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Treatment-Induced Tissue and Functional Changes in Orthodontics

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Abstract

Orthodontic treatment, while beneficial for dental alignment, carries various potential complications. Common issues include enamel demineralization (white spot lesions) due to poor oral hygiene, with prevalence up to 96% in some studies, and external root resorption, influenced by force magnitude and treatment duration. Periodontal problems like gingivitis and gingival hyperplasia are frequent due to plaque accumulation around appliances. Less common but significant are pulpal necrosis, especially in traumatized teeth, and alveolar bone loss. Patients often experience transient pain and discomfort. Allergic reactions, particularly to nickel, affect 10-20% of patients. The link between orthodontics and temporomandibular joint disorders (TMD) is debated, though pre-existing TMD may be exacerbated. Psychological stress and noncompliance are also concerns. Finally, post-treatment relapse is common without lifelong retention. Meticulous planning, patient education, and vigilant monitoring are crucial for minimizing these risks and ensuring successful outcomes.

Keywords: Complications, Functional changes, Orthodontics, Relapse, Root Resorption, Tissue changes, Treatment-induced Changes

Introduction

Orthodontic treatment, although primarily aimed at improving dental alignment and aesthetics, is not without potential complications. These adverse effects can arise due to a range of factors, including individual patient responses, the techniques applied during treatment, and the materials used in orthodontic appliances. Commonly observed complications include periodontal problems such as gingival enlargement and inflammation resulting from plaque accumulation around brackets and wires.1 External root resorption is another significant concern, particularly in teeth subjected to excessive or prolonged orthodontic forces. Enamel demineralization and discoloration are frequent outcomes of poor oral hygiene during treatment, leading to aesthetic and structural concerns.2 Additionally, pulpal changes such as degeneration or necrosis may occur, especially in teeth with a history of trauma or prior endodontic therapy. Beyond the physical complications, patients may also experience psychological stress, including anxiety and in rare cases, alopecia, as a response to treatment-related discomfort or aesthetic concerns.3 Soft tissue damage in the form of ulcers or lacerations caused by sharp appliance components can further impact patient comfort. Moreover, allergic reactions to materials such as nickel or latex used in orthodontic appliances can complicate the clinical course. [Fig 1] Despite these risks, many of these effects are preventable or manageable through meticulous treatment planning, patient education, and adherence to best clinical practices. Understanding and addressing these potential complications is crucial for optimizing patient outcomes and ensuring safe, effective orthodontic care.4 This article aims to review the common adverse effects associated with orthodontic therapy.

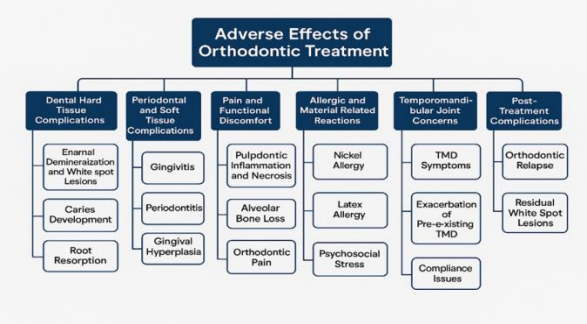

Figure 1: Classification of adverse effects of orthodontic treatment

Dental Hard Tissue Complications

Enamel demineralization, often manifesting as white spot lesions (WSLs), represents one of the most prevalent complications observed during orthodontic treatment. WSLs appear as chalky, opaque patches on the enamel surface and result from subsurface mineral loss caused by acidogenic bacterial plaque accumulating around orthodontic attachments such as brackets and wires. [Fig 2&3] The risk of developing these lesions increases substantially in patients with suboptimal oral hygiene practices, particularly among adolescents, who are generally less vigilant about dental care during orthodontic therapy.5 Epidemiological studies suggest that the prevalence of WSLs among orthodontic patients ranges widely from approximately 30% up to 96%, depending on factors such as population demographics, oral hygiene compliance, and the duration and type of treatment administered. Notably, WSLs can develop within as little as four weeks after the commencement of orthodontic therapy if oral hygiene is poor. Preventive measures for WSLs require a multifaceted approach. Essential strategies include rigorous patient education and motivation to maintain excellent oral hygiene, professional prophylactic cleanings, and regular use of high-fluoride dentifrices and mouth rinses.6 The adjunctive application of professionally administered fluoride varnishes, fluoride-releasing bonding agents, and remineralizing substances (such as casein phosphor peptide amorphous calcium phosphate) has demonstrated effectiveness in both reducing the incidence and promoting the remineralization of early lesions. In some cases, additional approaches such as microabrasion, sealants, or resin infiltration may be considered to manage persistent lesions after appliance removal.7

Figure 2: Enamel demineralization

Figure 3: White Spot Lesion

Root resorption represents another significant and often silent consequence of orthodontic intervention. Characterized by the loss of cementum and underlying dentin, primarily at the root apex, root resorption can undermine long-term tooth stability and longevity if severe. This complication is recognized as multifactorial in origin: mechanical factors (such as the magnitude, duration, and type of force applied; the direction of tooth movement; and interruptions in force application), biological variability, and patient-related factors (including genetics, age, history of dental trauma, pre-existing root shapes, and alveolar bone density) all contribute to susceptibility.8 [Fig 4] Research indicates that heavier orthodontic forces, continuous application of force (as opposed to intermittent), longer treatment durations, and certain types of tooth movement (particularly intrusion and torque) significantly increase the risk of root resorption, whereas lighter and more controlled forces are safer. To mitigate this risk, clinicians recommend careful case selection, individualized treatment planning, application of gentler forces, and regular radiographic monitoring. Most often, routine monitoring is performed using periapical or panoramic radiographs; for higher-risk cases or uncertain findings, cone-beam computed tomography (CBCT) may provide additional detail, though standard radiographs are generally adequate and expose patients to less radiation.9

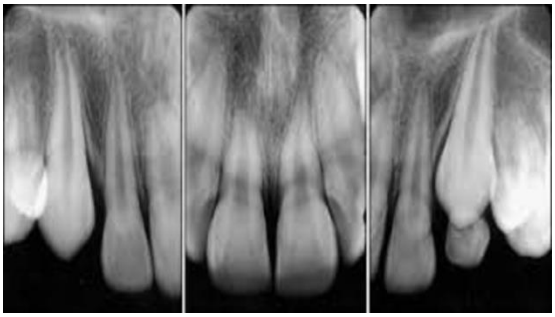

Figure 4: Root Resorption

Periodontal and Soft Tissue Changes

Orthodontic appliances, particularly fixed ones, significantly hinder effective plaque control, creating an environment conducive to the accumulation of bacterial biofilm. This accumulation commonly leads to gingivitis, characterized by inflammation, bleeding on probing, and gingival tenderness. If not addressed promptly, gingivitis can progress to periodontitis, a more severe and potentially irreversible condition involving alveolar bone loss and periodontal pocket formation.10 Studies have shown that orthodontic patients exhibit increased levels of Porphyromonas gingivalis and Aggregatibacter actinomycetemcomitans, which are key pathogens in the pathogenesis of periodontitis. The risk is notably higher in adults and individuals with pre-existing periodontal compromise, where the mechanical stress of tooth movement may exacerbate tissue breakdown. Gingival

hyperplasia, or the overgrowth of gingival tissues, is another prevalent issue associated with orthodontic therapy, often resulting from chronic mechanical irritation and sustained inflammatory responses.11 Research indicates that gingival overgrowth can occur in up to 50% of orthodontic patients, especially those with poor oral hygiene. [Fig 5] Furthermore, soft tissue trauma from sharp or protruding components such as brackets, ligatures, and archwires frequently causes mucosal injuries, including ulcers, abrasions, and localized pain.12 Although these lesions are usually self-limiting, they can reduce patient compliance and increase treatment-related discomfort. [Fig 6] Preventive strategies, including rigorous oral hygiene instruction, the use of fluoride mouth rinses, the application of wax on appliances to reduce mucosal irritation, and regular periodontal assessments, are critical in minimizing these adverse effects.13 Employing smooth-surfaced appliances and customized archwires can also help reduce biofilm retention and mechanical trauma. Regular professional cleanings and reinforcement of hygiene practices throughout treatment are essential for maintaining periodontal health and optimizing treatment outcomes.14

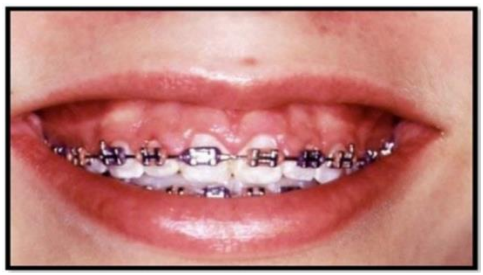

Figure 5: Periodontal effect of orthodontic treatment

Figure 6: Soft tissue Trauma

Pulpal and Alveolar Effects

Although relatively rare, pulpal necrosis can occur as an adverse outcome of orthodontic treatment, particularly when excessive force is applied or when a tooth has a history of previous trauma or deep restorations. The vascular supply to the dental pulp may be compromised during rapid or forceful orthodontic tooth movement, leading to ischemia, pulpdontic inflammation (pulpitis), or even necrosis.15 Research has shown that orthodontic forces above 150 grams can significantly increase the likelihood of pulpal damage, especially in teeth with prior trauma or compromised vitality. Moreover, alveolar bone loss may develop in susceptible individuals, particularly those with poor plaque control, pre-existing periodontitis, or inadequate alveolar bone support. Improper biomechanics, such as uncontrolled tipping or intrusion movements, can exacerbate bone resorption. Studies indicate that up to 20% of adult orthodontic patients with untreated periodontal disease may experience detectable alveolar bone changes during treatment, underscoring the importance of periodontal screening and monitoring throughout therapy.16

Pain and Discomfort

Pain and discomfort are among the most commonly reported side effects of orthodontic treatment. This discomfort typically manifests within a few hours of appliance placement or adjustment, peaks within the first 24–48 hours, and gradually subsides over the next 3 to 7 days. The pain is primarily attributed to inflammatory responses in the periodontal ligament (PDL) due to mechanical stress and the release of prostaglandins, cytokines, and other inflammatory mediators. According to studies, up to 95% of patients report some degree of pain or soreness, especially during the initial phases of treatment.17 This discomfort can negatively affect mastication, speech, and sleep, particularly in adolescents. Management strategies often include the use of nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen, which effectively reduce PDL inflammation without significantly affecting tooth movement. Other supportive approaches include soft diets, reassurance, cold compresses, and avoiding hard or sticky foods during the peak pain period.18

Allergic Reactions

Orthodontic materials can provoke hypersensitivity reactions in susceptible individuals, with nickel allergy being the most commonly encountered. Nickel is a component of stainless steel, widely used in brackets, archwires, and bands. Sensitized patients may develop contact dermatitis, stomatitis, burning mouth symptoms, or lichenoid lesions in response to nickel-containing components. [Fig 7] The prevalence of nickel sensitivity in orthodontic patients ranges from 10% to 20%, with a higher incidence in females and individuals with a history of metal allergies. Similarly, latex, used in orthodontic elastics and gloves, may induce allergic reactions ranging from mild urticaria to anaphylaxis in latex-sensitive patients. As a precaution, patients with a known history of metal or latex allergies should be treated with biocompatible alternatives, such as titanium archwires, ceramic or polycarbonate brackets, and latex-free elastics. Clinicians should also obtain a detailed medical and allergy history before initiating treatment.19

Figure 7: Allergic Reactions

Temporomandibular Joint Disorders (TMD)

The potential link between orthodontic treatment and temporomandibular joint disorders (TMD) remains a subject of debate in the orthodontic literature. While some patients may develop or report TMJ symptoms such as joint pain, clicking sounds, muscle tenderness, or limited mouth opening [Fig 8] during or after orthodontic treatment, most systematic reviews and meta-analyses have failed to establish a direct causal relationship. In fact, a longitudinal study by Luther (1998) found that orthodontic therapy neither significantly increases nor decreases the risk of TMD in the general population. However, for patients with pre-existing TMD, orthodontic treatment especially involving mandibular repositioning or changes in occlusal vertical dimension may exacerbate symptoms. Therefore, a comprehensive evaluation of TMJ function, including clinical examination, patient history, and possibly imaging, should be performed prior to starting treatment, particularly in symptomatic individuals.20

Figure 8: TMD after Orthodontic Treatment

Psychological and Behavioural Considerations

Beyond physiological side effects, orthodontic treatment can exert a psychological and behavioural impact, especially among adolescents and appearance-conscious adults. Factors such as self-consciousness about wearing braces, changes in speech, dietary restrictions, prolonged treatment durations, and frequent dental visits can lead to anxiety, frustration, and reduced motivation. For some individuals, particularly those with pre-existing anxiety or body image concerns, orthodontic treatment may result in psychosocial stress. Studies report that approximately 20%–30% of adolescent orthodontic patients experience moderate psychological distress related to treatment.21 Noncompliance is another behavioural concern, often linked to lack of understanding, peer pressure, or perceived inconvenience. Strategies to address these challenges include motivational interviewing, transparent communication, peer support groups, and involving the patient in decision-making. Psychological preparedness and setting realistic expectations at the outset of treatment are key to improving compliance and patient satisfaction.22

Relapse After Treatment

Orthodontic relapse refers to the unwanted movement of teeth back toward their original malocclusion after treatment completion. Relapse is a multifactorial phenomenon influenced by residual growth, soft tissue pressures (especially from the tongue and lips), periodontal fibre memory, and occlusal forces.23 Certain types of movements, such as rotation and spacing, are inherently less stable and more prone to relapse. Retention plays a critical role in maintaining treatment outcomes. Studies suggest that over 60% of patients show some degree of relapse within 10 years if retention protocols are not properly followed. Noncompliance with removable retainers significantly increases this risk. Hence, lifelong retention, particularly in the form of fixed lingual retainers or long-term wear of removable retainers, is often recommended to ensure stability. Regular post-treatment follow-ups and patient education about the importance of retainer use are essential in preventing relapse and preserving results.24,25

Conclusion

Orthodontic treatment offers substantial benefits in improving dental function and aesthetics, but clinicians must remain aware of its potential adverse effects. These complications, though often manageable or preventable, can compromise treatment outcomes and patient satisfaction. A thorough understanding of the etiological factors, patient-specific risk profiles, and effective preventive strategies is vital. Moreover, regular monitoring, use of biocompatible materials, and patient education should be integral parts of every orthodontic protocol to ensure safe and successful therapy.

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Figure Legends

Figure 1: Classification of adverse effects of orthodontic treatment

Figure 2: Enamel demineralization

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Figure 7: Allergic Reactions

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Figure 8: TMD after Orthodontic Treatment

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