sequences that target pro-inflammatory genes, like CGRP, to the trigeminal ganglia in order to relieve orthodontic pain.[43,44] However, the application of gene therapy in clinical practice is currently limited due to safety concerns. Nevertheless, the inherent biosafety concerns linked to this treatment may soon be addressed, paving the way for its prospective adoption as a feasible and universally acceptable method for relieving orthodontic pain.[45]

4.6. Orthodontic pain patient education: empowering patients for comfortable treatment

Orthodontic therapy can result in substantial enhancements in an individual's smile and oral well-being, however frequently accompanied by a certain level of discomfort or pain. Providing patients with education is an essential part of orthodontic therapy, as it enables them to comprehend the treatment process and gives them the necessary information and techniques to appropriately handle any discomfort associated with orthodontic treatment.[46]

4.7. The significance of patient education

Managing Expectations: Informing patients of the possibility of discomfort related to orthodontic treatment aids in the management of their expectations.[47] Understanding that experiencing a certain degree of pain is typical might alleviate feelings of concern and irritation when it arises. Empowerment: Patients experience a greater sense of control over their orthodontic treatment when they comprehend the causes of their discomfort and learn how to alleviate it.[48] This sense of empowerment can result in increased adherence and a more favorable orthodontic encounter.[48] Enhancing treatment adherence: Patients who possess adequate knowledge and understanding are more inclined to comply with their prescribed treatment regimen. Recognizing the significance of wearing orthodontic appliances accurately and according to the orthodontist's guidelines can result in improved treatment results.[49]

4.8. Soft dietary plan for relieving orthodontic discomfort

Orthodontic therapy is a practice that aims to enhance dental health and achieve a more aligned and aesthetically acceptable set of teeth. However, persons undergoing treatment may experience feelings of discomfort or pain, especially after changes or the use of new dental devices. One practical way to reduce this pain is by adopting a soft diet.[50] A soft diet consists of food products that are specifically chosen for their easy chewing, swallowing, and digesting. These food items have properties that promote oral health because they are less likely to cause irritation and discomfort to the teeth, gums, and orthodontic equipment when eaten during meals.[51] This discussion will outline the basic components and benefits of a soft diet in reducing orthodontic discomfort. Implementing a soft diet while undergoing orthodontic treatment might help individuals effectively cope with the temporary discomfort that is frequently encountered. This strategy provides a practical and enjoyable way to maintain a pleasant and satisfying dining experience while working towards achieving desirable oral aesthetics.[52]

5. Conclusion

Orthodontists must exert their highest level of professional discretion to assess the pain tolerance of each patient. By establishing efficient communication strategies between orthodontists and patients, and providing personalized nutritional recommendations, it is possible to reduce the level of pain and discomfort experienced by patients to some extent. Orthodontic pain, which is categorized as inflammatory pain, shares many similarities with general inflammation, although it has its own unique characteristics.[53] The specific biochemical mechanisms underlying the occurrence of orthodontic discomfort are not fully understood. Although there is a significant amount of information available on the sensory pathways, our knowledge of the secondary pathways related to emotions, memory, and cognition is still restricted. Keim (2004) states that many orthodontic training programs do not prioritize pain management and prevention. This is a significant issue, especially considering the increasing concerns expressed by patients and parents. Orthodontists need to use logical reasoning to address these concerns and there is a need to focus research efforts on this topic. Although the effectiveness of NSAIDs in reducing orthodontic pain has been proven, additional studies are necessary to validate their influence on tooth movement.[54] Further verification is needed to assess the effectiveness of alternative methods, such as mechanical techniques, low-level laser therapy, and behavioral approaches. Furthermore, gene therapy, a burgeoning and pragmatic method, holds potential for future management of orthodontic discomfort. However, based on the current available information, analgesics remain the established and conventional method for pain management. Moreover, it is crucial for orthodontists to have a thorough understanding of the pharmacological mechanisms and the pros and cons involved with administering analgesics.[55] Each medicine has its own set of instructions. However, pain management is a complex issue. This article has aimed to provide a thorough overview of the latest research progress in this specific field. Orthodontic researchers and practitioners should prioritize and actively participate in addressing this topic by conducting more randomized clinical trials. This will help in developing precise methodologies for assessing, evaluating, and managing the pain and discomfort experienced by orthodontic patients. Therefore, it is crucial to carry out further research that combines various approaches to managing orthodontic discomfort, using strong study methods and including large sample numbers.[56]

6. Future Perspectives

1. Advanced Pain Management: Explore targeted therapies and precision medicine to address specific pathways of orthodontic discomfort.
2. Digital Integration: Utilize virtual reality and augmented reality for distraction during procedures and real-time feedback for precise adjustments.
3. Biological Approaches: Investigate stem cell therapy and tissue engineering for tissue repair and inflammation reduction.
4. Patient Education: Empower patients with self-management strategies through digital platforms and comprehensive resources.
5. Interdisciplinary Collaboration: Foster collaboration among orthodontists, pain specialists, and psychologists for holistic treatment approaches.

In summary, the future of orthodontic pain management holds exciting possibilities, driven by advances in technology, personalized medicine, and interdisciplinary collaboration. By embracing novel approaches and prioritizing patient-centered care, orthodontists can strive to minimize pain and discomfort while optimizing treatment outcomes for their patients. Ongoing research efforts and clinical innovation will be essential for realizing these future perspectives and improving the overall patient experience in orthodontics.

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Not Applicable.

8. Consent for Publication

Not Applicable.

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11. Conflict of Interest

None.

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