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Clinical Evaluation of Pain Control Methods in Patients Undergoing Combined Orthodontic and Restorative Dental Treatments

Keywords
Orthodontic pain; Postoperative sensitivity; Pain management; Restorative dentistry; Multidisciplinary dental care

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Abstract
Pain is a frequent clinical issue of clinical interest in patients who have combined orthodontic and restorative dental procedures. Application of orthodontic force and restorative treatments including adhesive bonding as well as the placement of composite stimulate different but overlapping inflammatory and neurophysiological mechanisms, which may result in discomfort accumulation with prolonged treatment. Multidisciplinary cases pain management needs therefore an integrated and mechanism-based approach. The review consolidates the current evidence on the biological nature of the orthodontic and restorative pain, appraises pharmacological therapies encompassing nonsteroidal anti-inflammatory drugs and combinations of these therapies, and extends to the non-pharmacological therapies which include photobiomodulation, mechanical stimulation, and technique-sensitive restorative techniques. Existing evidence indicates that multimodal pain management guidelines, involving the integration of preventive therapeutic interventions and selective pharmacotherapeutic interventions, are a more effective approach towards maximising patient comfort without losing the effectiveness of treatment. Nevertheless, the problem of heterogeneity of the study design, the short-term outcome measurement and scanty data on combined-treatment protocols is still a major drawback. It is proposed to employ a structured and patient-centred decision-making algorithm that involves the assessment of risks, optimisation of the procedures, and focused analgesia to reduce the cumulative inflammatory load and increase adherence. Research is advised to rely on standardised methods and combined clinical studies on multidisciplinary care in the future.

1. Introduction

Pain has become one of the most common adverse experiences in dental practice and one of the most important predictors of patient satisfaction, compliance, and success of overall treatment outcomes. In modern dentistry, the need to provide multidisciplinary treatment, particularly the fusion of orthodontic care with restorative care, has grown significantly. Adult patients who desire aesthetic and functional rehabilitation may need orthodontic alignment before the restorative correction, placement of an implant, veneers fabrication, or full-mouth rehabilitation. Although this approach is clinically beneficial, it exposes patients to a variety of sources of nociceptive stimulation during prolonged periods of time. Orthodontic pain mainly correlates with the use of mechanical force on the teeth, which leads to the compression of the periodontal ligament, ischemia, the release of inflammatory mediators and sensitisation of nerves. It is always clinically observed that the highest level of pain occurs during the first 24-48 hours after arch wire placement or activation. A multicentre randomised controlled trial comparing chewing gum and ibuprofen demonstrated that orthodontic pain is significant enough to necessitate structured analgesic strategies, underscoring its clinical importance in routine orthodontic care[1].

Simultaneously, dental procedures that may cause postoperative sensitivity and pulpal irritation include restorative dental procedures, such as the preparation of cavities, adhesive bonding, placement of composite, and indirect restoration. In the presence of orthodontics and restoration procedures, the incremental inflammatory effect can lead to greater pain especially where the treatments are based on a sequence or simultaneously, which may influence the adherence to the long-term treatment plans. The process of orthodontic movement of the teeth depends on the controlled application of force that triggers a biological cascade of effects on the periodontal ligament including production of prostaglandins, cytokines and vascular alterations. Although this inflammatory reaction is necessary for bone remodelling, it also triggers the nociceptors, which cause pain perception. Not only has adjunctive mechanical intervention been examined to speed tooth movement but also been examined to stimulate or inhibit perception of pain. The biological interaction between mechanical stimulation and tissue response was observed when a randomised clinical trial that examined supplemental vibration in aligner-based therapy indicated that mechanical adjuncts have the potential to alter the dynamics of movement and patient-reported discomfort[2].

Photobiomodulation is a new modality with dual therapeutic implications. Low-level laser therapy (LLLT) was demonstrated to increase cellular metabolism, increase microcirculation, and possibly cause a decrease in the expression of inflammatory mediators. On the inflammatory environment that leads to pain production, there was support that LLLT can speed up orthodontic tooth movement by way of providing an indirect finding that LLLT may play a role in osteolytic inflammatory environment generation greatly contributing to pain generation[3]. Additional support came in through a triple-blind randomised controlled trial, which affirmed that there are clinically viable uses of LLLT that can change the biological response during orthodontic treatment, which further supports its possible use as an adjunctive method of pain modulation[4]. In addition to the accelerating effects, direct analgesic effects have been reported. A placebo-controlled randomised clinical trial stated that LLLT was associated with pain relief after the initial arch wire insertion in cases of premolar extractions, which revealed a reduction in the pain at the beginning of treatment of clinical significance[5].

In the orthodontic practice, pharmacological analgesia continues to be the pillar of pain management. This poses a broad prescription of the nonsteroidal anti-inflammatory drugs (NSAIDs) because of their inhibitory property on the cyclooxygenase enzymes and consequently, lowering the formation of prostaglandins. Nevertheless, it has been criticised as one of the potential impacts on the movement of orthodontic teeth because prostaglandins are essential to bone remodelling. A Cochrane systematic review comparing the use of pharmacological agents to manage orthodontic pain found that NSAIDs and acetaminophen can effectively reduce discomfort in the short term but found that due to the heterogeneity of studies there is no clear clinical advice that can be given[6]. The review underlined the importance of the balanced analgesic choice that should not adversely influence the progress of the treatment but should help alleviate the pain. Because patients who receive combined orthodontic and restorative procedures might need recurrent use of analgesics, closer attention to the dosage, time, and systemic impact is paid.

Non-pharmacological interventions have been discovered in response to the apprehensions related to pharmacological side effects and the use of medications on a long-term basis. Neuromodulatory devices have been suggested to stimulate bone remodelling and relieve pain by using vibration devices that cause low-magnitude oscillatory forces. A systematic review of the effects of vibrational devices on orthodontic tooth movement provided mixed results with some proving that it may be more efficient and comfortable to treat patients[7]. Despite the lack of consistency in results, these devices can be seen as a developing field of interest in multimodal pain management approaches. A combination of these adjunctive measures can be especially useful in multidisciplinary situations when it is necessary to reduce the cumulative discomfort to keep patients motivated and compliant.

This review aims to critically assess modern pain management techniques in orthodontic and restorative dental practices for patients. Precisely, it will summarise the existing knowledge about the biological processes of treatment-related pain, contrast pharmacological and non-pharmacological interventions, and offer clinically applicable recommendations to achieve maximum patient comfort and treatment outcomes during multidisciplinary dental care.

2. Pathophysiological Basis of Pain in Combined Orthodontic–Restorative Therapy

The mechanisms that mediate the occurrence of pain during combined orthodontic and restorative dental treatment are mainly the inflammatory and neurophysiological processes that occur because of mechanical, chemical, and procedural stimuli. The use of forces on teeth that are either controlled force to compress and stretch the periodontal ligament in orthodontics causes vascular changes, ischemia, and release of inflammatory mediators, including prostaglandins, interleukin, and tumour necrosis factor-alpha. The cascade triggers peripheral nociceptors and serves to cause the typical peak in discomfort first seen within the first 24-48 hours of application of forces. A meta-analysis and systematic review of the effects of chewing gum as a non-pharmacological intervention demonstrated that orthodontic pain peaks immediately after mechanical loading, which reinforced the hypothesis of the biological concept of acute inflammatory response after mechanical loading[8]. Neural sensitisation processes also have an impact on the inflammatory response. Pain perception can be increased by continuous or recurrent orthodontic stimulation that decreases the thresholds of the nociceptive system. Comparative clinical studies of the post-arch wire placement use of paracetamol and chewing gum showed that pain following an orthodontic force application is high enough to justify the use of

structured modulation techniques, with special consideration to the biological role of mediator-driven nociception during the initial stages of treatment[9].

Mechanical stimulation through mastication has been proposed to modify periodontal ligament blood flow and reduce stagnation-related ischemia, thereby attenuating inflammatory pain. A randomised clinical trial investigating chewing gum as a non-pharmacological alternative confirmed that controlled masticatory activity may alleviate discomfort, suggesting that modulation of local circulatory dynamics can influence the inflammatory microenvironment responsible for pain perception[10]. Another biologically important process of pain relief is called photobiomodulation. Low-level laser therapy is thought to cause the mitochondrial activity increase, adenosine triphosphate synthesis, and a decrease in the concentration of inflammatory mediators, and in turn the reduction of peripheral nerve sensitisation. A randomised controlled trial between low-level laser therapy and chewing gum showed that there is a significant decrease in orthodontic pain and the cellular bio-stimulation of cells is significant in the regulation of inflammatory and neural responses[11] (Figure 1).

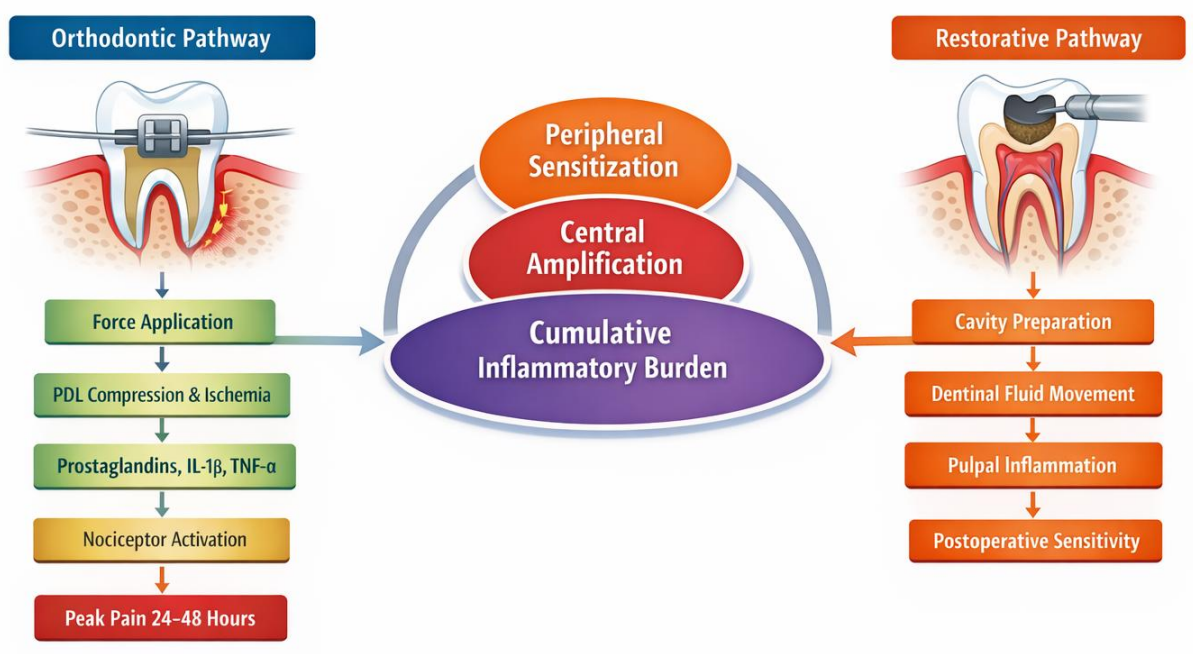

Figure 1. Pathophysiological Mechanisms of Pain in Combined Orthodontic–Restorative Therapy

In the same way, acute periodontal compression and inflammatory activation are reflected by pain caused by the positioning of elastomeric separators. The evidence of using chewing gum after the insertion of the separators was in a randomised controlled trial that showed decreased discomfort supporting the notion that mechanical modulation of periodontal tissues can affect the biological cascade underlying orthodontic pain[12]. Additional nociceptive pathways could be triggered when orthodontic treatments are coupled with restorative interventions e.g. adhesive bonding, dentin preparation, or placing composite. Though restorative procedures may trigger pulpal irritation and changes in dentinal fluid, this may exacerbate periodontal inflammation. The amplification of peripheral sensitisation and central amplification of the pain signals may occur because of the convergence of these stimuli in some cases. As such, to be able to develop targeted and multimodal approaches to pain management, it is necessary to know the common biological processes in combined therapy (Table 1).

Table 1. Biological Mechanisms of Pain in Orthodontic and Restorative Procedures

Pain Source	Primary Biological Mechanism	Key Mediators	Clinical Manifestation	Supporting Evidence
Orthodontic force application	Periodontal ligament compression and ischemia	Prostaglandins, IL-1β, TNF-α	Peak pain at 24–48 hrs	8
Archwire placement	Acute inflammatory cascade activation	COX-mediated mediators	Early-stage discomfort	9
Elastomeric separators	Mechanical compression of PDL	Local inflammatory cytokines	Short-term acute pain	12
Restorative cavity preparation	Dentinal fluid movement (hydrodynamic theory)	Pulpal neuropeptides	Postoperative sensitivity	28
Adhesive procedures	Polymerisation shrinkage stress	Pulpal inflammatory response	Delayed hypersensitivity	39

3. Methodological Considerations in the Assessment of Dental Pain

Proper evaluation of the dental pain is vital in comparing interventions, judging clinical efficacy, and transferring research to practice. Pain is subjective and depends on biological, psychological, and procedural issues in orthodontic and multidisciplinary dental care; thus, standard outcome measures of meaningful comparison across studies are needed. Most clinical trials on pain-control measures use patient-reported outcome scales, the Visual Analogue Scale (VAS) and Numerical Rating Scale (NRS) since they are easy to use, responsive to short term variation, and can be used in any dental procedure. A comparative clinical trial between ibuprofen, chewing gum, and bite wafers after initial archwire placement demonstrated the reliance of orthodontic pain studies on structured patient scoring which is usually documented over a series of time intervals that reflect high levels of intensity and resolution patterns[13].

Pain in orthodontics is highly time sensitive with discomfort usually increasing following the activation of the orthodontic appliances and then reducing slowly and thus, serial measurements are extremely important. One randomised clinical trial that compared the use of chewing gum with ibuprofen documented pain levels at a time interval and it was observed that temporal pain mapping (e.g., immediately, 24 hours, 48 hours, etc.) can be used to establish differences of intervention-specific pain during peak periods[14]. This method is particularly applicable in conjunctive orthodontics/restorative treatment where pain can be triggered with each orthodontic activation or restorative procedure, and longitudinal observation, as opposed to single-point assessment, is necessary. Pain measurement can also need a distinction between the insertion-related pain, postoperative pain, and delayed inflammatory pain in procedure-specific situations. A randomised, double blind controlled trial comparing topical anaesthesia with photobiomodulation in the placement of miniscrews clarified the need to have measures of immediate procedural pain and of later inflammatory pain, usually on a VAS scale with a specified follow-up period[15]. This difference is clinically significant where responses to interventions can be useful in decreasing one of the pain components (e.g., insertion pain) but little on delayed soreness (Figure 2).

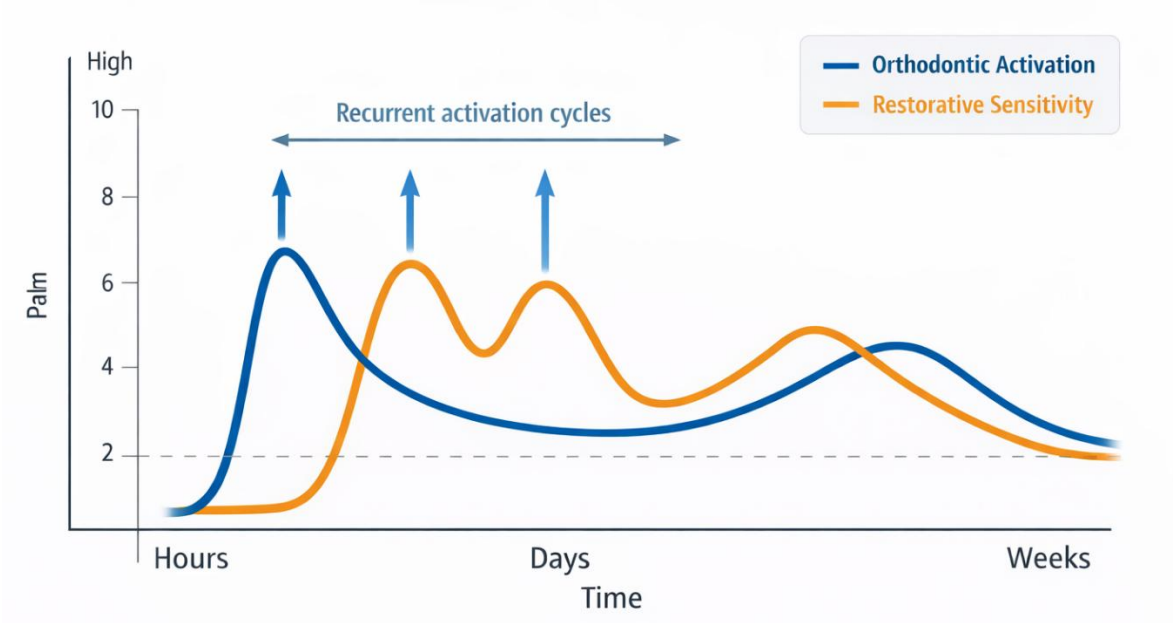

Figure 2. Temporal Profile of Pain Intensity During Multidisciplinary Treatment

Systematic reviews support the application of standardised measures and regular time schedules to improve the heterogeneity and enhancement of evidence synthesis. In a recent systematic review and meta-analysis of pain reduction in orthodontic separation, it was found that differences in pain scale, assessment times, and reporting procedures are some of the factors that lead to differing findings across studies[16]. This form of methodological inconsistency restricts the direct comparison of interventions and makes it more difficult to gain a methodological interpretation at the level of guidelines. Similarly, a systematic review of the efficacy of pharmacological pain control in separator placement reported that non-congruent pain measurement tools (e.g, different scales, non-uniform schedules of follow-up, and missing follow-up): weaken the strength of the pooled conclusions and recommend the implementation of a standardised pain assessment paradigm in orthodontic studies[17].

Interpretation of the benefit of intervention is also described by pre-emptive analgesia trials that show an influence on outcome measurement. A randomised clinical trial of pre-emptive tenoxicam to chewing gum after placing the archwire was based on formal pain scoring at specified time points, which showed that scales that are valid and regular measurement schedules are needed to state whether the effect is that of preventive analgesia or natural patterns of pain resolution[18]. Altogether, these investigations show that future studies in the field of combined orthodontic and

restorative protocols must focus on validated pain scales, predetermined assessment timeframes based on the experienced pain peaks, and report transparency to enhance evidence quality and clinical usefulness.

4. Pharmacologic Approaches to Pain Modulation in Multidisciplinary Dental Care

The main aims of pharmacological pain management in orthodontics and combined dentistry are to minimise the inflammatory process caused by compression of the periodontal ligament, the use of separators, and the use of appliances. Nevertheless, the use of medications in orthodontics has been commonly contrasted with non-pharmacological treatment since patients and clinicians need an effective alternative that would not impose adverse effects on the system and would not interfere with biologic movement of teeth. Here, chewing gum has been explored as an adjunct or comparison in painful orthodontic treatments such as the insertion of separators where there is a clinical need to employ pain management measures during early stages of inflammation[19].

The most frequently used pharmacological agents in the treatment of orthodontic pain are still the nonsteroidal anti-inflammatory drugs (NSAIDs), especially ibuprofen, which inhibit the production of prostaglandins and nociceptors. In comparing the clinical effects of ibuprofen and chewing gum, it is clear that NSAIDs can be used to bring meaningful pain relief during the orthodontic discomfort process, and it is also necessary to consider the fact that it is better to adjust the choice of a drug and its use with the time intervals of the highest intensity of pain[20]. Though not pharmacological, vibration is mentioned more in conjunction with medications since the suggested effects on neuromodulation and tissue response can decrease the perceived necessity to use repeated doses of analgesics. A recent systematic review and meta-analysis assessing the use of vibration in orthodontics indicates an increasing interest in the use of adjunctive modalities with pharmacologic forms of treatment to increase the comfort without compromising the effectiveness of treatment[21] (Figure 3).

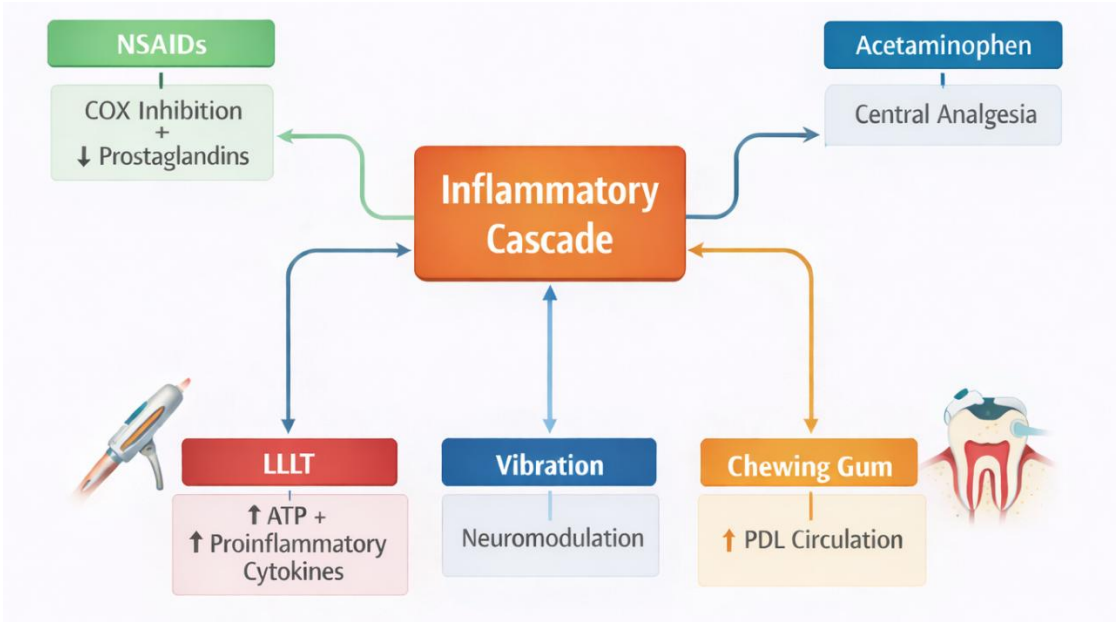

Figure 3. Mechanism-Based Modulation of Dental Pain: Pharmacologic and Adjunctive Strategies

Equally, systematic evaluation of vibration in clinical and in vivo trials indicated inconsistent results, which supports the fact that adjunctive modalities can be used as a complement to, rather than a substitute of evidence-based pharmacological pain management, especially in individuals receiving long-term or multi-phased care[22]. The syntheses of evidence concern the efficacy of pharmacological methods in the analgesic effect during the initial days of the stimulation of appliances or the introduction of a separator. An organisation review and meta-analysis assessment on analgesics means orthodontic pain concurs with the efficiency of the regularly utilised agents, yet it also reveals the variability in dosing regimens and the use of outcome measures among the trials and thus prevents the comparison and the adoption of the uniform guidelines[23].

The choice of analgesics administered during combined orthodontic and restorative care should also be in accordance with larger dental pain management concepts. The evidence-based guideline of the American Dental Association on the acute dental pain in adolescents, adults, and the elderly supports a non-opioid initial pharmacotherapy and the enhancement of the optimal dosage technique to achieve the best analgesia with minimal risks, which is especially important when the patient experiences recurrent pain during multiple gum cuts[24] (Table 2).

Table 2. Pharmacological Interventions for Orthodontic Pain Control

Drug/Class	Mechanism of Action	Clinical Effect	Impact on Tooth Movement	Evidence

Ibuprofen	COX inhibition	Reduces inflammatory pain	Possible modulation	20
Tenoxicam (pre-emptive)	Long-acting NSAID	Early pain reduction	Limited evidence	18
NSAIDs (systematic evidence)	Prostaglandin suppression	Effective short-term control	Needs caution	23
Combination analgesics	Dual central/peripheral action	Superior analgesia	No clear adverse orthodontic effect	26
ADA guideline recommendation	Non-opioid first-line therapy	Safe pain control	Clinically recommended	24

5. Non-Pharmacologic and Adjunctive Pain Control Strategies

Non-pharmacological towards dental pain management are increasingly gaining significance in the modern context of dental care, where the tendency to reduce opioid intake and limit the use of systemic drugs is constantly growing. Large randomised clinical trials of nonopioid versus opioid regimens following extractions of third molars support the view that sufficient pain control may be induced without the use of opioids, and that multimodal and safer pain management paradigms are becoming more common in dentistry[25]. This change promotes the use of adjunctive and non-pharmacological approaches in orthodontics and restorative care to limit the total medication exposure. Although the combination pharmacotherapy like the analgesics acetaminophen and ibuprofen has demonstrated a high level of analgesic therapy in the postoperative dental pains[26], non-pharmacological interventions can also complement the main procedures and contribute to the increased comfort and decreased frequency of dosing. In multidisciplinary scenarios, with patients who have recurrent inflammatory stimuli, the adoption of behavioural advice, mechanical modulation (e.g. controlled mastication), or the support of physiotherapy adjuncts may be applied to reduce pain between procedural sessions.

Procedural factors are important in the determination of postoperative sensitivity in restorative dentistry. A randomised clinical trial between total-etch and self-etch bonding systems showed that the adhesive strategy has a direct impact on the level of pain after surgeries[27]. These results allow emphasising that nociceptive responses can be adjusted by technique-sensitive clinical decisions instead of medications, which is the key point to recognise the preventative aspect of non-pharmacological pain management. In the same vein, the significant role of reducing stresses associated with polymerisation shrinkage, maximising bonding regimens and proper isolation to minimise pulpal irritation was underscored by a comprehensive review on postoperative sensitivity on anterior composite restorations as well as posterior composite restorations in general[28]. These technique-based interventions are the life-threatening non-pharmacological interventions that directly affect the biological causes of restorative pain.

The perception of pain and tolerance to treatment is also affected by factors that relate to the patient. A randomised clinical trial subgroup study on third-molar surgery found that there is a difference between male and female analgesic response, implicating the possibility of a role of biological and psychosocial variables in influencing pain experience and pain management outcome [29]. Appreciation of this variability is in favour of customised, multimodal approaches integrating optimised clinical methodology, patient education and selective pharmacotherapy. (Table 3)

Table 3. Non-Pharmacological Interventions and Their Clinical Effectiveness

Intervention	Proposed Mechanism	Clinical Outcome	Evidence Strength	Reference
Chewing gum	Improved PDL circulation	Reduced peak pain	Moderate	32
Bite wafers	Mechanical stimulation	Comparable to analgesics	Moderate	37
Low-Level Laser Therapy	Photo biomodulation	Reduced inflammatory pain	Moderate-Strong	34
LLLT (separator pain)	Cellular ATP activation	Significant pain reduction	Strong	35
Vibration devices	Neuromodulation	Mixed evidence	Low-Moderate	22

6. Restorative Protocol Optimisation for the Prevention of Postoperative Sensitivity

Pulpal irritation, movements of dentinal fluids, and polymerisation stress shrinkage are identified as the main factors that lead to postoperative sensitivity after restorative procedures. When combined orthodontic and restorative treatment is used, it is important to ensure that some discomfort that is caused by restorative treatment is minimized not to increase the level of inflammatory response already caused by orthodontic forces. Pain management is therefore an action that involves not only pharmacological assistance but also preventive and technique-sensitive restorative interventions that minimise nociceptive stimulation at its source[30]. Even though analgesics may alleviate inflammatory pain, the analgesics do not get rid of the original sources of the pain. Clinical trial evidence assessing pre- and post-operative analgesic drugs in orthodontic cases shows that medication is most effective in the management of inflammatory pain and

not mechanical or technique-related triggers of pain[31]. This difference is also significant with regard to restorative dentistry as procedural optimisation could be more effective in preventing sensitivity than systemic analgesics alone.

Mechanical stimulation interventions, including chewing gum, have been observed to modulate periodontal and inflammatory pain reactions to orthodontic therapy[32]. Although this evidence applies to orthodontics, it describes a general biological concept, namely that the manipulation of local tissue dynamics can be used to affect nociceptive perception. Careful preparation of the cavity regulated etching procedures, incremental placement of composite, and sufficient curing methods can be used to provide the action of a biological modulation during restorative procedures to decrease the stress of polymerisation and fluid migration in the dentina. (Figure 4)

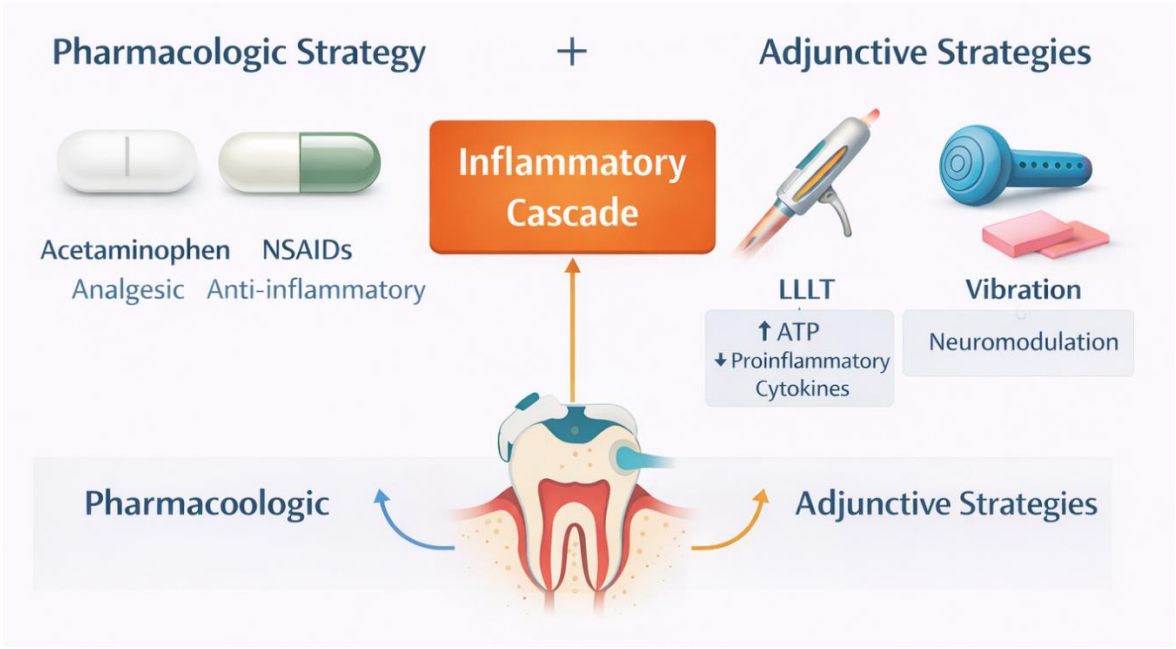

Figure 4. Preventive Restorative Protocol Optimisation to Reduce Postoperative Sensitivity

In further comparison of clinical analysis of chewing gum and bite wafers with ibuprofen, during separator placement, more evidence is depicted that alleviating mechanical stress and procedural elements may have a considerable impact on pain results in the context of separator placement[33]. Applying this notion to restorative dentistry highlights the need to reduce the amount of occlusal trauma, provide appropriate marginal adaptation and not to over-dehydrate dentin when using bonding procedures. Hence, non-invasive methods of ensuring pulpal health, lessening the effects of shrinkage and ensuring dentin integrity are very crucial measures of the minimisation of postoperative sensitivity. Considering the multidisciplinary cases, a systematic schedule of orthodontic activation and restorative therapy and a careful adhesive application can significantly decrease cumulative pain and improve patient tolerance in general. (Table 4)

Table 4. Restorative Factors Influencing Postoperative Sensitivity

Variable	Clinical Implication	Pain Risk Level	Supporting Study
Self-adhesive resin	Simplified bonding	Lower sensitivity	38
Total-etch adhesive	Higher dentin permeability	Increased risk	39
Bulk-fill composite	Reduced shrinkage stress	Lower postoperative pain	40
Polymerization technique	Incremental curing reduces stress	Reduced hypersensitivity	28

7. Comparative Effectiveness and Synthesis of Current Evidence

The relative efficacy of pain-control methods used in orthodontic treatment increasingly supports the use of multimodal methods, especially those methods decreasing the use of systemic analgesics and still provide clinically significant pain relief. Among the existing data, photo-biomodulation has been brought into the limelight as anti-inflammatory and neuromodulatory and current randomised trials offer more clinical evidence. The results of a randomised controlled trial comparing low-level laser therapy during molar distalization in relation to control of patient-reported pain revealed that laser therapy had significant effects in reducing pain in orthodontic stages that involved long-term application of force and prolonged tissue remodelling[34]. Interventions related to separator pain are a good model to compare since they usually result in predictable acute pain. Another randomised, double-blind, placebo-controlled split-mouth study provided evidence that low-level laser therapy had a significant effect in reducing pain due to orthodontic separators, which reinforced the idea that specific photo-biomodulation could affect the acute inflammatory pain in the early post-activation stage[35].

In addition to individual trials, greater synthesis has also been initiated with the aim of assessing the consistency and biological plausibility of laser-based analgesia. A

recent review on the effects of low-level laser therapy on orthodontic pain has identified the mechanistic pathways such as the downregulation of inflammatory mediators, enhanced microcirculation, and alteration of peripheral nerve conduction along with the variability of parameters and protocols of studies[36]. Mechanical adjuncts that can modify occlusal loading and tissue stimulation have also been tested along with photo-biomodulation. A meta-analysis and systematic review that compared chewing bite wafers to traditional analgesic medications reported that bite wafers have the potential to be used to generate quantifiable pain relief in persons with fixed appliances and may represent clinically significant advantages, as well as be used as an additional or alternative intervention in a subset of patients[37]. Taken together, these findings suggest that pharmacological interventions continue to be effective in the short term, but interventions like low-level laser therapies and bite wafers also prove to be promising in comparison, especially when they are used as part of multimodal patient-centred pain management programs. (Table 5)

Table 5. Comparative Effectiveness of Pain Control Modalities

Modality	Type	Effect Size Trend	Clinical Applicability	Evidence
NSAIDs	Pharmacologic	High short-term	Widely applicable	23
Chewing gum	Mechanical	Moderate	Safe adjunct	8
LLLT	Biostimulator	Moderate-High	Equipment-dependent	11
Vibration	Mechanical	Inconsistent	Adjunctive only	7
Adhesive optimization	Preventive	High (restorative phase)	Essential	27

8. Clinical Translation: Decision-Making Framework for Multidisciplinary Pain Management

The prevention of clinical pain in combined orthodontic-restorative therapy must be viewed as a systematic, sequential, and patient-centred procedure, since the pain can result from orthodontic stimulation, restorative tissue handling or post-surgical sensitivity. An effective algorithm will start with the determination of the most significant source of pain at each visit (orthodontic inflammatory vs restorative hypersensitivity) and the choice of the interventions that address the aetiology and reduce the current dose of medication over a treatment course. Restorative trials have shown that the choice of techniques is one of the leading factors in determining the postoperative sensitivity. That is, in prevention by planning the operation, it is usually better to avoid the occurrence of symptoms rather than treat them. A split-mouth and controlled study of the effects of restorations on postoperative sensitivity using self-adhesive resin revealed that the choice of adhesive and bonding method has a direct impact on the success of the clinical outcomes of postoperative sensitivity, and the adhesive selection is the right choice to take at the initial stage of clinical algorithms[38].

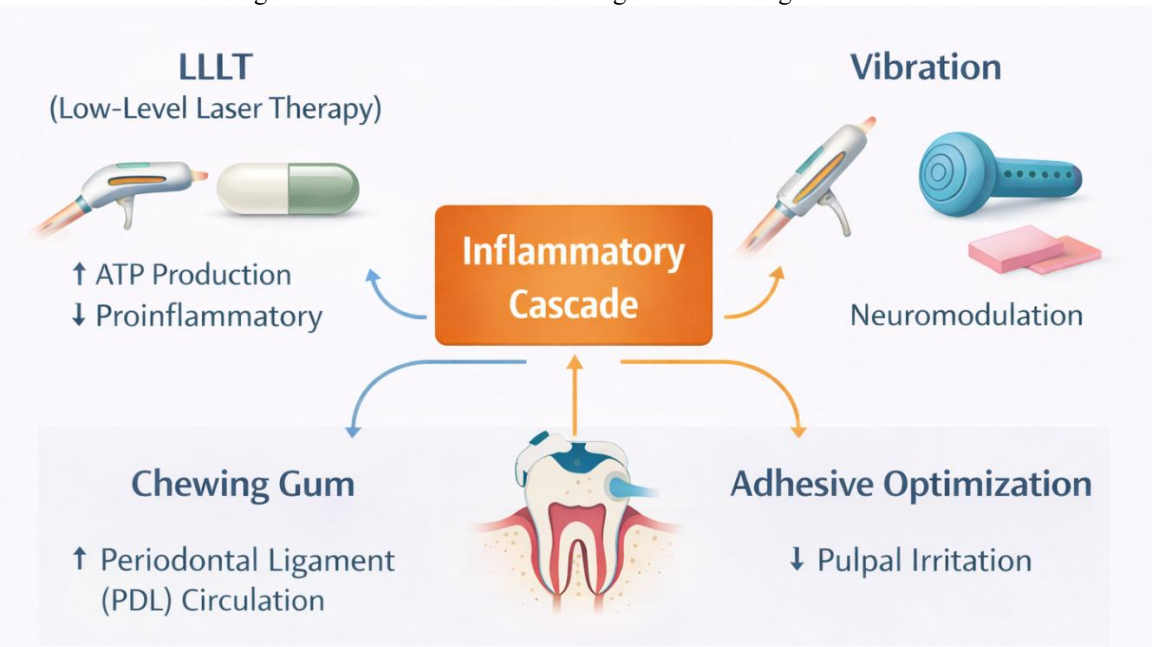

Figure 5. Clinical Decision-Making Algorithm for Pain Management in Combined Orthodontic–Restorative Treatment

The second decision node of multidisciplinary care is the choice of adhesive strategy according to the risk of hypersensitivity of the patient (deep cavities, exposed dentin, previous sensitivity history, anxiety). A randomised clinical trial of total-etch versus universal adhesive systems showed a difference in postoperative hypersensitivity detailing that clinicians can significantly lower the chances of pain by choosing a bonding protocol as opposed to using analgesics alone after treatment to manage pain[39]. The choice of material and the method of placement ought to be next taken into consideration particularly when orthodontic treatment predisposes to more or further occlusal readjustments or frequent restorative visits. To support the necessity to

incorporate restorative material planning in the multidisciplinary pain-management pathways, a randomised split-mouth trial between self-adhesive and conventional bulk-fill resin composites showed that the type of composite and mode of restoration have an influence on the development of postoperative sensitivity[40]. (Table 6)

Table 6. Proposed Clinical Decision-Making Framework for Combined Treatment

Clinical Scenario	Primary Pain Source	First-Line Strategy	Adjunct Option	Evidence Base
Initial archwire placement	PDL inflammation	NSAID	Chewing gum	13
Separator placement	Acute compression	Pre-emptive NSAID	LLLT	16
Miniscrew placement	Insertion trauma	Topical anesthesia	PBMT	15
Deep composite restoration	Pulpal irritation	Adhesive selection	Desensitizer	38
Combined visit (activation + restoration)	Dual inflammatory response	Multimodal approach	Mechanical adjunct	24

9. Limitations of Current Evidence and Future Research Priorities

Although there is an increasing knowledge base on the management of orthodontic pain and postoperative sensitivity with restorative dentistry, there are numerous constraints that limit the validity and applicability of existing evidence. To begin with, most of the studies assess orthodontic or restorative pain on its own, but not in the context of the actual combined treatment programs. Such a distinction restricts our knowledge of cumulative or overlapping inflammatory reactions that exist in the multidisciplinary cases. Second, there is a great deal of heterogeneity in study design with differences in pain scales, how the measurements are conducted, intervention protocols, dosage parameters (especially photo-biomodulation) and follow-ups. This kind of variation makes cross-trial comparison difficult and reduces the capability to implement standard clinical recommendations.

The next significant limitation is that it is based mainly on short-term outcome evaluation. Most studies concentrate on pain during the initial 24-72 hours of intervention, whereas combined orthodontic restorative care may last months and years. There is a lack of longitudinal data assessing recurrent inflammatory exacerbations, adaptation of the patients and chronic analgesic exposure. Moreover, in most randomised clinical trials the sample size is very small, and blinding is not always uniformly used which may expose them to the risk of bias.

Future studies are advised to focus more on well-structured randomised control trials that will specifically study the pain management procedures in patients receiving combined orthodontic and restorative therapies. They should include the use of standardised outcome measures, standardisation in reporting of pain assessment intervals and inclusion of validated patient-reported outcome measures. Research ought also to investigate multimodal approaches that involve the combination of preventive restorative measures, optimum orthodontic activation programs, and non-pharmacological supplementary measures. In addition, such new directions as biomarker-based pain measurement, digital pain monitoring tools, and individualised analgesic regimes related to patient-specific risk factors should be explored. Enhanced methodological rigour and emphasis on multidisciplinary dental care through integrated clinical scenarios will improve the development of evidence-based patient-centred pain management interventions.

10. Conclusion

The prevention and treatment of pain in patients who receive combined orthodontic and restorative treatments to the mouth demands a multifaceted and biological approach to this problem. The application of orthodontic forces and restorative procedures has different though overlapping effects on the initiation of an inflammatory and neurophysiological response that may become cumulative and cause increasing patient discomfort. In cases where these treatments are done either sequentially or simultaneously, poor pain management can adversely affect compliance, satisfaction and success of overall treatment. Both pharmacological and non-pharmacological interventions can be used to minimise the discomfort associated with procedures, which is justified by current evidence. Nonsteroidal anti-inflammatory drugs and combination analgesics are still effective in the management of short-term inflammatory pain, whereas adjunctive methods like photo-biomodulation, mechanical stimulation, and optimised restorative techniques help to reduce the number of nociceptive triggers at their origin. Notably, preventive measures, especially the choice of adhesive, the choice of material and careful surgical procedure are critical in alleviating postoperative sensitivity during restorative stages. An interdisciplinary evidence-based approach utilising multimodal, patient-centred treatment, combining risk assessment, mechanism-based intervention, and structured follow-up is the most effective route towards cumulative discomfort management in multidisciplinary cases. Evidence-based recommendations will be further narrowed down in future studies on standardised methodologies and combined-treatment protocols. Finally, pain management is optimised to improve clinical and patient results as well as long-term compliance and adherence to treatment in routine dental treatment.

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